Contents

Alaska Outer Continental Shelf

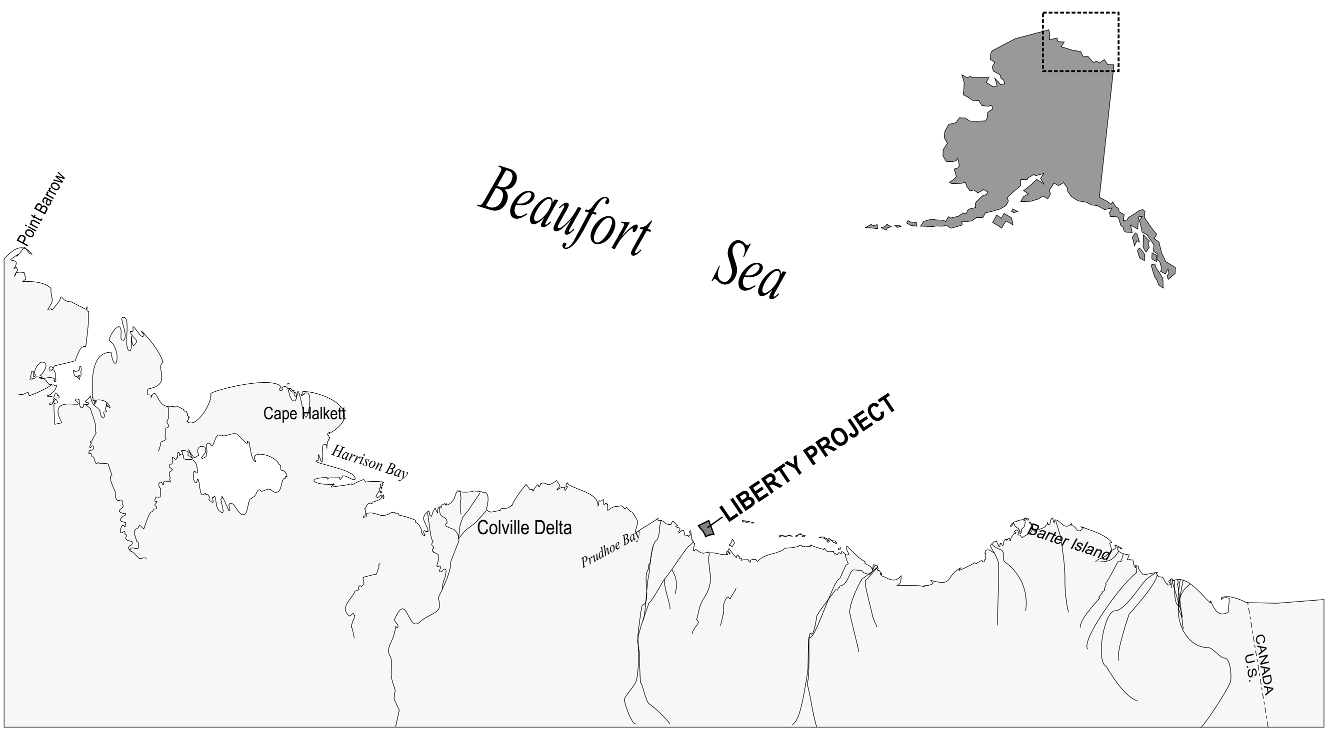
OCS EIS/EA
MMS 2001-001

Liberty Development and Production Plan

Draft Environmental
Impact Statement

Volume I

(Executive Summary, Sections I through IX, Bibliography, Index)



U.S. Department of the Interior
Minerals Management Service
Alaska OCS Region

Contents

Liberty Development and Production Plan, Draft Environmental Impact Statement,
OCS EIS/EA, MMS 2001-001, in 3 volumes:
Volume I, Executive Summary, Sections I through IX, Bibliography, Index
Volume II, Tables, Figures, and Maps for Volume I
Volume III, Appendices

The summary is also available as a separate document:
Executive Summary, **MMS 2001-002.**

The complete EIS is available on CD-ROM (**MMS 2001-001 CD**) and on the Internet (**http://www.mms.gov/alaska/cproject/liberty/**).

This Environmental Impact Statement (EIS) is not intended, nor should it be used, as a local planning document by potentially affected communities. The exploration, development and production, and transportation scenarios described in this EIS represent best-estimate assumptions that serve as a basis for identifying characteristic activities and any resulting environmental effects. Several years will elapse before enough is known about potential local details of development to permit estimates suitable for local planning. These assumptions do not represent a Minerals Management Service recommendation, preference, or endorsement of any facility, site, or development plan. Local control of events may be exercised through planning, zoning, land ownership, and applicable State and local laws and regulations.

With reference to the extent of the Federal Government's jurisdiction of the offshore regions, the United States has not yet resolved some of its offshore boundaries with neighboring jurisdictions. For the purposes of the EIS, certain assumptions were made about the extent of areas believed subject to United States' jurisdiction. The offshore-boundary lines shown in the figures and graphics of this EIS are for purposes of illustration only; they do not necessarily reflect the position or views of the United States with respect to the location of international boundaries, convention lines, or the offshore boundaries between the United States and coastal states concerned. The United States expressly reserves its rights, and those of its nationals, in all areas in which the offshore-boundary dispute has not been resolved; and these illustrative lines are used without prejudice to such rights.

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U.S. Environmental Protection Agency
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U.S. Department of the Interior
Minerals Management Service
Alaska OCS Region

January 2001

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COVER SHEET

Beaufort Sea Oil and Gas Development/Liberty Development and Production Plan
Environmental Impact Statement
2001

Draft (X) **Final ( )**

Type of Action:

Administrative (X) Legislative ( )

Area of Proposed Effect:

Offshore Beaufort Sea marine environment and onshore North Slope of Alaska Coastal Plain

Lead Agency:

U.S. Department of the Interior,
Minerals Management Service

Cooperating Agencies:

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ABSTRACT

An Interagency EIS Team was created to assist MMS in preparing this EIS. The U.S. Army Corp of Engineers and the Environmental Protection Agency are cooperating agencies. Participating agencies include the U.S. Department of the Interior, Fish and Wildlife Service; U.S. Department of Commerce, National Marine Fisheries Service; State of Alaska, Pipeline Coordinator's Office; State of Alaska, Division of Governmental Coordination; and the North Slope Borough.

BP Exploration (Alaska) Inc. (BPXA) proposes to produce oil from the Liberty Prospect (OCS Lease Y-01650) located approximately 5 miles offshore and 1.5 miles west of the abandoned Tern Exploration Island in Foggy Island Bay in the Alaskan Beaufort Sea. BPXA's proposed action for the Liberty Prospect is to construct a self-contained offshore drilling operation (development) with processing (production) facilities located on a man-made artificial gravel island in 22 feet of water in Foggy Island Bay.

BPXA proposes to construct a 12-inch common-carrier oil pipeline buried in an undersea trench (approximately 6.1 miles long) from offshore Liberty Island to an onshore landfall and then connected by an elevated onshore pipeline to a tie in with the existing onshore Badami oil pipeline (approximately 1.5 miles long). This infrastructure will, in turn, transport sales quality oil (hydrocarbons) to the Trans-Alaska Pipeline System. Buried with this pipeline in the offshore portion of this project will be an external detection system capable of detecting the presence of leaking hydrocarbons, this is in addition to two internal monitoring systems the length of the project.

BPXA determined that the Liberty Prospect contains approximately 120 million barrels of recoverable crude oil. Production facilities on Liberty Island would be designed to produce up to 65,000 barrels of crude oil per day and 120 million standard cubic feet of natural gas per day. There would be producing wells, gas-injection wells, water-injection wells, and either one or two Class I industrial waste-disposal wells. The life of the proposed Liberty Prospect development is anticipated to be approximately 15-20 years.

This draft Environmental Impact Statement (EIS) covers the proposed Beaufort Sea Oil and Gas Development/Liberty Development and Production Plan. This document includes the purpose and background of the proposed action, alternatives, description of the affected environment, and the predicted environmental effects of the proposed action and the alternatives. The alternative analysis evaluates five sets of component alternatives (island location and pipeline route, pipeline design, upper slope protection system, gravel mine site, and pipeline burial depth) that focus on the different effects to modifying major project elements. The EIS also evaluate the range of alternatives that could be chosen by combining the different options from the component alternatives. In addition to the mitigation required by MMS in the lease and those built into the BPXA Proposal, two proposed mitigating measures and their potential effects are evaluated. The EIS also evaluates potential cumulative effects resulting from the BPXA Proposal and alternatives.

THE LIBERTY EIS

WHAT IT INCLUDES

AND

HOW IT IS

STRUCTURED

The Liberty EIS – What it Includes and How it is Structured

These four pages give you a quick overview of what is in the draft environmental impact statement (EIS) and how it is structured. Because the draft EIS is somewhat complex, we urge you to read these pages first.

This EIS evaluates BP Exploration (Alaska), Inc. (BPXA's) Liberty Project in Foggy Island Bay in the Beaufort Sea and a variety of alternatives. It is the first EIS that the Minerals Management Service (MMS) has prepared for an oil and gas development and production project in Federal waters off Alaska.

We have restructured the standard EIS format to quickly get to issues and alternatives we identified while gathering extensive "scoping" information between spring 1998 and summer 2000. Despite our best efforts to write concisely, the EIS is lengthy, so we have included a variety of summaries. For those wanting more than a summary of a particular subject, please be sure to read the detailed analysis that follows each summary. We urge all readers to make a copy of the table of contents of the EIS and keep handy when reading the EIS to assist you in locating referenced sections more quickly.

Traditional Knowledge information and observations appear throughout the EIS, along with those of Western science.

We have attempted to use and cite the latest and best information available to prepare the EIS. When information in the literature was limited, authors used their best professional judgment in describing effects that may occur as a result of the Liberty Project and the alternatives.

If you have any suggestions about the format and writing style of the draft EIS, we hope you include them in your comments. If you feel any critical references were omitted, please describe and cite them as specifically as possible. Thank you.

Executive Summary – The Executive Summary has six sections:

A describes the proposed Liberty Project, the purpose and need for this EIS, and the proposed BPXA Development and Production Plan and development schedule.

B describes MMS's relationship with other Government agencies regarding this EIS.

C. provides a brief summary of the scoping process, environmental justice, Indian trust resources, government-to-government coordination, and an overview of the issues that resulted from scoping.

D summarizes the effects of the Proposal.

E summarizes the alternatives and their effects.

F summarizes the cumulative-effects analysis.

LIBERTY EIS - The EIS has nine sections and eleven appendices.

Section I – Introduction and Results of the Scoping Process briefly states the purpose and need for the Proposed Action and outlines the key steps in the EIS process. It discusses traditional knowledge, environmental justice, Indian trust resources and the format and structure of the EIS. This section then discusses the scoping process and summarizes the most significant scoping issues, the alternatives analyzed in the EIS, and other potential alternatives derived from scoping but not selected for full analysis (see the Scoping Report, Appendix E).

Section II - Description of Alternatives has four parts:

II.A describes BPXA's Proposed Liberty Development and Production Plan (Alternative I), including hydrocarbon resources, design and construction of the gravel island and pipeline, island slope protection, drilling activities, production, transportation, waste management, abandonment, and mitigation measures built into the project. It also discusses safety systems for development and production, pipeline safety, and oil-spill prevention and response capability.

II.B describes the No Action Alternative (Alternative II).

II.C defines and discusses five sets of "component alternatives." Each set varies a single component identified as important during scoping. Each component alternative is a "complete" alternative in that it includes all the same elements as the BPXA Proposal except for the one component at issue. For ease in making comparisons, each set of component alternatives starts with the BPXA Proposal.

The five sets of component alternatives are as follows:

- **three island locations and pipeline routes** (Liberty Island/Liberty pipeline route, Tern Island/Tern Pipeline route, and Southern Island/Eastern pipeline route),
- **four pipeline designs** (single walled pipe, steel pipe in steel pipe, steel pipe in plastic pipe, and flexible pipe),
- **two types of upper slope protection for the production island** (gravel bags and steel sheetpile),
- **two gravel mine sites** (Kadleroshilik River and Duck Island), **and**
- **two pipeline burial depths** (design trench depth and a 15' trench depth)

Note that decisionmakers for this project can select one alternative from each of the above five sets of component alternatives. That means there are 96 possible combinations of components to choose from, including the components proposed by BPXA (3 x 4 x 2 x 2 x 2 = 96).

II.D defines and discusses three "combination alternatives." The Liberty Interagency Team formulated each of these combinations by selecting one alternative from each of the five sets of component alternatives. In Section IV.D, these three combination alternatives will be compared with each other and with the Proposal to assess their relative effects on the environment.

The Combination Alternatives, with the BPXA Proposal shown for comparison, are:

Combination Alternative A

- Use Liberty Island and Liberty Pipeline Route
- Use Pipe-in-Pipe Pipeline Design
- Use Steel Sheetpile for Upper Slope Protection
- Use Duck Island Gravel Mine
- Use a 7-foot Burial Depth

Combination Alternative B

- Use Southern Island and Eastern Pipeline Route
- Use Pipe-in-HDPE Pipeline
- Use Gravel Bags for Upper Island Slope Protection
- Use the Kadleroshilik River Mine Site
- Use the 6-foot Burial Depth as designed by for the Steel Pipe-in-HDPE pipeline design

Combination Alternative C

- Use Tern Island and Tern Pipeline Route
- Use Steel Pipe-in-Pipe Pipeline Design
- Use Steel Sheetpile for Upper Slope Protection
- Use Duck Island Mine Site
- Use a 15-foot Burial Depth

The BPXA Proposal (Liberty Development and Production Plan)

- Use Liberty Island and Liberty Pipeline Route
- Use Single-Wall Pipeline Design
- Use Gravel Bags for Upper Island Slope Protection
- Use the Kadleroshilik River Mine Site
- Use a 7-foot Burial Depth

Because this approach of analyzing "component alternatives" and "combination alternatives" is a bit unusual, the following should help explain our rationale for using both in this EIS:

As a first step, we evaluated each alternative in each set of component alternatives and compared it to the other alternatives in the set. Because all the component alternatives are "complete" alternatives, the comparisons can be made on an even footing. The Liberty Interagency Team believes that using component alternatives is a good way to focus analysis on the issues and concerns related to a particular component. It also facilitates comparison among the choices in each set. However, by using this approach, the component alternatives are all the same as the BPXA proposal except for the one component that we vary within each set. Also, this approach does not provide for concurrent evaluation of two or more components. In essence, analyzing only component alternatives does not facilitate either evaluating a reasonable range of alternatives or selecting multiple alternative components as required under the National Environmental Policy Act.

We therefore took a second step to overcome these limitations. Using the component alternatives as building blocks, the Liberty Interagency Team developed three more alternatives that we refer to as "combination alternatives." These were selected from the possible 96 combinations mentioned above. Each combination alternative is also a "complete" alternative and each varies substantially from the other combination alternatives. One of them (Combination Alternative C) has none of the component alternatives included in the BPXA Proposal. The other two have some components in common with the BPXA Proposal and some that are different. So as a group, the combination alternatives range from the BPXA Proposal to a proposal as different from BPXA's as possible. Evaluating a reasonable number of examples that cover the spectrum of 96 alternatives in this manner allows the decisionmaker to ultimately select any of those 96 possibilities. (See Forty Most Asked Questions Concerning the Council on Environmental Quality National Environmental Policy Act Regulations, 46 *Federal Register* 18026, as amended.)

Section III - Effects of BPXA's Proposed Liberty Development and Production Plan (Alternative I). This section and Section IV are the heart of the EIS. This section has four major parts:

III.A summarizes the most important effects of the Proposal by natural resource and species.

III.B describes the MMS Alaska Outer Continental Shelf Region Environmental Studies Program and MMS-sponsored studies applicable to the Beaufort Sea area. This section also lists the Liberty pipeline design studies undertaken to respond to the concerns of some Federal Agencies.

III.C. fully describes the BPXA Liberty Proposal.

III.C.1 addresses project integrity issues such as BPXA's Oil Discharge Prevention and Contingency Plan (BPXA, 2000), island design and slope protection, pipeline safety, and the chance and size of oil spills.

III.C.2 and C.3 are detailed analyses of the effects of the Liberty Proposal related to two major issues: (1) spills from the offshore platform and pipeline and (2) disturbances from drilling, construction, boats, helicopters, and ice roads. For each of these issues, the analysis is broken out by biological and human resources. Under each resource, we give a summary and then the details of the effects. In the detailed portion, we first describe the "general effects" of development of the hydrocarbon resources in the Liberty Prospect, regardless of which alternative is chosen. We then describe the "specific effects" of PBXA's proposed plan for development of those resources. The specific effects of the alternatives may be different. Note that the EIS does not repeat the "general effects" analysis of Section III over and over again when we present the analyses of alternatives in Section IV. If readers want to refresh their understanding of the general effects on a resource, then readers will need to refer back to the "general effects" analysis provided in Section III of the EIS.

III.D discusses effects related to other issues such as discharges from the island, gravel mining, small spills, economics, abandonment, unavoidable and irreversible effects, global climate change, and national security and navigation. As in Sections III.C.2 and C.3, we first describe the "general effects" of development of the Liberty Prospect, regardless of which alternative is chosen. We then discuss the "specific effects" of BPXA's proposed plan.

Section IV - Effects of Alternatives – This section and Section III are the heart of the EIS. This section has five parts:

IV.A is an introduction that reintroduces the phrases "component alternatives " and "combination alternatives" and gives other important information about this section.

IV.B covers the effects of the No Action Alternative (Alternative II). It discusses effects that would be expected to occur if the Liberty Project is not approved.

IV.C gives a detailed assessment of the effects of each alternative in the five sets of component alternatives that were described in Section II. For ease in comparison, we also include an assessment of the effects of BPXA's proposed component in each set. This section focuses on comparisons among the alternatives in each set of component alternatives. To avoid redundancy, if an effect of an alternative is the same as that of the Proposal, we do not repeat it from Section III. The portion of this section dealing with pipeline design alternatives (Section IV.C.2) provides extensive detail on the results of four contracts focused on this of subject.

IV.D compares the three combination alternatives with each other and with BPXA's Proposal. We first give the physical properties and then the potential benefits, concerns, and effects of each combination relative to the others. This section is presented in summary form to avoid repeating the detail given in Section IV.C.

Section V – Cumulative Effects has three parts:

V.A introduces MMS's approach to analyzing cumulative effects and gives our general conclusions.

V.B discusses the scope of activities included in the analysis, including past, present and reasonably foreseeable production.

V.C analyzes cumulative effects related to the Liberty Project on natural, biological, and human resources and compares cumulative effects of North Slope/Beaufort Sea hydrocarbon development with the specific effects of the BPXA Proposal.

Section VI - Description of the Affected Environment describes the biological, socioeconomic, and physical environment surrounding the Liberty Project, relying on both Western science and Traditional Knowledge.

Section VII - Review and Analysis of Comments Received. This section is reserved for the Final EIS.

Section VIII - Coordination and Consultation briefly describes how the Liberty Project evolved and how the EIS was developed. It also identifies the participating and cooperating agencies of the Liberty Interagency Team and scoping meetings with other Federal, State, and local agencies; interest groups; and the public. The section concludes with a list of attendees at public meetings conducted for Liberty and a list of contributing authors and supporting staff members.

Section IX - Low Probability, Very Large Oil Spill describes the hypothetical assumptions for two very large spills, a blowout and tanker spill, and the potential effects on each resource should such an unlikely spill occur.

Bibliography

Appendices
- Appendix A - Oil-Spill-Risk Analysis
- Appendix B - Overview of Laws, Regulations, and Rules
- Appendix C - Endangered Species Act, Section 7 Consultation and Coordination. The Biological Assessment and the Biological Opinion for the endangered species will be in the Final EIS.
- Appendix D - EIS Supporting Documents

EIS Structure–4

EXECUTIVE SUMMARY

Contents

The contents on this page are linked to the appropriate page in the EIS. Click on the item to jump to the page.

CONTENTS OF EXECUTIVE SUMMARY

Executive Summary: Liberty Development and Production Plan, Environmental Impact Statement

In February 1998, BP Exploration (Alaska) Inc. (BPXA) submitted a Development and Production Plan (Plan) to the Minerals Management Service (MMS) for the proposed Liberty Project; a pipeline Right-of-Way application was submitted March 3, 1998. The Plan has since been revised. Revision 1 was issued in November 1998 and Revision 2 in July 2000. The Plan and application initiated a Federal review process for BPXA's proposed project. The Liberty Prospect is in Federal waters of the Beaufort Sea northeast of the Prudhoe Bay oil field. This project would develop and produce oil and gas from the Liberty Prospect to transport and sell oil to U.S. and world markets. The MMS's Regional Supervisor for Field Operations must consider BPXA's Plan and applications. If he approves the proposed Plan and applications, he would monitor the project to ensure that activities comply with MMS regulations. No development activity can occur on the lease until the Plan is approved.

This document includes the purpose and background of the proposed action, alternatives, description of the affected environment, and the proposed environmental effects of the proposed action and the alternatives. The alternative analysis in the EIS evaluates the effects of modifying five project components (island location and pipeline route, pipeline design, upper slope-protection system, gravel mine site, and pipeline burial depth). The EIS also evaluates three alternatives that could be chosen by combining project components and compares them to each other and to the BPXA Proposal.

In addition to the mitigation required by MMS in the lease and those built into the BPXA Proposal, the EIS evaluates effectiveness of two potential mitigating measures. The EIS also evaluates potential cumulative effects resulting from the BPXA Proposal and alternatives.

A. LIBERTY PROJECT, PLAN, AND SCHEDULES

1. Environmental Impact Statement Schedule

We (MMS) determined that approving BPXA's Plan would be "a major Federal action that may significantly affect the quality of the human environment pursuant to the National Environmental Policy Act"; therefore, we should prepare an environmental impact statement (EIS). Under this Act, the EIS will evaluate reasonable alternatives, including BPXA's Proposal and a No Action Alternative, as well as how each alternative may affect the environment. We will use information in the EIS in our Record of Decision to either approve the Plan and applications or decide on other actions. Currently, MMS intends to issue the final EIS in fall 2001. Under the Outer Continental Shelf Land Act, MMS needs to make a decision within 60 days of issuance of the final EIS; however, under the National Environmental Policy Act, no decisions can be made until 30 days after the issuance of the final EIS. Final agency decisions would be made in early 2002. Some of the alternatives, if chosen, may result in delays in the Liberty Project of 18-24 months to collect additional engineering data and allow time for specific design and testing work. This information would be necessary for technical approval of the project but is not expected to change the environmental effects. For purposes of analysis in the EIS, we have not adjusted the timelines for starting the different alternatives. Therefore, all the alternatives are on the same footing for the analysis of environmental effects.

We will respond to the public comments on the draft EIS in the final EIS. We have not committed to any specific course of action and will maintain an open mind throughout the development of the final EIS and decision processes. We will continue to consider and evaluate all reasonable options. The agency-preferred alternative(s) will be identified in the final EIS based on the analysis and full consideration of comments received. We especially encourage the public to comment on the sections describing the alternatives.

2. The Need and Purpose for the Liberty Project

Need: To satisfy the demand for domestic oil and decrease the dependence of the United States on foreign oil imports.

Purpose: To recover oil from the Liberty Prospect and transport it to market.

This project helps satisfy the mandate of the Outer Continental Shelf Lands Act to explore for and develop offshore mineral resources by developing the oil resources of OCS Lease Y-01650 issued by the MMS in Foggy Island Bay in the Alaskan Beaufort Sea.

3. Description of the Plan

Under the Outer Continental Shelf Lands Act, the MMS is required to analyze the environmental effects of BPXA's proposed action, as described in the Development and Production Plan (Sec. II.A of the EIS).

Note: We have included in the Executive Summary, several tables, and a map from the EIS. To lessen confusion, we are keeping the same table or map number used in the EIS. Citations are listed in the EIS bibliography.

BPXA proposes to develop the Liberty oil field from a manmade gravel island constructed on the Federal Outer Continental Shelf in Foggy Island Bay (see Map 1) The gravel island would be located in water about 22 feet deep and inside the barrier islands. The Liberty Project is about 5 miles off the coast nearly midway between Point Brower to the west and Tigvariak Island to the east. The proposed gravel island would be between the McClure Islands and the coast. The overall project includes the following:

- a manmade offshore gravel island;
- stand-alone processing facilities and associated infrastructure on the island;
- about 6.1 miles of offshore buried oil pipeline and about 1.5 miles of onshore elevated pipeline connecting the island facilities to the Badami Pipeline;
- an onshore gravel mine site at the Kadleroshilik River used during construction and then rehabilitated; and
- onshore and offshore ice roads.

4. Development Schedule

If the project were approved, construction of the ice roads presently are planned to begin in November or December of 2002, which would be Year 1 of the project as described in the EIS. The planned construction process would occur over 2 years. The gravel island would be constructed in 1 year (Year 2), and the offshore pipeline would be constructed the next year (Year 3). To the extent possible, construction would occur during the winter. If construction were delayed, all construction would occur in a single season (Year 3).

A drill rig would be transported to the island by a barge in the summer of Year 2 or moved over an ice road in the winter of Year 3. An infrastructure module would be sealifted to the island in July/August of Year 2. Process modules would be sealifted to the island in July/August of Year 3. Drilling would start in the first quarter of Year 3. Oil shipment (production) would start in the fourth quarter of Year 3. The economic life of the field is estimated at about 15 years.

B. COLLABORATION WITH OTHER AGENCIES

1. Interagency Team Meetings

The Liberty Interagency Team was created in the spring of 1998 to discuss a broad range of issues related to the development and content of the Liberty EIS. The Liberty Interagency Team consists of five Federal Agencies (MMS, Fish and Wildlife Service, U.S. Army Corps of Engineers, National Marine Fisheries Service, and the Environmental Protection Agency); two State of Alaska Agencies (State Pipeline Coordinator's Office and the Division of Governmental Coordination); and the North Slope Borough. The Interagency Team met periodically during the EIS preparation process. Scoping and EIS alternatives were major issues of discussion for the Liberty Interagency Team.

2. EIS Partnerships

For the purposes of preparation of this particular EIS, the Corps of Engineers and the Environmental Protection Agency are cooperating agencies. They, along with the MMS, will consider using this EIS as their National Environmental Policy Act documentation for review of the Liberty Project. Both the Corps of Engineers and the Environmental Protection Agency have attended frequent meetings with MMS and have reviewed draft EIS text. The Corps of Engineers Preliminary Section 404(b)(1*)*

Evaluation - Liberty Development Project and *Evaluation of Proposed Liberty Project Ocean Disposal Sites for Dredged Material at Foggy Island Bay* can be found in Appendices G and H of the EIS. The Environmental Protection Agency draft National Pollution Discharge Elimination System draft permit can be found in Appendix I-2 of the EIS. The Fish and Wildlife Service, National Marine Fisheries Service, North Slope Borough, the State Pipeline Coordinator's Office, and the State Division of Governmental Coordination have entered into a participating relationship with MMS and have attended meetings and exchanged information, as time permitted.

The MMS is writing Biological Assessments on the Liberty Project for both the Fish and Wildlife Service and the National Marine Fisheries Service. The Fish and Wildlife Service and National Marine Fisheries Service each will write individual Biological Opinions on species specific to their jurisdiction regarding the Liberty Project in accordance with Section 7 Endangered Species Act consultation procedures. The Fish and Wildlife Service and the Biological Resources Division of the U.S. Geological Survey each prepared an analysis that can be found in Appendix J of the EIS. The Fish and Wildlife Service prepared the report *Exposure of Birds to Potential Oil Spills at the Liberty Project* and the Biological Resources Division evaluated potential effects to polar bears in their report *Estimating Potential Effects of Hypothetical Oil-Spills from the Liberty Oil Production Island on Polar Bears*.

National Marine Fisheries Service is responsible for the authorization of the incidental taking of certain species of marine mammals under the Marine Mammal Protection Act and/or the Endangered Species Act. The EIS describes the type and extent of such takings.

C. ISSUES

1. Scoping

"Scoping" is an ongoing public process to determine the public concerns about BPXA's proposed plan and to identify issues to be analyzed in depth in the EIS. Scoping also is used to develop alternatives to BPXA's Plan and mitigating measures that could eliminate or reduce potential development impacts. Alternatives could include technological modifications to the Plan or different drilling locations or pipeline routes. The scoping process includes an evaluation of the issues, alternatives, and mitigating measures that will be addressed further in the EIS and those that will not.

As part of the scoping process, we have received comments in response to our Notice of Intent to Prepare an EIS in the *Federal Register* Notice of February 23, 1998, and from public meetings and the Liberty Interagency Team. We received seven comment letters in response to the Notice. Scoping meetings were held during March and April 1998 in Nuiqsut, Barrow, Anchorage, Kaktovik, and Fairbanks. Additional scoping comments were provided as part of the information update meetings in these communities in October and November 1999.

During scoping meetings, attendees expressed concerns about the effects of development on the physical and biological resources in and adjacent to the Liberty Prospect and on the Inupiat inhabitants of Alaska's North Slope. These concerns, characterized as issues, are associated with planned activities or accidental events that are or may be part of the construction and operation of oil and gas facilities.

The planned activities would alter the local environment. These disturbances, often in the form of noise, may last only a few minutes; whereas, physical changes to the environment, such as construction of the gravel island, may last 15-20 years or more. Short-term disturbances include the noise from aircraft overflights or marine transport of facilities and supplies. Disturbances also may last up to several months; these include noise and physical changes to the environment associated with mining and hauling gravel for island construction, changes to seafloor sediments, and suspension of sediments that result from trenching for the pipeline.

Accidental events include crude oil spills during production, during transport through the pipelines, or from diesel fuel used to power electrical generators if natural gas, produced from the Liberty reservoir, is not available. Such events have a very low probability of happening.

Primarily, the issues express concerns about the effects of disturbances and large offshore oil spills on the environment. These effects are analyzed in the EIS for the following essential resources and systems:

- endangered and threatened species (bowhead whales and spectacled and Steller's eiders)
- seals
- polar bears
- marine and coastal birds
- terrestrial mammals
- fishes and essential fish habitat
- lower trophic-level organisms
- vegetation-wetland habitats
- subsistence harvests
- sociocultural systems
- archaeological resources
- economy
- water quality
- air quality

Associated with disturbance and oil-spill issues are concerns that include:

- risk of damage to the island and production facilities from storm waves, currents, and ice forces
- risk of damage to the offshore pipeline from ice gouging, strudel scouring, and permafrost melting
- leak detection for the buried pipeline
- offshore pipeline design and the risk of failure and leaks
- height of onshore pipeline
- erosion in the area where the pipeline crosses the shoreline
- oil-spill-response and cleanup capability, especially in broken ice
- waste disposal
- discharges of production fluids
- air emissions
- abandonment
- population growth and balance between modern lifestyles and the lifestyle of the Inupiat people
- timing and size of the prospective workforce and how it would affect community economies
- use of gravel bags to prevent gravel erosion of the island
- disregard for local traditional knowledge in making decisions
- use of Tern Island as either a drilling site or a source of gravel
- locating the Liberty drilling and production facility either onshore or in waters no deeper than 6 feet
- global climate change
- alternative energy sources

The issues raised during scoping also are used to develop alternatives and mitigating measures for this EIS.

2. Traditional Knowledge

We include in the EIS analysis what local indigenous people on the North Slope say and have said about development on the outer continental shelf. We developed a protocol to extract, from past testimony and community meetings, traditional knowledge that relates to oil and gas activities in the Alaskan Beaufort Sea. Various sources of traditional knowledge (TK) were queried to provide this information. Sections III.C.3.h and i (Subsistence-Harvest Patterns and Sociocultural Systems) in the EIS illustrate how traditional knowledge was incorporated into the EIS and into the design, construction, and planned operations of the proposed project to minimize potential conflicts with subsistence users.

This information endeavors to capture the traditional Inupiat perspective about the potential effects of the Liberty Project and other oil and gas development activities on the North Slope. In some instances, the words of individual speakers are incorporated and cited. In other cases, when several people shared an observation or concern, it is paraphrased in a single statement and cited.

The TK-gathering efforts undertaken specifically for the Liberty Project include: (1) meeting minutes from the 1999 community meetings conducted under the auspices of Environmental Justice (see the following and Appendix E of the EIS); (2) use of an interim portion of the Inupiat TK collection study by the Barrow nonprofit Ukpeagvik Inupiat Corporation; (3) the Arctic Nearshore Impact Monitoring in Development Area study that includes a task for gathering subsistence whaling TK from Nuiqsut whalers; and (4) an in-depth assessment and use by MMS analysts of existing TK sources. These sources include TK citations for the Northstar final EIS; the TK database developed by Dames and Moore for the Northstar Project from MMS hearing transcripts; Native interviews from the North Slope Borough's *Mid-Beaufort Sea Traditional Resource Survey*; TK from the North Slope Borough document *Cross Island: Inupiat Cultural Continuum*; and TK gleaned from the North Slope Borough's *Subsistence Harvest Documentation Project Data for Nuiqsut, Alaska* (North Slope Borough, 1997a).

3. Environmental Justice, Indian Trust Resources, and Government-to-Government Coordination

Executive Order 12898, Environmental Justice, requires that Federal Agencies identify and address disproportionately high and adverse human health and environmental effects of its actions on minority and low income populations.

To meet the direction of this Order (*Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations*) and the accompanying memorandum from President Clinton to the heads of all departments and agencies, MMS held Environmental Justice Meetings in Barrow, Nuiqsut, and Kaktovik. Environmental Justice, as a formal part of the Sociocultural Systems analysis, is discussed in Section III.C.3.i., Effects of Disturbance on Sociocultural Systems in the EIS. The MMS met with local tribal governments to discuss subsistence issues and the Liberty Project during scoping meetings in the community of Nuiqsut on March 18, 1998; in the community of Barrow on March 19, 1998; and in the community of Kaktovik on March 31, 1998. In these first meetings, MMS established a dialogue on environmental justice with these communities. Followup meetings to address environmental justice issues were held in Barrow on November 1, 1999; in Nuiqsut on November 2, 1999; and in Kaktovik on November 5, 1999.

The environmental justice concerns raised during scoping and from the Environmental Justice Meetings are covered in the EIS in the sections on Subsistence-Harvest Patterns, Sociocultural Systems, and marine mammals (see Sec.

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III.C.3 in the EIS). The analyses in these sections incorporate TK of the Inupiat people of the North Slope communities of Barrow, Nuiqsut, and Kaktovik, along with Western scientific knowledge. Environmental Justice is discussed in more detail in Appendix B, Part E of the EIS.

The Department of the Interior and the MMS are responsible for ensuring that Indian Trust Resources of federally recognized Indian Tribes and their members that may be affected by these project activities are identified, cared for, and protected (Appendix B, Part D of the EIS). No significant impacts were identified during the EIS scoping process, including the Environmental Justice Meetings, that pertain to this topic. Native allotments in the project are discussed in Section III.C.3.i of the EIS.

Executive Order 13084 (*Consultation and Coordination with Indian Tribal Governments*) states that the U.S. Government will continue "to work with Indian tribes on a government-to-government basis to address issues concerning Indian tribal self-government, trust resources, and Indian tribal treaty and other rights." To meet that direction, MMS has met with the local tribal governments of Barrow, Nuiqsut, and Kaktovik; as well as the Inupiat Community of the Arctic Slope (the recognized regional tribal government), and an important nongovernmental Native organization, the Alaska Eskimo Whaling Commission. Notes from the 1999 meetings are included in Appendix E of the EIS. These tribal governments were contacted by letter and given the opportunity to participate in the development of this EIS. None of the letters sent received a response; nonetheless, in Liberty meetings held on the North Slope, we have met with these groups to keep them informed of this Proposal and will continue to do so. Local Inupiat government representatives are members of our Outer Continental Shelf Lease Sale Advisory Committee that meets to discuss and resolve issues that arise from recent lease sales.

4. Major Issues

Based on scoping concerns, MMS has determined that the major issues are:

- disturbances from planned project activities;
- oil spills from accidental events; and
- cumulative effects of past, present, and future development on the people and environment of Alaska's North Slope.

Generally, the above issues are analyzed more fully than other concerns that include:

- discharges (water discharges and air emissions)
- gravel mining
- small oil spills
- seawater intake
- economic effects
- abandonment of the project
- global climate change
- alternative energy sources

Air pollution also is an important issue for North Slope inhabitants. The effects of emissions from burning fossil fuels during Liberty drilling and production operations are analyzed in detail under the discussion of discharges under the heading of Other Issues.

These issues served as the basis for the development of alternatives and were used to configure the analysis in the alternatives as well as the analysis of the proposed Development and Production Plan. The major issues/perturbations mentioned below apply to each analyzed alternative, as well as the proposed Development and Production Plan.

a. Disturbances

The Liberty Project involves constructing a gravel island about 5 miles offshore, using gravel hauled by truck over ice roads to a prepared subsea pad, and construction of a pipeline from the island to an existing onshore pipeline. The island and pipelines would be constructed mainly in winter, and most potential disturbance from construction would occur in that season. Construction of the subsea pipeline trench and the onshore pipeline would permanently disturb habitats. The following are examples of disturbances:

- sediment and turbidity from the dumping of gravel during construction of the proposed island and from the pipeline trenching and backfilling activities;
- noise from construction and drilling activities; and
- noise from the transportation of people and materials to and from the gravel island.

Helicopters, supply boats, and some barges would provide transport over water. Long-term disturbances would include noise from various kinds of transportation and any other drilling that might occur over the operational life of the field.

Releases of particulate matter and attendant turbidity in the water may come from remnant fill from the pipeline trench, particulate leaching from the island, and final island preparation (reshaping). When refilling pipeline trenches, the excess fill not deposited back into the trench would be placed on the ice parallel to the pipeline and would filter into the Beaufort Sea as breakup progresses. Particulate matter would leach from the island after initial construction and before the placement of filter fabrics and cement blocks; some island reshaping may be necessary, but this would be a short-term action.

The project descriptions in Section II.A.1 and Table II.A-1 of the EIS more thoroughly discuss Liberty development and potential sources of noise and habitat disturbance.

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b. Large Offshore Oil Spills

The potential effects of oil spills were a major concern raised during scoping. For purposes of analysis, we divide oil spills into two classes. We define large oil spills as greater than or equal to 500 barrels, and small spills as less than 500 barrels. See Sections IX.A and B in the EIS for an analysis of a very large oil spill.

(1) Spill Assumptions and Sizes

The assumptions about large oil spills are a mixture of project-specific information, modeling results, statistical analysis, and professional judgement. For purposes of analysis, we assume that one large spill occurs from the proposed or alternative Liberty gravel island locations or along the proposed or alternative offshore/onshore pipeline routes. After we analyze the effects of a large oil spill, we consider the chance of a large oil spill occurring. Even though the chance of one or more large spills occurring and entering offshore waters is low (on the order of 1%), we analyze the consequences of an oil spill because it is a significant concern to all stakeholders. The analysis of a large spill represents the range of effects that might occur from a range of offshore or onshore spill sizes at Liberty facilities. Table III.C-4 of the EIS shows the large spill sizes we assume for analysis. These hypothetical spills range from 715-2,956 barrels for crude and diesel oil. The spills are broken out as follows:

Crude Oil

- gravel island: 925 barrels
- offshore pipeline: 715, 1,580, and 2,956 barrels
- onshore pipeline: 720 and 1,142 barrels

Diesel

- storage tank: 1,283 barrels

A large spill from the Liberty facilities could happen at any time of the year. We assume that the island would not absorb any oil. Depending on the time of year, we assume that a spill reaches the following environments:

- gravel island and then the water or ice
- open water
- broken ice
- on top of or under solid ice
- shoreline
- tundra or snow

(2) Oil-Spill-Trajectory Analysis

We analyze spills from nine locations. We use the location of the Liberty, Southern, and Tern gravel islands as the sites where large oil spills would originate, if they were to occur from an island. (Liberty Island is the site proposed by BPXA. Southern and Tern Islands are alternative sites selected by MMS for the EIS analysis.) We also use the Liberty, Tern, and eastern pipeline sites, with each pipeline divided into two segments. The two pipeline segments represent spills that would occur nearshore and offshore. (Similarly, the Liberty pipeline route was proposed by BPXA and the Tern and eastern routes were selected for analysis as EIS alternatives.)

In general, there is a 0-2% difference in the chance of oil-spill contact with the majority of the environmental resource areas when we compare Liberty Island, Southern Island, and Tern Island to each other. Each of these islands is within 1.2-1.4 miles of each other, and no geographic barriers to spills exist between these island locations. There is a 3-12% difference in the chance of contact with resources directly adjacent to the area where we hypothesize a spill would start. For example, the largest difference (12%) is to the Boulder Patch, because Liberty Island is directly adjacent to it, and the Southern Island and Tern Island are slightly farther away. Changing the location of the island would cause an insignificant change in the chance of oil spill contact to the majority of the environmental resource areas.

In general, there is a 0-2% difference in the chance of contact to the majority of the land segments when we compare Liberty Island, Southern Island, and Tern Island to each other. The reader should note, however, that the closer the island is located to shore, the greater the probability of oil contacting the nearby coastline. The coastline between the Sagavanirktok and Kadleroshilik rivers has a 3-4% difference in the chance of contact from Southern Island or Tern Island when we compare them to Liberty Island. While these differences are measurable, they do not result in effects to the resources that are substantial.

(3) The Chance of a Large Spill Occurring

The analysis of historical oil-spill rates and failure rates and their application to the Liberty Project provides insights, but not definitive answers, about whether oil may be spilled from a site-specific project. Engineering risk abatement and careful professional judgment are key in confirming whether a project would be safe.

We conclude that the designs for the Liberty Project would produce minimal risk of a significant oil spill reaching the water. If an estimate of chance must be given for the offshore production island and the buried pipeline, our best professional judgment is that the chance of an oil spill greater than or equal to 500 barrels occurring from the Liberty Project and entering the offshore waters is on the order of 1%. We uses the volume of oil produced as the basis for projecting oil spills; therefore, the chance of an oil spill is essentially the same for all alternatives evaluated in this EIS.

We base our conclusion on the results gathered from several spill analyses done for Liberty. All showed a low likelihood of a spill, on the order of a 1-6% chance or less. More importantly, we also base our conclusion on the engineering design factors that BPXA has included in the project, especially for the buried pipeline. The combination of pollution-prevention measures, design, testing, quality assurance, and proactive monitoring lead us to conclude that the proposed and alternative pipelines would be safe.

We base the analysis of effects on the following assumptions:

- One large spill occurs.
- The spill size is one of the sizes shown in Table III-C.4 of the EIS.
- All the oil reaches the environment; the island absorbs no oil.
- The spill starts at the gravel island or along the pipeline.
- The spill could occur at any time of the year.
- A spill under ice does not move significantly until the ice breaks up.
- The spill area varies over time and is calculated from Ford (1985).
- The time and chance of contact from an oil spill are calculated from an oil-spill-trajectory model.
- Effects are analyzed for the location where the chance of contact is highest.

The analysis in Section III.C.2 first considers context and intensity effects of an oil spill to the resources and then considers whether the effects would be local or regional. The analysis next evaluates the adverse effects resulting from the oil-spill-cleanup efforts on the resource (noise, disturbance, etc.) and provides an assessment of the mitigation benefits that might occur. However, the effectiveness of oil-spill recovery and cleanup is uncertain and depends on weather conditions, wind and wave conditions, and other variables at the time of the spill. Oil-spill recovery can range from very little to almost all of the oil.

The BPXA Proposal includes the use of either the “Leak-Detection and Location System” (LEOS) for detecting any leaks from the pipeline or the use of an equivalent system. Siemens developed LEOS about 30 years ago. The LEOS system detects leaks by means of a low-density polyethylene tube, which is highly permeable to oil and gas molecules. The tube is pressure tight and contains air at atmospheric pressure when installed. In the event of an oil leak, some of the leaking oil diffuses into the tube due to the concentration gradient. The air in the tube is tested every day when a pump at the island pulls the air at a constant speed through the tube into a detector unit. The detector unit is equipped with semiconductor gas sensors that can detect very small amounts of hydrocarbons. An electrolytic cell onshore injects a specific amount of hydrogen gas into the tube just before each daily test. This gas is transported through the tube at each test and generates a “marking peak” that not only notes the test is complete but helps to verify that the equipment is functioning and properly calibrated. The LEOS system can detect a leak, when the total volume of the leak reaches 0.3 barrel, within 24 hours. Because the air moves through the tube at a specific rate, this system can accurately determine within meters the location of a pipeline leak. Should a leak be detected, an alarm sounds. This system has been installed in underground pipelines and in aquatic environments, mostly in Europe. Recently, LEOS was successfully installed as part of the Northstar development. During testing in September 2000, it pinpointed hydrogen gas coming from the pipeline anodes (Franklin, 2000, pers. commun.). In Europe, the LEOS system has detected two hydrocarbon leaks in the soils saturated with water. The sizes of both leaks were below the detection threshold by conventional leak detection systems (INTEC, 1999a). While the LEOS system is operating to specifications for the Northstar Project, its long-term effectiveness in the arctic undersea has not been demonstrated.

The BPXA Proposal also includes what has been considered as the best available technology for leak detection—Pressure-Point Analysis and Mass-Balance Line-Pack Compensation—which can detect spills over 0.015% of the line flow. During peak production flow rates, a leak of more than about 98 barrels per day can be detected by these two systems.

If a leak is detected by any of these three systems, the pipeline would be shut down.

c. Cumulative Effects of Past, Present, and Future Development

Oil and gas activities considered in the analysis include past development and production, present development, reasonably foreseeable future development, and speculative development. Some activities beyond the 20-year life of the Liberty Project are considered too speculative to include at this time, while other similar activities are included in this analysis. Furthermore, we exclude future actions from the cumulative-effects analysis, if those actions are outside the geographic boundaries or timeframes established for the cumulative-effects analysis. We address uncertainty through monitoring, and note that monitoring is the last step in determining the cumulative effects that ultimately might result from an action.

To keep the cumulative-effects analysis useful, manageable, and concentrated on the effects that are meaningful, we weigh more heavily other activities that are more certain and geographically close to Liberty, and we analyze more intensively effects that are of greatest concern. This would include activities in the Beaufort Sea and on the North Slope. To be consistent with the MMS 5-Year OCS Oil and Gas Program, the Liberty cumulative analysis also evaluates effects from transporting oil through the Trans-Alaska Pipeline System and tankering from Valdez to ports on the U.S. west coast.

Activities other than those associated with oil and gas also are considered. These include the sport harvest of wildlife, commercial fishing, subsistence hunting, and loss of overwintering range for certain wildlife species. More details on the cumulative-effects analysis are presented at the end of the Executive Summary.

5. Other Issues

a. Discharges (Water Discharges and Air Emissions)

The majority of wastes generated during construction and developmental drilling would consist of drill cuttings and spent muds. Some waste also would be generated during operations from well-workover rigs. Drilling fluids would be disposed of through onsite injection into a permitted disposal well or would be transported offsite to permitted disposal locations. In addition, domestic wastewater, solid waste, and produced waters would be generated during the project and injected into the disposal well. Solid wastes, including scrap metal, would be hauled offsite for disposal at an approved facility.

In case the disposal well cannot be used, BPXA has applied for a National Pollution Discharge Elimination System permit authorizing marine discharges of treated sanitary and domestic wastewater from the seawater-treatment plant, the desalination-unit filter backwash, construction dewatering, and fire-control test water.

Chronic discharges of contaminants would occur during every breakup from fluids entrained in the ice roads. Entrained contaminants from vehicle exhaust, grease, antifreeze, oil, and other vehicle-related fluids would pass into the Beaufort Sea system at each breakup. These discharges are not expected to be major; however, they would exist over the life of the field.

Sources of potential air emissions would be oil or gas turbine electric generators; heavy construction equipment; tugboats and support vessels; and drill-rig-support equipment, including boilers and heaters. The use of best available control technology and compliance with the Environmental Protection Agency emission standards would be required. Water discharge and air emission considerations would apply to all alternatives.

b. Gravel Mining

BPXA would need about 990,000 cubic yards of gravel to construct the following elements of the Liberty Project:

- the drilling and production island and, if needed, potential relief well island(s);
- pads for pipeline landfall;
- backfill for parts of the pipeline trench; and
- a pad for the tie in with the Badami pipeline.

BPXA has proposed mining a new site in the winter, approximately 53 acres on a partially vegetated island in the Kadleroshilik River floodplain, located about 1.4 miles upstream from the Beaufort Sea. Mining activities are planned to occur in two phases and would occur on about 31.5 acres; about 24 acres of wetlands would be lost or disturbed by the mining activities (see Table III.D-6 of the EIS). A reserve area, covering about 22.5 acres (about 17 acres of wetland area), would be used if additional gravel were needed. Gravel required for alternative island locations and pipeline routes would range from 792,000 cubic yards to 877,300 cubic yards. The alternative island design (Use Steel Sheetpile) would require about 50,000 additional cubic yards of gravel.

c. Small Oil Spills from Liberty Facilities

We analyze the consequences of small spills of crude and refined oil (for the proposed Development and Production Plan and all alternatives) to address concerns about chronic effects from numerous small spills. For purposes of analysis, we assume the following spill sizes:

Offshore or onshore crude oil:
17 spills less than 1 barrel and
6 spills greater than or equal to 1 barrel and less than 25 barrels.
Onshore or offshore refined oil:
53 spills of 0.7 barrels (29 gallons).

We assume:

- Offshore crude spills can begin anywhere on the Liberty gravel island or along the offshore pipeline.
- Small spills on the Liberty gravel island are kept within containment or cleaned up and do not reach the water.
- Onshore crude spills can begin anywhere along the onshore pipeline.
- Onshore or offshore refined oil spills can occur along the ice road, from barges, from helicopters, from the gravel island, or from trucks along the road system.
- Most of these spills are contained or cleaned up.

Typical refined products that spill on the Alaskan North Slope are aviation fuel, diesel fuel, engine lube oil, fuel oil, gasoline, grease, hydraulic oil, transformer oil, and transmission oil. Diesel spills on the Alaskan North Slope are 61% of refined oil spills by frequency and 75% by volume.

d. Seawater Intake

BPXA plans to locate a vertical intake pipe for a seawater-treatment plant on the south side of Liberty Island. The pipe would have an opening 8 feet by 5.67 feet and would be located approximately 7.5 feet below the mean low-water level. Recirculation pipes located just inside the opening would help keep large fish, other animals, and debris out of the intake. Two vertically parallel screens (6 inches apart) would be located in the intake pipe above the intake opening. They would have a mesh size of 1 inch by 1/4 inch. Maximum water velocity would be 0.29 feet per second at the first screen and 0.33 feet per second at the second screen. These velocities typically would occur only for a few hours each week while testing the fire-control water system. At other times, the velocities would be considerably lower. Periodically, the screens would be removed, cleaned, and replaced. The seawater intake system would be part of all alternatives.

e. Economic Effects

Employment, wages, royalties, and income to Federal, State, and local governments were noted as issues during scoping.

Local hire likewise was identified as an issue. This section evaluates the economic impacts of the project for those issues. Economic effects' considerations apply to all alternatives.

f. Abandonment of the Project

In Section III.D.6 of the EIS, we evaluate the effects of general actions (removal of all gravel bags, all facilities on the island, etc.) that would occur at abandonment. However, exact abandonment procedures of the Liberty Project would be developed before the end of the project's life. A goal for restoration of any project is to restore the affected environment to its original condition. In our effort to achieve that goal, we do not want to cause unnecessary environmental effects. At the time of abandonment, we likely would have new technologies, and we expect to have additional environmental information concerning the area and its resources. We want to evaluate both the new technologies and the additional environmental data in the abandonment plan. Therefore, we do not evaluate all the specific items of abandonment at this time. Those specific items would be evaluated in an environmental assessment on the abandonment plan that would be required at the end of the project. All environmental regulations in place at that time would be enforced. The MMS, Corps of Engineers, and applicable State agencies would review BPXA's abandonment plan and decide what actions are appropriate at the end of the project. Abandonment considerations apply to all alternatives.

g. Global Climate Change and Alternative Energy Sources

Global climate change and alternative energy sources are addressed in the MMS 1997-2002 Outer Continental Shelf Oil and Gas Leasing Program (USDOI, MMS, Herndon, 1996a) and are incorporated here by reference. In addition, the Council on Environmental Quality, in its *Draft Guidance Regarding Consideration of Global Climate Change in Environmental Documents Prepared Pursuant to the National Environmental Policy Act*, October 8, 1997, recommends addressing this issue at the program level rather than at the project level.

6. Alternatives to the Proposed Plan

Through the planning and scoping process, five sets of components alternatives were developed from the issues and concerns noted in A.4 above.(See Table I-1) They were configured around major project components: Drilling and Production Island Location and Pipeline Route; Pipeline Design; Upper Island Slope-Protection System; Gravel Mine Site; and Pipeline Burial Depth. The component alternatives (which include the BPXA-proposed project component) are described and analyzed further in Section E.3.a of the Executive Summary.

Combination Alternatives are the second grouping of alternatives developed in the EIS. They build on the analysis of effects identified by each component alternative, and provide decisionmakers and readers with the range of possible effects that may result from selecting and combining different project component alternatives. The Interagency Team developed three combination alternatives that are compared to each other and to the BPXA Proposal (see Table I-1 and Section E.3.b of the Executive Summary).

7. Significance Thresholds

Our EIS impact analysis addresses the significance of the impacts on the resources and systems listed in Section D.1 of the Executive Summary. It considers such factors as the nature of the impact (for example, habitat disturbance or mortality); the spatial extent (local or regional effect); the temporal effect and recovery times (years, generations); and the effects of mitigation (for example, implementation of the oil-spill-response plan).

The Council on Environmental Quality National Environmental Policy Act regulations (40 CFR 1508.27) define the term "significantly" in terms of both context and intensity. "Context" considers the setting of the Proposed Action, what the affected resource may be, and whether the effect on this resource would be local or more regional in extent. "Intensity" considers the severity of the impact, taking into account such factors as whether the impact is beneficial or adverse; the uniqueness of the resource (for example, threatened or endangered species); the cumulative aspects of the impact; and whether Federal, State, or local

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laws may be violated. The analysis in this document uses terminology that is consistent with that definition. Impacts may be beneficial or adverse. Impacts are described in terms of frequency, duration, general scope and/or size and intensity. The analysis in this EIS also considers whether the mitigation that is proposed as part of the project can reduce or eliminate all or part of the potential adverse effects.

For the EIS, we have defined a "significance threshold" for each resource as the level of effect that equals or exceeds the adverse changes indicated in the following impact situations:

- **Threatened and Endangered Species** (bowhead whale, spectacled and Steller's eiders): An adverse impact that results in a decline in abundance and/or change in distribution requiring one or more generations for the indicated population to recover to its former status.
- **Other Biological Resources** (seals, polar bear, marine and coastal birds, terrestrial mammals, lower trophic-level organisms, fishes, and vegetation-wetland habitats): An adverse impact that results in a decline in abundance and/or change in distribution requiring three or more generations (one or more generations for polar bears) for the indicated population to recover to its former status.
- **Subsistence-Harvest Patterns:** One or more important subsistence resources would become unavailable, undesirable for use, or available only in greatly reduced numbers for a period of 1-2 years.
- **Sociocultural Systems:** Chronic disruption of sociocultural systems occurs for a period of 2-5 years, with a tendency toward the displacement of existing social patterns.
- **Archaeological Resources:** An interaction between an archaeological site and an effect-producing factor occurs and results in the loss of unique, archaeological information.
- **Economy:** Economic effects that will cause important and sweeping changes in the economic well-being of the residents or the area or region. Local employment is increased by 20% or more for at least 5 years.
- **Water Quality:** A regulated contaminant is discharged into the water column, and the resulting concentration outside a specified mixing zone is above the acute (toxic) State standard or Environmental Protection Agency criterion more than once in a 1-year period and averages more than the chronic State Standard or Environmental Protection Agency criterion for a month. Turbidity exceeds 7,500 parts per million suspended solid concentration outside the mixing zone specified for regulated discharges more than once in a 3-year period and averages more than chronic State standards or Environmental Protection Agency criteria for a month. The accidental discharge of crude or refined oil in which the total aqueous hydrocarbons in the water column exceeds 1,500 micrograms per liter (1.5 parts per million)—the assumed acute (toxic) criteria—for more than one day and 15 micrograms per liter (0.015 parts per million)—the assumed chronic criteria and the State of Alaska ambient-water-quality standard—for more than 5 days.
  Violating the effluent limits of the NPDES Permit (Appendix I-2) might cause an adverse effect and could result in an Environmental Protection Agency enforcement action. Violations would be caused by exceeding an effluent limit or creating an oil sheen. The accidental discharge of a small volume of crude or refined oil also might cause an adverse impact and could result in concentrations of hydrocarbons that are greater than the acute criteria in a local area (less than 1 square mile) for less than a day and concentration that are greater than the chronic criteria in a larger area (less than 100 square miles) for less than 5 days. However an action of violation or accidental discharge of a small volume crude or refined oil would not necessarily constitute a significant environmental impact as defined in 40 CFR 1508.27.
- **Air Quality:** Emissions cause substantial increases in concentrations over more than half of the Federal attainment area (regional effect), resulting in the consumption of at least 50%, but not all of the available Prevention of Significant Deterioration criteria for Nitrogen dioxide, sulfur dioxide, or TSP or National Ambient Air Quality Standards concentration for particulate matter less than 10 micrograms in diameter, carbon monoxide, or ozone readily identifiable adverse long-term effects on human health or vegetation. No significant decrease in onshore visibility, as determined by Environmental Protection Agency visibility-analysis guidelines.

D. EFFECTS SUMMARIES

These summaries are divided into two types of effects, if the Proposal or an alternative is approved:

- those from routine operations, such as noise and disturbance from island and pipeline construction; and
- those that might occur from accidental events, such as oil spills.

In both instances, most of the effects would be minor, localized, and short term. Some of the effects would be more serious, but the resources are expected to recover. Recovery of a few resources might occur very slowly; therefore, the effects would be classified as significant as defined by Council on Environmental Quality National Environmental Policy Act Regulations.

For this EIS, we identify as "significant" those impacts where the effects exceed the significance threshold defined above. All other impacts are, therefore, insignificant; that is, they fail to exceed the threshold. We found that including the statement of "insignificant" effects for each resource over and over again to be very distracting and unnecessarily redundant. We hope the limited use of the terms "significant" and "insignificant" help the reader to focus on those effects we found to exceed the "significant" threshold.

We do not expect significant impacts to result from any of the planned activities associated with Alternative I (Liberty Development and Production Plan) or any of the other alternatives. Some significant impacts—adverse effects to spectacled eiders, common eiders, long-tailed ducks, and local water quality—would occur in the unlikely event of a large oil spill. However, the very low probability of such an event occurring (a less than 1% chance of oil entering the environment), combined with the seasonal nature of the resources inhabiting the area (for example, eiders are present in the Liberty area 1-4 months of the year), make it highly unlikely that an oil spill would occur and contact the resources. A resource may be present in the area but may not necessarily be contacted by the oil. Furthermore, Alternative I and the other alternatives include mitigation such as extra-thick-walled pipelines, pipeline burial depths more than twice the maximum100-year ice-gouging event, and advanced leak-detection systems (LEOS). Together, they reduce the likelihood of an oil spill and can detect very small volumes of oil and limit the size of potential chronic leaks to about 100 barrels of oil.

1. Effects Summary from Construction and Routine Operations from the BPXA Proposal

These are effects from construction and operations of the Liberty Project.

a. Bowhead Whales

Noise sources that may affect endangered bowhead whales are drilling and other noise associated with production operations, vessel traffic, aircraft traffic, construction, and oil-spill cleanup. Underwater industrial noise, including drilling noise measured from artificial gravel islands, has not been audible in the water more than a few kilometers away. Because the main bowhead whale migration corridor is 10 kilometers or more seaward of the barrier islands, drilling and production noise from Liberty Island is not likely to reach many migrating whales. Noise also is unlikely to affect the few whales that may be in lagoon entrances or inside the barrier islands due to the rapid attenuation of industrial sounds in a shallow water environment. Subsistence whalers have stated that noise from some drilling activities displaces whales farther offshore away from their traditional hunting areas.

Marine-vessel traffic outside the barrier islands probably would include only seagoing barges transporting modules and other equipment and supplies from Southcentral Alaska to the Liberty location, most likely between mid-August and mid- to late September in Year 2 and Year 3. Barge traffic continuing into September could disturb some bowheads. Whales may avoid being within 4 kilometers of barges. Fleeing behavior usually stops within minutes after a vessel has passed but may last longer. Vessels and aircraft inside the barrier islands should not affect bowhead whales.

Because island and pipeline construction would occur during the winter and be well inside the barrier islands, it is not likely to affect bowhead whales. Reshaping of the island and placement of slope-protection material should be completed by mid-August, before bowhead whales start their migration. Whales should not be affected by these activities, even during the migration, because the island is well shoreward of the barrier islands, and whales infrequently go there. Bowhead whales are not likely to be affected by sediment or turbidity from placing fill for island construction, island reshaping before placing slope-protection material, or pipeline trenching or backfilling.

b. Spectacled Eiders

Helicopter flights to Liberty Island during pack-ice breakup may disturb some threatened spectacled eiders feeding in open water off the Sagavanirktok River Delta. If they relocate to other areas, competition for food available during this period following migration may result in lowered fitness. Summer flights to the island may displace some eiders from preferred marine foraging areas or juveniles from coastal habitats occupied after they fledge. These flights are not likely to directly cause bird mortality, but extra energy and time used in response to disturbance and to find alternate areas may result in decreased survival to breeding age. Alternate foraging habitat, similar in appearance and with similar prey organisms evident, apparently is readily available, although the amount of high-quality foraging habitat in the Beaufort Sea area remains unknown.

Frequent flights over nesting or broodrearing eiders may cause them to relocate in less favorable habitat; eiders that abandon a nest probably would not renest. Females temporarily displaced from a nest by occasional onshore pipeline inspection flights may expose eggs to predation. Either situation may result in fewer young produced. Most onshore activities in the Liberty area are likely to affect at most only a few individuals, and careful selection of aircraft routes could eliminate most disturbance of nesting eiders. Development of the Liberty Prospect is expected to result in only a small amount of habitat loss, involving displacement of few eiders to alternate sites. Displacement of eiders from the vicinity of disturbing activities would eliminate them from only a small proportion of available similar habitat.

This likely would be a minor effect, unless it results in decreased survival either by itself or in combination with other factors. Spectacled eider mortality from collisions with island structures is estimated to be two or less per year. Collisions with the onshore pipeline are considered unlikely.

The small losses and displacements likely to result from the above activities may cause population effects that would be difficult to separate from natural variation in population numbers. However, any decline in productivity or survival resulting from the Liberty Project would be additive to natural mortality and interfere with the recovery from declines of the Arctic Slope spectacled eider population. Such disturbances of spectacled eiders probably would be considered a take under the Endangered Species Act. Steller's eiders are not expected to be found in the Liberty Project area.

c. Seals and Polar Bears

Construction activity would displace some ringed seals within perhaps 1 kilometer of the island and along the pipeline route in Foggy Island Bay. Seals and polar bears would be exposed to noise and disturbance from pipeline dredging and burial activities in Foggy Island Bay. This disturbance of seals and polar bears would be local, within about 1 mile along the pipeline route, and would persist for one season.

Food smells coming from the camp on the island may attract a few bears to the production-island. This attraction could require deliberate hazing of these polar bears, but this effect would not be substantial to bear abundance or distribution.

Low-flying helicopters or boats would cause some ringed and bearded seals to dive into the water, and a few females might be temporarily separated from their pups. This displacement is expected to be brief (a few minutes to less than 1 hour). Low-flying helicopters moving to and from the Liberty Project area could briefly disturb a few polar bears. These disturbances would not affect overall seal or bear abundance and distribution in Foggy Island Bay.

Vehicle traffic on the ice roads from the Endicott causeway directly to the Liberty production island and along the coast to Foggy Island Bay/Kadleroshilik River could disturb and displace a few denning polar bears and a small number of denning ringed seals. The number of bears and seals potentially displaced is expected to be low and would not affect the populations of ringed seals and polar bears.

d. Marine and Coastal Birds

Helicopter flights to Liberty Island during the pack-ice breakup may disturb some loons and king or common eiders feeding in open water off the Sagavanirktok River Delta. If they relocate to other areas, competition for food available during this period following migration may result in lowered fitness. During the summer, flights to the island may displace some long-tailed ducks, eiders, glaucous gulls, and other species from preferred marine foraging areas and snow goose and brant family groups from coastal broodrearing areas. These flights are not likely to directly cause bird mortality, but extra energy and time used in response to disturbance and to find alternate areas may result in decreased fitness and, potentially, survival to breeding age in some individuals. Alternate foraging habitat, superficially similar in appearance and with similar prey organisms evident, apparently is readily available, although the amount of high-quality foraging habitat in the Beaufort Sea area remains unknown. Collision of birds with Liberty Island or structures under conditions of poor visibility could result in substantial adverse effects, if they involve species whose Arctic Coastal Plain populations are or may be declining.

Frequent flights over nesting or broodrearing waterfowl and shorebirds on the mainland may cause birds to relocate in less favorable habitat. Birds that abandon a nest might not renest or might be delayed to a less favorable period. Adults temporarily displaced from nests by occasional onshore pipeline inspection flights may expose eggs or nestlings to predation. Any of these situations may result in fewer young produced.

Most onshore activities in the Liberty area are likely to disturb relatively few birds. Construction and vehicle traffic in winter may displace a few ptarmigan from near the activity. Spill-cleanup activities may displace some nesting, broodrearing, juvenile, or staging waterfowl and shorebirds from preferred habitats, resulting in lower survival. Development of the Liberty Prospect is expected to result in a small amount of habitat loss involving displacement of a few birds to alternate sites. This is likely to be a minor effect, unless it results in decreased survival either by itself or in combination with other factors. Mortality from collisions with onshore structures is expected to be negligible.

The small losses and displacements likely to result from the above activities are expected to cause minor changes in numbers that may be difficult to separate from natural variation in population numbers for any species . Such changes are not expected to require lengthy recovery periods. However, any mortality resulting from development of the Liberty Prospect would be additive to natural mortality, requiring some time for recovery from such losses, and may interfere with the recovery of Arctic Coastal Plain populations should declines in these species (for example, long-tailed ducks and common eiders) take place.

e. Terrestrial Mammals

Helicopter and ice-road traffic, encounters with people, and mining and construction operations could disturb individual or small groups of these mammals for a few minutes to a few days or no more than about 6 months within about 1 mile of these activities. These disturbances would not affect populations. This traffic could briefly disturb some caribou, muskoxen, and grizzly bears, when the aircraft pass overhead or nearby, but would not affect terrestrial mammal populations.

Traffic for constructing the ice roads, production island, pipeline, gravel pads and for hauling gravel and supplies could disturb some caribou and muskoxen along the ice roads during the 2 years of development and during other winters, when further work on the project is needed. This traffic would occur during December though early May, with more ice-road construction and traffic occurring during the 2 years of development. Some continued ice-road activity would occur during the 15 years of production to support project operations. These disturbances would have short-term effects on individual animals and would not affect populations.

Encounters between grizzly bears and oil workers or with facilities could lead to the removal of problem bears. However, the amount of onshore activity associated with Liberty (1.4 miles of onshore pipeline with no onshore camp facilities) is not likely to result in the loss of any bears. Arctic fox numbers could increase in the project area because of the possible availability of food and shelter on the production island. However, the amount of onshore activity associated with Liberty would not result in a substantial increase in fox abundance. BPXA's wildlife interaction plan and treatment of galley wastes should help to reduce the availability of food to foxes.

f. Lower Trophic-Level Organisms

These organisms include those in the Boulder Patch kelp habitat. The Boulder Patch is the largest known kelp community along the Alaskan arctic coast. A section of the Boulder Patch with more than 10% coverage of the seafloor is about a mile northwest of the BPXA proposed Liberty Island location (see Map 1 and Sec. VI.A.5.b of the EIS).

BPXA's proposed Development and Production Plan would disturb lower trophic-level organisms in three primary ways: (1) island construction would bury about 22 acres of typical benthic organisms; (2) pipeline trenching would disturb additional benthos, burying up to 14 acres with very low (1%) coverage of kelp, boulders, and suitable substrate; and (3) sediment plumes would reduce Boulder Patch kelp production by up to 6% during 1 year. The buried 14 acres would equal less than 0.1% of the Boulder Patch kelp habitat. The density of the kelp, boulders, and suitable substrate in the pipeline corridor is very low, averaging about 1% coverage, and the lost kelp biomass and production probably would be less than 0.01% of the Boulder Patch totals, but the effect (kelp substrate burial) would last forever.

Some of the suspended sediment from pipeline trenching and island construction would drift over other parts of the Boulder Patch, reducing light penetration and kelp production during 1 year. This reduction is estimated to be less than 6%, about one-third of which would be due to the proximity between the Boulder Patch to the Zone 1 disposal area for excess sediments. However, in relation to the large range of natural variability, these suspended sediment effects would be barely detectable.

The island's concrete slope from 6-feet deep to the seafloor could be colonized by kelp and other organisms that grow on hard substrates. This portion of the concrete slope could become a home for colonies of species similar to those of the Boulder Patch area. Upon abandonment, the concrete mats probably would become buried naturally or would be removed, cutting back on the new kelp habitat.

g. Fishes

Noise and discharges from dredging, gravel mining, island construction, island reshaping, and pipeline trenching associated with Liberty are expected to have no measurable effect on fish populations. While a few fish could be harmed or killed, most in the immediate area could avoid these activities and would be otherwise unaffected. Effects on most overwintering fish are expected to be short term and sublethal, with no measurable effect on overwintering fish populations. Placement of the concrete mat could create additional food resources for fishes and could have a beneficial effect on nearshore fish populations in the Beaufort Sea. Gravel mining would create potential new fish habitat at the mine site.

h. Essential Fish Habitat

The Magnuson Fishery Conservation and Management Act (16 U.S.C. 1801-1882) established and delineated an area from the State's seaward boundary out 200 nautical miles as a fisheries conservation zone for the United States and its possessions. The Act established national standards for fishery conservation and management, and created eight Regional Fishery Management Councils to apply those national standards in fishery management plans. Another provision of the Act requires that Fishery Management Councils identify and protect essential fish habitat for every species managed by a fishery management plan (50 CFR 600). The essential fish habitat is defined as the water and substrate necessary for fish spawning, breeding, feeding, and growth to maturity. The Act also requires Federal Agencies to consult on activities that may adversely affect essential fish habitats designated in the fishery management plans. An adverse effect is "…any impact which reduces the quality or quantity of EFH." Activities may have direct (for example, physical disruption) or indirect (for example, loss of prey species) effects on essential fish habitats and be site-specific or habitatwide. Loss of prey is considered an adverse effect on essential fish habitat, because one component of the essential fish habitat is that it be necessary for feeding. Adverse effects must be evaluated individually and cumulatively.

Habitat Areas of particular concern have been recognized for salmon in Alaska. These include all anadromous streams, lakes, and other freshwater areas used by salmon and nearshore marine and estuarine habitats such as eel grass beds, submerged aquatic vegetation, emergent vegetated wetlands, and certain intertidal zones. Although it is possible that all five species of salmon that live in Alaskan waters could be found in the Beaufort Sea, there are no commercial salmon fisheries there. Only pink salmon appear to be present in the Liberty area in sufficient numbers to permit small (0-1.5 kilograms per year per person) subsistence fisheries for residents of Nuiqsut and Kaktovik (State of Alaska, Dept. of Fish and Game, 1998). Although chum salmon are believed to be present in the Liberty area, in recent years, they appear to be little used for subsistence purposes by those villages.

The waters surrounding the development have been designated as essential fish habitat for Alaskan salmon. None of the lifestages of Pacific salmon have been documented to use or inhabit the areas expected to be disturbed directly by Liberty construction and operations. Regardless, essential fish habitat would be adversely affected by disturbances to potential prey, to prey habitat, to potential substrate, and to marine and fresh waters. All of these disturbances are expected to be fairly localized and short term.

i. Vegetation-Wetland Habitats

Disturbances mainly come from constructing gravel pads and ice roads and installing the onshore pipeline and tie in with the Badami pipeline. The development of the Kadleroshilik River Mine site would result in the loss of about 24 acres of wetland habitat. Gravel pads, the pipeline trench, and the 1.4-mile-long onshore pipeline would destroy only 0.8 acre of vegetation and affect a few acres of nearby vegetation and have only local effects on the tundra ecosystem. Ice roads would have local effects (compression of tundra under the ice roads) on vegetation, with recovery expected within a few years, and no vegetation would be killed. The construction and installation of the onshore pipeline and gravel pads on State land would be required to have a Section 404/10 permit and approval by the Corps of Engineers, as stated in the Liberty Development and Production Plan (BPXA, 2000a). The permit and approval process is expected to minimize adverse effects on wetlands.

j. Subsistence-Harvest Patterns

For the communities of Nuiqsut and Kaktovik, disturbances periodically could affect subsistence resources, but no resource or harvest area would become unavailable and no resource population would experience an overall decrease. Disturbance and noise could affect subsistence species that include bowhead whales, seals, polar bears, caribou, fish, and birds. Disturbances could displace subsistence species, alter or reduce subsistence-hunter access to these species and, therefore, alter or extend the normal subsistence hunt; but potential disruptions to subsistence resources should not displace traditional practices for harvesting, sharing, and processing those resources. Beluga whales rarely appear in the Liberty Project area. We do not expect belugas to be affected by noise or other project activities, neither do we expect changes in Kaktovik's subsistence harvest of beluga whales.

k. Sociocultural Systems

Effects on the sociocultural systems of communities near the Liberty Project area could occur as a result of disturbance from industrial activities; changes in population and employment; and effects on subsistence-harvest patterns. They could affect the social organization, cultural values, and social health of the communities. Together, effects may periodically disrupt, but not displace, ongoing social systems, community activities, and traditional practices for harvesting, sharing, and processing subsistence resources.

Alaska Inupiat Natives, a recognized minority population, are the predominant residents of the North Slope Borough, the area potentially most affected by Liberty development. Inupiat Natives may be disproportionately affected because of their reliance on subsistence foods, and Liberty development may affect subsistence resources and harvest practices. Disproportionately adverse effects on Alaskan Natives could result from Liberty development under the Proposal. Effects would focus on the Inupiat community of Nuiqsut, and possibly of Kaktovik, within the North Slope Borough. Effects to subsistence resources and subsistence harvests are expected to be mitigated substantially though not eliminated.

l. Archaeological Resources

The Prehistoric Resource Analysis concluded that there is potential for preserved prehistoric archaeological sites to exist within the project area. As a result of this analysis, we requested that BPXA must prepare an archaeological report

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based on geophysical data. The report concluded that "Suitable situations for the preservation of archaeological remains of terrestrial origin cannot be identified in the present data…."

Onshore surveys have recorded two Historic Period sites. Both contain ruins of historic sod houses; and one site also contains a grave. Offshore, there are two known shipwrecks near the project area—the *Reindeer* and the *Duchess of Bedford*. They have been identified through literature sources but have not yet been ground-truthed. While we do not expect a shipwreck to be present in the project area, the information on these wrecks is insufficient to pinpoint their location. The Cultural Resource Assessment received from BPXA concluded that: "…there is no evidence, archival or physical, to indicate the presence of a shipwreck within the project area."

Any bottom- or surface-disturbing activity, such as pipeline construction, island installation, vessel anchors, or oil-spill-cleanup activities could damage previously unidentified archaeological sites. Physical disturbance of sites could cause destruction of artifacts, disturbance or complete loss of site context, and resulting loss of data. Archaeological sites are a nonrenewable resource and could not be replaced.

m. Economics

We examined the effects of construction activities on the Alaskan economy and the subsistence aspects of the economy. We do not expect disturbances to affect the cash economies. Some of the general effects of developing the Liberty Prospect are noted below and discussed in more detail in Section III.D.5 of the EIS.

Employment and wages are a function of the types of activities shown in Table II.A-1 and described in Section II.A.1 of the EIS, the amount of time required to complete them, and where they occur.

Royalties to the State and Federal governments and a spill conservation tax are a function of the production of oil. Federal income tax (and State income tax, if instituted by the State) is a function of the wages paid to workers. The ad valorem tax to the North Slope Borough is a function of the value of onshore infrastructure. The North Slope Borough and Nuiqsut would have an opportunity to see a share of the State royalty share.

BPXA has committed to hiring local workers on the North Slope and within Alaska. However, the oil industry employs few village residents, even though they provide training programs and try to recruit. Many of the contractors BPXA hires for design, construction, drilling, and operations are Native corporations, subsidiaries of such corporations, or otherwise affiliated with such corporations through joint ventures or other relationships. This relationship should benefit the local economy.

The North Slope Borough has tried to improve employment of its Inupiat people in the oil industry at Prudhoe Bay. The Borough believes the oil industry has not done enough to train unskilled laborers or to allow them to go subsistence hunting, which is central to their traditional culture. The Borough also is concerned that the oil industry uses recruiting methods common to Western industry and would like to see the industry become more serious about hiring its residents.

Disruptions to the harvest of subsistence resources could affect the economic well-being of North Slope Borough residents mainly by the loss of some part of those resources.

n. Water Quality

The greatest effect on water quality from gravel island and pipeline construction would be additional turbidity caused by increases in suspended particles in the water column. Increases in turbidity generally are expected to be considerably less than the 7,500 parts per million suspended solids used in the analysis as an acute (toxic) criterion for water quality (Sec. III.C.3.l (2) of the EIS); exceptions may occur within the immediate vicinity of the construction activity. Turbidity increases from construction activities generally are temporary and expected to occur during the winter and end within a few days after construction stops. Material excavated from the pipeline trench but not used for backfill most likely would be left in an area where active erosion of sediment particles could occur during breakup and open water. This material would be similar in composition to seafloor sediments in the trenching and disposal areas, and its contribution to the future turbidity from waves and currents is expected to be about the same as the sediments existing at the seafloor surface prior to pipeline construction. Construction activities are not expected to introduce or add any chemical pollutants.

o. Air Quality

We believe that essentially no disturbances to wildlife, plants, or people would occur due to degradation of air quality caused by Liberty Project activities. The Liberty Proposal would cause a small, local increase in the concentrations of criteria pollutants. Concentrations would be within the Prevention of Significant Deterioration Class II limits and National Ambient Air Quality Standards. Therefore, the effects would be low. (See supporting materials and discussions in Secs. III.D.1.m and VI.C.3. of the EIS). The air-quality analysis is based on the specific emission controls and emission limitations that BPXA would apply to meet the appropriate Environmental Protection Agency regulations. This would include the requirement to use dry, low nitrogen oxide technology for the turbines to further reduce emissions. These controls become part of the proposed project and are written into the permit and, thus, are binding. The use of best available control technology and compliance with the Environmental Protection Agency emission standards is the primary factor in reducing emissions of criteria pollutants (such as nitrogen oxides and sulfur dioxide). BPXA also plans voluntary reduction of greenhouse gases (notably carbon dioxide); this also would result in a slight additional reduction in emissions of other pollutants. These voluntary measures, however, would not be part of the permit and, therefore, are not enforceable. BPXA's Development and Production Plan, especially Sections 12.3 and 6.2.1, have some additional information; their *Part 55 Permit Application for the BP Exploration (Alaska) Inc. Liberty Development Project*, includes a thorough discussion of control measures.

2. Effects Summary for a Large Oil Spill

In the following, we discuss effects that would be expected in the unlikely event of an oil spill.

a. Bowhead Whales

We do not know with certainty what effects an oil spill would have on bowhead whales, but some conclusions can be drawn from studies that have looked at the effects of oil spills on other cetaceans. If a spill occurred and contacted bowhead habitat during the fall whale migration, it is likely that some whales would be contacted by oil. Some of these whales likely would experience temporary, nonlethal effects, including one or more of the following symptoms:

- oiling of their skin, causing irritation
- inhaling hydrocarbon vapors
- ingesting oil-contaminated prey
- fouling of their baleen
- losing their food source
- moving temporarily from some feeding areas

Some whales could die as a result of contact with spilled oil. Geraci (1990) reviewed a number of studies on the physiologic and toxic effects of oil on whales and concluded there was no evidence that oil contamination had been responsible for the death of a cetacean. Nevertheless, the effects of oil exposure to the bowhead whale population are uncertain, speculative, and controversial. The effects would depend on how many whales contacted oil, the duration of contact, and the age/degree of weathering of the spilled oil. If oil got into leads or ice-free areas frequented by migrating bowheads, a substantial portion of the population could be exposed to spilled oil. Prolonged exposure to freshly spilled oil could kill some whales, but we expect that number to be very small with such a low chance of contact.

The potential for bowhead whales to be affected by spilled oil from the Liberty Project is relatively small, based on the estimated size of a spill and the relatively low chance of spilled oil reaching the main bowhead fall migration route outside the barrier islands (14% or less).

b. Spectacled Eiders

A large spill from Liberty Island or an associated marine pipeline would have the highest probability of contacting nearshore and offshore areas of Foggy Island Bay and the eastern Sagavanirktok River Delta, where spectacled eiders may be staging before migration. Oil could contact these eiders from early June to September although mortality from a spill that moves offshore would be difficult to estimate. A spill that enters open water off river deltas in spring could contact any migrant eiders present. Mortality resulting from the Liberty Project would be additive to natural mortality and interfere with recovery from any declines of the coastal plain population. Therefore, recovery of the spectacled eider population from even small losses is not likely to occur quickly. Any substantial spill-related losses are expected to have significant adverse effects on this population and would be considered a take under the Endangered Species Act. A Fish and Wildlife Service report *Exposure of Birds to Assumed Oil Spills at the Liberty Project* estimates exposure (mortality) of spectacled eiders to modeled oil spills originating in the Liberty Project area in summer. To calculate the potential numbers of birds oiled, an overlay of spectacled eider densities was used with MMS oil-spill-trajectory maps, using a Geographic Information System model developed by the Fish and Wildlife Service. See Appendix J of the EIS for the full report. The Fish and Wildlife Service estimates indicated just a few spectacled eiders would be oiled by a large spill (out of an estimated Arctic Coastal Plain population of about 9,500 individuals). Spill-cleanup activities may disturb nesting, broodrearing, or staging eiders or juveniles occupying coastal habitats, resulting in decreased survival.

The MMS estimates that small oil spills could cause a few deaths among nesting, broodrearing, or staging spectacled eiders. Reduction of prey populations from a spill could have a negative effect on the foraging success of spectacled eiders in the local area, especially in spring when there is limited open water. However, alternate foraging habitat, similar in appearance and with similar prey organisms evident apparently is available. However, the amount of high-quality foraging habitat in the Beaufort Sea area remains unknown. Potentially, one or two spectacled eiders and their productivity could be lost as a result of an onshore spill. Although there is no clear evidence of a significant recent decline in the coastal plain spectacled eider population, the overall effect of adverse factors associated with the Liberty Project seriously could impact the population, particularly that segment nesting in the eastern portion of the range, and effects from an oil spill would be significant. The threatened Steller's eider is not expected to occur in the Liberty Project area.

c. Seals and Polar Bears

Seals and polar bears most likely would contact a large spill in the Foggy Island Bay and Mikkelsen Bay areas. An estimated 60-150 ringed seals (out of a resident population of 40,000) and fewer than 50 bearded seals (based on their sparse distribution in the project area out of a population of several thousand) could be affected by the large spill. An estimated 5-30 polar bears could be lost if a spill contacted Cross Island when and where that many polar bears might be concentrated during a whale harvest. This represents a severe event. The more likely loss from Liberty development would be no more than one or two bears. The seal and polar bear populations are expected to recover individuals killed by the spill within 1 year, and there would be no effect on the population.

Amstrup, Durner, and McDonald (2000) estimated that a 5,912-barrel spill could contact from 0-25 polar bears in open-water conditions and from 0-61 polar bears in autumn mixed-ice conditions (out of an estimated resident Beaufort Sea population of 1,800 individuals). The 5,912-barrel-spill size used in the Fish and Wildlife Service model is twice the size of the large spill (2,956 barrels) estimated by MMS. The Fish and Wildlife Service used this larger size as a type of worst-case analysis. The oil-spill trajectories contacted small numbers of bears far more often than they contacted large numbers of bears. In October, 75% of the trajectories oiled 12 or fewer polar bears while in September, 75% of the trajectories oiled 7 or fewer polar bears (Amstrup, Durner, and McDonald; 2000). The median number of polar bears that could be affected by a 5,912-barrel spill in October was 4.2. These results are comparable to the estimate of 5-30 bears given. We conclude that a spill from Liberty is likely to affect 12 or fewer polar bears. The polar bear population is expected to recover this likely loss within 1 year.

Secondary effects on polar bears could come from oil contaminating food sources. A spill might affect the abundance of some prey species in local, coastal areas of Foggy Island Bay where epibenthic food such as amphipods (small shrimp) concentrate, but a spill should not greatly decrease abundant food, such as arctic cod. Local changes in the abundance of some food sources would not affect the seal populations or, in turn, affect the polar bear population in the Beaufort Sea.

d. Marine and Coastal Birds

A large spill would have the highest probability of contacting nearshore and offshore areas of Foggy Island Bay and the eastern Sagavanirktok River Delta, where waterfowl and other aquatic birds may be staging before migration. The long-tailed duck is one of the dominant sea ducks in the Arctic. Mortality from a spill contacting long-tailed ducks in lagoons or other protected nearshore areas of the Harrison Bay to Brownlow Point area surveyed by the Fish and Wildlife Service, where these ducks concentrate during the molt period, is estimated to exceed 1,400 individuals at the average bird densities used in a model developed by the Fish and Wildlife Service. This is equivalent to about 1% of the average coastal plain population. The 5,912-barrel-spill size used in the Fish and Wildlife Service model is twice the size of the large spill (2,956 barrels) estimated by MMS. The Fish and Wildlife Service used this larger size as a type of worst-case analysis. Total kill could range much higher (potentially up to 35% of this central Beaufort population), if oil were to contact areas of high bird density. The 1,400-bird-minimum estimate would result in a significant adverse effect on population numbers and productivity (out of an estimated Arctic Coastal Plain population of about 115,500 individuals), especially if many of those molting in this area come from declining subpopulations. Should long-tailed ducks be contacted by a spill outside the barrier islands, mortality is likely to be considerably lower than this number due to lower bird density.

Flocks of staging king and common eiders could contact oil in nearshore and/or offshore areas. These eider populations have declined 50% in the past 20 years, and substantial oil-spill mortality would aggravate this effect. These species, plus the long-tailed duck and red-throated loon, that have a limited capacity for population growth (loons and sea ducks, in general), are expected to recover slowly from oil-spill mortality. Those that are declining probably will not return to target population levels until the trend is reversed or becomes very small. In particular, because of historic or current declines in common eiders and long-tailed ducks, and the estimated mortalities from an assumed oil spill, a large offshore spill would result in significant impacts to these species.

For most bird species, the relatively small losses likely to result from a spill may be difficult to separate from the natural variation in population numbers, but their populations are not expected to require lengthy recovery periods.

A spill that enters open water off river deltas in spring could contact migrant loons and eiders. Some of the several hundred broodrearing, molting, or staging brant and snow geese could contact oil in coastal habitats. Also, several thousand shorebirds could encounter oil in shoreline habitats, and the rapid turnover of migrants during the migration period suggests that many more could be exposed. Effects are expected to be similar to those outlined above.

An onshore pipeline spill in summer probably would affect only a few nests, even considering all species. If the oil spread to streams or lakes, long-tailed ducks, brant, and greater white-fronted geese that gather on large lakes to molt could be adversely affected in larger numbers. Losses of oiled birds in this case could range up to a few hundred individuals, a minor effect for species whose populations are relatively abundant and stable or increasing. Reduction of prey populations from a spill may reduce foraging success of shorebirds and sea ducks that depend on this local energy source for molt or migration. However, alternate foraging habitat, similar in appearance and with similar prey organisms evident apparently is readily available during the open-water season following the breeding period, although the amount of high-quality foraging habitat in the Beaufort Sea area remains unknown.

e. Terrestrial Mammals

A large offshore spill is most likely to contact some coastal areas from the Sagavanirktok River Delta east to Mikkelsen Bay. Caribou may use some of these areas for relief from insects. The main potential effect on terrestrial mammals that contact spilled oil could be the loss of fewer than 100 caribou (out of an estimated resident population of the Central Arctic Herd of 18,000 individuals) and a few muskoxen, grizzly bears, and arctic foxes. These losses are expected to be replaced by normal reproduction within about 1 year.

A 1,500-barrel onshore pipeline spill could occur and oil less than 5 acres of vegetation along the pipeline landfall to the Badami tie in. Such a spill is not expected to directly affect caribou or other terrestrial mammals and would cause very minor ecological harm.

Secondary effects could come from disturbance associated with spill-cleanup activities and temporary local displacement of some caribou, muskoxen, grizzly bears, and foxes. These activities, however, would not affect the terrestrial mammals’ movements or overall use of habitat.

f. Lower Trophic-Level Organisms

A large oil spill would have only short-term effects on plankton but have long-term effects on the fouled coastlines. Up to 15% of the sound’s coastline would be affected by a large spill. While the ice-gouged coastline is inhabited by mobile, seasonal invertebrate species that would recover within a year, fractions of the oil would persist in the sediments for about 5 years in most areas, and could persist up to 10 years in areas where water circulation is reduced. Liberty crude is highly viscous and particularly resistant to natural dispersion, and very little would be dispersed down in the water column and affect benthic communities such as the Boulder Patch kelp habitat. However, diesel oil, which would be used on the island for startup and emergency fuel, could be dispersed down to the seafloor. If 1,500 barrels of diesel were spilled from a fuel-delivery barge at the island during the open-water season, the concentration would be toxic within an area of about 18 square kilometers (7 square miles), as noted in the water quality section of the EIS. Such toxicity probably would stunt the seasonal growth of kelp plants and reduce the population size of associated invertebrates for several years. Oil-spill response in general would have both minor beneficial and adverse effects on these organisms.

g. Fishes

The likely effects on arctic fishes from a large crude-oil spill, diesel-fuel spill or pipeline spill that entered offshore waters would depend primarily on the season and location of the spill, the lifestage of the fishes, and the duration of the oil contact. Due to their very low numbers in the spill area, no measurable effects are expected on fishes in winter. Effects would be more likely to occur from an offshore oil spill moving into nearshore waters during summer, where fishes concentrate to feed and migrate. The probability of an offshore oil spill contacting nearshore waters in summer ranges from less than 1-26%. If an offshore spill did occur and contact the nearshore area, some marine and migratory fish may be harmed or killed. However, it would not be expected to have a measurable effect on fish populations, and recovery would be expected within 5 years. In general, the effects of fuel spills on fish are expected to be less than the effects of crude-oil spills.

If a pipeline oil spill occurred onshore and contacted a small waterbody with restricted water exchange supporting fish, it would be expected to kill or harm most of the fish within the affected area. Recovery would be expected in 5-7 years. Because of the small amount of oil or diesel fuel likely to enter freshwater habitat, the low diversity and abundance of fish in most of the onshore area, and the unlikelihood of spills blocking fish migrations or occurring in overwintering areas or small waterbodies, an onshore spill of this kind is not expected to have a measurable effect on fish populations on the Arctic Coastal Plain.

h. Essential Fish Habitat

The most likely threat to salmon in essential fish habitat would occur if spilled oil came in contact with spawning areas or migratory pathways. However, salmon are not believed to spawn in the intertidal areas or the mouths of streams or rivers of the Beaufort Sea. Therefore, contact between spilled oil and spawning areas is very unlikely. If spilled oil concentrated along the coastline at the mouths of streams or rivers, the potential movements of a small number of salmon could be disrupted during migrations.

Zooplankton and fish form most of the diet for salmon in the Beaufort Sea. Zooplankton populations could be subjected to short-term, localized, negative effects from oil spilled as a result of Liberty development. Juvenile lifestages of salmon inhabit fresh or estuarine waters and generally feed on insects. Oil spilled in wetland habitat could kill vegetation and associated insect species and, thus, have an adverse effect on essential fish habitat lasting from less than 10 years to several decades. Because of the predominance of shorefast ice in the Liberty area, there is no resident marine flora in waters less than 6 feet deep. Therefore, no effects are expected on marine plants in those waters.

Salmon and their prey require relatively clean water in which to live and perform their basic life functions. Essential fish habitat would be adversely affected to the extent that water quality would be degraded. Water quality would be significantly degraded over a fairly large area for a period from days to months, if a large spill of crude or diesel oil occurred. The relative effect of an oil spill on water quality during times of open water would be relatively long lived and widespread, as compared to times of broken or complete ice cover. The effects of a diesel spill generally would be more acute and widespread than the effects of a crude oil spill under similar environmental conditions.

i. Vegetation-Wetland Habitats

Main potential effects of a large offshore spill on vegetation and wetlands include oil fouling, smothering, asphyxiation, and poisoning of plants and associated insects and other small animals. In this case, complete recovery of moderately oiled wetlands of the Sagavanirktok River east to Mikkelsen Bay would take perhaps 10 years or longer. A second main effect is the disturbance of wetlands from cleanup activities. Complete recovery of heavily oiled coastal wetlands from these disturbances and oil could take several decades.

A large onshore spill would oil no more than 5 acres of vegetation along the pipeline landfall to the Badami tie in and would cause some ecological harm. Oiled vegetation should recover within a few years but may take more than 10 years to fully recover.

j. Subsistence-Harvest Patterns

The chance of a large spill from the offshore production island and the buried pipeline occurring and entering offshore waters is estimated to be low. Based on the assumption that a spill has occurred, the chance of an oil spill during summer from either Liberty Island or the pipeline contacting the important traditional bowhead whale and seal harvest areas of Cross and McClure Islands over a 360-day period would be up to 16%. A spill also could affect other subsistence resources and harvest areas used by the communities of Nuiqsut and Kaktovik.

No harvest areas would become unavailable for use and all resources, except possibly bowhead whales, would remain available for use. Some resource populations could suffer losses and, as a result of tainting, bowhead whales could be rendered culturally unavailable for use. Tainting concerns in communities nearest a spill event could seriously curtail traditional practices for harvesting, sharing, and processing bowhead whales and threaten a pivotal underpinning of Inupiat culture. Whaling communities unaffected by potential spill effects are likely to share bowhead whale products with impacted villages. Harvesting, sharing, and processing of other subsistence resources should continue.

k. Sociocultural Systems

Effects on the sociocultural systems of the communities of Nuiqsut and Kaktovik could come from disturbance from small changes in population and employment and periodic interference with subsistence-harvest patterns from oil spills and oil-spill cleanup. Effects from these sources are not expected to displace ongoing sociocultural systems, but community activities and traditional practices for harvesting, sharing, and processing subsistence resources could be seriously curtailed in the short term if there are concerns over the tainting of bowhead whales from an oil spill.

Alaska Inupiat Natives, a recognized minority population, are the predominant residents of the North Slope Borough, the area potentially most affected by Liberty development. Inupiat Natives may be disproportionately affected because of their reliance on subsistence foods, and Liberty development may affect subsistence resources and harvest practices. Disproportionately adverse effects on Alaskan Natives could result from Liberty development under the Proposal. Effects would focus on the Inupiat community of Nuiqsut, and possibly of Kaktovik, within the North Slope Borough. Effects to subsistence resources and subsistence harvests are expected to be mitigated substantially though not eliminated.

l. Archaeological Resources

The geography, prehistory, and history of the Liberty Prospect is very different from that of Prince William Sound where the effects of the *Exxon Valdez* oil spill were concentrated; therefore, direct analogies cannot be drawn regarding the numbers and types of sites that may be affected should such a spill occur in the Liberty Prospect area. However, general finds and conclusions regarding the types and severity of impacts to archaeological sites present within the *Exxon Valdez* oil spill area are applicable to this proposed project. The most important understanding that came from the *Exxon Valdez* oil spill was that the greatest impacts to archaeological sites were not from effects from the oil itself, but from the cleanup activities (Bittner, 1993, Dekin, 1993). The effects from cleanup activities were due both to physical disturbance of sites from cleanup equipment and due to vandalism by cleanup workers. Regardless, researchers concluded that less than 3% of the archaeological resources within the spill area suffered any substantial effects (Mobley, et al., 1990, Wooley and Haggarty, 1993) and that a similar level of effect would be projected in the unlikely event that an oil spill occurred from the Liberty development.

m. Economics

Employment generated to clean up possible large oil spills of 715-2,956-barrels is estimated to be 30-125 cleanup workers for 6 months in the first year, declining to zero by the third year following the spill.

n. Water Quality

During open water, hydrocarbons dispersed in the water column from a large (greater than or equal to 500 barrels) crude oil spill could exceed the 0.015-parts per million chronic criterion for 10-30 days in an area that ranges from 30-45 square kilometers (11.6-17.4 square miles) to 51-186 square kilometers (19.7-71.8 square miles). Hydrocarbons in the water could exceed the 1.5-parts per million acute (toxic) criterion during the first day in the immediate vicinity of the spill. A large crude oil spill in broken sea ice or when the sea ice melts could exceed the chronic criterion for several days in an area of about 7.6 square kilometers (2.9 square miles). Hydrocarbons from a 1,283-barrel diesel oil spill during open water could exceed the acute (toxic) criterion for about 7 days in an area of about 18 square kilometers (7 square miles). During broken sea ice or melting ice conditions, a 1,283-barrel diesel spill could exceed the acute (toxic) criterion for about 1 day in an area of about 1 square kilometer (0.4 square mile) and the chronic criterion for more than 30 days in an area of about 103 square kilometers (39.8 square miles). The effects from a spill occurring under the ice would be similar to those described for broken-ice or melting conditions; the oil would be trapped and essentially remain unchanged until breakup occurred and the ice began to melt.

A large crude or refined oil spill (greater than or equal to 500 barrels) would have a significant effect on water quality by increasing the concentration of hydrocarbons in the water column to levels that greatly exceed background concentrations; however, the chance of a large spill occurring and oil entering the offshore waters is estimated to be about 1%. Also, regional (more than 1,000 square kilometers [386 square miles]), long-term (more than 1 year) degradation of water quality to levels above State and Federal criteria because of hydrocarbon contamination is very unlikely.

o. Air Quality

Oil spills from the offshore gravel island and the buried pipeline could cause a small, local increase in the concentrations of gaseous hydrocarbons (volatile organic compounds) due to evaporation from the spill. The concentrations of volatile organic compounds would be very low and normally be limited to only 1 or 2 square kilometers (0.4-0.8 square mile). During open-water conditions, spreading of the spilled oil and action by winds, waves, and currents would disperse the volatile organic compounds so that they would be at extremely low levels over a relatively larger area. During broken-ice or melting ice conditions, because of limited dispersion of the oil, there would be some increase in volatile organic compounds for several hours, possibly up to 1 day. The effects from a spill occurring under the ice would be similar to but less than those described for broken ice or melting conditions; the oil would be trapped and essentially remain unchanged until the ice began to melt and breakup occurred. Some of the volatile organic compounds, however, would be released from the oil and dispersed, even under the ice. In any of these situations, moderate or greater winds would further reduce the concentrations of volatile organic compounds in the air. Concentrations of criteria pollutants would remain well below Federal air-quality standards. The overall effects on air quality would be minimal.

E. ALTERNATIVES AND MITIGATION

1. Decision Options

The project as proposed by BPXA and described in their Development and Production Plan (BPXA, 2000a) is presented in the EIS and is being evaluated by the MMS and other permitting and regulatory agencies. Construction of the project would not take place unless these agencies approve the project or a modified project.

At the completion of this EIS process, the decisionmakers will have three options available:

- Accept the Project as proposed in the Liberty Development and Production Plan (Alternative I);
- Deny the Project (No Action - Alternative II); or
- Accept the project with modification by choosing one or more of component alternatives or one of the combination alternatives described below and/or any proposed mitigating measures.

Alternative I was briefly described in Section A and the effects of Alternative I were summarized previously in Section D.

2. Alternative II – No Action

A decisionmaker not wanting to approve the project would select the second decision option, Alternative II, the No Action Alternative. Under this alternative, the Liberty Development and Production Plan would not be approved. None of the potential 120 million barrels of oil would be produced, and none of the environmental effects that would result from the proposed development would occur. There would be no potential oil spills and no effects to the flora and fauna in the Foggy Island Bay. Economic benefits, royalties, and taxes to Federal and State governments would be forgone.

To replace the potential 120 million barrels of oil not developed from Liberty, a large portion of the oil would be imported from other countries. The associated environmental impacts from producing oil and transporting it to market still would occur. These imports have attendant environmental effects and other negative effects on the Nation's balance of trade.

The Most Important Substitutes for Lost Production: The energy that would have flowed into the United States' economy from this development would need to be provided from a substitute source. Possible sources include:

- Other domestic oil production
- Imported oil production
- Other alternative energy sources such as
  - Imported Methanol
  - Gasohol
  - Compressed Natural Gas
  - Electricity
- Conservation in the areas of transportation, heating, or reduced consumption of plastics
- Fuel-switching
- Reduction in the consumption of energy

Environmental Impacts from the Most Important Substitutes: If imports increased to satisfy oil demands, effects to the environment would be similar in kind to those of the Proposal but would occur in different locations. The species of animals and plants affected might be different and would depend on the location of the development. Some effects still could occur within the United States from accidental or intentional discharges of oil from tankers or pipelines. These events would:

- generate greenhouse gases and air pollutants from transportation and dockside activities;
- degrade air quality from emissions of nitrogen oxides and volatile organic compounds;
- degrade water quality; and
- destroy flora and fauna and water.

Imported oil imposes negative environmental impacts in producing countries and in countries along trade routes. By importing oil we are exporting environmental impacts to those countries from which the United States imports and to countries along or adjacent to the transportation routes as well.

Substituting energy-saving technology or consuming less energy would conserve energy and result in positive net gains to the environment. However, these efforts may require additional manufacturing. The amount of gain would depend on the extent of negative impacts from capital-equipment fabrication.

Onshore oil production has notable negative impacts on surface water, groundwater, and wildlife. It also can cause negative impacts on soils, air quality, and vegetation and cause or increase noise and odors. Offshore oil production may result in impacts similar to those of the Proposal, but they would occur in a different location.

Consumers probably could switch to natural gas to heat their homes and businesses or for industrial uses. While natural gas production would create environmental impacts, they would be at a lower level than those impacts normally associated with oil spills. Other alternative transportation fuels may constitute part of the fuel-substitution mix that depends on future technical and economic advances.

Natural resources in the Arctic Ocean, Beaufort Sea and, to a more limited extent, Foggy Island Bay still would be exposed to other ongoing oil and gas activities in the area, as described in Section I.F of the Executive Summary and Section V of the EIS.

3. Component and Combination Alternatives and Their Effects

For the balance of our alternatives analysis, we use both "component alternatives" and "combination alternatives." First, we define and discuss five sets of component alternatives. Each set varies a single project component identified during scoping as being important. Each component alternative is a "complete" alternative in that it includes all the same elements as the BPXA Proposal except for the one component at issue. For ease in making comparisons, each set of component alternatives also includes the BPXA proposed project component. See Tables IV.D-1 and IV.D-2 of the EIS.

The five sets of component alternatives areas follow:

- **Three island locations and pipeline routes** (Liberty Island/Liberty pipeline route, Tern Island/Tern Pipeline route, and Southern Island/eastern pipeline route)
- **Four pipeline designs** (single-wall pipe, steel pipe-in-steel pipe, steel pipe-in-plastic pipe, and flexible pipe)
- **Two types of upper slope protection for the production island** (gravel bags and steel plate)
- **Two gravel mine sites** (Kadleroshilik River and Duck Island)
- **Two pipeline burial depths** (design trench depth and a 15-foot trench depth)

The decisionmakers for this project can select one alternative from each of the above five sets of component alternatives. That means there are 96 possible combinations of components to choose from, including the components proposed by BPXA (3 x 4 x 2 x 2 x 2 = 96).

Some of the alternatives (Island Location and Pipeline Routes and/or Pipeline Design), if chosen, may result in delays in the Liberty Project of 18-24 months to collect additional engineering data and allow time for specific design and testing work. This information would be necessary for technical approval of the project but is not expected to change the environmental effects. For purposes of analysis in the EIS, we have not adjusted the timelines for starting the different alternatives. Therefore, all the alternatives are on the same footing for the analysis of environmental effects.

After the evaluation of the component alternatives, we define and discuss three "combination alternatives." The Liberty Interagency Team formulated each of these combinations by selecting one alternative from each of the five sets of component alternatives. In Section IV.D of the EIS, these three combination alternatives are compared with each other and with the Proposal to assess their relative effects on the environment.

Because this approach of analyzing "component alternatives" and "combination alternatives" is a bit unusual, the following should help explain our rationale for using both in this EIS.

As a first step, we evaluated each alternative in each set of component alternatives and compared it to the other alternatives in the set. Because all the component alternatives are "complete" alternatives, the comparisons can be made on an even footing. The Liberty Interagency Team believes that using component alternatives is a good way to focus analysis on the issues and concerns related to a particular component. It also facilitates comparison among the choices in each set.

However, by using this approach, the component alternatives are all the same as the BPXA Proposal except for the one component that we vary within each set. Also, this approach does not provide for concurrent evaluation of two or more components. In essence, analyzing only component alternatives does not facilitate either evaluating a reasonable range of alternatives or selecting multiple alternative components as required under the National Environmental Policy Act.

We therefore took a second step to overcome these limitations. Using the component alternatives as building blocks, the Liberty Interagency Team developed three more alternatives that we refer to as "combination alternatives." These were selected from the possible 96 combinations mentioned previously. Each combination alternative also is a "complete" alternative, and each varies substantially from the other combination alternatives.

The Combination Alternatives, with the BPXA Proposal shown for comparison, are:

Combination Alternative A
- Use Liberty Island and Liberty Pipeline Route
- Use Pipe-in-Pipe Pipeline Design
- Use Steel Sheetpile for Upper Slope Protection
- Use Duck Island Gravel Mine
- Use a 7-Foot Burial Depth

Combination Alternative B
- Use Southern Island and Eastern Pipeline Route
- Use Pipe-in-HDPE Pipeline
- Use Gravel Bags for Upper Island Slope Protection
- Use the Kadleroshilik River Mine Site
- Use the 6-Foot Burial Depth as designed by for the Steel Pipe-in-HDPE pipeline design

Combination Alternative C
- Use Tern Island and Tern Pipeline Route
- Use Steel Pipe-in-Pipe Pipeline Design
- Use Steel Sheetpile for Upper Slope Protection
- Use Duck Island Mine Site
- Use a 15-Foot Burial Depth

The BPXA Proposal (Liberty Development and Production Plan)
- Use Liberty Island and Liberty Pipeline Route
- Use Single-Wall Pipeline Design
- Use Gravel Bags for Upper Island Slope Protection
- Use the Kadleroshilik River Mine Site
- Use a 7-Foot Burial Depth

Note that one of these options, Combination C, has none of the component alternatives included in the BPXA Proposal, while Combination A and Combination B have some components in common with the BPXA Proposal and some that are different. Therefore, as a group, the combination alternatives range from the BPXA Proposal to a proposal as different from BPXA's as possible. Evaluating a reasonable number of examples that cover the spectrum of 96 alternatives in this manner allows the decisionmaker to ultimately select any of those 96 possibilities. (See Questions 1a and 1b, *Forty Most Asked Questions Concerning the Council on Environmental Quality National Environmental Policy Act Regulations*, 46 *Federal Register* 18026, as amended.)

Some of the alternatives (Island Location and Pipeline Route or Pipeline Design), if chosen, may result in delays of 18-24 months, to collect additional data and for design and testing. For purposes of analysis in the EIS, we have not adjusted the timelines for starting the different alternatives. This keeps all the alternatives on the same footing for the analysis of environmental effects.

Many of the Liberty Project key elements are shown in Table II.A-1. Elements that are also part of the project and would apply to all alternatives, but which are not shown in the table, include the following:

Contents

- Island and pipeline construction would occur over 2 years.
- Excess trenching material would be disposed of at approved ocean dumping sites.
- Natural gas would be used to fuel all activities on the island when production begins.
- Ice roads would be constructed annually in winter to provide access to the island.
- During broken-ice and open-water conditions, marine vessels would be used to transport personnel and materials to the island; helicopters would be used year-round as needed.
- Waste materials from the island would either be reinjected into the disposal well or disposed of at approved sites.
- Drilling waste material (muds, cuttings, and produced waters) would be reinjected into a disposal well.
- The field would be developed using waterflood and gas reinjection to maintain reservoir pressure.
- The Oil Discharge Prevention and Contingency Plan (BPXA, 2000b) would apply to all alternatives.

For the most part, the effects to the natural resources and species affected by a change in one component of the project (one alternative) differ from the effects to natural resources and species affected by a change in another component (another alternative). The overall effects of any combination of alternatives can be seen by simply combining or adding the effects identified for each natural resource.

The EIS devotes extensive text to the effects of the component alternatives, but only includes the highlights of the benefits, concerns, and effects of the combination alternatives. Our rationale for this is that the component alternatives are the building blocks for the combination alternatives. With a thorough understand of the building blocks, the reader or decisionmaker can easily review the combination alternatives formulated by the Liberty Interagency Team or use the blocks to construct and assess whatever combination is preferred.

a. Effects of Component Alternatives

For ease of reading up to this point, we have not attached roman numerals to the component alternatives, but will do so in the following. Also, the reader should note that for the purpose of alternative analysis, MMS assumes an oil spill would occur, and that the probability of an oil spill occurring (less than 1%) is the same for all alternatives.

(1) Effects of Alternative Drilling and Production Island Locations and Pipeline Routes

This set of component alternatives evaluates the different impacts of using three different island locations and their corresponding pipeline routes (see Map 1 of the EIS):

- Alternative I – Use the Liberty Island and Pipeline Route (Liberty Development and Production Plan)
- Alternative III.A – Use the Southern Island Location and Eastern Pipeline Route
- Alternative III.B – Use the Tern Island Location and Pipeline Route

(Note that this set and each of the other four sets of component alternatives include BPXA's Proposal for comparison.) Spill rates and the chance of occurrence of small, large, and very large oil spills are the same for the proposed Development and Production Plan, component alternatives, and combination alternatives.

The Eastern and Tern Pipeline Routes share the same shoreline crossing as well as the onshore pipeline route. If either Alternative III.A or III.B is selected, BPXA would be required to submit for our review additional geophysical survey data that sufficiently cover the proposed area of offshore disturbance. An archaeological report would be prepared to address whether the data show any evidence of areas having prehistoric or historic site potential. Based on this analysis, we would require that any areas of archaeological site potential either be investigated further to determine conclusively whether a site exists at the location or that the area of the potential site be avoided by all bottom-disturbing activities.

As indicated in Section E.3.a(1), the differences in island locations and pipeline routes for Alternatives I, III.A, and III.B do not provide measurable differences in effects to the following resources:

- Bowhead Whales
- Seals and Polar Bears
- Fishes
- Subsistence-Harvest Patterns
- Sociocultural Systems
- Archaeological Resources
- Air Quality

(a) Alternative I – Use Liberty Island Location and Pipeline Route (Liberty Development and Production Plan)

The Liberty Island and its pipeline route are shown in Map 1 of the EIS. This alternative is the Proposed Action - BPXA's Liberty Development and Production Plan. The features of this alternative are shown in Table II.A-1 of the EIS. Liberty Island is in about 22 feet of water and about 5 miles from shore. The Liberty pipeline route would go southwest to shore. The offshore pipeline is about 6.1 miles long. The distance for hauling the gravel is about 7 miles to the island from the Kadleroshilik River Mine Site. The proposed Liberty gravel island would be centered above the Liberty reservoir. This location would minimize the number of high-departure wells needed to develop the reservoir and maximize the total oil recovered. The present island location had no observed permafrost to a minimum of 50 feet below the island location. Liberty Island would be about 1mile southeast of the Boulder Patch. For purposes of analysis, we assume a trench with a 7-foot minimum burial depth.

Alternative I would have effects to the following resources:

Spectacled Eiders: Disturbance of nesting or broodrearing spectacled eiders may result in loss of eggs or young to predators; however, displacement of more than a few eiders (or females with broods) by onshore facilities or activities is considered unlikely. Significant adverse population effects are *not* expected to occur as a result of disturbance.

A large oil spill from Liberty Island or associated marine pipeline would have the highest probability of contacting nearshore and offshore areas of Foggy Island Bay and the eastern Sagavanirktok River Delta, where spectacled eiders may be staging before migration. Recovery of the spectacled eider population from even small losses is not likely to occur quickly. Any substantial spill-related losses are expected to have significant adverse effects on this population.

Marine and Coastal Birds: Helicopter flights to Liberty Island may disturb some loons and king or common eiders feeding in open water off the Sagavanirktok River Delta during breakup or displace long-tailed ducks and eiders from preferred marine foraging areas in summer, adversely affecting fitness in some individuals. Snow goose and brant family groups could be displaced from coastal broodrearing areas, but alternative sites generally are available. Spill-cleanup activities may displace some nesting, broodrearing, juvenile or staging waterfowl and shorebirds from preferred habitats, resulting in lowered fitness. The small losses and displacements likely to result from the above activities are expected to cause minor changes in numbers but are not expected to require lengthy recovery periods.

A large oil spill from Liberty Island or the associated marine pipeline would have the highest probability of contacting nearshore and offshore areas of Foggy Island Bay and the eastern Sagavanirktok River Delta, where waterfowl and other aquatic birds may be molting or staging before migration. Mortality from a spill contacting long-tailed ducks in lagoons or other protected nearshore areas, where they concentrate during the molt period is estimated to exceed 1,200 individuals (equivalent to about 1% of the average coastal plain population) at average bird densities. Species that have a limited capacity for population growth (loons and sea ducks, in general), are expected to recover slowly from oil-spill mortality. Those that are declining (eiders, long-tailed ducks, red-throated loons) probably would not return to a target population level until the trend is reversed or becomes very small. In particular, because of historic or current declines in common eiders and long-tailed ducks and the estimated mortalities from an assumed oil spill, a large offshore spill would result in significant impacts to these species. Losses of other species (for example, the northern pintail, geese, glaucous gull, most shorebirds, and songbirds) through oiling could range up to a few hundred individuals, a minor effect for species whose populations are relatively abundant and stable or increasing.

Terrestrial Mammals: Disturbances would have short-term effects on individual animals and would not affect populations.

Crude oil or diesel fuel is most likely to contact some coastal areas from the Sagavanirktok River Delta east to Mikkelsen Bay. Caribou may use some of these areas for relief from insects. The main potential effect on terrestrial mammals that contact spilled oil could be the loss of fewer than 100 caribou and a few muskoxen, grizzly bears, and arctic foxes. These losses are expected to be replaced by normal reproduction within about 1 year. Secondary effects could come from disturbance associated with spill-cleanup activities and temporary local displacement of some caribou, muskoxen, grizzly bears, and foxes. These activities, however, would not affect the terrestrial mammals' movements or overall use of habitat.

Lower Trophic-Level Organisms: Alternative I would disturb lower trophic-level organisms in three primary ways: (1) island construction would bury about 23 acres of typical benthic organisms; (2) pipeline trenching would disturb additional benthos, burying up to 14 acres with very low (1%) coverage of kelp, boulders, and suitable substrate; and (3) sediment plumes would reduce Boulder Patch kelp production by up to 6% during 1 year. The buried 14 acres would equal less than 0.1% of the Boulder Patch kelp habitat. The density of the kelp, boulders and suitable substrate in the pipeline corridor is very low, averaging about 1% coverage, and the lost kelp biomass and production probably would be less than .01% of the Boulder Patch totals, but the effect (kelp substrate burial) would last forever.

Some of the suspended sediment from pipeline trenching and island construction would drift over other parts of the Boulder Patch, reducing light penetration and kelp production during 1 year. This reduction is estimated to be less than 6%, about one-third of which would be due to the proximity between the Boulder Patch to the Zone 1 disposal area for excess sediments. However, in relation to the large range of natural variability, all of these suspended sediment effects would be barely detectable.

A portion of the concrete slope would be a temporary home for colonies of species similar to those of the Boulder Patch area. Upon abandonment, the concrete mats probably would be removed or would become buried naturally, eliminating the additional kelp habitat.

Lower trophic-level organisms would be affected by a large oil spill. It would have only short-term effects on plankton, including phytoplankton, zooplankton, and epontic species on the bottom of the ice cover, but longer term effects on the fouled coastlines. Very little of Liberty crude, which is highly viscous and particularly resistant to natural dispersion, would be dispersed down in the Stefansson

Sound water column and affect deep benthic communities such as the Boulder Patch kelp habitat. However, diesel oil, which would be used on the island for startup and emergency fuel, could be dispersed down to the seafloor. If 1,500 barrels of diesel were spilled from a fuel-delivery barge at the island during the open-water season, the concentration would be toxic within an area of about 18 square kilometers (7 square miles), as noted in the water quality section (see Sec. III.A.2 (l) in the EIS). Such toxicity probably would stunt the seasonal growth of kelp plants and reduce the population size of associated invertebrates for several years. Oil-spill responses in general would have both beneficial effects of some and adverse effects on other lower trophic-level organisms.

Essential Fish Habitat: As a result of disturbances caused by Liberty Island construction and operation, fish and zooplankton might experience short-term, localized but unmeasurable effects.

Vegetation-Wetland Habitat: Disturbances mainly come from constructing gravel pads and ice roads and installing the onshore pipeline and tie-in with the Badami pipeline. Gravel pads, pipeline trench, and the 1.4-mile-long onshore pipeline would destroy only 0.8 acre of vegetation and affect a few acres of nearby vegetation and have only local effects on the tundra ecosystem. Ice roads would have local effects (compression of tundra under the ice roads) on vegetation, with recovery expected within a few years, and no vegetation would be killed.

The main potential effects of a large offshore spill on vegetation and wetlands include oil fouling, smothering, asphyxiation, and poisoning of plants and associated insects and other small animals. In this case, complete recovery of moderately oiled wetlands of the Sagavanirktok River east to Mikkelsen Bay would take perhaps 10 years or longer. A second main effect is the disturbance of wetlands from cleanup activities. A large onshore spill would oil no more than 5 acres of vegetation along the pipeline landfall to the Badami tie-in and would cause very minor ecological harm. Complete recovery of heavily oiled coastal wetlands from these disturbances and oil could take several decades.

Economy: The Liberty Project would generate approximately $100 million in wages and 870 full-time equivalent construction jobs for 1 year in Alaska during 14-18 months of construction; 1,248 indirect full-time equivalent jobs during the 14-18 months of construction; and $480 million capital expenditure.

Water Quality: The greatest effect on water quality from gravel island and pipeline construction would be additional turbidity caused by increases in suspended particles in the water column. Increases in turbidity generally are expected to be considerably less than the 7,500 parts per million suspended solids used in the analysis as an acute (toxic) criterion for water quality; exceptions may occur within the immediate vicinity of the construction activity. Turbidity increases from construction activities generally are temporary and expected to occur during the winter and end within a few days after construction stops. Material excavated from the pipeline trench but not used for backfill most likely would be left in an area where active erosion of sediment particles could occur during breakup and open water. This material would be similar in composition to seafloor sediments in the trenching and disposal areas and its contribution to the future turbidity from waves and currents is expected to be about the same as the sediments existing at the seafloor surface prior to pipeline construction. Construction activities are not expected to introduce or add any chemical pollutants.

(b) Alternative III.A – Use the Southern Island Location and Eastern Pipeline Route

The Southern Island location and Eastern Pipeline Route are shown in Map 1 of the EIS. The features of this alternative are shown in Table II.A-1 of the EIS. This alternative was developed in response to scoping comments requesting analysis of island locations in shallower water to eliminate or reduce effects to bowhead whales.

The features of Alternative III.A that affect the resources differently than Alternative I are island size, island and pipeline location closer to shore, island and pipeline location farther from the Boulder Patch, and offshore and onshore pipeline lengths. The Southern Island is in shallower water and requires about 20% less gravel than Liberty Island and is about 2 miles closer to shore than Liberty Island. The Southern Island and the offshore end of the eastern pipeline are about 2.5 miles from the Boulder Patch; whereas, Liberty Island and the offshore end of the Liberty pipeline are about 1 mile away. The offshore segment of the eastern pipeline is about 1.9 miles shorter than the Liberty pipeline, but the onshore part is 1.6 miles longer.

The effects of disturbances decrease the level of suspended sediments because of the smaller island size, shorter offshore pipeline length, and longer distance to the Boulder Patch. Noise levels increase because of the longer onshore pipeline. The likelihood of a large oil spill contacting the shore in Foggy Island Bay increases because of the shorter distance between the island and the shore. Compared to Alternative I, these differences would change impacts to the following resources in the ways described:

Spectacled Eiders: Compared to Alternative I, helicopter inspections of the onshore pipeline would slightly increase disturbances to nesting (from 0.75-1.5 nests) and broodrearing spectacled eiders.

The probability of a large oil spill contacting nesting or broodrearing spectacled eiders in the southern part of Foggy Island Bay after 30 days is 2-14% greater than for Alternative I. Any substantial spill-related losses are expected to have significant adverse effects on this population.

Marine and Coastal Birds: Disturbances to nesting and broodrearing birds from helicopter inspections of the onshore pipeline would increase compared to Alternative I.

The probability of a large oil spill contacting nesting or broodrearing birds in the southern part of Foggy Island Bay after 30 days is 2-14% greater than for Alternative I.

Terrestrial Mammals: Terrestrial mammals may frequent coastal habitats, and the probability of a large oil spill contacting these habitats after 30 days is 0-4% greater than for Alternative I.

Lower Trophic-Level Organisms: Trenching for the eastern pipeline would not destroy any kelp habitat; trenching for the Liberty pipeline would destroy about 14 acres. Suspended sediments from constructing the eastern pipeline would reduce kelp production in the Boulder Patch about 1% less than from Liberty pipeline construction.

The general effects of a crude-oil spill on lower trophic-level organisms would be similar to those for Alternative I; however, the longer distance between the alternative island site and the Boulder Patch kelp habitat would reduce slightly the risk of diesel fuel spill effects to the kelp community.

Essential Fish Habitat: The potential adverse effects of this alternative on essential fish habitat could be reduced slightly because the size of the island footprint and amount of offshore trenching would be reduced.

Vegetation-Wetland Habitats: The probability of a large oil spill contacting coastal vegetation and wetland habitats after 30 days is 0-4% greater than for Alternative I.

Economy: Alternative III.A would generate fewer jobs, less wages, and less revenue to the government than the Proposal. This alternative would result in a decrease of approximately $1.7 million in wages for 12 months, 9 direct jobs in Alaska for 12 months, 14 indirect jobs in Alaska for 12 months, and $10 million in net present value to the company. The net present value to the government is estimated to be $107million, or $7 million less than the Proposal.

Water Quality: Constructing a smaller island and shorter pipeline reduces the suspended sediments by about 14% and 32%, respectively, and decreases the time the suspended sediments would affect the water quality by 3 to 5 and 15 days, respectively, compared to Alternative I.

(c) Alternative III.B - Use the Tern Island Location and Tern Pipeline Route

The Tern Island and Tern Pipeline Route are shown in Map 1 of the EIS. The features of this alternative are shown in Table II.A-1 of the EIS. This alternative was developed in response to scoping comments regarding the use of the abandoned exploration island as a source of gravel or as a drilling/production island.

The features of Alternative III.B that affect the resources differently than Alternative I are the amount of gravel used to construct the island, the island and pipeline location closer to shore, the island and pipeline location farther from the Boulder Patch, and the offshore pipeline length. Tern Island is in deeper water than Liberty Island but requires about 25% less gravel because of gravel than has remained after the island was abandoned as an exploration drilling site. Tern Island is about 0.6 mile closer to shore than Liberty Island. Tern Island and the offshore end of the pipeline are about 4 miles from the Boulder Patch; whereas, Liberty Island and the offshore end of the Liberty pipeline are about 1 mile. The offshore segment of the Eastern Pipeline is about 0.6 mile shorter than the Liberty pipeline.

The effects of disturbance associated with suspended sediments decrease because of the smaller amount of gravel used to construct the island, the shorter offshore pipeline length, and longer distance to the Boulder Patch. The likelihood of a large oil spill contacting the shore in Foggy Island Bay decrease slightly because of the location of the island and pipeline in relation to the nearshore currents. Compared to Alternative I, these differences would change impacts to the following resources in the ways described:

Spectacled Eiders: The probability of a large oil spill contacting nesting or broodrearing spectacled eiders in the southern part of Foggy Island Bay after 30 days is 10-20% lower than for Alternative I. Any substantial spill-related losses are expected to have significant adverse effects on this population.

Marine and Coastal Birds: The probability of a large oil spill contacting nesting or broodrearing birds in the southern part of Foggy Island Bay after 30 days is 10-20% lower than for Alternative I.

Terrestrial Mammals: Terrestrial mammals may frequent coastal habitats, and the probability of a large oil spill contacting these habitats after 30 days is 0-4% greater than Alternative I.

Lower Trophic-Level Organisms: Trenching for the eastern pipeline would not destroy any kelp habitat; trenching for the Liberty pipeline would destroy about 14 acres but there would be minor, short-term effects to organisms in the silty/sandy sediments. Suspended sediments from constructing the eastern pipeline would reduce kelp production in the Boulder Patch by about 1% of that for Liberty pipeline construction.

The general effects of a crude-oil spill on lower trophic-level organisms would be similar to those for Alternative I; however, the longer distance between the alternative island site and the Boulder Patch kelp habitat would reduce slightly the risk of diesel fuel spill effects to the kelp community.

Essential Fish Habitat: The potential adverse effects of this alternative on essential fish habitat could be slightly reduced primarily because of expected smaller effects on fish and algae at the Boulder Patch. The longer distance between Tern Island and the Boulder Patch would reduce the risk of diesel fuel spills to the kelp and associate fish communities. The disturbance effects would be slightly lower for this alternative, because pipeline trenching would not eliminate kelp. Less material would be used to construct Tern Island than Liberty Island, and the total amount of particulate matter suspended would be less. The turbidity plume would be expected to have a shorter duration than the plume associated with Liberty.

Vegetation-Wetland Habitats: The probability of a large oil spill contacting coastal vegetation and wetland habitats after 30 days is 0-4% greater than for Alternative I.

Economy: Alternative III.B would generate fewer jobs, less wages, and less revenue to the government than Alternative I. This alternative would result in a decrease of approximately $1.7 million in wages for 12 months, 9 direct jobs in Alaska for 12 months, 14 indirect jobs in Alaska for 12 months, and $10 million in net present value to the company. The net present value to the government is estimated to be $107 million, or $7 million less than Alternative I.

Water Quality: Constructing an island with less gravel and a shorter pipeline reduces the suspended sediments by about 25% and 10%, respectively, decreases the time the suspended sediments affect the water quality by about 15 days for island construction and 5 days for pipeline construction, as compared to Alternative I.

(2) Effects of Alternative Pipeline Designs

This set of component alternatives evaluates the different impacts of using four different pipeline designs:

- Alternative I - Use Single Steel Wall Pipe System (Liberty Development and Production Plan)
- Alternatives IV.A - Use Pipe-in-Pipe System
- Alternative IV.B - Use Pipe-in-HDPE System
- Alternative IV.C - Use Flexible Pipe System

Alternatives IV.A, IV.B, and IV.C were identified during scoping by members of the Liberty Interagency Team. Some of the team members expressed concern about pipeline safety and wanted MMS to investigate further whether alternative pipeline designs could reduce the potential for oil spills to enter the marine environment. Each of the alternatives in this section evaluates the impacts of using different pipeline designs. Each of these design alternatives is based on a conceptual engineering report by INTEC (2000).

Evaluation of the pipeline designs in the EIS is based on the following reports:

An Engineering Assessment of Double Versus Single Wall Designs for Offshore Pipelines in an Arctic Environment (Center for Cold Oceans Resource Engineering [C-CORE], 2000). This study compared the advantages and disadvantages of pipe-in-pipe and single-wall pipe designs in general and was not based on a specific project.

Pipeline System Alternatives - Liberty Development Project Conceptual Engineering (INTEC, 1999a). The INTEC report contains conceptual engineering designs for the four pipeline designs that are described as the pipeline design alternatives: single-wall pipeline, a steel-in-steel pipe-in-pipe system, a steel pipe-in-HDPE (high-density polyethylene) system, and a flexible pipe system.

Independent Evaluation of Liberty Pipeline System Design Alternatives (Stress Engineering Services, Inc. [Stress], 2000). This study provides an independent review of the INTEC (1999a) report.

INTEC revised their *Pipeline System Alternatives - Liberty Development Project Conceptual Engineering Report* (INTEC, 1999a) after receiving comments from members of the Interagency EIS Team and reviewing the results of the report prepared by Stress. The main body of the revised report is identical to the original report, but INTEC's responses to comments and an addendum, in which all pipeline systems are designed with a 7-foot burial depth, were added to the report. The revised report is referred to in this EIS as INTEC (2000).

Independent Risk Evaluation for the Liberty Pipeline (Fleet Technology Limited [Fleet], 2000). This study was done to get an independent assessment to the risks of spills from the four conceptual pipeline designs in the INTEC (2000) report. The analysis was performed both for the original designs and the designs contained in Addendum A of the INTEC (2000) report, which all have a 7-foot burial depth.

The four studies above generally concurred with, or concluded that:

- All four pipeline designs proposed by INTEC could be constructed and operated safely;
- The probability of a spill is low for any of the four pipeline designs;
- The steel pipe-in-pipe design provides secondary containment for certain types of failures that, with other design factors held constant, lowers the probability of oil entering the environment; and,
- The pipe-in-pipe designs would be more complex to construct and repair than the single-walled designs.

For the purpose of this draft EIS, we have categorized all pipeline failures as either functional or containment failures. A functional failure is one where the pipeline is no longer capable of operating as designed, such as bending excessively, becoming oval instead of staying round or, in the case of a pipe-in-pipe system, developing a leak in one but not both pipes; however, the failure does not result in a leak to the environment. A containment failure is one that would allow oil to enter the environment; in the case of a pipe-in-pipe system, this would require a leak in both pipelines. Both functional and containment failures would require the pipeline to be returned to within design basis parameters or require the operator to prove to the proper regulatory agency(ies) that it is safe to continue operating the pipeline before it can be returned to service.

"Risk" is the product of the probability of a spill and the associated consequences. Pipelines have low probabilities of failure when compared to other types of oil transportation systems. This is attributed to their simplistic design and the fact that most are buried out of harm's way. Any pipeline can be designed to satisfy a target safety level but has certain inherent advantages and disadvantages. Double-wall pipelines reduce the probability of a containment failure but increase the probability of functional failures. The reduction in the probability of containment failure potentially is larger than the increase in the probability of functional failure. The single-wall pipe has a lower probability of functional failure but a higher probability of a containment failure.

The MMS believes that, in general, it is more prudent to spend both time and money trying to reduce the likelihood of an oil spill than in trying to mitigate spill consequences. Because no amount of effort absolutely could guarantee that a pipeline leak would not occur, the MMS participates in and supports oil-spill-cleanup research and testing, and insures compliance with the Oil Pollution Act of 1990 readiness requirements. Pipeline failure rates and expected spill volumes are shown in Table II.C-5 of the EIS.

All of these designs are expected to be able to be constructed in a single construction season, but it is possible that a second construction season may be needed if there are problems with construction for any of the designs. The more complex the construction processes, the higher the potential for multiple-year construction. All offshore pipeline systems evaluated would be constructed during the Year 3 of the project, which is the second winter construction season. This pipeline would be constructed using construction equipment similar to what is used onshore, such as the process used for the Northstar Project. Construction and fabrication of the pipeline would occur from the surface of the ice. The LEOS leak-detection system would be installed with all pipelines. In addition to the LEOS system, pressure-point analysis and mass-balance line-pack compensation leak-detection systems would be installed with all pipeline alternatives. Excess trenching material would be disposed at approved ocean dumping sites.

Higher pipeline construction costs result in higher pipeline tariffs. Higher pipeline tariffs reduce royalty revenue to the Federal Government from the project and likewise reduce Section 8(g) payments to the State.

For purposes of analysis, MMS assumes and evaluates an offshore oil spill for all pipeline alternatives. This analysis does not include differences in pipeline failure rates as calculated by the four pipeline studies. While the decisionmaker may consider the differences in failure rates, they do not provide measurable differences of environmental impacts to the following resources:

- Bowhead Whales
- Eiders
- Seals and Polar Bears
- Marine and Coastal Birds
- Terrestrial Mammals
- Fishes
- Vegetation-Wetland Habitats
- Subsistence-Harvest Patterns
- Sociocultural Systems
- Archaeological Resources
- Air Quality.

(a) Alternative I – Use Single-Wall Pipe System (Liberty Development and Production Plan)

The major advantages of a single-wall pipeline are simpler construction, lower construction costs, lower life-cycle costs, and greater inspection reliability (C-CORE, 2000).

The single-wall pipeline system does not have many of the same construction, operations, and maintenance concerns as the other systems, because it is the most widely used type of pipeline and the inspection and monitoring tools were developed to work on these types of systems. However, by its very design, it does not provide any secondary containment capabilities and, therefore, has a higher risk of a containment failure than the steel pipe-in-pipe system.

For the offshore pipeline, BPXA proposes a single-wall steel pipeline system that would be constructed with a 12.75-inch outside diameter pipe with a 0.688-inch wall thickness. The system would be protected from corrosion by a dual-layer fusion-bonded epoxy coating and sacrificial anodes. The system would be buried with a minimum burial depth of 7 feet.

Alternative I would have effects to the following resources:

Lower Trophic-Level Organisms: Alternative I would disturb lower trophic-level organisms in three primary ways: (1) island construction would bury about 23 acres of typical benthic organisms; (2) pipeline trenching would disturb additional benthos, burying up to 14 acres with very low (1%) coverage of kelp, boulders, and suitable substrate; and (3) sediment plumes would reduce Boulder Patch kelp production by up to 6% during 1 year. The buried 14 acres would equal less than 0.1% of the Boulder Patch kelp habitat. The density of the kelp, boulders, and suitable substrate in the pipeline corridor is very low, averaging about 1% coverage, and the lost kelp biomass and production probably would be less than .01% of the Boulder Patch totals, but the effect (kelp substrate burial) would last forever.

Some of the suspended sediment from pipeline trenching and island construction would drift over other parts of the Boulder Patch, reducing light penetration and kelp production during 1 year. This reduction is estimated to be less than 6%, about one-third of which would be due to the proximity between the Boulder Patch to the Zone 1 disposal area for excess sediments. However, in relation to the large range of natural variability, all of these suspended sediment effects would be barely detectable.

A portion of the concrete slope would be a temporary home for colonies of species similar to those of the Boulder Patch area. Upon abandonment, the concrete mats would probably be removed or would become buried naturally, eliminating the additional kelp habitat.

Essential Fish Habitat: As a result of disturbances caused by Liberty Island construction and operation, fish and zooplankton might experience short-term, localized, but unmeasurable effects.

Economy: The Liberty Project would generate approximately $100 million in wages and 870 full-time equivalent construction jobs for 1 year in Alaska during 14-18 months of construction; 1,248 indirect full-time equivalent jobs during the 14-18 months of construction; and $480 million capital expenditure.

Water Quality: The greatest effect on water quality from gravel island and pipeline construction would be additional turbidity caused by increases in suspended particles in the water column. Increases in turbidity generally are expected to be considerably less than the 7,500 parts per million suspended solids used in the analysis as an acute (toxic) criterion for water quality; exceptions may occur within the immediate vicinity of the construction activity. Turbidity increases from construction activities generally are temporary and expected to occur during the winter and end within a few days after construction stops. Material excavated from the pipeline trench but not used for backfill most likely would be left in an area where active erosion of sediment particles could occur during breakup and open water. This material would be similar in composition to seafloor sediments in the trenching and disposal areas, and its contribution to the future turbidity from waves and currents is expected to be about the same as the sediments existing at the seafloor surface prior to pipeline construction. Construction activities are not expected to introduce or add any chemical pollutants.

(b) Alternative IV.A – Use Pipe-in-Pipe System

The primary benefit provided by this pipeline design is that it reduces the probability of a containment failure.

The C-CORE (2000) study indicated that pipe-in-pipe systems have several advantages over a single-wall pipeline. The primary benefit is the ability to contain leaks from the carrier pipe in the annulus. It is possible that some oil may spill during pipeline repair operations, but spill volumes would be small and spill-response equipment would be onsite; therefore, the effects this would have on the environment would be minor. Containing a leak in the annulus of the pipeline could provide some flexibility in scheduling the pipeline repair to minimize the impacts on the species that inhabit the area. For example, if a leak occurred during spring breakup, it might be possible to wait and repair the leak the following winter rather than in the summer when waterfowl and bowhead whales are in the area. Another benefit of pipe-in-pipe is that the annulus surrounding the carrier pipeline may provide an advantage for leak detection.

The conceptual pipe-in-pipe system would be constructed with a steel inner pipe with an outside diameter of 12.75 inches and a wall thickness of 0.500-inch. The inner pipe would be placed in a steel outer pipe with an outside diameter of 16.00 inches and a wall thickness of 0.844 inch. The inner pipe would be supported in the outer pipe with annular spacers, or centralizers. The outer pipe would be protected from external corrosion by a dual-layer fusion-bonded epoxy and sacrificial anodes. The inner pipe would be protected from corrosion by a dual-layer fusion-bonded epoxy. For the EIS analysis, we assume the double-wall pipeline design, as well as the other pipeline designs, can be built in a single winter construction season. However, due to the substantially increased weight of the double-wall system, as compared to the other designs, INTEC (2000) calculated that floating sea ice along the pipeline route would have to be 2 feet thicker for the pipe-in-pipe design than the other alternatives to ensure safe working conditions. This additional ice thickness would take approximately 10 additional days to achieve. Because this alternative requires additional time to prepare a safe worksite when compared to the others, it is more sensitive to weather delays and, therefore, would have a higher potential for requiring a second winter construction season. The added complexity of the construction process also increases the potential for construction-related problems and further would increase the potential for a second winter construction season. The system would be buried with a minimum burial depth of 5 feet.

Using a pipe-in-pipe design adds some complexity to construction, operations, maintenance, and monitoring plans. The added complexity is a result of the following concerns. The steel outer pipe can be cathodically protected in the same fashion as a single-wall pipeline and the status of the cathodic protection monitored at the island and shore crossing, but it cannot be smart pigged; therefore, its overall corrosion-monitoring capabilities are somewhat reduced when compared to a single-wall pipeline. The design does not incorporate a cathodic protection system for the inner pipe and instead relies on protective coatings to prevent corrosion of the inner pipe. The Stress (2000) report suggests that it may be feasible to install a cathodic protection system to the inner pipe that should work in the event that the annulus becomes contaminated with water. There are approximately twice as many welds, some of which cannot be tested by both nondestructive testing methods that would be used on the other welds. While either test alone should be sufficient to determine if a weld is acceptable, each test method works differently and is better at detecting certain types of weld imperfections.

The feature of Alternative IV.A that affects the resources differently than Alternative I is the pipeline burial depth. The pipe-in-pipe pipeline system is heavier than the single steel wall pipeline system in Alternative I and, thus, needs less of the overburden fill material to prevent upheaval buckling from thermal expansion when oil flows through the pipeline. The minimum burial depth for the pipe-in-pipe and single steel wall systems are 5 and 7 feet, respectively; the average minimum trench depths are 9 and 10.5 feet, respectively. The volume of material excavated and later used as backfill for the pipe-in-pipe and single steel wall trenches is 557,300 and 724,000 cubic yards, respectively.

The effects of disturbances from pipeline construction would decrease because of the shallower excavation depth and smaller seafloor surface area affected. Disturbances from suspended sediments would decrease because of the smaller volume, about 23% less, of sediment excavated and used as backfill.

This alternative, compared to Alternative I, would change the impacts to the following resources in the ways described:

Lower Trophic-Level Organisms: Shallower burial along the Alternative I pipeline route would permanently eliminate 15 fewer acres of very diffuse kelp, boulder, and suitable substrate than would the Alternative I burial depth. The amount of turbidity generated by shallower burial would be only two-thirds of that for Alternative I, probably causing less reduction in annual kelp production during the construction phase.

Essential Fish Habitat: Water quality is expected to be improved, because the total amount of suspended-particulate matter would be less than under Alternative I (Liberty Development and Production Plan).

Economy: Alternative IV.A would generate more jobs, greater wages, and greater capital expenditure than Alternative I. This alternative would result in an increase of $4 million in wages for 7 months; 45 direct jobs in pipeline construction in Alaska for 7 months; 68 indirect jobs in Alaska for 7 months; and $20 million in capital expenditures. The increased cost of this alternative is based primarily on additional labor, welding, and material costs.

Water Quality: The duration of turbidity from pipe-in-pipe pipeline construction is expected to be 11 days shorter than the Liberty pipeline (49 days). The overall effects of turbidity are expected to be about 23% less for the pipe-in-pipe pipeline construction compared to the Liberty pipeline construction.

(c) Alternative IV.B – Use Pipe-in-HDPE System

The primary benefits provided by this pipeline design are that it provides secondary containment against small leaks, and the outer pipe cannot corrode.

This alternative uses a steel carrier pipe, which is identical to Alternative I. That carrier pipe is placed inside a high-density polyethylene sleeve with a diameter of 16.25 inches and a wall thickness of 0.75 inches.

Using a pipe-in-HDPE design adds some complexity to the construction, operations, maintenance, and monitoring of the system. The complexity arises from concerns in the following areas. The HDPE system is more susceptible to damage during installation than the other alternatives due to weaker material properties of the HDPE as compared to steel. The design does not incorporate a cathodic protection system for the inner pipe and instead relies on protective coatings to prevent corrosion of the inner pipe. The Stress (2000) report suggests that it may be feasible to install a cathodic protection system to the inner pipe that should work in the event the annulus becomes contaminated with water. The condition of the HDPE outer pipe cannot be monitored as effectively as a single-wall pipeline. Because corrosion is not a concern for the outer HDPE pipe, the lack of outer pipe monitoring capabilities for the pipe-in-HDPE design are not as relevant a concern as they are with the steel pipe-in-pipe design. However, the outer pipe of the pipe-in-HDPE design is weaker than the outer pipe of the steel pipe-in-pipe design; therefore, the reduced outer pipe defect monitoring capabilities are more of a concern as they relate to physical damage to the outer pipe. As designed, the HDPE casing would not be able to contain the operating pressure of the pipeline. It would be possible to design an HDPE pipe to contain the full operating pressure of the pipeline, but the diameter and wall thickness of the pipe would be so large that pipeline buoyancy would become a major concern during design and installation. The ability to verify the joining of the HDPE and the ability to repair HDPE to original integrity is unknown.

The minimum burial depth for the pipe-in-HDPE is 6 feet; the average minimum trench depth is 10 feet. The volume of material excavated and later used as backfill for the pipe-in-HDPE is 673,920 cubic yards.

The effects of disturbance from pipeline construction would decrease because of the shallower excavation depth and the smaller seafloor surface area affected. Disturbance from suspended sediments would decrease because of the smaller volume, about 7% less, of sediment excavated and used as backfill.

This alternative, compared to Alternative I, would change the impacts to the following resources in the ways described:

Lower Trophic-Level Organisms: The pipe-in-HDPE would require less burial depth, causing fewer effects than Alternative I in two important ways: (1) shallower burial in the Alternative I pipeline route would permanently eliminate 2 fewer acres of very diffuse kelp, boulder, and suitable substrate than the Alternative I burial depth; and (2) the amount of turbidity generated by shallower burial would be only two-thirds of that for Alternative I, probably causing less reduction in annual kelp production during the construction phase.

Essential Fish Habitat: Water quality is expected to be improved slightly, because the total amount of suspended-particulate matter would be slightly less than under Alternative I.

Economy: Alternative IV.B would generate more jobs, greater wages, and greater capital expenditures than Alternative I. This alternative would result in an increase of $2.1 million in wages for 7 months; 19 direct jobs in pipeline construction in Alaska for 7 months; 29 indirect jobs in Alaska for 7 months; and $12.9 million in capital expenditures. The increased cost of this alternative is based primarily on additional installation costs, and they reflect the new costs developed by INTEC for single season construction of the pipeline. Note that all pipeline designs have a standard 10% contingency (see INTEC, 2000).

Water Quality: The duration of turbidity from pipe-in-pipe pipeline construction is expected to be 4 days shorter than the Liberty pipeline (49 days). The overall effects of turbidity are expected to be about 7% lower for the pipe-in-HDPE pipeline as compared to the Liberty pipeline construction.

(d) Alternative IV.C – Use Flexible Pipe System

The primary benefit of the flexible pipeline system is that it requires the least amount of trenching and, therefore, introduces the least amount of sediments into the water column. Also, because it is shipped on large spools, its installation process is very simple and can be completed more quickly then any of the other pipeline designs. The probability of a containment failure is, at best, no better than for a single-wall pipeline, and the system has the highest probability of a functional failure. Because the system is manufactured in long, continuous sections, it may be necessary to replace entire sections of the pipe, approximately 2,800 feet in length, depending on the location and nature of the damage. The flexible pipe system is constructed of multiple layers of metallic and nonmetallic materials—a design that makes pipeline monitoring more complex than the other systems.

For purposes of analysis in the EIS, we do not consider the annulus of the flexible pipe to have any containment capabilities, even though the flexible pipe has many different layers in its design.

This pipe system would be constructed with an internal diameter of 12 inches of flexible pipe with a wall thickness of 1.47 inches. The flexible pipe is a nonbonded pipe made of thermoplastic layers and steel strips. The plastic layers provide very limited containment, and they transfer the pressure loads to the steel strips. The pipe has eight layers: an inner interlocked steel carcass; a pressure thermoplastic sheath; two layers of armor wires; fabric tape; and a polyethylene external sheath. The minimum burial depth for the flexible pipe system is 5 feet; the average minimum trench depth is 8.5 feet. The volume of material excavated and later used as backfill is 498,960 cubic yards.

The effects of disturbances from pipeline construction would decrease because of the shallower excavation depth and less of the seafloor surface area is affected. Disturbances from suspended sediments would decrease because of the smaller volume, about 31% less, of sediment excavated and used as backfill as compared to the single wall pipeline.

This alternative, compared to Alternative I, would change the impacts to the following resources in the ways described:

Lower Trophic-Level Organisms: Shallower burial in the Alternative I pipeline route would permanently eliminate 2 fewer acres of very diffuse kelp, boulder, and suitable substrate than the Alternative I burial depth. The amount of turbidity generated by shallower burial would be only two-thirds of that for Alternative I, probably causing less reduction in annual kelp production during the construction phase.

Essential Fish Habitat: Water quality is expected to be improved, because the total amount of suspended-particulate matter would be less than under Alternative I.

Economy: Alternative IV.C would generate more jobs, greater wages, and greater capital expenditures than Alternative I. This alternative would result in increases of $0.9 million in wages for 7 months; 8 direct jobs in pipeline construction in Alaska for 7 months; 12 indirect jobs in Alaska for 7 months; and $5.1 million in capital expenditures. The increased cost of this alternative is based primarily on increased material cost.

Water Quality: The duration of turbidity from flexible pipe pipeline construction is expected to be 15 days shorter as compared to the Liberty pipeline (49 days). The overall effects of turbidity are expected to be about 31% lower for the flexible pipeline construction compared to Liberty pipeline construction.

(3) Effects of Alternative Upper Island Slope-Protection Systems

This component set of alternatives evaluates the effects for two options that provide upper slope protection to the gravel island.

- Alternative I - Use Gravel Bags, would use gravel bags similar to those used at the Endicott Island.
- Alternative V - Use Steel Sheetpile, would use steel sheetpile similar to the system installed at the Northstar Project.

Contents

The impacts to the following resources would be the same for both, because they are not impacted differently by the unique aspects of this alternative:

- Bowhead Whales
- Eiders
- Seals and Polar Bears
- Marine and Coastal Birds
- Terrestrial Mammals
- Lower Trophic-Level Organisms
- Fishes and Essential Fish Habitat
- Vegetation-Wetland Habitat
- Subsistence-Harvest Patterns
- Archaeological Resources
- Economy
- Water Quality
- Air Quality

(a) Alternative I - Use Gravel Bags (Liberty Development and Production Plan)

Gravel bags would be used in the upper portion of the island slope starting at 7-8 feet above sea level and continuing to the top of the berm, which is 23 feet above sea level and 8 feet above the working surface of the island. The bags would be placed in an overlapping pattern. A gravel bench covered with concrete mats extending more than 40 feet from the base of the gravel bags to the sea surface would dampen wave energy approaching the island and induce natural formation of ice rubble. The gravel bags would be used only in the upper portion of the island to keep them from contact with direct forces from ice or wave action which would lessen potential damage and dislocation, and protect the surface of the island from the unlikely event of further ice rideup.

BPXA's proposed use of gravel bags for this project is quite different from previous exploration island construction. The bags proposed for use in Liberty Island construction are made from a polyester material that does not float. BPXA would monitor ice events at or near the island and repair or replace any torn or ripped bags as part of their ongoing maintenance program. With proposed BPXA maintenance, it is highly unlikely that a gravel bag would be ripped or torn during an ice event and not repaired before a wave event could wash the bag into the ocean. In the unlikely event a bag or part of a bag is washed into the marine environment, the bag would not float but sink to the bottom. BPXA would remove all of the gravel bags used in the upper slope-protection system at project abandonment.

Alternative I would have effects to the sociocultural systems described below.

Sociocultural Systems: Using gravel bags would contribute to ongoing concerns of local subsistence hunters about gravel bags from past gravel exploration islands contaminating the environment and creating navigation hazards for whaling boats. This increased stress of local Inupiat could be considered a slight increase in effects to sociocultural systems and could be construed as not taking into account local knowledge and concern for the local offshore environment and its resources.

(b) Alternative V - Use Steel Sheetpile

This alternative was developed to eliminate the potential of gravel bags entering the environment and becoming a hazard to local navigation, especially to bowhead whaling vessels.

Under this alternative, steel sheetpile would protect the upper part of Liberty Island; no gravel-filled bags would be on the island. The sheetpile would be similar to that used for Seal Island in the Northstar Development Project. This alternative would eliminate the need for gravel bags as upper slope protection, which would eliminate the possibility of damaged bags entering the environment as a result of a storm or ice event. The sheetpile would be designed to carry the surface loads. It would protect the island above the concrete blocks used for lower slope protection and would weather to a natural rust color. The steel sheetpile would be removed when the island is abandoned.

The specific components of using steel sheetpile for upper island slope protection, as described, would change the impacts only to sociocultural systems as described in the following:

Sociocultural Systems: Using steel sheetpile in island construction would relieve ongoing concerns of local subsistence hunters about gravel bags from past gravel exploration island developments contaminating the environment and creating navigation hazards for whaling boats. Using steel sheetpile would serve to reduce overall stress in the local Inupiat population, particularly Nuiqsut, over the development of Liberty Island in the Beaufort Sea offshore environment. This reduction in stress of local Inupiat could be considered a slight reduction in effects to sociocultural systems and also could be construed as taking into account local knowledge and concern for the offshore environment and its resources.

(4) Effects of Alternative Gravel Mine Sites

This set of component alternatives evaluates two different gravel mine sites.

- Alternative I - Use the Kadleroshilik River Mine Site (Liberty Development and Production Plan), evaluates the effects of creating a new mine site at the Kadleroshilik River.
- Alternative VI - Use Duck Island Mine Site evaluates the existing Duck Island Mine Site (see Map 1 of the EIS), which was used as a gravel source for the Endicott Project and other projects. Key components of these alternatives are summarized in Table II.A-1 of the EIS.

The differences in mine site locations for Alternatives I and VI do not provide measurable differences to the following resources:

- Bowhead Whales
- Subsistence-Harvest Patterns
- Sociocultural Systems
- Archaeological Resources

(a) Alternative I – Use Kadleroshilik River Mine (Liberty Development and Production Plan)

The Kadleroshilik River mine site is approximately 1.4 miles south of Foggy Island Bay, with a ground surface elevation of 6-10 feet above mean sea level (BPXA, 2000a). The mine site is in a region of riverine barrens and alluvial floodplain. BPXA has estimated that the proposed site is about 40% dry dwarf shrub/lichen tundra, 10% dry barren/dwarf shrub and forb grass complex, and 50% river gravel. The development of this mine site would destroy about 24 acres of wetland habitat.

The development mine site is approximately 31 acres, with the primary excavation area developed in two cells. The first cell would be approximately 19 acres and developed in Year 2; it would support construction of the gravel island. The second cell is approximately 12 acres and would support pipeline construction activities in Year 3 (Noel and McKendrick, 2000).

Mining would not extend into the active river channel; a dike approximately 50 feet wide would be left in place between the mine site and the river channel while mining operations are under way. Gravel would be excavated by blasting, ripping, and removing material in two 20-foot lifts to a total depth of 40 plus feet below the ground surface. Some portion of the lower 20-foot lift may be left in place, if all gravel available from the site is not needed to meet island requirements.

After usable gravel has been removed from the mine, material unsuitable for construction (for example, unusable material stockpiled during mining) would be placed back into the mine excavation. This backfilled material would be used to create a shelf (at approximately mean water level) along one side of the mine to improve future habitat potential. The backfilled area would provide substrate and nutrients to support revegetation and improve future habitat potential of the constructed shelf along the mine wall.

Alternative I, would have effects to the following resources:

Spectacled Eiders: Obtaining gravel from the proposed Kadleroshilik River quarry site would avoid disturbing any habitat at the Duck Island gravel mine site on the Sagavanirktok River Delta that might be used by spectacled eiders. The potential for eider use of the Kadleroshilik quarry site likely is considerably greater than for the Duck Island quarry site because of its undisturbed character and vegetative cover. However, less than 1% of the gravel island site in the Kadleroshilik River would be characterized as good spectacled eider nesting habitat. The nesting density and average density of eiders at tundra sites in the general vicinity of the two sites were similar (0.3-0.5 nests/square kilometer and 0.4 birds/square kilometer, respectively) in 1994. The numbers of nesting eiders displaced from the Kadleroshilik area (Alternative I) is likely to be very low but greater than from the Duck Island site (Alternative VI) as a result of habitat disturbance. Significant adverse population effects are not expected to occur as a result of disturbance.

Seals and Polar Bears: Using the Kadleroshilik River mine site rather than the Duck Island gravel mine site may increase potential noise and disturbance of denning polar bears in the Kadleroshilik River area during winter. However, the number of bears potentially displaced would be low and would not affect polar bear populations.

Marine and Coastal Birds: Obtaining gravel from the proposed Kadleroshilik River quarry site instead of the Duck Island gravel mine site would avoid disturbing any habitat at the Duck Island site that might be used by any of several species that may nest, forage, or rest in the area the following summer. The potential for bird use of the Kadleroshilik quarry site likely is substantially greater than for the Duck Island quarry site because of its undisturbed character and vegetative cover. However, we would expect relatively lower densities of fewer nesting species than nearby tundra areas due to the lower proportion of habitat types generally preferred by species likely to nest there. Total nest density and total average density of individuals for 14 bird species in the general vicinity of the two sites were similar (43.3-46.3 nests/square kilometer and 111.2-136.2 birds/square kilometer) in 1994. The numbers of nesting birds displaced from the Kadleroshilik area (Alternative I) is likely to be low but considerably greater than from the Duck Island site as a result of habitat disturbance.

Terrestrial Mammals: Using the Kadleroshilik River mine could increase potential noise and disturbance to muskoxen from ice-road traffic and mining activities in the Kadleroshilik River area during winter. The highest levels would be during construction, but some activities would be expected during the 15-year life of the project. The disturbances would have short-term effects on individual animals and would not affect the population.

Lower Trophic-Level Organisms: Alternative I would disturb lower trophic-level organisms in three primary ways: (1) island construction would bury about 23 acres of typical benthic organisms; (2) pipeline trenching would disturb additional benthos, burying up to 14 acres with very low (1%) coverage of kelp, boulders, and suitable substrate; and (3) sediment plumes would reduce Boulder Patch kelp production by up to 6% during 1 year. The buried 14 acres would equal less than 0.1% of the Boulder Patch kelp habitat. The density of the kelp, boulders, and suitable substrate in the pipeline corridor is very low, averaging about 1% coverage, and the lost kelp biomass and production probably would be less than .01% of the Boulder Patch totals, but the effect (kelp substrate burial) would last forever.

Some of the suspended sediment from pipeline trenching and island construction would drift over other parts of the Boulder Patch, reducing light penetration and kelp production during 1 year. This reduction is estimated to be less than 6%, about one-third of which would be due to the proximity between the Boulder Patch to the Zone 1 disposal area for excess sediments. However, in relation to the large range of natural variability, all of these suspended sediment effects would be barely detectable.

From 6-feet deep to the seafloor, the island's concrete slope temporarily would benefit kelp and other organisms that need a hard substrate for settlement. This portion of the concrete slope would be a temporary home for colonies of species similar to those of the Boulder Patch area. Upon abandonment, the concrete mats probably would be removed or would become buried naturally, eliminating the additional kelp habitat.

Fishes : To our knowledge, the Kadleroshilik River does not support overwintering fish. However, if it did, the effects from mining at the Kadleroshilik mine site during the winter on most overwintering fish would be expected to be short term and sublethal, with no measurable effect on overwintering fish populations. After the mine site becomes accessible to fishes, it may benefit them by providing the first viable overwintering habitat in this region of the Kadleroshilik River. This assumes that the mine site depth is adequate (i.e., 20 feet or more), and that oxygen levels remain sufficient during winter to support the number of fishes under the ice. While the Kadleroshilik River mine site possibly could create overwintering habitat, the Duck Island mine site would eliminate any possibility of disturbing fish.

Essential Fish Habitat: The Kadleroshilik River mine site would create potential overwintering habitat on the Kadleroshilik River for fish that potentially would serve as prey for salmon.

Vegetation-Wetland Habitats: Gravel mining is likely to have a minimal effect on overall vegetation-wetland habitats in the project area. The development of this mine site would destroy about 24 acres of wetland habitat. The gravel mining operations on State land would be required to have Section 404/10 permit and approval by the Corps of Engineers, as stated in BPXA's Development Project Development and Production Plan (BPXA, 2000a). The permit and approval process is expected to minimize adverse effects on wetlands. We assume that all associated work would occur in winter, resulting in little or no dust on adjacent vegetation. Any moisture-regime changes as a result of snow drifting would be confined to fewer than 20 acres at the mine site. Conducting mining operations during winter would lessen impacts on vegetation and wetland habitats. Winter operations and the use of ice roads for transporting the gravel would avoid the need to build gravel roads that would increase effects on tundra vegetation along any onshore transportation routes. Rehabilitation of the mine site would include flooding of the mine pit by connecting it with a river channel. The pit also would be used as a source of water for the construction of ice roads during winter.

Economy: Alternative I would generate approximately $100 million in wages and 870 full-time equivalent construction jobs for 1 year in Alaska during 14-18 months of construction; 1,248 indirect full-time equivalent jobs during the 14-18 months of construction; and $480 million capital expenditure.

Water Quality: The general effects of disturbances are analyzed in Section III.C.3.l(2)(a) in the EIS. The greatest effect on water quality from gravel island and pipeline construction would be additional turbidity caused by increases in suspended particles in the water column. Increases in turbidity generally are expected to be considerably less than the 7,500 parts per million suspended solids used in the analysis as an acute (toxic) criterion for water quality (Sec. III.C.3.l (2) in this EIS); exceptions may occur within the immediate vicinity of the construction activity. Turbidity increases from construction activities generally are temporary and expected to occur during the winter and end within a few days after construction stops. Material excavated from the pipeline trench but not used for backfill most likely would be left in an area where active erosion of sediment particles could occur during breakup and open water. This material would be similar in composition to seafloor sediments in the trenching and disposal areas, and its contribution to the future turbidity from waves and currents is expected to be about the same as the sediments existing at the seafloor surface before pipeline construction. Construction activities are not expected to introduce or add any chemical pollutants.

Air Quality: The proposed Liberty Project would affect air quality in several ways, but the overall effects would be very low. The general effects of a large spill and the effects of oil-spill-cleanup activities are analyzed in Section III.C.2.m(2) of the EIS. An oil spill could cause an increase in hydrocarbon air pollutants, as discussed in Section III.C.2.m and summarized in Section III.A.1.a(13) of the EIS. The overall effects on air quality would be minimal.

The most noticeable effects on air quality are caused by emissions from equipment. This is discussed in detail in Section III.D.1.m of the EIS. That section concludes that the Liberty Proposal would cause a small, local increase in the concentrations of criteria pollutants. Concentrations would be within the Prevention of Significant Deterioration Class II limits and National Ambient Air Quality Standards. Therefore, the effects would be low.

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(b) Alternative VI - Use the Duck Island Gravel Mine

This alternative was developed to provide less onshore noise disturbance and habitat alteration from gravel mining.

Under Alternative VI, the existing Duck Island gravel mine would be mined to provide gravel for the project. To get the required gravel for the project from the Duck Island mine site, BPXA would need to deepen a portion of the gravel pit by 20-40 feet (6-12 meters). This site does not require any overburden to be removed, and it would reduce the snow and ice removal cost by about half. Eventually, BPXA would need to rehabilitate the site, but the Liberty Project would share a portion of the total costs.

Under this alternative, BPXA also would need to remove water from the mine before extracting the gravel. At the current permitted rate, it would take more than 400 days to remove the estimated 600 million gallons of water from the mine site. This water could go to adjacent tundra or creeks under the current general National Pollutant Discharge Elimination System permit. However, BPXA's preferred construction method would be to obtain a modified permit to increase appreciably the discharge rate (5-6 million gallons per day) to avoid a delay in the construction schedule.

The Duck Island mine site is about 17.4 miles (28 kilometers, or about 2.7 times) farther from the Liberty Island construction sites than the proposed Kadleroshilik mine. For purposes of analysis, the EIS assumes the use of two different sizes of haul vehicles and the use of a temporary dumping site. The larger of the vehicles (B70's) would haul the gravel from the mine site to a temporary site near the base of the Endicott Causeway. The gravel would be reloaded at the temporary site into smaller trucks (Maxhauls), which would haul the gravel to the island location. This is similar to the process used in the construction the Northstar gravel island. An ice road 7.9-miles (12.7 kilometers) long from the base of Endicott to the gravel island would need to be constructed and maintained. From there, the distance to any of the three island locations (Liberty, Southern, and Tern) is approximately the same.

This alternative could delay the planned rehabilitation of the Duck Island mine site by a year or more.

The effects of disturbances from noise would decrease at a different mine site, and increase from different and longer haul routes. The effects of disturbances from habitat alternation would decrease at the mine site and increase along the haul route.

The specific components of the Alternative VI - Use Duck Island Mine Site as described above would change the impacts to the following resources in the ways described:

Spectacled Eiders: Obtaining gravel from the Duck Island gravel mine site on the Sagavanirktok River Delta instead of the proposed Kadleroshilik River quarry site would avoid disturbing any potential nesting habitat at the latter site; and, thus, any spectacled eiders that nest in that area would not be displaced from disturbed habitat the following summer. Because the potential for eider use of the Duck Island quarry site is likely much lower than the Kadleroshilik site, this may be viewed as a modest benefit. The nesting density and average density of eiders on tundra habitats in the general vicinity of the two sites were similar (0.3-0.5 nests/square kilometer and 0.4 birds/square kilometer) in 1994. The numbers of nesting eiders displaced from the Kadleroshilik area (Alternative I) is likely to be very low but greater than from the Duck Island site (Alternative VI) as a result of habitat disturbance. Significant adverse population effects are not expected to occur as a result of disturbance.

Seals and Polar Bears: Using the Duck Island Gravel Mine rather than the Kadleroshilik River mine site would avoid potential noise and disturbance of denning polar bears in the Kadleroshilik River area during winter. Using this gravel mine site probably would involve an increase in ice-road traffic to and from the Sagavanirktok River to Liberty Island, which could present a potential increase in disturbance of polar bears and seals in this area. The potential effect on polar bears from mining and other development activities could be reduced along the coast of the Kadleroshilik River.

Marine and Coastal Birds: Obtaining gravel from the Duck Island gravel mine site on the Sagavanirktok River Delta instead of the proposed Kadleroshilik River quarry site would avoid disturbing any potential nesting habitat at the latter site, and, thus, any of several species that may nest in that area would not be displaced from disturbed habitat the following summer. Because the potential for bird use of the Duck Island quarry site is likely much lower than the Kadleroshilik site, this may be viewed as a modest benefit. Total nest density and total average density of individuals for 14 bird species on tundra habitats in the general vicinity of the two sites were similar (43.3-46.3 nests/square kilometer and 111.2-136.2 birds/square kilometer) in 1994. The numbers of nesting birds displaced from the Kadleroshilik area (Alternative I) is likely to be low but considerably greater than from the Duck Island site as a result of habitat disturbance.

Terrestrial Mammals: Using the Duck Island Gravel Mine site rather than the Kadleroshilik River mine site would avoid potential noise and disturbance to muskoxen from ice-road traffic and mining activities in the Kadleroshilik River area during winter. Using the Duck Island gravel mine site would involve a general increase in ice-road traffic to and from this mine site to Liberty Island, which could disturb some overwintering caribou in the area.

Lower Trophic-Level Organisms: For this alternative, the effects of island construction and pipeline trenching would be the same as analyzed for Alternative I, except that gravel probably would be hauled over the Endicott access road and across an ice road to the Liberty island site. A direct ice road would pass over 5 miles of Boulder Patch kelp habitat and could reduce the light transmission and growth of kelp during the spring.

Fishes : While the Duck Island mine site would eliminate any possibility of disturbing fish, it also would eliminate the possibility of creating overwintering habitat on the Kadleroshilik River, as discussed for Alternative I.

Essential Fish Habitat: The potential net effect of this alternative on essential fish habitat is expected to be similar to Alternative I. However, using the Duck Island mine site as a source for gravel would eliminate any possibility of disturbance of fish or algae from increased turbidity and sedimentation downstream of the mine site. It also would eliminate the potential countervailing effect of creating overwintering habitat on the Kadleroshilik River for fish that potentially would serve as prey for salmon.

Vegetation-Wetland Habitats: Using Duck Island-Sagavanirktok River gravel mines rather than the Kadleroshilik River mine site would avoid disturbance of the sparsely vegetated gravel bar on the Kadleroshilik River. Consequently, the disturbance effect on vegetation and wetlands from mining activities would be avoided. Disturbance of vegetation and wetlands from the Liberty Project would still occur at the pipeline landfall site and along the onshore pipeline route. Effects would be local and have very little overall effect on the vegetation and wetlands habitats.

Economy: Alternative VI would generate more jobs, greater wages, and greater costs than Alternative I. This alternative would result in an increase of approximately $4.4 million in wages for 14 months, 20 direct jobs in Alaska for 14 months, 30 indirect jobs in Alaska for 14 months, approximately $15 million in costs for gravel island construction, and additional costs associated for gravel mining and hauling for pipeline construction. The increased costs are based on three factors: (1) dewatering the Duck Island site would cost about $2.4 million; (2) the distance from the Duck Island mine to the island is about 17.3 miles or about 2.7 times farther from the Kadleroshilik mine, causing increased costs of hauling; and (3) the Duck Island haul route would include preparation of a longer floating-ice segment than the route to the island in Alternative 1.

Water Quality: Increasing the mine dewatering rate from 1.5-5 million gallons per day most likely would have little if any measurable effect on the quality of the receiving waters.

Air Quality: The general effects from using this alternative gravel mine site on air quality are expected to be the same as those analyzed for Alternative I in Section IV.C.4.a(10) of the EIS.

If the Duck Island gravel mine is used as a source of gravel for Liberty Island, the gravel would need to be hauled about 17.4 miles (28 kilometers), or about 2.7 times farther to the Liberty Island construction site than from the proposed Kadleroshilik mine. The potential effects of increasing this gravel-hauling distance are analyzed in Section IV.C.4.(b)(10) of the EIS.

The effect on air quality at the Liberty Island site from using gravel from the Duck Island mine site should be the same as for Alternative I, using gravel from the Kadleroshilik River mine site.

The differences in air-quality effects from hauling the gravel from the Duck Island mine site (a greater distance than from BPXA's proposed Kadleroshilik mine site) would be a slight increase in the fugitive dust from trucks traveling the greater distance and in the air emissions from truck engines operating for a longer period of time. These air emissions would remain at negligible levels and should have no substantial effect on regional air quality.

(5) Effects of Alternative Pipeline Burial Depths

For purposes of analysis for the EIS, burial depth is defined as the distance between the top of the installed pipeline and the original seafloor, and trench depth is defined as the depth of the trench in relation to the original seafloor. Burial depth always would be less than trench depth. In various locations in the EIS, and in some of the pipeline studies, the term "depth of cover" is used. This term has the same meaning as burial depth.

This set of component alternatives evaluates two different pipeline burial depths. Alternative I - Use a 7-Foot Burial Depth, evaluates excavating a trench with a trench depth of 8-12 feet (10.5 foot average trench depth) and burying the pipeline with a minimum burial depth of 7 feet. Alternative VII - Use a 15-Foot Pipeline Trench Depth, evaluates excavating a trench to a maximum 15-foot trench depth, which would result in a minimum 11-foot burial depth. Key components of these alternatives are summarized in Table II.A-1 of the EIS.

The following resources are not affected differently by the unique aspects of this alternative:

- Bowhead Whales
- Eiders
- Marine and Coastal Birds
- Terrestrial Mammals
- Vegetation-Wetlands Habitat
- Subsistence-Harvest Patterns
- Sociocultural Systems
- Archaeological Resources
- Air Quality

(a) Alternative I - Use a 7-Foot Burial Depth (Liberty Development and Production Plan)

For this alternative, the pipeline trench would be an average of 10.5 feet (3.2 meters) deep. The trench depth may vary between 8 and 12 feet (2.4 and 3.7 meters). The trench would be dug using conventional trenching equipment and constructed on the ice surface. The minimum burial depth, assuming a single-wall steel pipe, is 7 feet. The trench at the seafloor would be 61-132 feet wide (18.5-40 meters) for this alternative. This alternative would require excavating and backfilling approximately 724,000 cubic yards of soil (see Table II.A-2 of the EIS). Trenching is estimated to take about 58 days.

Alternative I would have effects to the following resources:

Seals and Polar Bears: Construction activity would displace some ringed seals within perhaps 1 kilometer of the production island and along the pipeline route in Foggy Island Bay. This disturbance of seals and polar bears would be local, within about 1 mile along the pipeline route, and would persist for one season.

Lower Trophic-Level Organisms: Alternative I would disturb lower trophic-level organisms in three primary ways: (1) island construction would bury about 23 acres of typical benthic organisms; (2) pipeline trenching would disturb additional benthos, burying up to 14 acres with very low (1%) coverage of kelp, boulders, and suitable substrate; and (3) sediment plumes would reduce Boulder Patch kelp production by up to 6% during 1 year. The buried 14 acres would equal less than 0.1% of the Boulder Patch kelp habitat. The density of the kelp, boulders, and suitable substrate in the pipeline corridor is very low, averaging about 1% coverage, and the lost kelp biomass and production probably would be less than .01% of the Boulder Patch totals, but the effect (kelp substrate burial) would last forever.

Some of the suspended sediment from pipeline trenching and island construction would drift over other parts of the Boulder Patch, reducing light penetration and kelp production during 1 year. This reduction is estimated to be less than 6%, about one-third of which would be due to the proximity between the Boulder Patch to the Zone 1 disposal area for excess sediments. However, in relation to the large range of natural variability, all of these suspended sediment effects would be barely detectable.

From 6-feet deep to the seafloor, the island's concrete slope temporarily would benefit kelp and other organisms that need a hard substrate for settlement. This portion of the concrete slope would be a temporary home for colonies of species similar to those of the Boulder Patch area. Upon abandonment, the concrete mats probably would be removed or would become buried naturally, eliminating the additional kelp habitat.

Fishes: Noise and discharges from dredging, gravel mining, island construction, island reshaping, and pipeline trenching associated with Liberty are expected to have no measurable effect on fish populations. While a few fish could be harmed or killed, most in the immediate area would avoid these activities and would be otherwise unaffected. Effects on most overwintering fish are expected to be short term and sublethal, with no measurable effect on overwintering fish populations. Placement of the concrete mat would create additional food resources for fishes and would have a beneficial effect on nearshore fish populations in the Beaufort Sea.

Essential Fish Habitat: As a result of disturbances caused by Liberty Island construction and operation, fish and zooplankton might experience short-term, localized but unmeasurable effects. This would include potential adverse effects from noise during construction and operations and from increased turbidity and sedimentation as a result of dredging, gravel mining, island construction, and pipeline trenching (see Secs. III.C.3.e and III.C.3.f of the EIS). Marine plants could be subjected to short-term, localized, negative effects due to mechanical removals of individuals and from sedimentation resulting from pipeline trenching and island construction. Pipeline construction is expected to bury up to 14 acres of kelp and solid substrate, and sediment plumes are expected to reduce kelp production by 6% during 1 year. The effect of disturbance on water quality is discussed in Section III.C.3.l in this EIS. Water quality primarily would be affected by increased turbidity that would result from gravel island and pipeline construction, Liberty Island abandonment, and gravel mine reclamation. Turbidity and salinity of seawater discharged from the Liberty Island production facility are expected to be slightly higher than water in surrounding Foggy Island Bay. All of these disturbances are expected to be fairly localized and short term.

Economy: Alternative I would generate approximately $100 million in wages and 870 full-time equivalent construction jobs for 1 year in Alaska during 14-18 months of construction; and 1,248 indirect full-time equivalent jobs during the 14-18 months of construction.

Water Quality: The greatest effect on water quality from gravel island and pipeline construction would be additional turbidity caused by increases in suspended particles in the water column. Increases in turbidity generally are expected to be considerably less than the 7,500 parts per million suspended solids used in the analysis as an acute (toxic) criterion for water quality; exceptions may occur within the immediate vicinity of the construction activity. Turbidity increases from construction activities generally are temporary and expected to occur during the winter and end within a few days after construction stops. Material excavated from the pipeline trench but not used for backfill most likely would be left in an area where active erosion of sediment particles could occur during breakup and open water. This material would be similar in composition to seafloor sediments in the trenching and disposal areas, and its contribution to the future turbidity from waves and currents is expected to be about the same as the sediments existing at the seafloor surface before pipeline construction. Construction activities are not expected to introduce or add any chemical pollutants.

(b) Alternative VII – Use a 15-Foot Pipeline Trench Depth

This alternative was developed to reduce potential ice scouring and ice gouging effects to the pipeline.

For this alternative, the pipeline trench depth would be 15-feet (4.6 meters) rather than the proposed 10.5 feet (3.2 meters). This alternative assumes the trench would be dug using the same equipment and constructed on the ice surface, the same as for the other alternatives. For purposes of analysis, we assume an 11-foot minimum burial depth, regardless of the pipeline route or pipeline design. The trench at the seafloor would be 120-200 feet (36.5-61 meters) wide. This greater width would be needed for the 6.1 miles (9.8 kilometers) of offshore pipeline. Table II.C-3 of the EIS provides information about the trench excavation and backfill quantities for this alternative in combination with the three pipeline routes evaluated in this EIS.

This alternative would require excavating approximately 1,438,560 cubic yards of soil, which almost doubles (98%) the amount of soil excavated under Alternative I. The total area disturbed is greater, about 81 acres, compared to 59 acres for Alternative I. The additional excavation work would add an additional 30 days of trenching time. Increasing the number of days needed for trenching also increases the number of days required for ice maintenance. This alternative would add to the likelihood of not completing the installation of the pipeline in a single winter construction season because of increased excavation and backfill handling.

The effects of disturbances from suspended sediments would increase because of the deeper pipeline excavation depth and increased trenching and backfilling times. Effects of disturbances from habitat alteration would increase because of the greater seafloor area disturbed and from noise increases associated with longer trenching and backfilling times.

The differences would change some of the impacts to the following resources in the ways described:

Seals and Polar Bears: Burying the offshore pipeline deeper would double the amount of benthic habitat altered by pipeline installation. This alternative would increase the amount of time that seals and polar bears would be exposed to noise and disturbance from pipeline dredging and burial activities in Foggy Island Bay. The disturbance of seals and polar bears would be local within about 1 mile along the pipeline route and would persist for one season.

Lower Trophic-Level Organisms: Deeper burial in the Alternative I pipeline route would permanently eliminate an additional 3 acres of very diffuse kelp, boulder, and suitable substrate. The amount of turbidity generated by deeper burial would be about two times greater than Alternative I, possibly causing additional reduction in annual kelp production during the construction phase.

Fishes : Alternative VII would be expected to have a slightly greater effect on fishes from temporary displacement than Alternative I, due to more trenching and disturbance.

Essential Fish Habitat: The potential adverse effects of this alternative on essential fish habitat could be slightly increased compared to Alternative I. The risk of oil spills to essential fish habitat would be unchanged. However, deeper burial in the proposed pipeline route would permanently eliminate an additional 3 acres of diffuse kelp and solid substrate. Moreover, the amount of suspended sediments from deeper burial would be about two times greater than Alternative I, possibly causing additional reduction in annual kelp production during the construction phase.

Economy: Alternative VII would generate more jobs and greater wages than Alternative I. Assuming labor costs for construction of the deeper pipeline would increase by as much as two times over those of Alternative I, this alternative would result in increases of $10.8 million in wages, 100 direct jobs in pipeline construction for 7 months in Alaska, and 150 indirect jobs in Alaska. This twofold factor is about in proportion to the volume of additional material to be handled in this alternative as compared to Alternative I. Higher pipeline construction costs result in higher pipeline tariffs. Higher pipeline tariffs reduce royalty revenue to the Federal Government from the project and likewise reduce Section 8(g) payments to the State.

Water Quality: The duration of turbidity from pipeline construction and trenching to a depth of 15 feet is expected to be longer than for the Liberty pipeline trenched to an average depth of 10.5 feet. The overall effects of turbidity are expected to be about 98% greater for the 15-foot trench compared to the 10-foot trench.

b. Comparison of Effects Among Combination Alternatives

As indicated in Section E.3 of the Executive Summary, the Liberty Interagency Team developed three combination alternatives to compare to the BPXA Proposal. A discussion of their relative features and merits follows. Table I-1 shows the relationship between the component alternatives and combination alternatives. Table IV.D-2 compares selected features between the combination alternatives.

Combination Alternative A and the BPXA Proposal (Liberty Island Location - 22-foot water depth) are located at the optimal location for the producing the Liberty Prospect. Combination Alternative B (Southern Island Location - 18 foot water depth) and Combination Alternative C (Tern Island Location - 23-foot water depth) are both 1.5 miles away from the optimal location. Combination Alternatives B and C would require more directional drilling, which increases costs, the time required to develop the field, and the amount of muds and cuttings.

Combination Alternative A (Liberty Island Location with Steel Sheetpile) requires the most gravel; about 20% more gravel than Combination Alternative B (Southern Island Location with Gravel Bags); 7% more gravel than the BPXA Proposal (Liberty Island with Gravel Bags); and, 26% more gravel than Combination Alternative C. Although Combination Alternative C has the largest footprint on the seafloor (26.8 acres), it incorporates existing gravel from the Tern Exploration Island. Combination Alternative B has the smallest footprint (21.9 acres). The BPXA Proposal and Combination Alternative A have footprints of 22.4 and 25.8 acres, respectively. Combination Alternative B and C use the least amount of gravel. The reduction in gravel is not likely to result in a lower level of effects to most resources.

Combination Alternative A and the BPXA Proposal (Liberty Island Location) are closest to the Boulder Patch area, about 1 mile away. Combination Alternative C (Tern Island) is about 1.5 miles away, and Combination Alternative B is the farthest at 2.5 miles away. Combination Alternative B reduces the impacts of construction (sediment effects) to water quality and the kelp biological community in the Boulder Patch.

Combination Alternative A and the BPXA Proposal use the Liberty Pipeline Route that is 6.1 miles long. It is longer than the routes for Combination Alternative B (Eastern Pipeline Route) and Combination Alternative C (Tern Pipeline Route), which are 4.2 and 5.5 miles long, respectively. However, the length of a pipeline in 8 feet or more of water is about the same for Combination Alternatives A and B and for the BPXA Proposal. Combination Alternative C (Tern Pipeline Route) has the greatest length in water depths over 8 feet. Combination Alternative A and the BPXA Proposal have the same 7-foot burial depth. One can argue that a longer offshore pipeline is less safe and would increase the potential for an oil spill, but MMS has found that the oil-spill rate per mile is very small and, for offshore pipelines between 6.1 and 4.2 miles in length, the calculated oil-spill rate essentially is the same. Furthermore, if ice gouging and length of pipe in water depths more than 8 feet beyond the bottomfast-ice zone are the concern, then Combination Alternative C (Tern Pipeline Route) has the greatest length of pipeline in 8 feet or more of water.

The longer offshore pipeline length for the Liberty Pipeline Route and the 7-foot burial depth would require 724,000 cubic yards of material to be excavated and backfilled. Combination Alternative B has a shorter offshore length and a shallower burial depth (6-foot), with a smaller volume of 466,190 cubic yards of material to be excavated and backfilled. Combination Alternative C requires the largest volume of material (1,298,100 cubic yards), which is related to the 15-foot burial depth. There would be some effects to the kelp community and water column during pipeline construction. The pipeline route (Liberty Pipeline Route) in Combination Alternative A and the BPXA Proposal goes through areas with less than 10% boulders and sediment. Effects to water quality would be less than those in Combination Alternative C, which has a deeper pipeline burial depth. Combination Alternative B has the least effects on water quality. The sediment effects to water quality are short term and local for all alternatives.

Combination Alternatives A, B, and C all offer potential secondary oil containment and have lower risks of containment failure than the single wall pipeline contained in the BPXA proposal. The Fleet (2000) report estimates the probability of a containment failure that releases 1,000 barrels or more of oil to the environment for Combination Alternatives A and C (Pipe-in-Pipe) at 0.00234 (0.234%) (Fleet, 2000). The BPXA Proposal and Combination B probability is estimated at 0.0138 (1.38%) (Fleet, 2000). The Combination Alternatives A, B, and C are more likely to suffer a functional failure than the single-wall pipeline design in the BPXA Proposal. The secondary containment afforded by the pipeline designs in Combination Alternatives A, B, and C could provide some flexibility in scheduling a pipeline repair to minimize the impacts on the species that inhabit the area.

The Pipe-in-HDPE Pipeline design in Combination Alternative B eliminates the problems of corrosion to the outer pipe. However, the HDPE pipeline is not capable of handling the operating pressure in the carrier pipeline; therefore, it is important to monitor the annular space and shut down the pipeline if a leak occurs.

Combination Alternative A and the BPXA Proposal use the Liberty Pipeline Route with an onshore pipeline length of 1.5 miles. Combination Alternatives B and C use the same pipeline route onshore (Eastern Pipeline Route), which is 3.1 miles long.

Combination Alternative C (Pipe-in-Pipe and 15-Foot Burial Depth) would be the most expensive pipeline to install. Combination Alternative A (Pipe-in-Pipe and 7-Foot Burial Depth) is next, followed by Combination Alternative B (Pipe-in-HPDE). The BPXA Proposal (Single-Wall Steel Pipe and 7-Foot Burial Depth) is the least expensive. Increased pipeline costs translate to increased pipeline tariffs, which decreases Federal and State revenue from the project.

In Appendix D-1 of the EIS, MMS estimates the cost of the BPXA Proposal at $384 million and a Net Present Value of $58 million. Combination Alternative A would increase costs by $51.5 million, an increase of 13%. Combination Alternative B would increase costs by $24.5 million, an increase of 6%. Combination Alternative C would increase costs by $59 million, an increase of 16%. In this last case, expected costs would exceed expected revenue. Higher pipeline construction costs would also result in higher pipeline tariffs. Higher pipeline tariffs reduce royalty revenue to the Federal Government from the project and likewise reduce Section 8(g) payments to the State.

Combination Alternative A and the BPXA Proposal (Liberty Island Location) would be farther offshore than any of the other island locations and closer to the bowhead whale migration route. It is more likely that noise from drilling and production operations from this island location would affect bowhead whales and the subsistence hunting of bowhead whales. However, our analysis indicates that all of the island locations, including Liberty Island, are located more than 9 kilometers from the bowhead migration route, farther than noise is likely to travel. Bowhead whales and subsistence whale hunting should not be adversely affected by noise from any of the island locations.

Combination Alternatives A and C use steel sheetpile for the upper slope-protection system, which eliminates the potential for gravel bags to enter the marine environment. Gravel bags that are part of Combination Alternative B and the BPXA Proposal would be placed as a berm beginning 7 feet above sea level at the inner edge of a horizontal 40-foot concrete-block buffer zone. Because gravel bags are not used at or below the water line, it is unlikely that gravel bag material would enter the marine environment. These gravel bags would not float in the water. The placement of the steel sheetpile would increase the amount of noise during the construction period. However, construction of the steel sheetpile should be completed prior to the fall bowhead whale migration.

Combination Alternative B and the BPXA Proposal would use the Kadleroshilik River Mine Site. The Kadleroshilik River mine site would destroy about 24 acres of wetland habitat, but there also would be the potential for a new fish-overwintering site in the Kadleroshilik River. The haul distance of the gravel from the mine site to the gravel island would be about 6 miles. Combination Alternatives A and C would use the Duck Island Mine Site. It eliminates all potential effects at the Kadleroshilik River mine site, both beneficial and adverse. There would be no surface disturbance at the Kadleroshilik River mine site, and the potential for a new fish-overwintering site in the Kadleroshilik River would be lost. The mine site would need to be dewatered. The haul distance of the gravel would be increased from 6 miles to about 20 miles. The amount of equipment needed to transport the gravel would be increased, which translates to increased costs.

4. Mitigation

a. BPXA's Mitigating Actions

In planning for construction and design, BPXA has attempted to minimize impacts and to incorporate mitigating measures into the Liberty Project design. They are listed in Table I-3 of the EIS.

b. Mitigation Required by the MMS

The project also includes stipulations that are part of the lease OCS-Y-01650. This mitigation reflects the efforts of the people of the North Slope and their tribal and local governments working with MMS and other Federal and State agencies. The full text for these stipulations is found in Appendix B, Part B of the EIS. BPXA is required to comply with these stipulations.

Stipulation No. 1, Protection of Biological Resources. The Liberty Prospect is located near the Stefansson Sound Boulder Patch, a special biological resource. The drilling and production island locations and pipeline routes have been selected to avoid impacts to the Boulder Patch.

Stipulation No. 2, Orientation Program. Site personnel would receive training on at least an annual basis, and full training records would be maintained for at least 5 years.

Stipulation No. 3, Transportation of Hydrocarbons. Pipelines are the preferred mode of transportation hydrocarbons.

Stipulation No. 4, Industry Site-Specific Bowhead Whale Monitoring Program. Not applicable, because this stipulation applies to exploratory operations.

Stipulation No. 5, Subsistence Whaling and Other Subsistence Activities. BPXA proposes measures that include ongoing community liaison, development of a Cooperation and Avoidance Agreement with the Alaska Eskimo Whaling Commission, planning major construction activities for the winter season, and limiting vessel transit to the island to routes inside the barrier islands. An ongoing consultation process would be used to identify any concerns not addressed by BPXA's proposed mitigation and potential measures to be considered.

c. Mitigation and Traditional Knowledge

The above mitigating measures incorporate traditional knowledge and the cooperative efforts between the MMS, the State, and the people of the North Slope and their tribal and local governments to develop effective mitigating measures for our leasing program. The concerns of North Slope residents to protect their subsistence and cultural heritage are incorporated in the Orientation Program and the Subsistence Whaling and other Subsistence Activities stipulations. The Transportation of Hydrocarbons stipulation reflects the concerns of the North Slope residents to require that the transportation of oil and gas be done in a safe manner. The subsistence and sociocultural sections of this EIS highlight and note the information, concerns, and

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traditional knowledge that North Slope residents have provided.

d. Potential Mitigation

Mitigation was developed through public planning and scoping. This mitigation reflects the efforts of people of the North Slope and their tribal and local governments working with MMS and other Federal and State agencies. Other mitigating measures may be identified during the public hearing process, and they will be considered in the final EIS. The MMS expects to develop other mitigation in response to issues and comments received from the draft EIS.

Seasonal Drilling Restriction: The purpose of this mitigation is to provide protection to resources by eliminating the potential for a blowout during periods of broken ice during the development phase of the project. This mitigating measure is similar to the measure required by the State of Alaska for the Northstar Project. BPXA is prohibited from drilling the first development well into targeted hydrocarbon formations during the defined broken ice periods for the site location; drilling subsequent development wells into previously untested hydrocarbon formations during defined broken ice periods; and subject to the imposition of additional restrictions on a case-by-case basis.

This mitigating measure would reduce the risk of a large blowout type oil spill during the development of the Liberty Prospect and reduce the already low risk of a large oil spill even further. It could increase the length of time (a few weeks) needed to develop the field.

Recovery and Reuse of Gravel: The purpose of this mitigation is to offset the reduction in wetlands that would result from onshore mining activities and gravel pad construction (e.g., shore crossing pad and pipeline tie-in pad). This mitigation would recover gravel from abandoned gravel facilities and rehabilitate those sites to useable wetland habitats in an amount equal to or greater than the area lost from gravel mining and pad construction. The permittee would be required to recover and reuse available gravel from abandoned pads, roads, and airstrips within the immediate project area and/or within the Prudhoe Bay oil field complex and to rehabilitate the site.

This mitigation would require the permittee to assess abandoned onshore gravel sites near the Liberty Prospect and/or within the Prudhoe Bay oil field and develop gravel recovery and rehabilitation plans for abandoned site(s). These plans would need to include: the location, amount, and type of gravel; the aerial extent of the gravel site (size); the current owner and any ownership issues; any potential gravel contamination concerns and a proposal to deal with those concerns; the proposed timing for obtaining applicable local, state, and federal permits; and a rehabilitation plan, including timetable. If potential gravel contamination or travel costs prohibit the use of the recovered gravel for this offshore project, the gravel could be stockpiled in non-wetland or currently filled areas and used in other ongoing or future projects by the permittee.

This mitigation is based on recently permitted on- and offshore oil and gas developments (e.g., Northwest Eileen and Northstar). The effectiveness of this mitigation is evaluated in Section III.D.2.n of the EIS.

F. CUMULATIVE ANALYSIS

For the cumulative analysis, MMS found that all of the alternatives were very similar to those of BPXA's Proposal. That is, the differences in alternatives would result in very small differences in cumulative effects. These small differences are greatly overshadowed by the inherent uncertainty in making estimates of past, present, and reasonably foreseeable cumulative effects. Therefore, we present just one analysis for all the Alternatives.

1. Scope of Analysis

In light of our past experience, we base our cumulative-effects analysis for this EIS on a five-step process:

Step 1: We identify the potential effects of the Liberty Development and Production Plan that may occur on the natural resources and human environment

- in the Beaufort Sea,
- on the North Slope, and
- along the oil transportation route.

Step 2: We analyze other past, present, and reasonably foreseeable future oil-development activity on the North Slope/Beaufort Sea for effects on the natural resources and human environment that we found were potentially affected by the Liberty Development and Production Plan.

Step 3: We consider effects from other actions (sport harvest, commercial fishing, subsistence hunting, and loss of overwintering range, etc.) on these same natural resources and human environments.

Step 4: We attempt to quantify effects by estimating the extent of the effects (number of animals and habitat affected) and how long the effects would last (population-recovery time).

Step 5: To keep the cumulative-effects analysis useful, manageable, and concentrated on the effects that are meaningful, we weigh more heavily other activities that are more certain and geographically close to Liberty, and we analyze more intensively effects that are of greatest concern. We also focus our effort by using guiding principles from existing standards (see the following), criteria, and policies that control management of the natural resources of concern. Where existing standards, criteria, and policies are not available, our experts use their best judgment on where and how to focus the analysis.

Oil and gas activities occur on the Outer Continental Shelf in Alaska, the Gulf of Mexico, and California and are cited in the most recent 5-year Oil and Gas Program EIS (USDOI, MMS, Herndon, 1996a). To be consistent with the 5-Year Program EIS, the Liberty cumulative analysis also evaluates the effects for transporting oil through the Trans-Alaska Pipeline System and tankering from Valdez to ports on the U.S. west coast. Activities other than those associated with oil and gas also are considered. We also include by reference certain cumulative effects that are more national in scope, for example, global warming and alternative energy development.

Oil and gas activities considered in the analysis include past development and production, present development, reasonably foreseeable future development, and speculative development. Some activities beyond the 20-year life of the Liberty Project are considered too speculative to include at this time, while other such activities are included in this analysis. Furthermore, we exclude future actions from the cumulative effects analysis if those actions are outside the geographic boundaries or timeframes established for the cumulative-effects analysis. We address uncertainty through monitoring, and note that monitoring is the last step in determining the cumulative effects that may ultimately result from an action.

For this analysis, we used the Endangered Species Act of 1973 and the Liberty scoping process as appropriate vehicles to identify species that are potentially at risk from incremental cumulative effects from the Liberty Project. Effects on listed species identified for the Liberty Project by the National Marine Fisheries Service and the Fish and Wildlife Service under Section 7 of the Endangered Species Act are covered in this cumulative-effects analysis. The management of seals by the National Marine Fisheries Service and polar bears by the Fish and Wildlife Service under the Marine Mammal Protection Act of 1972 provides for monitoring these species' populations and managing/mitigating potential effects of development on these species. The State of Alaska, Department of Fish and Game monitors caribou, including the Central Arctic Herd. Water quality on the North Slope is regulated and/or monitored through various permitting and regulatory programs administered by the Environmental Protection Agency; the Alaska Departments of Natural Resources, Environmental Conservation, and Fish and Game; and the North Slope Borough. These programs have been established to protect against the significant degradation of water quality associated with specific human/development activities. In evaluating the cumulative effects to water quality, we consider the collective impacts associated with permitted/regulated activities as well as other nonregulated activities and/or naturally occurring events.

Air quality is regulated under the Clean Air Act. The major stationary sources of air pollutants are regulated under the Prevention of Significant Deterioration permitting process. For sources located on the outer continental shelf (such as the proposed Liberty Project), the Prevention of Significant Deterioration program is administered by the Environmental Protection Agency. For sources located in State waters and onshore, the Prevention of Significant Deterioration program is administered by the Alaska Department of Environmental Conservation. Minor sources of air pollutants are not subject to Prevention of Significant Deterioration permitting requirements. The analysis of cumulative effects to air quality in this EIS is based on five monitoring sites, three of which were deemed subject to maximum air-pollutant concentrations and two of which were deemed more representative of the air quality of the general Prudhoe Bay area.

Impacts to wetlands are regulated under Section 404 of the Clean Water Act and administered by the U.S. Army Corps of Engineers. In addition, the Administration has a No-Net-Loss goal for wetland functions and values. Under the Memorandum of Agreement between the Corps of Engineers and the Environmental Protection Agency, it is recognized that in areas such as the North Slope of Alaska (where there is a high proportion of wetlands), minimizing wetland losses would be the primary method of mitigation. However, compensatory mitigation could be required for unavoidable losses to high-use wetlands.

For the human environment (subsistence activities, sociocultural systems, and the economy), we focus our evaluation of cumulative effects associated with oil-development activities on the North Slope local environment, because this is where the most significant cumulative effects are expected to be concentrated. We have met with local tribal governments to discuss subsistence issues relating to the Liberty Project and have established a dialogue on environmental justice with these communities. Mitigation in place for the Liberty Project (measures developed for MMS's Beaufort Sea Lease Sale 144) evolved through negotiations with local, borough, and agency representatives, and Inupiat traditional knowledge had a large part in developing mitigation and the timing of project activities. Local Inupiat government representatives have been members of our Outer Continental Shelf Advisory Committee that have met to discuss and resolve issues that arise from the 5-Year Plan and recent lease sales. Conflict avoidance agreements between the oil industry and Inupiat whalers are an important mechanism for overcoming conflicts.

The cumulative effects on archaeological resources can be minimized through required surveys, consultations with the State Historical Preservation Officer to identify potential archaeological sites, and requirements to plan and schedule activities to avoid these locations. We analyze the potential for disturbance to archaeological resources on the North

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Slope and in the Beaufort Sea as well as the potential effects from the cleanup of oil spills along the transportation route.

2. Cumulative Effects

a. Significant Effects Conclusion

The MMS does not expect any significant cumulative impacts to result from any of the planned activities associated with the Proposal (Alternative I, Liberty Development and Production Plan) or any of the alternatives. In the unlikely event of a large offshore oil spill, some significant cumulative impacts could occur, such as adverse effects to spectacled eiders, long-tailed ducks, common eiders, subsistence resources, and local water quality. However, the probability of such an event combined with the seasonal nature of the resources inhabiting the area make it highly unlikely that an oil spill would occur and contact these resources. Spectacled eiders, long-tailed ducks, and common eiders are only present on the North Slope for 3-5 months out of the year. A resource may be present in the area but may not necessarily be contacted by the oil. An oil spill could affect the availability of bowhead whales, or the resource might be considered tainted and unusable as a food source. The potential for adverse effects to some key resources (bowhead whales, subsistence, the Boulder Patch, polar bears, and caribou) are of primary concern and warrant continued close attention. Effective mitigation practices (winter construction, an advanced leak-detection system, thick-walled pipeline designs, etc) also should be considered in future projects.

b. General Conclusions

The MMS found the following general conclusions were applicable and informative:

- The incremental contribution of the Liberty Project to cumulative effects is likely to be quite small. Construction and operations related to the Liberty Project would be confined to a relatively small geographic area, and oil output would be a small percentage (approximately 1%) of the total estimated North Slope/Beaufort Sea production.
- The Liberty Project would contribute a small percentage of risk (about 6%) to resources in State and Federal waters in the Beaufort Sea from potential offshore oil spills. Any subsequent spills are not expected to contact the same resources or to occur before those resources recover from the first spill. We recognize the importance of readily available abiotic standards to determine environmental quality. Abiotic measurements for air and water quality, for example, often provide a good indication of the quality of biological and cultural resources. We also recognize that as we move from the abiotic and the biotic to the human environment, the variables increase, making it more difficult to determine cumulative effects on the quality of life. Similarly, as we move from the terrestrial environment to the offshore environment, the variables of environmental quality increase. Migratory species present additional variables that reflect habitat and species condition outside the primary study areas. Humans introduce even more variables with their mobility and behavioral diversity. Hence, as we progress from abiotic to biotic, or from freshwater to marine, or from terrestrial and marine to sociocultural effects, our analysis, by necessity, becomes more difficult and less conclusive.

c. Keeping Cumulative Effects in Perspective

Concern about the potential for cumulative effects should be weighed with the following information:

- Expected oil and gas activities are likely to have fewer impacts on the environment than those activities conducted in the early years of the region’s development.
- Current industry practices and the environmental state of the North Slope/Beaufort Sea region frequently are observed and assessed, and much of this information is available to the public.
- A key element of the transportation system for development of North Slope/Beaufort Sea oil is the Trans-Alaska Pipeline System pipeline. The pipeline is 800 miles long, stretching from Pump Station 1 at Prudhoe Bay to the Valdez Marine Terminal with a corridor width of about 100 feet, it represents an area of about 16 square miles.
- Following the *Exxon Valdez* oil spill, substantive improvements have been made in tanker safety to reduce the potential for oil spills from tanker accidents.
- If a major oil spill occurred, there likely would be a great slowdown in new development during which additional safeguards certainly would be put in place and new concepts for pipeline placement and design would be researched.
- The actual sizes and locations of future oil and gas developments on the North Slope and in the Beaufort Sea are uncertain.

d. Cumulative Effects by Resource

Endangered Species (Bowhead Whales, Eiders, Other Species): Some bowhead whales temporarily may avoid noise-producing activities, and contact with spilled oil could cause temporary, nonlethal effects, and a few could die from prolonged exposure to freshly spilled oil. The Liberty Project's contribution to cumulative effects is expected to be limited to temporary avoidance behavior by a few bowhead whales in response to vessel traffic. Significant effects to spectacled eiders would occur if they are contacted by an oil spill. Disturbance may cause short-term energy loss if spectacled eiders are displaced from preferred habitat, and a large oil spill could result in significant losses in offshore and nearshore areas. Liberty would be additive to effects from all projects in this cumulative analysis, but only in the case of a large offshore oil spill would Liberty be expected to increase adverse cumulative effects to potentially significant population levels. Oil transportation from Liberty to ports along the U.S. west coast likely would contribute little to cumulative effects on species occurring along transportation routes.

Seals and Polar Bears: Ongoing activities that may affect polar bears and seals include disturbance, habitat alteration, and spilled oil. Overall effects (mainly from oil) should last no more than one generation (about 5-6 years) for ringed and bearded seals and about 7-10 years for polar bears. Liberty should only briefly and locally disturb or displace a few seals and polar bears. A few polar bears could be temporarily attracted to the production island with no substantial effects on the population's distribution and abundance.

Marine and Coastal Birds: Substantial numbers of birds potentially could be exposed to a large oil spill during migration periods as they pass through offshore staging areas, lagoons, or beaches in the petroleum development area. It is unknown what percentage actually use it as a stopover or staging area. Also, migrating birds may collide with production islands or structures under poor visibility conditions. Collision losses are expected to be relatively low, unless greater numbers of offshore production structures are constructed in the foreseeable future. Disturbance from support activities could cause displacement to less favorable foraging areas. Effects of Liberty would be additive to effects observed or anticipated for cumulative projects and, in the case of a large oil spill, could substantially increase adverse effects at the population level in several loon, waterfowl, shorebird, and seabird species. Mortality resulting from an oil spill would cause significant effects in long-tailed duck and common eider populations.

Terrestrial Mammals: About half the Central Arctic Caribou Herd uses coastal habitat adjacent to the Liberty area during summer. Oil development in the Prudhoe Bay area is likely to continue to displace some caribou during the calving season within about 4 kilometers of roads with vehicle traffic. Liberty is expected to contribute less than 1% of the local short-term disturbance of caribou. Liberty should only briefly and locally disturb or displace a few muskoxen and grizzly bears.

Lower Trophic-Level Organisms: Effects of additional drilling discharges, construction-related activities and oil spills are not expected to substantially affect organisms near Liberty island or elsewhere. Liberty is not expected to make a measurable contribution to the cumulative effects on these organisms.

Fishes and Essential Fish Habitat: Small numbers of fish in the immediate area of an offshore or onshore oil spill may be killed or harmed, but this would not have a measurable effect on fish populations. Marine and migratory fishes are widely distributed in the Beaufort Sea and are not likely to be affected by the Liberty Project. Oil is not expected to contact overwintering areas during winter. Hence, the Liberty Project is not expected to contribute measurably to the overall cumulative effect on fishes.

Vegetation-Wetland Habitats: Construction causes more than 99% of the effects, with spills having a very minor role. Rehabilitation of gravel pads can result in the growth of grasses-sedges within 2 years after abandonment of the pads. Natural growth of plant cover would be very slow. Liberty would contribute less than 1% of the cumulative disturbance effects on 9,000 acres now affected by oil development.

Subsistence-Harvest Patterns: Subsistence harvests in Nuiqsut and Kaktovik could be affected by Liberty development and other past, present, and future projects with one or more important subsistence resources becoming unavailable or undesirable for use for 1-2 years, a significant effect. Liberty is expected to have periodic effects on subsistence resources, with no harvest areas becoming unavailable for use and no resource population experiencing an overall decrease.

Sociocultural Systems: Liberty development and other past, present and future projects could disturb sociocultural systems for an entire season (1 year) but would not displace traditional practices for harvesting, sharing and processing resources. Liberty would contribute periodic disturbance effects on communities near the Liberty Project but would not displace any social systems, community activities or traditional practices.

Alaska Inupiat Natives, a recognized minority population, are the predominant residents of the North Slope Borough, the area potentially most affected by Liberty development. Inupiat Natives may be disproportionately affected because of their reliance on subsistence foods, and Liberty development may affect subsistence resources and harvest practices. Disproportionately adverse effects on Alaskan Natives could result from Liberty development under the Proposal. Effects would focus on the Inupiat community of Nuiqsut, and possibly of Kaktovik, within the North Slope Borough. Effects to subsistence resources and subsistence harvests are expected to be mitigated substantially though not eliminated.

Archaeological Resources: Existing laws and regulation protect archaeology resources and known sites are avoided when possible. Liberty's contribution to cumulative effects and the cumulative effects overall are expected to be minimal for archaeological resources because any surface-disturbing activities that could damage archaeological sites would be mitigated by current State and Federal procedures.

Economy: This cumulative analysis projects employment increases as follows: 2,400 direct oil industry jobs at peak, declining to 1,300; about 3,400 indirect jobs at peak, declining to 2,000; about 150 jobs for North Slope Borough residents at peak, declining to 50; about 5-125 jobs for 6 months for cleanup of an oil spill in the Beaufort Sea; and about 10,000 jobs and 25% price inflation for 6 months for cleanup of a tanker oil spill in the Gulf of Alaska. This cumulative analysis projects annual revenues as follows: $125 million Federal, $77 million State, and $28 million for the State and North Slope Borough. Liberty's contribution to the cumulative effects ranges from 1% to at peak level 36%.

Water Quality: Oil spills would degrade the marine environment and result in a greater than 1.5 parts per million acute criterion for about 3 or more days in an area of 15-20 square kilometers. A large crude or refined oil spill (greater than or equal to 500 barrels) would have a significant effect on water quality by increasing the concentration of hydrocarbons in the water column to levels that greatly exceed background concentrations; however, the chance of a large spill occurring is low. Also, regional (more than 1,000 square kilometers [386 square miles]), long-term (more than 1 year) degradation of water quality to levels above State and Federal criteria because of hydrocarbon contamination is very unlikely.

Resuspended sediments from construction activities are not expected to exceed acute water-quality criteria, and permitted discharges would be designed to ensure rapid mixing and dilution of the discharge. The effects from the Liberty Project from construction activities are expected to be short term, lasting as long as the individual activity, and have the greatest impact in the immediate vicinity of the activity.

Air Quality: Projects in the past and present have caused essentially no deterioration in air quality or contribute measurably to global climate change. Air emissions from the Liberty Project essentially would have no effects on air quality.

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VOLUME III – APPENDICES

ACRONYMS
ABBREVIATIONS
AND
SYMBOLS

List Of Abbreviations, Acronyms, And Symbols

NOTE: Most of these abbreviations, acronyms, and symbols are used in tables; only a few are used in text.

ACI	Alaska Consultants, Inc.
ADF&G	Alaska Dept. of Fish and Game
ANGTS	Alaska Natural Gas Transportation System
bbl	barrel(s)
Bbbl	billion barrel(s)
BP	British Petroleum
BPXA	BP Exploration (Alaska), Inc.
CFR	Code of Federal Regulations
CONCAWE	Conservation of Clean Air and Water in Europe
cu yd	cubic yard(s)
dB re 1 µP	decibels re 1 microPascal
DEC	Department of Environmental Conservation (State)
DPP	Development and Production Plan
EIS	environmental impact statement
EO	Executive Order
ERL	Effects Range-Low
ERM	Effects Range-Medium
FR	*Federal Register*
gal	gallon(s)
HDPE	high-density polyethylene
km^2	square kilometer
LEOS	Leak Detection and Location System
LNG	liquefied natural gas
m	meter(s)
Mbbl	thousand barrel(s)
MMbbl	million barrel(s)
MMS	Minerals Management Service
MPRSA	Marine Protection, Research and Sanctuaries Act
NPR-A	National Petroleum Reserve-Alaska
OCS	outer continental shelf
PAH	polycyclic (or polyneuclear) aromatic hydrocarbons
Plan	Development and Production Plan
ppb	parts per billion
ppm	parts per million
SCADA	Supervisory Control and Data Acquisition
TAGS	Trans-Alaska Gas System
TAPS	Trans-Alaska Pipeline System
TK	traditional knowledge
U.S.C.	U.S. Code
USCG	U.S. Coast Guard
USDOI	U.S. Department of the Interior
Yd^3	cubic yard(s)
µg/l	micrograms per liter
%	percent
°C	degrees Celsius
°F	degrees Fahrenheit

SECTION I

INTRODUCTION AND RESULTS OF THE SCOPING PROCESS

CONTENTS OF SECTION I

I. Introduction and Results of the Scoping Process

A. INTRODUCTION

In February 1998, BP Exploration (Alaska) Inc. (BPXA) submitted a Development and Production Plan (the Plan) to the Minerals Management Service (MMS) for the proposed Liberty Project, as required under 30 CFR 250.204, and a pipeline Right-of-Way application, as required under 30 CFR 250.1010. On November 2, 1998, BPXA submitted Revision 1 of the Plan. On July 31, 2000, BPXA submitted Revision 2 of the Plan (BPXA, 2000a). The Plan and application initiated the review process for BPXA's proposed project to develop and produce oil and gas from the Liberty Prospect and to transport and sell oil to U.S. and world markets. The Liberty Prospect is in Federal waters of the Beaufort Sea northeast of the Prudhoe Bay oil field. The MMS's Regional Supervisor for Field Operations must consider BPXA's Plan and applications. If he approves the proposed Plan (or an alternative) and the applications, he will monitor the project to ensure that activities comply with MMS regulations. No development activity can or will occur on the lease unless and until the Plan is approved. Seismic exploration for the Liberty Project was conducted in 1996. No seismic activity is proposed for the Liberty Plan.

We (MMS) determined that approving the Plan would be "a major Federal action that may significantly affect the quality of the human environment pursuant to the National Environmental Policy Act." Under the National Environmental Policy Act, this environmental impact statement (EIS) evaluates reasonable alternatives, including BPXA's Proposal and no action, as well as how each alternative may affect the environment. We will use information in this EIS in our Record of Decision to either approve the Plan and applications or decide on other actions. Currently, MMS intends to issue the draft EIS in January 2001 and the final EIS in November 2001. No decisions can be made until 30 days after the issuance of the final EIS. The agency(s) decisions would be made in early 2002. If the project is approved, construction of the ice roads would begin in November or December 2002, which would be Year 1 of the project as described in the EIS. Some of the alternatives, if chosen, may result in delays in the Liberty Project of 18-24 months to collect additional engineering data and allow time for specific design and testing work. This information would be necessary for technical approval of the project but is not expected to change the environmental effects. For purposes of analysis in the EIS, we have not adjusted the timelines for starting the different alternatives. Therefore, all the alternatives are on the same footing for the analysis of environmental effects.

The U.S. Army Corps of Engineers has statutory authority for the placement of dredged or fill materials in waters of the United States, including wetlands under Section 404 of the Clean Water Act of 1977 (U.S.C. 1344); for work performed in or affecting navigable waters of the U.S. under Section 10 of the Rivers and Harbors Act of 1899 (33 U.S.C. 403); and for the transport of dredged material for the purpose of dumping it into ocean waters under Section 103 of the Marine Protection, Research, and Sanctuaries Act of 1972 (33 U.S.C. 1413). The Corps of Engineers is a cooperating agency with the MMS as defined by the Council on Environmental Quality Regulations for Implementing the Procedural Provisions of the National Environmental Policy Act (40 CFR Parts 1500-1508). As a cooperating agency, the Corps of Engineers may adopt MMS's final EIS for the Liberty Plan and issue the Corps of Engineers' Record of Decision. Before adopting the final EIS, the Corps of Engineers will independently review the final EIS and will determine if its own National Environmental Policy Act procedures and evaluations requirements have been satisfied. If the Corps' review concludes that its comments and suggestions have been satisfied, the Corps could adopt MMS's final Liberty EIS. Without recirculating the EIS, the Corps of Engineers could then issue a Record of Decision to approve, deny, or modify (including selection of another alternative with the EIS) BPXA's proposed plan for those activities under the Corps of Engineers' jurisdiction.

The Environmental Protection Agency is a cooperating agency with MMS on the Liberty Development and Production Plan Draft EIS. The Environmental Protection Agency has primary responsibility for implementation of Sections 301, 306, 311 and 402 of the Clean Water Act.

The Environmental Protection Agency shares responsibility with the Corps of Engineers for implementation of Section 404 of the Clean Water Act and implementation of the Marine Protection, Research and Sanctuaries Act (MPRSA). The Environmental Protection Agency has primary responsibilities for implementation of Title V of the Clean Air Act in offshore waters. The Environmental Protection Agency also conducts reviews and evaluations of the draft and final EIS's for compliance with the National Environmental Policy Act and Council on Environmental Quality regulations pursuant to Section 309 of the Clean Air Act.

Section 301 of the Clean Water Act states that it is unlawful for any person to discharge any pollutant into the waters of the United States except where permits have been issued in compliance with Sections 402 and 404 of the Clean Water Act. Sections 301 and 306 of the Clean Water Act require that Environmental Protection Agency establish numeric limitations or criteria for discharges of water pollutants. Section 301 also specifically requires that Environmental Protection Agency establish technology-based effluent guidelines for new sources and requires that all Section 402 (National Pollution Discharge Elimination System) permits include effluent limitation protective of water quality. These criteria must be met at the "end of the pipe" where discharge occurs, unless the State issues a variance from its established water-quality standards and establishes a mixing zone for that particular discharge. The new source performance standards applicable to this facility are described at 40 CFR Part 435 Subpart A.

Section 311 of the Clean Water Act establishes requirements relating to discharge or spills of oil or hazardous substances. The Environmental Protection Agency requires that each facility that handles substantial quantities of oil to prepares a Spill Prevention, Containment, and Countermeasure Plan and a Facility Response Plan.

Section 402 of the Clean Water Act establishes the National Pollution Discharge Elimination System program. This program authorizes the Environmental Protection Agency to permit point-source discharges of effluent, including process wastewater and storm water. Discharges must meet all effluent limitations, including standards based on water quality, established under other sections of the Clean Water Act.

In accordance with Section 511(c)(1) of the Clean Water Act, National Pollution Discharge Elimination System permit actions for new sources are defined as major Federal actions subject to the National Environmental Policy Act (40 CFR Part 6, Subpart F). The Environmental Protection Agency, as a cooperating agency with MMS for this draft EIS, will issue a Record of Decision in conjunction with the final permit action.

In accordance with Section 404 of the Clean Water Act, the Environmental Protection Agency reviews and comments on Corps of Engineers decisions on the placement of dredged or fill materials in waters of the United States. Under Section 404(c), in prescribed circumstances, the Environmental Protection Agency is given the authority to take the permitting decision from the Corps or Engineers and make the decision itself. This could overturn a Corps of Engineers proposed permitting decision that the Environmental Protection Agency determines will have unacceptable adverse impacts on municipal water supplies, shellfish beds, fishery areas, or recreational areas.

In accordance with Section 102 of the MPRSA, the Environmental Protection Agency must designate areas suitable for use as ocean disposal sites. Under Section 103 of the MPRSA, the Corps of Engineers is responsible for authorizing the transport of material for the purpose of dumping it into the ocean. The Environmental Protection Agency is given the flexibility to make its designations either independently or collaboratively with the Corps of Engineers. If the Environmental Protection Agency chooses to proceed collaboratively with the Corps of engineers then, under MPRSA, the Environmental Protection Agency must concur with Corps of Engineers evaluations and decisions for ocean disposal of materials. If the Environmental Protection Agency does not concur, then, it will proceed independently to evaluate and come to a decision on the suitability of an area as an ocean disposal site.

The most basic goals of the Clean Air Act are to protect public health and welfare. Section 309 of the Clean Air Act requires that the Environmental Protection Agency review and comment on EIS's. In addition, the Environmental Protection Agency issues a Prevention of Significant Deterioration permit to address air pollutant discharges.

Other Federal agencies that have regulatory responsibility for this project include the the Fish and Wildlife Service; the National Marine Fisheries Service; the Department of Transportation, Office of Pipeline Safety; Federal Aviation Administration; U.S. Coast Guard; Occupational Safety and Health Administration; and Federal Energy Regulatory Commission. Within the State of Alaska many agencies, including the Division of Governmental Coordination, Department of Natural Resources, State Pipeline Coordination Office, and the Department of Environmental Conservation also have regulatory authority. The North Slope Borough also has regulatory authority over aspects of this project. In addition to the MMS, many of the above agencies have participated in the Interagency Team meetings (see Sec. I.G.2.a).

By regulation and law, the MMS is required to review and analyze the environmental effects of the BPXA Plan and the alternatives. For this EIS, BPXA's Plan is the Proposal, or Alternative I. Through the scoping process, we asked for comments and concerns about the project. We have used this information to focus our analysis and to generate reasonable alternatives for analysis. Through the remainder of the process, we will continue to solicit information and suggestions.

The draft EIS will be distributed for public comment and review. We will respond to the public comments in the final EIS. We have not committed to any specific course of action and will maintain an open mind throughout the development of the EIS and decision processes. We will continue to consider and evaluate all reasonable options. The Agency-preferred alternative(s) will be identified in the final EIS based on the analysis and full consideration of comments resulting from the public review of the draft EIS. We encourage the public to comment on the alternatives, including the combination alternatives.

B. NEED AND PURPOSE FOR THE PROJECT

Need: To satisfy the demand for domestic oil and decrease the dependence of the United States on foreign oil imports.

Purpose: To recover oil from the Liberty Prospect and transport it to market.

This project helps satisfy the mandate of the Outer Continental Shelf Lands Act to explore for and develop offshore mineral resources by developing the oil resources of OCS Lease Y-01650 issued by the MMS.

1. Goals of this Environmental Impact Statement

- To create an opportunity to exchange information among the applicant, permitting agencies, and the public.
- To evaluate the environmental effects of the Proposal and other reasonable geographic (different island locations and pipeline routes) alternatives, and component design (pipeline designs, burial depths, etc.) alternatives.
- To respond to the issues identified during scoping, so that readers can easily locate and track them.
- To meet the National Environmental Policy Act needs for review by multiple agencies and permitting authorities and to reduce duplicating and overlapping efforts between agencies.
- To include the pertinent information needed by other agencies in their decisionmaking process and to provide an opportunity for other agencies and the public to review and comment on the analysis before any final decisions are made.
- To include traditional knowledge of the North Slope's indigenous people into the document so that the MMS and other agencies can benefit from this information in their decisionmaking.
- To meet the National Environmental Policy Act requirements while maintaining a well-documented record so timely decisions can be made.
- To incorporate by reference recent analysis and information from the Beaufort Sea Oil and Gas Development/Northstar Project Final Environmental Impact Statement (U.S. Army Corps of Engineers, 1999) and reference that analysis, when appropriate, and minimize the need to repeat the Northstar data and applicable analysis.
- To evaluate potential impacts from the proposed action and alternatives within the EIS sufficiently so the Corps could incorporate them by reference in their required evaluations under Section 103 of the Marine Protection, Research, and Sanctuaries Act; Section 10 of the Rivers and Harbors Act; and Section 404 of the Clean Water Act; specifically CFR 230, Guidelines for Specification of Disposal Sites for Dredged or Fill Material, commonly referred to as the 404(b)(1) Guidelines; and the Corps procedures for implementing the National Environmental Policy Act (33 CFR 230-235), Appendix B, Implementation Procedures for the Regulatory Program. See Appendices G and H for the draft evaluations for the Corps permits. Their inclusion in the EIS provides the public with an opportunity to comment on those evaluations concurrently with the draft EIS.
- To evaluate the air- and water-quality impacts from the proposed action and alternatives within the EIS sufficiently so the Environmental Protection Agency could incorporate them by reference in their required evaluations under the Clean Water Act and Title V of the Clean Air Act.
- To provide information necessary for the National Marine Fisheries Service's authorization of certain small takes under section 101 (a) (5) of the Marine Mammal Protection Act, and/or the issuance of an Incidental Take Statement for the taking of threatened or endangered species.
- To include in the final EIS:
  - a Biological Assessment for Section 7 Endangered Species Act consultations with the National Marine Fisheries Service and the Fish and Wildlife Service and
  - a Biological Opinion for Section 7 Endangered Species Act consultations prepared by the National Marine Fisheries Service and the Fish and Wildlife Service.
- To meet the National Environmental Policy Act requirements for the proposed Plan, including the outer continental shelf portion of the proposed Right-of-Way for construction and operation of the pipelines, if the project is permitted.
- To evaluate the environmental effects of the Oil Discharge Prevention and Contingency Plan (BPXA, 2000b), including the effects of the different cleanup scenarios developed in the oil-spill-contingency plan. The National Environmental Policy Act does not require, nor does this EIS evaluation determine, the adequacy of the Oil Discharge Prevention and

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Contingency Plan (BPXA, 2000b). This evaluation, located in Section III.C.2, provides additional information about the environmental effects that may result and that MMS decisionmakers can consider when deciding approval, modification, or disapproval of the Development and Production Plan. (**Note:** The potential effects from a potential oil spill are fully evaluated in the EIS without adjusting or lowering those effects for cleanup efforts or other mitigation afforded by response planning.)

2. Scope of Analysis

The proposed project is to develop the Liberty oil field on OCS Lease Y-01650 in Foggy Island Bay in the Beaufort Sea of Alaska. (See Map 1 for the location and Sec. II.A for the project description.) This EIS analyzes the effects of the Liberty Project and reasonable alternative ways to develop these resources, including various alternative combinations. It also evaluates the "No Action Alternative." The EIS analysis focuses on the effects on the human, physical, and biological resources in the study area. The extent of the study area may vary between resources in the EIS (i.e., biological, social, and physical) as well as by primary, secondary, and/or cumulative impacts. Generally, the study area is described by resource in Section VI, Description of the Affected Environment, in this EIS. In assessing the cumulative effects (Sec. V), the analysis covers a broader geographic area—the Beaufort Sea, North Slope, Trans-Alaska Pipeline System corridor, and tanker routes to west coast ports.

C. STEPS OF THE ENVIRONMENTAL IMPACT STATEMENT PROCESS

1. Publish the Notice of Intent to Prepare an Environmental Impact Statement

On February 23, 1998, we published a Notice of Intent to Prepare an EIS based on BPXA's Development and Production Plan dated February 17, 1998. On February 19, 1998, we considered the Plan to be "submitted" according to Federal regulations (30 CFR 250.34(f) [63 *Federal Register [FR]* 290477]) and sent copies to Federal and State agencies, the North Slope Borough, and local communities (Barrow, Nuiqsut, and Kaktovik). Copies also were located in our office in Anchorage, the Noel Wien Library in Fairbanks, and the Tuzzy Consortium Library in Barrow. We sent notices that the Plan was available for review to our mailing list of interested parties. After distributing the Plan, we held scoping meetings in Anchorage, Barrow, Nuiqsut, Kaktovik, and Fairbanks. We also discussed it on a radio talk show (on station KBRW) in Barrow. The Development and Production Plan was revised and updated November 2, 1998 (Revision 1) and July 31, 2000 (Revision 2) (BPXA, 2000a).

2. Conduct Scoping

"Scoping" is a public process to determine the range of the issues relating to the BPXA's proposed plan and to identify issues and concerns to be analyzed in the EIS. This information may come from interagency discussions, public meetings, and written comments. Scoping also is used to develop alternatives to BPXA's Plan and mitigating measures that could eliminate or reduce potential development impacts. Alternatives could include technological modifications to the Plan or different drilling and production island locations or pipeline routes. The scoping process includes an evaluation of the issues, alternatives, and mitigating measures that will be addressed in the EIS and those that will not be addressed. The reasons for not addressing some of the issues, alternatives, or mitigating measures suggested during scoping are noted in the EIS and/or scoping report (Appendix E).

Scoping is an ongoing process. For the Liberty Plan EIS, scoping has consisted of two phases. The initial phase included the receipt and evaluation of comments from the publication of the Notice of Intent to Prepare an EIS (Sec. I.C.1) and scoping meetings; summaries of these comments are included in the Scoping Report (see Appendix E).

Scoping meetings took place in 1998 in Nuiqsut (March 18), Barrow (March 19), Anchorage (March 25 and April 8), Kaktovik (March 31), and Fairbanks (April 1). Our staff and BPXA's representatives attended these meetings; provided an overview of the Plan; and answered questions about the Liberty Project, process, and schedule.

Following the scoping meetings, we have continued scoping for the Liberty Plan EIS, and we continue to evaluate suggestions as we receive them. Additional scoping comments were provided as part of the information update meetings in Fairbanks, Barrow, Nuiqsut, Kaktovik, and Anchorage in October and November 1999. (The minutes of these meeting are provided in Appendix E.).

3. Prepare the Draft EIS

This EIS describes BPXA's Proposal, as outlined in the Plan, Revision 2, dated July 31, 2000 (Alternative I of this EIS), to develop and produce oil from Liberty. This EIS also:

- describes the affected environments (Sec. VI),

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- analyzes potential impacts to these environments (Secs. III.C and III.D),
- describes alternatives to the Proposal and analyzes the potential effects from these alternatives (Sec. IV),
- analyzes potential cumulative effects to these environments (Sec. V), and
- records consultation and coordination with others (Sec. VIII).

The draft EIS complies with the filing requirements of 40 CFR 1506.9 of the Council on Environmental Quality regulations and is filed with the Environmental Protection Agency. An announcement of the availability of this EIS has been published in the *Federal Register* and in the local media.

4. Take Public Comments

We will accept comments on the draft EIS for 60 days following its availability to the public. We will hold public hearings and announce their dates and locations in the *Federal Register*. The date, time, and location for the public hearings will be posted at http://www.mms.gov/alaska/cproject/cproject.htm.

5. Prepare the Final EIS

After considering the public's comments, we will determine the scope of the final EIS. It will contain comments on the draft EIS, responses to comments, and any resulting major changes from the draft EIS. The agency(s) preferred alternative(s) will be identified in the final EIS.

D. TRADITIONAL KNOWLEDGE

The traditional knowledge of the Inupiat people is important to understand when making decisions for projects on the North Slope and in the Beaufort Sea. This section describes how MMS gathered and incorporated traditional knowledge of the indigenous Inupiat people to help evaluate the potential effects of developing and producing oil under the Liberty Project.

The Inupiat have lived for many generations off the land and waters of Alaska's North Slope. "Traditional knowledge" refers to the Inupiat experience, familiarity, and awareness of the arctic landscape and the resources it holds. Traditional knowledge passes relatively unchanged from generation to generation, but it also adapts to changes in technology and socioeconomic conditions. Traditional knowledge includes expertise on the following:

- weather
- sea ice
- water currents
- fish and wildlife and their habitats
- historical and current uses of the land and water for subsistence or other traditional activities
- how human activities affect wildlife and the environment

The North Slope Borough, in its review of the Liberty preliminary draft EIS noted that: "It is important to recognize that this knowledge, often simply referred to as 'TK,' encompasses more than the vast amount of information passed down from many generations past. It also includes contemporary knowledge of events in the recent past; the size, behavior, and trends in regional wildlife populations; and experiences relating directly to impacts of industrial operations" (North Slope Borough, 2000).

The Northstar EIS provides another source of traditional knowledge information and is incorporated by reference. Chapter 2 of the Northstar EIS provide good background discussion and general description of traditional knowledge.

1. Cultural Basis of Traditional Knowledge

The Inupiat culture, like other Alaskan Native cultures, focuses on harvesting, processing, distributing, storing, and consuming wild foods (Stephen R. Braund and Assocs. and P.J. Usher Consulting Services, 1993). It also emphasizes using resources for clothing, shelter, fuel, and ceremonial items. The most significant beliefs and values grow from fundamental relationships between the following:

- people and the environment (including wild resources)
- other people
- their ancestry

The importance of the first two relationships stems from people depending on one another and the environment for their survival. The third relationship shows that the Inupiat depend on knowledge and skills passed between generations, and that they believe those who came before knew the correct and proper way to live.

2. The Protocol for Collecting and Using Traditional Knowledge

A protocol was developed to extract, from past testimony and community meetings, traditional knowledge that relates to oil and gas activities in the Alaskan Beaufort Sea. S.R. Braund and Assocs., under contract with Dames and Moore, developed a database for the Northstar EIS to catalogue testimony provided by local North Slope residents over the past 20 years of oil and gas development. The database

(Dames and Moore, 1988) was organized using the following categories:

- sources of testimony (including lease sale/development event, date, and location),
- name and residence of person providing the testimony,
- key words for subject of testimony and for issue/development impact, and
- specific quotes of individual testimony.

For this EIS, the database was queried to obtain selected summaries of information. Examples of potential summaries include all testimony over time by specific individual, all testimony regarding ice conditions in the Beaufort Sea, and all testimony from a particular lease sale. See Sections III.C.3.h and i (Subsistence-Harvest Patterns and Sociocultural Systems) for illustrations of how traditional knowledge was incorporated into this EIS and into the design, construction, and operations of the proposed project to minimize potential conflicts with subsistence users. The EIS analysts can search this system to learn such things as:

- what sea-ice issues were raised;
- which people in Kaktovik, for example talked about transportation issues;
- what each person said; and
- what each person's title or affiliation is.

This information captures the traditional perspective about the potential effects of the Liberty Project and other oil and gas development activities on the North Slope. In some instances, the words of individual speakers are incorporated and cited. In other cases, several people shared an observation or concern, which is paraphrased in a single statement and cited.

Traditional Knowledge gathering efforts undertaken specifically for the Liberty Project include: (1) meeting minutes from the 1999 community meetings conducted under the auspices of Environmental Justice (see Appendix B); (2) use of an interim portion of the Inupiat Traditional Knowledge collection study by the Barrow non-profit Ukpeakvik Inupiat Corporation; (3) the Arctic Nearshore Impact Monitoring in Development Area study that includes a task for gathering subsistence whaling Traditional Knowledge from Nuiqsut whalers; and (4) an in-depth assessment and use by MMS analysts of existing Traditional Knowledge sources that include: Traditional Knowledge citations for the Northstar final EIS, the Traditional Knowledge database developed by Dames & Moore for the Northstar Project from MMS hearing transcripts, Native interviews from the North Slope Borough's *Mid-Beaufort Sea Traditional Resource Survey*, Traditional Knowledge from the North Slope Borough document *Cross Island: Inupiat Cultural Continuum*, and Traditional Knowledge gleaned from the North Slope Borough's *Subsistence Harvest Documentation Project Data for Nuiqsut, Alaska* (North Slope Borough, 1997a).

3. Environmental Research

In response to local Inupiat concern, the MMS Environmental Studies Section designed a number of studies to address Native concerns. Ongoing studies include: (1) a bowhead whale feeding study in the Eastern Beaufort Sea that involves the collaboration of Kaktovik whaling captains; (2) the collection of Inupiat Traditional Knowledge into database form by the Barrow nonprofit Ukpeakvik Inupiat Corporation; and (3) the Arctic Nearshore Impact Monitoring in Development Area (ANIMIDA) study that includes a task for gathering subsistence whaling Traditional Knowledge from Nuiqsut whalers. Proposed studies that include Traditional Knowledge are: (1) the *Traditional Knowledge/Western Science Bowhead Whale Migration Seasonal Report* that will summarize activities of Native whalers and Western scientists in the Beaufort Sea in a semiannual newsletter written for the general Inupiat subsistence hunter; and (2) a socioeconomic and cultural change monitoring study on the North Slope. The MMS was asked to assist the North Slope Borough in its Bowhead Whale Census and provided personnel for this effort.

E. ENVIRONMENTAL JUSTICE, INDIAN TRUST RESOURCES, AND GOVERNMENT-TO-GOVERNMENT COORDINATION

Executive Order 12898, Environmental Justice, requires that Federal Agencies identify and address disproportionately high and adverse human health and environmental effects of its actions on minority and low income populations.

To meet the direction of Executive Order (EO) 12898 (*Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations*) and the accompanying memorandum from President Clinton to the heads of all Departments and Agencies, MMS held Environmental Justice Meetings in Barrow, Nuiqsut and Kaktovik. Environmental Justice, as a formal part of the Sociocultural Systems analysis, is discussed in Section III.C.3.i, Effects of Disturbance on Sociocultural Systems. The MMS met with local tribal governments to discuss subsistence issues and the Liberty Project during scoping meetings in the community of Nuiqsut on March 18, 1998, in the community of Barrow on March 19, 1998, in the community of Kaktovik on March 31, 1998. MMS has established a dialogue on environmental justice with these communities, and follow up meetings to address environmental justice issues were held on November 1, 1999, in Barrow; November 2, 1999, in Nuiqsut; and on November 5, 1999, in Kaktovik.

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The environmental justice concerns raised during scoping and from the environmental justice meetings are covered in this EIS in the sections on Subsistence-Harvest Patterns, Sociocultural Systems, and marine mammals (see Sec. III.C.3). The analyses in these sections incorporate Traditional Knowledge of the Inupiat people of the North Slope communities of Barrow, Nuiqsut, and Kaktovik, along with western scientific knowledge. Environmental Justice is discussed in more detail in Appendix B, Part H.

The Department of the Interior and MMS are responsible for ensuring that Indian Trust Resources of federally recognized Indian Tribes and their member that may be affected by these project activities are identified, cared for, and protected (Appendix B, Part G). No significant impacts were identified during the EIS scoping process, including the Environmental Justice meetings, that pertain to this topic. Native allotments in the project are discussed in Section III.C.3.i.

To meet the direction of EO 13084 (*Consultation and Coordination with Indian Tribal Governments*) which states that the U.S. government will continue "to work with Indian tribes on a government-to-government basis to address issues concerning Indian tribal self-government, trust resources, and Indian tribal treaty and other rights," MMS has met with the local tribal governments of Barrow, Nuiqsut, and Kaktovik as well as the Inupiat Community of the Arctic Slope (the recognized regional tribal government) and an important non-governmental Native organization the Alaska Eskimo Whaling Commission. Notes from the 1999 meetings can be seen in Appendix E. These tribal governments were contacted by letter and given the opportunity to participate in the development of this EIS. None of the letters sent received a response; nonetheless, in Liberty meetings held on the North Slope, we have met with these groups to keep them informed of this Proposal, and will continue to do so. Local Inupiat government representatives are members of our Outer Continental Shelf Lease Sale Advisory Committee that meets to discuss and resolve issues that arise from recent lease sales.

F. FORMAT AND STRUCTURE OF THIS EIS

1. Format of this EIS

Section I (this section) of the EIS discusses the reasons this EIS has been developed, describes the roles of the Federal Agencies, presents the Purpose and Need of the project, reviews the Scoping Process, and provides information of the issues, alternatives, and mitigating measures that are carried forward in this EIS. It also provides information about the issues, alternatives, and mitigating measures that were presented in scoping that are not being carried forward for further discussion in this EIS.

Section II of the EIS describes all of the alternatives. The alternatives in this EIS are organized into three options for the decisionmaker:

- Approve the project as submitted.
- Disapprove the project.
- Approve a modified project.

The BPXA Proposal (Alternative I) is described first. The No Action (Alternative II) is next and addresses the second option. Then, to address the third option, five sets of "component alternatives" are described, followed by three “combination alternatives” and the BPXA Proposal. The project elements that are common to all alternatives are not re-described in each section, but the reader needs to remember that all alternatives (both component and combination) are complete projects.

Section III of the EIS discusses the environmental effects of the BPXA Proposal by resource categories. This evaluates the effects of the first decision option mentioned above, “Approve proposal as submitted.” Each resource category -- bowhead whales, eiders, seals, polar bears, air quality, etc are discussed. Each discussion is divided into two parts: effects that are shared or general to all alternatives and effects that are specific to the BPXA Proposal. In format, the first part of the discussion in Section III is a summary of the effects. Subsequent parts address natural resources and the important issues that were raised in the scoping process.

Section IV of the EIS discusses the environmental effects of the alternatives. We start with the No Action Alternative, which analyzes the effects of the second decision option, “disapprove the project.”

We then turn to an assessment of effects of the rest of the alternatives. They are relevant to the third decision option, “approve a modified project.” We look at two groups of alternatives, one called “component alternatives” and the other called “combined alternatives.” These are described here and explained in detail in Section I.H.2 and in Sections II.C and D. In brief, we use the phrases “component,” “component alternative,” and “set of component alternatives” to give them important specific meanings. In describing the Liberty Project and various alternatives, we use the word “component” when referring to one of a few specific project elements. Examples of components are type of slope protection, pipeline design, and gravel mine site.

A “component alternative” is used to identify a specific alternative. Each “component alternative” evaluated in this EIS is a full alternative but focuses on a single project component. Examples of component alternatives are “Use the Kadleroshilik River Mine Site” and “Use the Duck Island Mine Site.” These two component alternatives are grouped together as a “set of component alternatives” called “Alternative Gravel Mine Sites.”

For the “component alternatives,” we first address the effects that are common to all the alternatives in the set and then discusses the effects specific to each “component alternative.”

The description and analysis of “component alternatives” provides the decisionmakers and readers with a good understanding of the impacts that would be expected to occur for the component alternatives in each set. To aid the decisionmakers and readers in understanding how to make tradeoffs in selecting particular combinations of component alternatives, we have developed three “combination alternatives” that we compare to each other and to the BPXA Proposal. The evaluation of the combination alternatives appears in Section IV.D. Together, these four combination alternatives do not reflect any agency’s (or agencies’) preferred alternative or preliminary decision. They are included to provide additional information and understanding.

Section V evaluates the cumulative impacts of the Liberty project (Alternative I). Because of the nature of this development project and because the effects of alternatives are similar to the effects of the Proposal, we do one cumulative evaluation for all alternatives.

Section VI describes the affected environment. Some readers may choose to read Section V before Sections III and IV to learn the basic features of the environment before reading the evaluation of the impacts.

2. Structure of the EIS

The Liberty Development and Production Plan submitted by BPXA (Liberty Plan) sets forth a complicated engineering strategy with many elements or engineering decisions. A very large number of EIS alternatives could be developed for this project if one or more alternatives were devised for each project element. The structure of this EIS was developed around alternatives for those elements that would address the key issues raised about the project during the scoping process. For this EIS alternatives are full alternatives, that is, they include all of the elements of the project. Therefore all of the alternatives in this EIS have many project elements and engineering decisions in common. A summary of some of the project elements common to all alternatives in this EIS follows:

- Construction of an offshore man- made gravel island.
- Gravel would be mined onshore and transported by trucks using ice roads to the island location.
- To the extent possible, construction would occur during the winter.
- The planned construction process would occur over two years.
- The oil would be transported from offshore to the shore via buried pipeline.
- This pipeline would be constructed using conventional construction equipment.
- Most construction and fabrication of the offshore pipeline would occur on work pads on the surface of the ice.
- The LEOS leak detect system would be installed with offshore pipelines.
- In addition to the LEOS system, a pressure point analysis and mass balance leak detection would be installed for leak detection.
- Excess trenching material would be disposed at approved ocean dumping sites.
- The onshore pipeline would be above ground on vertical support members and would be a minimum of 5-foot above ground. Two small gravel pads would be installed:
  - one at the shore crossing and
  - a second at the Badami Pipeline tie-in location.
- The Liberty Prospect would be developed using 23 wells.
- All of the drilling waste material (muds and cuttings) would be re-injected into a disposal well.
- The field would be developed using water flood and gas re-injection to maintain reservoir pressure.
- Production processing facilities and camp facilities would be constructed on the island.
- Natural gas would be used to fuel all activities on the island after the production facilities are constructed and operational on the island.
- Ice roads would be constructed annually during the winter to provide access to the island for construction and operation. During broken ice and open water conditions, helicopters and marine vessels would be used to transport personnel and materials to the island.
- Waste materials from the island would either be re-injected into the disposal well or disposed of at approved sites.
- The same oil-spill-response plan would apply to all alternatives.

To develop the EIS alternatives we turned to the scoping process to identify the important issues about this project. The main issues that emerged from the scoping process were:

1. oil in the environment;
2. noise disturbance to the environment;
3. other effects on physical and biological resources;
4. cumulative effects;
5. effects on subsistence;
6. effects on social and economic systems; and
7. conservation of oil and gas resources.

The alternatives that were developed to address these issues involve five project components. Five sets of “component alternatives” were developed to address the scoping issues:

The first set of component alternatives, **Alternative Drilling and Production Island Locations and Pipeline**

Routes, has *three* potential choices: Use Liberty Island location and Pipeline Route (Alternative I, Liberty Plan); Use Southern Island location and Eastern Pipeline Route (Alternative III.A); and Use Tern Island location and Pipeline Route (Alternative III.B).

The second set of component alternatives, **Alternative Pipeline Designs**, has *four* potential choices: Use Single Walled Steel Pipe (Alternative I, Liberty Plan); Use Steel Pipe-in-Steel Pipe (Alternative IV.A); Use Steel Pipe-in-HDPE (plastic) (Alternative IV.B); and Use Flexible Pipe (Alternative IV.C).

The third set of component alternatives, **Alternative Upper Island Slope Protection Systems**, has *two* potential choices: Use Gravel Bags (Alternative I, Liberty Plan) and Use Steel Sheetpile (Alternative V).

The fourth set of component alternatives, **Alternative Gravel Mine Sites**, has *two* choices: Use Kadleroshilik River Mine (Alternative I, Liberty Plan) and Use Duck Island Gravel Mine (Alternative VI).

The fifth set of component alternatives, **Alternative Pipeline Burial Depths**, has *two* choices: Use a 7-Foot Burial Depth (Alternative I, Liberty Plan) and Use a 15-Foot Trench Depth (Alternative VII).

Decisionmakers pursuing the third decision option ("approve a modified project"), as listed in Section I.F.1, would make on choice from each set of component alternatives. That means there are 96 possible combinations (4 x 3 x 2 x 2 x 2 = 96). The EIS cannot reasonably evaluate all 96 possible combinations that could be chosen. So instead, a two-step process was used to evaluate alternatives.

In the first step, we did a detailed evaluation of each separate component alternative. Each component alternative is a full alternative like the BPXA Proposal in that it includes all elements needed to develop a full project, but it focuses on the one changed component. For example, the Use Duck Island Gravel Mine Alternative (Alternative VI) is like BPXA's Proposal except that the gravel would be extracted from the Duck Island Site instead of the Kadleroshilik River Mine Site. This approach ensures the key concerns and issues identified by commenters would be the focus of our alternative evaluation.

However, this approach resulted in the evaluation of only 8 of the 96 possible combinations of component alternatives, and all of them have only one component that is different from BPXA's Proposal. Further, this approach does not facilitate an evaluation of concurrently selecting multiple component alternatives. As a second step, to ensure evaluation of wider range of alternatives, the Liberty Interagency Team developed three additional alternatives, referred to in the EIS as combination alternatives. These alternatives are full alternatives too, and include all of the elements needed to develop a full project.

These combination alternatives were selected to encompass the entire range of 96 possible alternatives. For example, one of the combination alternatives (Combination Alternative C) has none of the component alternatives included in the BPXA Proposal. So the combination alternatives in this EIS range from the BPXA Proposal to a proposal as different from BPXA's as possible, and includes two other combination alternatives in between. Evaluating a reasonable number of combinations that covers this range allows the decision maker to ultimately select any of those 96 possibilities. (See Question 1b of the Forty Most Asked Questions Concerning the Council on Environmental Quality National Environmental Policy Act Regulations, 46 *Federal Register* 18026 as amended.)

Table I-1 shows the relationship between the "component alternatives" and the "combination alternatives" evaluated in this EIS.

The EIS devotes extensive text to the effects of the component alternatives, but only includes the highlights of the effects of the combination alternatives. Our rationale for this is that the component alternatives are the building blocks for the combination alternatives. With a through understand of the building blocks, the reader or decision maker can more easily review the combination alternatives formulated by the Liberty Interagency Team or use the blocks to construct whatever combination is preferred. We found the effects of the component alternatives are additive, not synergistic. That is, the sum of the parts is not greater, but equal to the whole (see Sec. IV.E). Therefore, the effects of the combination alternatives are simply, the addition of the common and specific effects for each of the individual component alternative to the general effects of developing the Liberty Prospect.

3. Basis for Formulating the Alternatives

a. Liberty Environmental Impact Statement

In considering which of the proposed alternatives (see the Scoping Report in Appendix E) to select, we assessed their technical viability, economic feasibility, and environmental soundness, to ensure they met the Council on Environmental Quality Regulation requirement that it be "reasonable." Numerous other possible alternatives could have been analyzed but candidate alternatives that are uneconomic are not considered to be reasonable because BPXA would never proceed with a project that it expects would cost more than it would earn. Candidate alternatives that do not allow for full or nearly full development of the field or that are technically nonviable also would not be funded. In effect, such alternatives become the same as the No Action Alternative.

This project focuses our analysis on a very small area of the Beaufort Sea and the alternatives evaluated in this EIS reflect the many constraints of a development proposal:

- The resources are located where they were discovered. They cannot be moved to another location that may have fewer environmental effects.
- Extended-reach drilling for this application is limited to a distance of about 4 miles. (See Appendix D-3 for a more thorough analysis.)
- Some activities can be accomplished only during specific seasons in the Arctic; i.e., sealifts can only take place during the summer in open water.

We have studied and evaluated oil and gas leasing, including potential development in the Beaufort Sea in seven lease-sale EIS's. The information developed in these earlier evaluations is reflected in the Stipulations and Mitigating Measures that apply to Lease Y-01650 issued to BPXA for Sale 144. These mitigating measures (see Appendix B) and the MMS Rules and Requirements already have incorporated much of the biological, technical, and traditional knowledge. BPXA built these requirements and mitigating measures into their Plan. For instance, BPXA already is required to meet and coordinate with affected communities and Native organizations and to identify and avoid critical habitat and subsistence activities.

b. Northstar Environmental Impact Statement

The Northstar Final EIS (U.S. Army Corps of Engineers, 1999) discusses and evaluates various technical options available for offshore oil and gas operations in the Beaufort Sea. Section 3.4.2 of the Northstar Final EIS presents a comparison of various factors used by an oil company in the decisionmaking process for preparing a viable proposal. Numerous choices are available to configure technologies and facilities for the various phases of oil and gas activities: seismic surveys; exploration drilling; development/production; oil and gas processing; transportation of produced fluids; and facility decommissioning and abandonment.

As the Northstar EIS shows, one particular set of scenarios would work best in one instance, while another set would be more appropriate in different circumstances. The choices are dictated by environmental conditions at the site, technology available within the timeframe of the project, plus economic considerations and long term goals of the project. Characteristics such as water depth, distance from shore, reservoir depth below the seafloor, reservoir thickness, degree of faulting, reservoir permeability and porosity, and the overall areal extent of the reservoir are important. Selection of drilling and/or production structures and technology is based on the site-specific environmental and geological conditions of the offshore site, the structure of the reservoir, and project economics. In addition, oil recovery and processing methods, options for transportation of product, and relationships between onshore and offshore facilities influence structure design and location. Preparation of a viable proposal is a complicated process in which an oil company must weigh these variables before submitting its Development and Production Plan to the regulatory agencies.

Alternatives for the EIS also must be developed with these same factors in mind if they are to be reasonable and viable. Sections 3.5, 4.2, 4.3 and the first part of 4.4 of the Northstar EIS (U.S. Army Corps of Engineers, 1999) discuss the reasonable development options and the selection of alternatives for the Northstar Project. These sections provide the rationale for including or eliminating options and alternatives related to drilling methods, production structures, and recovery and transportation methods. The Liberty Environmental Report (BPXA, 1998a:Ch. 2) also identifies and discusses a wide range of different development and production concepts and methods that were considered and evaluated by BPXA as they determined the best way to develop this project. These documents adequately evaluate those technologies and methods and present the rationale and reasons for not considering them further. These discussions apply equally to the Liberty Project. Rather than repeat these lengthy evaluations, we recommend interested persons review those documents, which are incorporated by reference in this EIS.

G. SCOPING EFFORTS, ORGANIZATION, AND EIS ISSUES

1. Initial Scoping

In response to our Notice of Intent dated February 17, 1998, we received written comments from the following Federal and State agencies and other groups and individuals:

U.S. Department of Energy
State of Alaska, Division of Governmental Coordination
Greenpeace et al.
U.S. Department of the Interior, Office of the Secretary,
Office of Environmental Policy and Compliance
Alaska Public Campaigns and Media Center
David von den Berg
Petersburg Energy LLC

All written and oral comments from the scoping meetings are included in the Scoping Report and summarized in the following. We received oral comments from representatives from the Alaska Eskimo Whaling Commission, City of Barrow, City of Kaktovik, City of Nuiqsut, North Slope Borough (Office of the Mayor, Planning Commission, Planning Department, and Wildlife Management), Alaska Center for the Environment, Greenpeace, National

Resources Defense Council, and Northern Alaska Environmental Center. Among the key issues identified in scoping were concerns about potential oil spills; oil-spill containment and prevention; disturbances, such as noise and sediment plumes; discharges into the air and water; subsistence harvest and sociocultural disturbances; and cumulative effects. All of the key scoping issues analyzed in this EIS are summarized in Table I-2. See Appendix E for the Scoping Report, which also lists attendees at the meetings.

2. Additional Scoping - Interagency Team Meetings and Information Update Meetings

a. Interagency Team Meetings

The Liberty Interagency Team was created in the spring of 1998 to discuss a broad range of issues related to the development and content of the Liberty EIS. The Liberty Interagency Team has participation from five Federal Agencies (Minerals Management Service, Fish and Wildlife Service, U.S. Army Corp of Engineers, National Marine Fisheries Service, Environmental Protection Agency); two State of Alaska Agencies (State Pipeline Coordinator's Office and the Division of Governmental Coordination), and the North Slope Borough. The Interagency Team met periodically during the EIS preparation process. A description of the various agencies roles and permitting authority is provided in Section I.A. Scoping and EIS alternatives were major issues of discussion for the Liberty Interagency Team.

b. Information Update Meetings

The EIS was put on hold while the Northstar EIS and decision process was being concluded in the first half of 1999. In October and November 1999, we held a series of information update meetings in the same communities where we held scoping meetings in early 1998. The purpose of these meetings was to provide information on the status of the EIS and to gather additional information about environmental issues and concerns. The minutes of those meetings and a list of attendees at the meetings can be found in Appendix E.

The first in this series of Information Update Meetings was held in Fairbanks on October 28, 1999. Twelve persons attended, and those testifying primarily were in support of the project. No new scoping issues were raised.

Meetings on the North Slope took place in Barrow (November 1), Nuiqsut (November 2), and Kaktovik (November 5). The MMS team presented its developing protocol for Environmental Justice and explained that these concerns were handled primarily through scoping and public meetings, subsistence-resource research and data collection, and impact analysis and mitigation developed during the EIS process. Overall, no new scoping issues were identified, but many concerns were raised again that will be addressed in the EIS analyses.

3. Scoping Organization

The MMS organized the information gathered during scoping into three groups: issues, alternatives, and mitigating measures.

Key issues have been grouped in seven groups as noted below. A more detailed list of issues is provided in Table I-2. We use the term "key issues" to mean the most significant issues that were raised during scoping that are relevant and appropriate for evaluation in this EIS. By most significant issues, we mean issues that are of most concern (a) to our constituents as voiced in Liberty scoping and information update meetings and (b) as judged by MMS and Interagency Team experts in the human, marine, and coastal environment. In determining which are the most significant issues, we depended heavily on the results of more than $100 million in MMS-funded environmental and socioeconomic studies applicable to the Alaskan Beaufort Sea region. These key issues are analyzed in the Sections III, IV, V and IX. Some issues (for example, impact assistance) are discussed in the Scoping Report in Appendix E and in Section I.G.4 but are not evaluated further. Another set of issues (for example, project abandonment) are discussed as part of the Proposal (see Secs. II.A and III.D.6), but the effects essentially are the same for all alternatives, and they are not repeated in the alternatives analysis.

Alternatives are briefly mentioned in the Scoping Report and in Section I.H.3. They are described in detail in Sections II.B through D, and they are analyzed in Section IV of the EIS. Other candidate changes to the project, which were not selected as alternatives are discussed and evaluated in the Scoping Report or in Section I.H.5, but they are not carried forward for further evaluation.

Mitigating measures are mentioned in Section I.H. The project already incorporates a considerable amount of mitigation. This involves mitigation that is part of the BPXA Proposal; mitigation that is part of the MMS Lease through stipulation and information to lessees, and other Agency (Federal, State, and North Slope Borough) mitigation that is standard for permits to develop projects on the North Slope of Alaska. Other suggestions for mitigation were made during the scoping process. These are discussed in Sections I.H.7 and 8 but not carried forward for further evaluation.

4. List of Key Scoping Issues and Location of Analysis in this EIS

Table I-2 lists key issues and references applicable sections in the EIS where appropriate information or analyses may be found. The main issues that emerged from the scoping process were:

- Oil in the environment;
- Noise disturbance to the environment;
- Other effects on physical and biological resources;
- Cumulative effects;
- Effects on subsistence; and
- Effects on social and economic systems.

Conservation of offshore oil and gas resources is part of the MMS agency mandate.

The determination of the issues analyzed in this EIS is based on:

- Comments MMS received during the Liberty scoping and information update meetings (Appendix E) and other meetings between North Slope and Borough individuals and organizations and MMS staff.
- The MMS's experience in defining issues from comments (concerns) expressed throughout the EIS process for nine previous OCS oil and gas lease sales in the Beaufort and Chukchi Seas and a Federal oil and gas lease sale in the northeastern part of the National Petroleum Reserve-Alaska.

These comments generally relate to the perceived and/or potential effects oil and gas development activities might have on resources, activities, systems, and programs within and adjacent to the affected area.

The Council on Environmental Quality National Environmental Policy Act regulations emphasize identifying (40 CFR 1501.1(d)), describing (40 CFR 1500.1 and 1502.2(a)) and analyzing (40 CFR 1501.7(2)) significant issues. Identifying, describing, and analyzing significant issues examines both the context and intensity of significance as defined by the Council on Environmental Quality National Environmental Policy Act regulations (40 CFR 1508.27). Context considers where the proposed action would occur, what the affected resources may be, and whether the effects on these resources are local or regional in extent. Intensity considers the level of any potential impacts taking into account such factors as whether the impact is beneficial or adverse, the uniqueness of the resource (for example, threatened or endangered species), the cumulative aspects of the impact, and whether Federal, State, or local laws may be threatened.

5. Other Issues Raised During Scoping

- **Administrative errors or omissions in the Oil Discharge Prevention and Contingency Plan.** Many comments (mainly from the State of Alaska) noted specific errors and omissions in the Oil Discharge Prevention and Contingency Plan. These errors and omissions have been addressed in the revised oil-spill-contingency plan submitted with the revised Plan dated November 9, 1998. These comments were technical or administrative in nature and do not affect the scope or level of the development proposal being analyzed in the EIS.
- **Expanding agreements about whales to cover bearded seals.** The process for MMS lease sale Stipulation 5, Subsistence Whaling and Other Subsistence Activities (which applies to the Liberty lessees), would cover all subsistence marine mammals, not just whales. The National Marine Fisheries Service uses a Letter of Authorization to monitor bearded seals and to authorize incidental take of marine mammals. BPXA would request a Letter of Authorization (or an Incidental Harassment Authorization) from the National Marine Fisheries Service to allow incidental take of bowhead whales and ringed and bearded seals during project construction and operations. The MMS would coordinate and cooperate with the National Marine Fisheries Service on this monitoring.
- **Assessing technical and engineering issues for the proposed pipeline and gravel island.** A number of technical and engineering issues for the proposed pipeline and gravel island design are analyzed in the EIS. However, the detailed pipeline engineering would be verified through MMS and State of Alaska technical review of the pipeline right-of-way applications. The gravel island design would be verified through our Platform Verification program. The pipeline and gravel island would have to meet a separate, very rigorous evaluation and review that considers all engineering aspects of pipeline and gravel island integrity. If these review agencies determine that additional measures are required for environmental protection or design integrity, the application must be modified. In the event that significant design changes do occur and if they significantly could change the type and level of effects evaluated in the EIS, a supplemental National Environmental Policy Act document would be prepared. As described in Section II, the MMS believes there is sufficient information to evaluate reasonable foreseeable adverse environmental effects.
- **Need for air-quality monitoring.** No air-quality monitoring currently is proposed by BPXA for this project. Information on existing air quality is included in BPXA’s Prevention of Significant Deterioration permit application (Part 55) submitted to the Environmental Protection Agency and used in modeling the air quality impacts from proposed plan activities. As described in the (Part 55) permit, there has been long-term monitoring at the Prudhoe Bay Unit, and air-quality monitoring currently is being conducted at the Badami Unit. Final determinations for additional

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monitoring would be determined by EPA at the end of the permit review process.

- **In situ burning.** In situ burning is a response technique in oil-spill-contingency plans for cleaning up and disposing of spilled oil during periods of broken ice when mechanical response is limited. The effects of in situ burning of oil were evaluated in the Beaufort Sea Lease Sale 144 final EIS (USDOI, MMS, 1996a), which is incorporated here by reference. The Regional Response Team has guidelines to evaluate options for situ burning that would be followed by the Federal On-Scene Coordinator before any in situ burning is approved.
- **Climate change and alternative energy sources.** These issues are broad topics and reflect worldwide operations. Analytical tools and techniques that would allow the assessment of the contribution of a single development project, such as Liberty, to the global effects do not exist. Global warming and alternative energy sources are addressed in other MMS programmatic National Environmental Policy Act documents. The most recent documents are *Outer Continental Shelf Oil and Gas Leasing Program: 1997-2002 Final EIS* (USDOI, MMS, Herndon 1996a) and *Energy Alternatives and the Environment* (USDOI, MMS, Herndon, 1996b).
- **Sharing Federal money.** Only Congress can pay out Federal money or pass laws that would allow us to share Federal revenues with local communities. While such "impact assistance" bills have been introduced in Congress, it is not known whether and in what form they would be enacted.

For the reasons noted, these issues are not considered further in this EIS.

H. ALTERNATIVES AND MITIGATING MEASURES ANALYZED IN THIS EIS

The format and structure of the alternatives are discussed in Section I.F. The following text gives a summary description of each alternative.

1. Summary Description of the Liberty Development and Production Plan - Alternative I, the Proposed Action

This is BPXA's proposed action, as described in the Development and Production Plan (Sec. II.A). The MMS is required to analyze the environmental effects of this plan under the Outer Continental Shelf Lands Act.

BPXA proposes to develop the Liberty oil field from a manmade gravel island constructed on the Federal Outer Continental Shelf in Foggy Island Bay (Map 1) The gravel island would be located in water about 22 feet deep and inside the barrier islands. The Liberty Project is about 6 miles off the coast nearly midway between Point Brower to the west and Tigvariak Island to the east. The proposed gravel island would be between the McClure Islands and the coast. The overall project includes the following:

- a manmade offshore gravel island;
- stand-alone processing facilities and associated infrastructure on the island;
- about 6.1 miles of offshore buried oil pipeline and about1.5 miles of onshore elevated pipeline connecting the island facilities to the Badami Pipeline;
- an onshore gravel-mine site at the Kadleroshilik River, used during construction and then rehabilitated; and
- onshore and offshore ice roads.

2. Summary Description of No Action - Alternative II

This alternative addresses the disapproval or withdrawal of BPXA's proposed Plan. Consideration of this alternative is required by the Council on Environmental Quality National Environmental Policy Act Regulations.

3. Component Alternatives

This section describes each component alternative for each of the five sets of component alternatives. (Refer back to Section I.F for an explanation of these alternatives.) Each component alternative is a full alternative and contains all the elements needed for a full project. Each set includes alternatives developed through the scoping process and the BPXA Proposal (Alternative I). Note that each of the following component alternatives is technically viable, economically feasible, and environmentally sound, and allows for a comparative analysis of the significant issues.

a. Summary Description of Alternative Drilling and Production Island Locations and Pipeline Routes

Alternative I - Use Liberty Island Location and Pipeline Route

Alternative III.A - Use Southern Island Location and Eastern Pipeline Route

Alternative III.B - Use Tern Island Location and Pipeline Route

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This set of component alternatives examines different drilling and production island locations and pipeline routes. These alternatives are depicted on Map 1and described in further detail in Section II.C.1.

Alternative I evaluates the Liberty Drilling and Production Island location the 6.1 mile Liberty offshore pipeline route.

Alternative III.A evaluates constructing the island closer to shore to reduce the impacts on bowhead whales. It also evaluates an eastern pipeline route, with a different shore-crossing location. This alternative was developed in response to comments made at the scoping meeting in Barrow.

Alternative III.B evaluates construction of the drilling island at the abandoned Tern Island exploration site and a pipeline route due south. This island location is estimated to have about 238,000 cubic yards of gravel, which would decrease the amount gravel needed to construct the island. It is located about 5.5 miles from shore. It is slightly closer to shore than the Liberty Island location in Alternative I but farther from shore than the Southern Island location in Alternative III.A. This alternative was developed in response to comments made at the scoping meeting and from comments from members of the Interagency Team.

Both alternatives III.A and III.B would use the same shore-crossing location and onshore pipeline.

b. Summary Description of Alternative Pipeline Designs

Alternative I - Use Single Steel Wall Pipe System

Alternative IV.A - Use Pipe-in-Pipe System

Alternative IV.B - Use Pipe-in-HDPE System

Alternative IV.C - Use Flexible Pipe System

This set of component alternatives evaluates constructing the pipeline using four different pipeline designs. Alternative I is the component proposed by BPXA in their Development and Production Plan. Alternative IV.A incorporates a pipe-in-pipe design, where both the inner and outer pipes are made of steel. Alternative IV.B evaluates the project by incorporating an inner steel pipe and an outer plastic pipe made of high-density polyethylene for the pipeline design. Alternative IV.C evaluates the project using a flexible pipeline design. See Section II.C.2 for additional discussion and a more complete description of these alternatives.

c. Summary Description of Alternative Upper Island Slope-Protection Systems

Alternative I - Use Gravel Bags

Alternative V - Use Steel Sheetpile

This set of component alternatives considers the design of the upper slope protection. Alternative I is the component proposed by BPXA in their Development and Production Plan. Alternative V evaluates using steel sheetpile to protect the upper slope of the island instead of gravel bags. This alternative resulted from the scoping meeting in Nuiqsut from knowledge that the Northstar Project was designed and used steel sheetpile. North Slope residents are concerned that gravel bags may threaten navigation and the environment. See Section II.C.3 for additional discussion and a more complete description of these alternatives.

d. Summary Description of Alternative Gravel Mine Sites

Alternative I - Use Kadleroshilik River Mine

Alternative VI - Use Duck Island Gravel Mine

This set of component alternatives analyzes the location of the gravel source. Alternative I is the component proposed by BPXA in their Development and Production Plan. Alternative VI evaluates the project using gravel from the existing Duck Island gravel mine instead of developing a new mine site in the Kadleroshilik River. This alternative resulted from coordination with the Corps of Engineers. See Map 1 for mine site location and Section II.C.4 for additional discussion and a more complete description of these alternatives.

e. Summary Description of Alternative Pipeline Burial Depths

Alternative I - Use a 7-Foot Burial Depth

Alternative VII - Use a 15-Foot Trench Depth

This set of component alternatives analyzes different burial depths of pipeline. Alternative I is the component proposed by BPXA in their Development and Production Plan. Alternative VII evaluates the project digging the offshore pipeline trench deeper (to a maximum depth of 15 feet) and providing a minimal burial depth of 11 feet. During scoping, several persons suggested that the pipeline be buried deeper than what BPXA proposed. The MMS, along with the State Pipeline Coordinator’s Office, will evaluate BPXA’s proposed pipeline design. The trench and burial depth are among the many factors that will be considered. This alternative analyzes all of the environmental effects of excavating a deeper trench and greater burial depth. See Section II.C.5 for additional discussion and a more complete description of these alternatives.

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4. Summary Description of Combination Alternatives

The combination alternatives include three formulated by the Liberty Interagency Team and the BPXA Proposal for comparative purposes. (Refer back to Section I.F for an explanation of these alternatives.) The various components alternatives selected for each of the combination alternatives are as follows:

a. Combination Alternative A

The component alternatives formulated for this alternative are as follows:
- The Liberty Island and Liberty Pipeline Route (Alternative I)
- Steel Pipe-in-Steel Pipe Pipeline Design (Alternative IV.A)
- Steel Sheetpile for Upper Slope Protection (Alternative V)
- The Duck Island Mine Site (Alternative VI)
- A 7-Foot Burial Depth (Alternative I).

b. Combination Alternative B

The component alternatives formulated for this alternative are as follows:
- Gravel Bag for Upper Slope Protection (Alternative I)
- The Kadleroshilik River Mine Site (Alternative I)
- The Southern Island and Eastern Pipeline Route (Alternative III.A)
- Steel Pipe-in-HDPE Pipeline Design (Alternative IV.B)
- The 6-Foot Burial Depth (Alternative IV.B) as designed by for the Steel Pipe-in-HDPE pipeline design.

c. Combination Alternative C

The component alternatives formulated for this alternative are as follows:
- The Tern Island and Tern Pipeline Route (Alternative III.B)
- Steel Pipe-in-Steel Pipe Pipeline Design (Alternative IV.A)
- Steel Sheetpile for Upper Slope Protection (Alternative V)
- The Duck Island Mine Site (Alternative VI
- A 15-foot Trench Depth (Alternative VII).

d. BPXA Proposal (Liberty Development and Production Plan)

The component alternatives in the BPXA Proposal (Alternative I) are as follows:
- The Liberty Island and Liberty Pipeline Route
- Single-Wall Pipeline Design
- Gravel Bags for Upper Slope Protection
- The Kadleroshilik River Mine Site
- A 7-Foot Burial Burial Depth

Additional information for each of the combination alternatives is provided in Section II.D. The relationship between component alternatives and combination alternatives is shown in Table I-1.

5. Other Potential Alternatives

A number of other potential alternatives were identified during scoping, evaluated by BPXA during initial project development, or studied by MMS. We considered these potential alternatives but determined that they were not technically reasonable and/or did not warrant additional analysis to be presented here. The following discussion is the rationale for why a more detailed analysis of these various potential alternatives was not carried further in the EIS. These summaries are based on the following:
- the discussion included in the Scoping Report (Appendix E);
- information provided by BPXA in their Environmental Report (BPXA, 1998a);
- a supplemental assessment of alternatives provided by BPXA dated November 2, 1998;
- the MMS *Assessment of Extended-Reach Drilling Technology to Develop the Liberty Reservoir from Alternative Surface Locations* paper (see Appendix D-3), and
- the MMS *Economic Analysis of the Development Alternatives For the Liberty Prospect, Beaufort Sea, Alaska* (economic paper) (see Appendix D-1).

a. Other Potential Drilling and Production Island Alternatives

By the nature of the oil and gas resources in the Liberty Prospect, alternatives are limited by location and geology. Based on current technology and the drilling and production history of current extended-reach drilling technology, MMS concluded that the maximum reasonable horizontal offset for analyzing alternative drilling locations to develop the Liberty reservoir is about 23,000 feet. All wells drilled from the southern island (Alternative III.A) and Tern Island (Alternative III.B) locations would fall within this offset. In considering potential island alternatives, we looked at developing Liberty from onshore and from a bottomfast-ice location. We found that none of the onshore wells, and only half of the bottomfast-ice location production wells would be within the 23,000 foot offset distance. In addition, directional drilling from onshore and the bottomfast-ice location would drive the costs up beyond the economic threshold (see the following details for these and other island locations).

(1) Develop the Field from an Island Located in the Bottomfast Ice

This potential alternative was suggested by members of the Interagency Team and in a scoping meeting held in Barrow. The potential drilling location is closer to shore and farther away from the bowhead migration route and from the Boulder Patch area. It would be located in about 6 feet of water in bottomfast ice during the winter season. It would require a shorter pipeline with a shorter portion buried under the bottomfast ice. This could reduce the effects of sedimentation associated with trenching. Less gravel would be needed to construct the island.

The bottomfast-ice location is about 4 miles from the proposed Liberty Prospect. Developing the prospect from this location would require extended-reach drilling beyond the demonstrated capability of industry on the North Slope.

Preliminary economic evaluation for this site calculated a positive net present value, but it identified several important issues, including:

- industry ability to drill and maintain the required extended-reach drilling wells,
- effective recovery (conservation) of resources,
- limitations for gas handling/disposal, and
- cost estimates for extended-reach drilling wells beyond demonstrated industry capabilities.

We further evaluated the economics of this potential alternative, drawing on the technical and economic analysis included in two separate papers prepared by MMS geologists and engineers: *Assessment of Extended-Reach Drilling Technology to Develop the Liberty Reservoir from Alternative Surface Locations (Appendix D-3)* and *Economic Analysis of the Development Alternatives For the Liberty Prospect, Beaufort Sea, Alaska* (Appendix D-1) In the following text, we present the highlights of and conclusions we drew from these documents.

(a) Technical Feasibility of Extended-Reach Drilling

The extended-reach drilling paper estimates that the current capability of North Slope extended-reach drilling has a maximum lateral distance of 23,000 feet. However, half of the wells required for the bottomfast-ice drilling location exceed this distance. It is speculative as to whether long extended-reach drilling wells can be drilled, completed, and safely managed from this site.

The paper discusses extended-reach drilling in other settings, both on the North Slope of Alaska and elsewhere. The applicability of extended-reach drilling experience from other fields is questionable, because each new field often encounters a unique set of geologic conditions that affect drilling costs and long-term operations. Key issues noted in the extended-reach drilling paper include:

- No oil field in the world has been developed from the start using only extended-reach drilling wells. Typically, long step-out drilling is justified on a well-by-well basis after the field has begun production from conventionally drilled wells. Decisions by oil and gas companies to fund potential projects are based on known reserves that are developable using proven technology. Projects that are based on speculative resources and unproven technology are rarely funded, because they are too risky.
- Oil fields are developed and start production using conventionally drilled wells. Companies can then use geology and drilling constraint knowledge from those wells to design later extended-reach drilling wells. A learning curve is particularly important to the success of an extended-reach drilling program. Extended-reach drilling wells are far more expensive than conventional wells, and successful development plans must use knowledge from conventional drilling to control costs.
- Extended-reach drilling is used as a development strategy only where it is cost effective. The cost of expensive, long-offset wells is balanced against the cost and delays associated with installing additional platforms for drilling locations. The primary platform for a new field typically is set in the optimal location directly above the subsurface reservoir.
- Extended-reach drilling is a relatively recent technology that has made great advances in the last decade. Record-length extended-reach drilling wells in fields such as Wytch Farm (in the United Kingdom) and Niakuk (Alaska) have been in production for only 5-7 years, and there is no experience with long-term well performance. Consequently, there is no way to judge whether drilling-development strategy for extended-reach drilling would be reliable over the 15-year life of the Liberty Project.
- Companies perform well interventions (or workovers) as standard practice when production rates fall during the life of the field. Without workovers, most wells would have shorter production lives and produce less petroleum. Measured depths of most extended-reach drilling wells place them outside the reach of many conventional intervention tools. Special equipment would have to be designed to perform workovers in long extended-reach drilling wells and their costs and performance are uncertain.

The MMS technical evaluation concludes that 7 of the 14 production wells planned for Liberty would be eliminated if drilled from the bottomfast-ice location, as their lateral drilling distances are greater than 23,000 feet, a distance that extended-reach drilling wells can be drilled, based upon current technology and experience. Assuming equal oil-recovery allocations for each production well locations, the elimination of half the production wells would cut the reserve volume in half (or from 120 million barrels to 60 million barrels). Recovery is reduced further with the elimination of gas-reinjection and water-reinjection wells used for reservoir pressure maintenance. Without pressure maintenance the ultimate recovery from the seven remaining production wells is estimated to be about 30-45 million barrels. (See the extended-reach drilling paper Appendix D-3)

(b) Economic Evaluation

Uncertainties in drilling completion and scheduling affects the economic risk to the project in several ways:

- Drilling problems tend to increase as the drilled distance and the departure ratio increase.
- Increases in drilling time slow the development of the field, both stretching out the production profile and lowering its peak rate. Scheduling changes could affect the cash flow economics of the alternatives using extended-reach drilling wells.
- All of the required wells from this location exceed current extended-reach drilling wells on the North Slope, and it is speculative as to whether or not the required wells can be drilled and effectively managed.
- Little data are available for recent extended-reach drilling well costs and, even if available, these data may not be particularly relevant because drilling conditions are often unique to each area. Well costs for extended-reach drilling could be much higher than those projected in the MMS economic model, because no extended-reach drilling wells have been drilled to these distances on the North Slope.
- A prudent investor would use higher drilling costs or higher discount rates to hedge this uncertainty. However, published data on extended-reach drilling wells is limited, and little real data are available to validate the cost estimates used in the Discounted Cash Flow analysis. Most articles published about new technologies tend to present successful activities. Detailed descriptions of problems or failures in drilling and field performance are not exposed. Individual companies also are faced with a limited database for extended-reach drilling, because the technology is relatively new.

We have determined the best way to incorporate risk into the economic model is to adjust the discount rate upward. The added “risk premium” provides a hedge against the many uncertainties associated with extended-reach drilling.

For consistency, the preliminary MMS economic analysis used a constant discount rate for all alternatives evaluated (See Appendix D-1). However, that approach fails to incorporate the higher risks and costs noted previously. The economic analysis was refined to use a higher discount rate for extended-reach drilling wells. It also removes gas production, both costs and sales, from the model to reflect the recent decision by BPXA to eliminate natural gas production from the Liberty Project. This economic analysis shows negative value for the project (-$8.09 million). This negative economic value would be even higher, if the reduction in recoverable resources noted in the following text were included into the economic model.

(c) Conservation of Resource Issues

Seven of the 14 production wells planned for Liberty would be eliminated, as their lateral drilling distances are greater than 23,000 feet. Assuming equal oil-recovery allocations for each production well locations, the elimination of half the production wells would cut the reserve volume in half (from 120 million barrels to 60 million barrels). Recovery is reduced further with the elimination of gas reinjection and reduced reinjection of water to about 30-45 million barrels.

The bottomfast-ice location would eliminate both planned gas-injection wells and two of the six water-injection wells. This would adversely affect the reservoir management program. Without the reinjection of gas and with only partial reinjection of water, the recovery efficiency would be reduced. Therefore, the oil production at the Liberty Prospect would be lower. Estimating the precise reduction in recovery efficiency is difficult without more extensive detailed evaluation of the reservoir characteristics. However, a reasonable estimate would be a reduction of 25-50% for the remaining seven production wells. This translates to an ultimate recovery of only 30-45 million barrels, compared to the expected recovery of 120 million barrels in the original Liberty development plan.

The reduction of recoverable reserves creates a “conservation of resource” issue. One of the primary responsibilities of MMS is to monitor production activities to ensure that oil and gas reservoirs are developed in a responsible manner. This regulatory responsibility is set by both Agency policies and Federal rules (30 CFR 250.1101). Approving a development plan that knowingly leaves behind over half of the producible resources would be counter to these directives. We draw the reasonable conclusion that the bottomfast site would violate “conservation of resources” principles.

(d) Natural Gas Handling and Disposal Issues

All gas-injection wells would be eliminated under the assumption that drilling from the bottomfast site would be restricted to lateral distances of 23,000 feet or less. In fact, the bottomhole locations for gas injection wells are among the longest wells from the bottomfast site (25,960 and 24,260 feet lateral distances). Gas-injection wells serve a dual purpose; first, they are a primary component in the reservoir pressure-maintenance strategy; second, they are used to safely dispose of a product that does not have current marketability.

Gas handling issues include the following:

- Large amounts of natural gas would be recovered during oil production (as "bubble-out" or associated/dissolved gas). The production rates for the project would be restricted to the capability of the production facility to handle and disposal of the gas.
- Without a market for gas, gas disposal becomes a serious consideration. Historically, the majority of gas production from all North Slope fields has been reinjected and small amounts are used as fuel for field operations. First, it is unlikely that a buyer for this gas can be found on the North Slope. Secondly, the gas delivery costs may not be offset by income from gas sales.
- Without the options of off-unit gas sales or gas reinjection, gas flaring becomes the next option. However, air quality restrictions are not likely to be ignored for the bottomfast site. But gas flaring is also counter to MMS's requirement to conserve resources.

Considering realistic scenarios, gas disposal options are very limited for this location. Added costs for new gas pipelines or expenses associated with gas handling or disposal in other North Slope fields would further decrease the viability of the alternative. The option of gas flaring conflicts with the current policies of the MMS and the Environmental Protection Agency.

(e) Conclusion

This bottomfast alternative is neither technically or economically feasible and it would create an unreasonable conservation of resources issue.

(2) Develop the Field from Onshore

This potential alternative would require constructing facilities onshore. Less gravel mining would be necessary to construct the development facility. This potential alternative would eliminate or reduce potential effects to the marine environment. There would be no offshore pipeline or drilling location. Onshore development would result in some habitat loss due to the construction of development pads.

However, this location is farther away from the Liberty Prospect, and it would require greater extended-reach drilling well distances than described and evaluated for the bottomfast drilling location above. All of the extended-reach drilling technical and economic issues evaluated in (2) above apply to this location. Additional analysis is provided in the extended-reach drilling and economic papers in Appendix D.

For the same reasons stated in (2) above, only two production wells could be reached from the onshore location. Therefore, we determined that the Liberty Prospect could not be developed from onshore. Drilling from onshore makes the project uneconomic with a negative value of over (-$36 million). The onshore location has the same resource conservation concerns as the bottomfast ice location above.

(3) Construct Satellite Facilities

This potential alternative would involve the construction of additional gravel island(s) to develop reserves that cannot be developed from the Liberty Island location. This presumes that there are additional proven reserves that cannot be developed from the Liberty site. This is not the case. As such, is it not an alternative to BPXA's proposed Liberty Project but would be a new and expanded proposal.

BPXA selected the proposed Liberty Island location to efficiently produce the targeted Liberty reservoir. Other potential oil-bearing formations are present but have not been demonstrated or proven economical to develop. The Liberty Plan provides for further appraisal of other potential reserves. The Plan acknowledges that if additional reserves are proven, they can be developed from the Liberty site without new or expanded facilities, but that they would extend the operating life of the project.

Our prelease resource evaluation of the Liberty Prospect concluded that a single production island was the only economically viable alternative. Independent of the environmental effects of the island location, BPXA's proposed island location also is consistent with our assessment of the best location for developing the targeted Liberty reservoir and other potential reserves.

Construction of additional islands, therefore, is unnecessary. It would result in adverse additional environmental effects that would multiply the effects from gravel mining, island construction, and additional pipeline construction from the Proposal.

(4) Use a Caisson-Retained Island

There are several types of caisson-retained islands, which are described in the Northstar Final EIS (U.S. Army Corps of Engineers, 1999:Ch. 3). For the remainder of this section, a caisson-retained island is defined as a hollow concrete or steel ring that is placed on the seafloor or on a berm and filled with sand and/or gravel. Installation of a caisson-retained island would require dredging of the seafloor and constructing a berm on which to place the caisson. The principal advantage of a caisson-retained island is that it would require less gravel to construct than a conventional gravel island with a comparable-sized working surface. This has been particularly important when fill material has been unavailable, unsuitable, or haul distances are long. Although the amount of gravel required would be reduced for a caisson-retained island it would still require a significant amount of gravel to construct the gravel berm and to fill the caisson. The environmental effects of mining gravel to build a berm and fill a caisson would be similar to those of constructing a conventional gravel island.

None of the caisson-retained islands were originally designed for long-term development. Caisson-retained islands have experienced some integrity and safety problems during their use for exploratory drilling in the Beaufort Sea, such as sediment washout and wave overtopping.

The Molikpaq has been modified for use as a production facility for development offshore of Sakhalin Island. A caisson-retained island for Liberty would require either construction of a new caisson or significant modification to an existing one. The Tarsiut caisson-retained island has been described in Chapter 3 of the Northstar Final EIS and would require extensive modification for use as a long term development/production platform. The Northstar EIS estimated modification costs for the Molikpaq to be between $85 and $112 million. Modifications to the Tarsiut or construction of a new caisson-retained island would be much greater. Finally it is noted in the Northstar Final EIS that maintenance requirements for a caisson-retained island are unknown (U.S. Army Corps of Engineers, 1999).

The MMS concludes that while a caisson-retained island could reduce the total volume of gravel compared to a conventional gravel island, there is not sufficient information to indicate that a caisson-retained island is an equivalent or superior production platform to a conventional gravel island and it is not economically reasonable.

b. Other Potential Pipeline and Processing Alternatives

We considered the following potential alternatives:

(1) Construct a Pipeline West to Endicott and Use Liberty Island Processing Facilities

This was a suggestion from some members of the Interagency Team. It eliminates the need for any new onshore pipelines and gravel pads. It also eliminates the need for a new shore-crossing location in undisturbed tundra.

The pipeline would run from the proposed island location to the Endicott satellite drilling island using one of two general routes. One route (northern Endicott route) would go about straight west from the Liberty field through the southern portion of the Boulder Patch area. It generally is in water depths of about 10 feet or more. The second route (Southern Endicott Route) is south of the first route and would be routed to avoid any trenching through the Boulder Patch area. It would be shoreward of the Boulder Patch in shallower water, with about half of the route in water depths of 6-8 feet. This route would be much closer to shore where strudel scour is more prominent. See Sections I.H.5.b(7)(b) and II.C.5.a for a description and explanation of strudel scour. We could not identify a route to Endicott that avoided both the strudel scour areas and the Boulder Patch area.

The pipeline could be installed using the same techniques as those identified in the Plan. Both routes would allow for the transition from offshore to onshore at the satellite drilling island, which is a manmade gravel structure. Both routes would eliminate the need for constructing any new onshore pipelines, because they would connect to the Endicott pipeline system at the causeway. Permafrost can penetrate manmade gravel islands, and this potential alternative still would require the pipeline design to accommodate some pipeline settling and strain, although it is likely less than either the BPXA proposed route or the eastern pipeline route. The MMS economic model indicates that this potential alternative would provide some economic benefits and would increase the economic returns to both the Government and BPXA (see Economic Paper, Appendix D-1).

When the river ice starts to melt each spring, water from the rivers floods over the sea ice, penetrating and funneling through the sea ice and scours the sediments on the sea floor. This strudel scour can adversely affect pipelines. Within the Foggy Island Bay area, the area off of the mouths of the Sagavanirktok River (generally west of the Liberty Prospect) are at a much greater risk to strudel scour than those to the south of the Liberty Prospect. The southern Endicott route would have the highest risk of strudel scour, because it would be routing the pipeline to cross the area right in front of the Sagavanirktok River in water depths of 5-7 feet for a distance of more than a mile and a half. The Northern Endicott Route would be farther away from mouths of the Sagavanirktok River, but the river water still floods and travels over the ice above this proposed route. Both of these routes require the pipelines to run parallel to the shoreline and to the mouth of the Sagavanirktok River. The BPXA-proposed and eastern pipeline routes are designed so the pipelines are routed perpendicular to the shoreline. They also are located between mouths of rivers where strudel scour is less likely to occur.

The mouth of the Sagavanirktok River is a more important wildlife (primarily birds and fish) use area than either of the alternative shore crossing. Locating a pipeline across the mouth of the Sagavanirktok River could increase the risks to the birds and fish that live or feed in the mouth of the river. The southern Endicott route has a much higher occurrence of strudel scour than any of the other alternative pipeline routes. The proposed onshore pipeline would be constructed to the established standard for aboveground pipelines on the North Slope. Our analysis of onshore effects from the pipeline has not identified significant impacts.

The additional risk from strudel scour for the Southern Endicott Route outweigh any potential benefits; therefore, this potential route alternative will not be considered any further.

The northern Endicott route would stay farther offshore. Strudel scour in this area is considerably less than for the southern Endicott route but may be greater than that associated with the BPXA Proposal or eastern pipeline routes, because it runs parallel to the shoreline and river mouth for a much greater distance. There have been some strudel scour events near the Endicott causeway.

The Boulder Patch, a unique area of bottom growth, is classified by the amount of the surface covered by boulders. One type is where boulders cover more than 25% of the area. The second type is where boulders cover between 10% and 25% of the area. We estimate that a pipeline to Endicott would have about 1.2 miles in the area of 25% boulder cover, and 3.3 miles in areas of 10-25% boulder cover. We assumed a trenching depth of 9 feet, with a 4-1 slope. We calculated the aerial extent disturbed as follows:

- 25% or more boulder coverage =11-13 acres
- 10-25% boulder coverage = 32-34 acres
- Total boulder patch area disturbed = 43-47 acres

Even though this is a small percent of the total area of the Boulder Patch, the potential adverse environmental costs is not warranted. Therefore, the Northern Endicott Route will not be considered further as an EIS alternative, because it is not environmentally sound.

(2) Construct a Pipeline West to Endicott and Use Endicott Processing Facilities

This potential alternative would have the same pipeline routes as in (1) above, and, for the same reasons, is not considered as environmentally sound as the Proposal and does not warrant further analysis. In addition to the environmental concerns stated above, the flow through the pipeline would be three-phase (the simultaneous flow of crude oil, gas, and water through a single pipeline), and leak detection for this flow is more difficult.

(3) Run a Pipeline Southeast to Badami and Use Badami as a Central Processing Unit

BPXA noted in their Environmental Report (BPXA, 1998a) that this alternative would require the transport of three-phase fluids to the Badami CPU. The pipeline length would be approximately 16 miles and would need to cross the Shaviovik River (BPXA, 1998a). The flow through the pipeline would be three-phase (see above), and leak detection for this flow is more difficult than for processed oil. The pipeline would also need to traverse a larger area with increased potential strudel scour. (BPXA, 1998a) This potential alternative is dropped from further consideration because of the increased risk to the pipeline associated with the three phased flow, the increased strudel scour, and need for a river crossing.

(4) Construct a 300-Foot Gravel Jetty and Island at the Shore Crossing to Avoid Trenching at the Shore Crossing

This was proposed by members of the Interagency Team as a possible way to reduce the potential pipeline stress due to thaw settlement. When the pipeline starts operating and the warm oil flows through the pipeline, a thaw bulb would develop around the pipe and if thaw-unstable permafrost is melted the pipe would settle. The pipeline would be designed to accommodate the expected amount of settling. This potential alternative would reduce or eliminate concerns for thaw settlement of a trenched pipeline by constructing a gravel jetty at the shore crossing location. The offshore pipeline would transition to aboveground offshore and outside of the permafrost zone. The jetty would need to protrude into Foggy Island Bay a minimum of 300 feet from the shoreline to avoid the permafrost zone. We estimate this would require between 50,000 and 70,000 cubic yards of gravel to construct; also, the island would need concrete matting or additional gravels bags to provide structural protection from ice and wave forces, such as at the Endicott causeway.

(a) Background Information About Thaw Settlement

Thaw settlement occurs in some permafrost when the ice is melted. This causes the soil, and whatever is placed on or in the soil, to sink. If the amount of thaw settlement is consistent along the entire pipeline, the pipeline would settle uniformly and thaw settlement does not create a problem.

Differential thaw settlement occurs when one area of the pipeline settles at a different rate than the adjacent area. When this occurs, the section of pipeline where the soil has settled the most is no longer supported from underneath. The pipeline in the subsided area now must bear the weight of the pipeline and the overlying soil. The pipeline may bend into the space created by the soil settlement, which creates a strain in the pipeline wall.

(b) Analysis of Liberty Shore Crossing

Two proposed pipeline shore crossings currently are under consideration in the EIS, one for the proposed Liberty Pipeline Route and another for the Eastern Pipeline Route. (See Map 1) Geotechnical borings and analyses along the proposed Liberty pipeline route indicate the presence of ice-bonded, potentially thaw-unstable, permafrost to a distance of about 300 feet offshore.

Fieldwork was performed by Duane Miller & Associates and laboratory and modeling work performed by Nixon Geotech Ltd. for the proposed island location and pipeline routes in 1997 and 1998. This work indicates that thaw-stable material is encountered within 15 feet of the surface and the maximum amount of thaw-settlement expected is 1 foot, both on and offshore. For design purposes a maximum differential thaw-settlement of 1 foot is assumed, this assumes that an area of no settlement is adjacent to an area of maximum settlement. All four of the pipeline designs evaluated in this EIS are designed to safely handle the 1-foot maximum differential thaw settlement expected.

Saltwater incursion into the pipeline trench would increase the rate of thaw and the size of the thaw bulb surrounding the pipeline. However, modeling indicates that the thaw bulb, without saltwater incursion, would extend beyond the depth at which thaw-stable material is encountered, therefore increasing the depth of the thaw bulb due to saltwater incursion would not significantly affect the total amount of thaw-settlement.

During construction, the shore-crossing area would be monitored during excavation and any ice lenses or other problem areas can be identified as they are being trenched. When and if such an area is identified, corrective measures could be taken. These measures could include over excavating the pipeline trench and backfilling with thaw-stable gravel material before installing the pipeline.

After the pipeline is installed, pigs would be run as necessary to ensure the design criteria is being complied with. From these pig runs, the U.S. Department of Transportation, the MMS, the State Pipeline Coordinator's Office, and BPXA would be able to estimate the amount of strain developing in the pipeline. Because thaw settlement is a gradual process that occurs over the life of the project, the pig runs would detect cumulative settlement that exceeds the design criteria. If the pigging process detected a problem with thaw settlement, remedial action would be required. This action could include more frequent pigging, a reduction in the maximum allowable flowrate, or excavation and repair of the problem area.

(c) Comparison of Gravel Requirements

Bore tests indicate the thaw stable soils begin at depths of 10-15 feet below the seafloor. For purposes of analysis, if the trench were excavated to a depth of 15 feet and the bottom 7 feet of the trench backfilled with select gravel, the maximum gravel needed would be less than 2,000 cubic yards, which is considerably less than the 50,000-70,000 cubic yards of the gravel needed for the jetty.

The jetty could change the flow of the current nearshore and could result in changes to the water quality. We do not consider this alternative to be environmentally sound.

(5) Use Horizontal Directional Drilling through the Shore-Crossing Transition Zone Rather than Trenching

Horizontal directional drilling was proposed as a way to reduce the amount of surface disturbance and to reduce or eliminate potential oil spills from thaw settlement. The information and analysis provided about thaw settling and the stability of the soil at the shoreline crossing in (4) above also apply to this alternative. In fact, the MMS believes that trenching the pipeline allows for better assessment of the soils encountered along the pipeline route, than does horizontal directional drilling. Any unstable soils encountered during trenching can be excavated and replaced with thaw-stable gravel. With horizontal directional drilling, unstable soils could not be replaced and differential settling could result.

The coastline in this area is eroding naturally and likely would continue to erode through the life of the project. Directional drilling would not prevent natural erosion; neither is stopping erosion necessarily preferable. The proposed shore crossing is intended to accommodate the natural erosion rate at the shoreline without compromising the integrity of the pipeline.

For directional drilling to be feasible, certain geotechnical conditions and design criteria must be met. Directional drilling likely would add to the alignment problem encountered, especially offshore. Pipeline alignment in the BPXA-proposed design would be much easier. Also, the proposed open-trench construction would allow thaw-stable select gravel backfill materials to be used. Pipeline settlement and stress is anticipated, and using thaw-stable materials where needed in the trench would reduce and control the potential for differential settling much better than directional drilling We believe that further pursuit of this suggestion is not warranted, because it is not as technically sound as the Proposal.

(6) Add More Remote Sensing in the Middle of the Pipeline and at Each End

Collecting midpoint data would provide an additional set of data to verify pipeline conditions. Calibration and maintenance of the midpoint remote-sensing site would be difficult, as the instruments would have to be in a subsea vault. Adding a communications cable to the pipeline bundle to transmit information from the midpoint of the pipeline to the island would be relatively simple. Placing instrumentation through the pipeline wall midpoint would increase the risk of a leak. For a 7.6-mile long pipeline, the extra sensors would contribute little more information about pipeline integrity than could be obtained at the endpoints of the pipeline. With so little information gain and the increased risks of a leak, this proposed alternative is not as environmentally sound as the Proposal. The Leak Detection and Location System (LEOS) runs the whole length of the offshore pipeline and collects data on a daily basis. With LEOS as part of the project, adding additional mass balance and pressure point analysis sensors at the pipeline midpoint would not increase the overall leak detection threshold; therefore, we see no advantage of carrying this suggestion forward. See Section II.A.1.b(3)(b) for a description of the LEOS system.

(7) Vary the Offshore Trench Depth of the Pipeline

This potential alternative was suggested by members of the Interagency Team. They suggest the pipeline burial depth be varied along the route based on ice gouging and strudel scour risks. This could possibly reduce potential effects from sediment during construction.

However, the minimum required pipeline trench and burial depth depends on three different forces: ice gouging, strudel scour, and upheaval buckling. Each of these factors requires a different depth of cover to ensure pipeline integrity. The force that requires the deepest burial depth should determine the minimum required depth of cover. This EIS evaluates four different pipeline designs (single wall steel pipe, pipe-in-pipe, pipe-in-HDPE, and flexible pipe) and each pipeline design has a different burial depth unique to that pipeline in relationship to ice gouging, strudel scour, and upheaval buckling.

(a) Ice Gouging

Minor ice gouging occurs in Foggy Island Bay. First-year sea ice is present in the area. Multiyear ice is obstructed from entering Foggy Island Bay by the barrier islands and shoals to the north of the Liberty project. Although no ice gouging was observed in the bottomfast-ice area (from shore to about 6-8 feet of water depth), ice-gouging likely occurs in this area but evidence is quickly erased due to wave and current action in this shallow water. Side-scan sonar was used to identify ice gouging in the project area. The deepest ice gouges were determined to be less than 2 feet. For pipeline design purposes, a 3-foot deep ice gouge was selected. However, other design criteria, i.e., upheaval buckling, require a deeper pipeline burial depth. The minimum depth below the original sea floor for the four alternatives ranges from 5-7 feet. (INTEC, 2000). As burial depth increases, there is a decreased risk of an ice keel contacting the pipeline and decreased stresses applied to the pipeline from soil displacement associated with a no-impact ice-gouge event. It is unlikely that a non-impact ice-gouging event would cause the pipeline to leak oil to the environment. More likely, a no-impact ice-gouge event would cause the pipeline to be displaced more than anticipated or to buckle but not leak. A no-impact ice-gouge event is where an ice keel passes over the pipeline but does not come into direct contact with the pipeline. Due to soil displacement beneath the ice keel, stresses would be applied to the pipeline that might cause the pipeline to move. No-impact ice-gouge events could cause a leak if a series of other unlikely events were to simultaneously occur. For example if an ice keel passed directly over a weld on the pipeline and that weld contained the maximum allowable size of welding defect and that defect was oriented on the pipe at the point of greatest strain, a leak might occur.

(b) Strudel Scour

Strudel scour generally occurs out to a water depth of approximately 10 feet. As with ice gouging, protection from strudel scour increases with burial depth. Strudel scours occur when rivers overflood the sea ice close to the river deltas during breakup. This overflooding drains through the holes in the ice into the seawater below. The force of the water flowing through these holes can be high enough to scour the seafloor. The size and shape of the scour depends on the size and shape of the hole or crack in the ice, water depth, overflood depth, and seabed soil type. Within Foggy Island Bay, the heaviest concentration of strudel scour is just past the bottomfast-ice zone in front of the mouths of the Sagavanirktok and Kadleroshilik rivers.

Strudel-scour surveys in the Sagavanirktok River Delta were conducted during the summers of 1981 and 1982 and during the Liberty Project site-specific surveys conducted in 1997 and 1998. The evaluation of these studies showed that scour densities in the vicinity of the Liberty pipeline were very low. The pipeline would be designed to accommodate the stresses that are expected to occur from strudel scouring.

For strudel scour to pose a threat to pipeline integrity, it must occur directly over the pipeline and be deep enough to cause the soil beneath the pipeline to be removed. BPXA annually would monitor strudel scour events and backfill any strudel scours that occur over the pipeline. Winter-access ice roads in the vicinity of the pipeline would be managed so they do not contribute to strudel scours forming near the pipeline. As a contingency, the location of strudel scours also can be managed by drilling holes in the ice to let the water drain in a location away from the pipelines.

(c) Upheaval Buckling

Upheaval buckling of pipelines is the instability of a pipe that results from excessive axial compressive force in the pipe. If there is not enough vertical downward force on the pipe to resist the instability, then vertical motion of the pipe occurs. Once an upheaval buckle begins and the pipeline starts to move upwards out of the trench, the axial force is relieved. As the pipeline continues to expand, it would feed into the buckle. The axial force comes from the thermal expansion of the pipeline from about 28 degrees Fahrenheit during installation to about 150 degrees Fahrenheit during operations.

Another way to deal with upheaval buckling would be to place other heavier material on the pipeline, such as large gravel bags, large cement blocks, etc.

For the pipeline designs being considered in this EIS, the single-wall pipeline requires the greatest amount of overburden to prevent upheaval buckling. This would require gravel mats at the high points along the pipeline and a minimum of 5 additional feet of native soil. The pipe-in-pipe system would require a minimum of 2 feet of native backfill to prevent upheaval buckling. The pipe-in-HDPE system would require 6 feet of native backfill to prevent upheaval buckling. For the flexible pipe system, it is estimated that 4 feet of native backfill would prevent upheaval buckling.

(d) Minimal Burial Depth for Liberty Pipeline Designs

For the single-wall pipe system, with a minimum burial depth of 7 feet, upheaval buckling is the controlling factor. For the pipe-in-pipe system, with a minimum burial depth of 5 feet, ice gouging is the controlling factor. For the pipe-in-HDPE system, with a minimum burial depth of 6 feet, upheaval buckling is the controlling factor. For the flexible pipe system, with a minimum burial depth of 5 feet, ice gouging is the controlling factor. All four pipeline designs already have been optimized for burial depth based on what factor requires the greatest amount of backfill to ensure structural integrity.

(e) Conclusion

The entire pipeline route is subject to ice-gouging and/or strudel-scour. If there is an area where the pipeline could be buried shallower, it might be from shoreline through the bottomfast ice zone.

Varying pipeline burial depth is not beneficial, because the pipelines already are optimized for a burial depth that provides adequate protection. For the single-wall pipeline and the pipe-in-HDPE systems, the minimum burial depth is governed by upheaval buckling and must be maintained along the entire pipeline route. For the other alternatives, pipeline burial depth is governed by ice gouging and potentially could be reduced in the shallower areas nearshore. However, the environmental benefits of this shallower burial depth, in terms of less sediment disturbance due to the shallower trench, would be minor and pipeline integrity would not be improved. Overall, this suggestion is not as environmentally sound as the Proposal.

(8) Use Horizontal Directional Drilling from a Series of Islands

Complex engineering and the costs make this potential alternative so expensive as to make it equivalent to the No Action Alternative. It would require about six satellite island sites large enough to house a horizontal drilling rig and support equipment. Environmental disturbance at multiple sites makes this alternative undesirable. The suggested is not environmentally sound or economically viable and is dropped from further consideration.

(9) Change Pipeline Steel Grade

Different steel grades would have slightly different performance characteristics. Changing steel grade would not significantly affect pipeline safety or the installation process. Therefore any difference in environmental impacts, compared to the pipeline designs already being analyzed, would be negligible. During final engineering design the pipeline design would be thoroughly analyzed and if necessary the pipeline steel grade would be changed to provide optimal performance. This option is dropped from further consideration due to the negligible difference in environmental impacts.

(10) Change Pipeline Wall Thickness

Varying pipeline wall thickness would have minor effects on a pipeline’s performance characteristics. Increasing wall thickness would increase the pipeline’s weight and therefore make it more resistant to upheaval buckling, however certain pipeline inspection tool’s effectiveness decreases as wall thickness increases. Varying pipeline wall thickness would have minor affects on the pipeline’s safety and therefore would not have a significant effect on the pipeline’s leak probability. Varying the pipeline wall thickness could effect pipeline burial depth, but the effects of varying the burial depth are addressed elsewhere in this EIS. During final engineering design the pipeline design would be thoroughly analyzed and if necessary the pipeline wall thickness would be changed to provide optimal performance. This option is dropped from further consideration since the environmental impacts are expected to be within the range of those analyzed for other alternatives.

(11) Use of the Suction-Cutter Dredge as Primary Trenching Tool

BPXA’s Proposal includes the use of a backhoe for the majority of the trench construction. BPXA has proposed to use a suction-cutter dredge to smooth the bottom of the trench before laying the pipeline. BPXA has estimated that no more than 10% of the total material dredged would be from cleanup activities using the suction-cutter dredge. During planning for the Northstar development, BPXA proposed using the suction-cutter dredge as an alternative primary trenching technique for pipeline trench construction. The stated advantages of the suction-cutter dredge were that it could potentially trench at a faster rate and possibly reduce water-quality effects (total suspended sediments) compared to the backhoe at the excavation site. Although BPXA eventually elected not to use a suction-cutter dredge for Northstar, the implications of this technology to reduce potential environmental effects warranted further assessment.

Various types of dredges have been used successfully in the Canadian Arctic for island construction and harbor creation. These include both cutter-head and trailing dredges using floating pipelines or hopper barges for transporting the dredged material. These dredges are designed to move large amounts of material from one location to another during open water or in minimum ice conditions. Experience using these dredges for trench construction in winter in a slotted trench is nonexistent. Modification of this technology however, led to the design of the dredge proposed for use at Northstar.

The main concern related to any excavation on the seafloor is the impact of the sedimentation caused by the movement of the excavated material through the water column. The relative effects of various types of dredges on sedimentation have received considerable analysis by the Corps of

Engineers. The Corps of Engineers has modeled both plume behavior and sediment distribution. BPXA also has conducted some plume modeling, which assumes maximum concentrations of particulate matter for comparative analysis. While these concentrations appear conservative for assessment purposes, there are limited site-specific data about the sediments along the length of the proposed pipeline trench route, which may require future validation.

The suction-cutter dredge is a hydraulic suction pipeline with dual rotating cutter head attached to the suction intake to mechanically assist in the dredging of consolidated materials. Mechanical mixing by the rotating cutter heads is a major factor in sediment resuspension by this type of dredge. Several factors affect the amount of resuspension by this type of dredge. These include the material to be removed as well as the design of the dredge and its operational factors. Because this type of dredge works by breaking up the sediments, it creates the potential of making more of the removed material available for suspension. The presence of fine sediments can increase the turbidity cloud when using a cutter head dredge (see U.S. Army Corps of Engineers, 1983). The intake velocity of the suction mouth must be sufficient to remove all of the material excavated by the cutter-head blades, or that excess would enter the water column. In addition, the depth of the cut and the speed at which the activity takes place also can contribute to excessive suspension (U.S. Army Corps of Engineers, 1988). Sediment resuspension by cutter head dredges is chiefly in the lower portion of the water column (U.S. Army Corps of Engineers, 1983).

Using the proposed type of dredge would require that sufficient water is available to provide for hydraulic transport of the excavated material. This may limit the use of the dredge in bottomfast ice, unless provisions are made to ensure that sufficient water is made available. The introduction of additional water to the trench may increase the slump from the trench sides, thereby increasing the amount of material to be removed to reach the design depth.

For Liberty, two options are available for disposal of the trenched material. The material could be either sidecast to the edge of the trench limit or brought to the surface for disposal.

The design proposed for testing during the Northstar trenching activity called for excavated material to be side cast next to the trench through a horizontal discharge pipe (DA Permit O-950372, Beaufort Sea 441). Two items must be considered when discussing this option. The first is the turbidity created when the material is deposited to the side of the trench. This material would consist of a noncohesive slurry created during the excavation process. This material would be deposited as described in U.S. Army Corps of Engineers (1983) as a mound with the gravels and sands forming the high portion of the mound and the fines being carried downcurrent to some distance based on the size of the material. This mound would need to be sufficiently distant from the trench to prevent slumping of the material into the trench or causing the trench walls to collapse into the trench. Based on the excavation limits detailed in the Development and Production Plan, this distance would need to be in excess of 40 feet from the trench centerline. This may preclude having this material available for backfill into the trench after pipeline placement. Also, this option is available only where sufficient water depth is available to provide clearance for the discharge pipe that would extend approximately 10 feet above and horizontal to the seafloor before the start of excavation. With a projected ice thickness of 8 feet, this method would require water depths greater than 18 feet to allow for sidecasting the material. This water depth is available for an approximately 1-mile long section of the Liberty pipeline. Disposing the dredged material in this way likely would increase the suspended-sediment levels during trenching due to the reintroduction of the dredged material into the water column at the trench location. It is unlikely that this material would be usable for immediate backfill of the trench because of the high levels of introduced water during excavation.

Bringing the material to the surface is the second option for disposing or stockpiling of the dredged material. The major issue in dealing with the surface disposal of the excavated material is dealing with the water introduced by the excavation method. The hydraulic system of the suction-cutter dredge proposed for use at Northstar is capable of discharging 1,600 gallons per minute. Over the course of an hour, 96,000 gallons of slurry would be discharge by a single dredge. According to the Corps of Engineers Engineering Manual (U.S. Army Corps of Engineers, 1983), the discharge from a suction-cutter dredge would be a slurry consisting of a maximum of 20% solids. The Northstar proposal stated that the type of dredge proposed for that operation would produce a slurry ranging from 10-70% solids by weight, depending on where in the trench the excavation occurred. The Northstar Proposal indicated that the dredge would excavate approximately 150 cubic yards of solids per hour within this discharge volume of 96,000 gallons of slurry.

For dredges used in open water, two methods of surface disposal are available. Either the slurry is placed within a barge or hopper from which the water is decanted back into the ocean and the remaining material is dumped at another location, or the slurry is piped to a disposal area removed from the excavation site and dewatered at the disposal site.

For on-ice disposal, each of these methods presents unique issues. Transportation of the excavated solid, using conventional earthmoving equipment, would require that the excess water be removed from the solids before transportation. One of two options would be required: (1) Use settling ponds to allow for the settling of the solids from the slurry. This would have to happen before the material freezes, so that the water can be pumped from the pond and the solids placed into the equipment. In an arctic environment, the use of settling ponds on the ice is impractical as a separation method. (2) Use solids-removal equipment such as hydrocylones and vibratory shakers to separate the water from the solids. Each potential excavation site would require a dedicated separation facility, for each dredge, capable of handling approximately 96,000 gallons of slurry per hour. A system potentially could be designed to handle the separation using standard oil field equipment; however, disposal of the processed water still could be of some concern.

The second disposal option would be to transport the slurry through an insulated/heated pipeline to either a permitted disposal area that would not interfere with construction activities or be placed back in the trench if the material would not jeopardize the vertical stability of the pipeline. On-ice disposal would require constructing containment areas to limit the spread of the slurry while still maintaining a permitted depth of material. Based on Northstar's stated excavation rate of 150 cubic per hour and a pump capacity of 1,600 gallons per minute using the suction-cutter dredge, more than 200 million gallons of slurry would need to be disposed of on the ice surface. Because of the nature of the disposal method and water/ice content of the material, none of this material would be available for backfill into the trench. All backfill would need to mined from the onshore mine site.

The BPXA Proposal calls for using backhoe excavators for trench excavation. The Corps of Engineers, in the Sediment Resuspension by Selected Dredges report (U.S. Army Corps of Engineers, 1988), compares the sediment-suspension rates from the use of various dredges. While the report does not specifically address the type of dredge proposed for Liberty, some comparisons can be made with the clamshell-type dredge discussed in the report. This type of excavation requires that the material removed from the seafloor be transported to the ocean surface in an open container. This exposes the top surface of the excavated material to the full water column at the excavation site. As the bucket is lifted, an increase in the total suspended solids in the water column is created due to erosion and leakage of material from the bucket. This amount may be up to an order of magnitude greater than the amount created from a properly operated suction-cutter dredge. The effects of sedimentation caused by this backhoe method of trenching is covered in detail within the draft EIS. The Corps of Engineers' report does include one advantage of the backhoe type excavator over the suction-cutter dredge. A backhoe excavator is capable of excavating material at near in situ density. This allows for the use of conventional earth-moving equipment for transporting the material, as detailed in the original plan, and allows for the use of the material as a source of backfill for the pipeline trench.

It was suggested that this alternative trenching method may provide for a decrease in the time required to complete the proposed pipeline trench, which, in effect, would decrease the time that turbidity would be present in the pipeline corridor.

The Proposal currently calls for using up to seven backhoe excavators for trenching work. These excavators are each estimated to move between 120 and 240 cubic yards of material per hour. The material is brought to the surface of the ice and either stockpiled for later use or placed back in to the trench immediately after pipeline laying.

Production estimates for the suction-cutter dredge are up to 150 cubic yards of material per hour, depending on the location of the cutter in the trench. The material removed from the trench would be placed on the seafloor, when possible, immediately next to the trench for use as backfill (if usable). At maximum production levels, this method would require five additional units be used to match the production on the backhoe excavators. In addition, during the Northstar trenching effort, considerable instability of the sides of the trench was encountered. While this may not be true during Liberty trenching, the additional volume of material created would require that additional trench cleanout take place before the installation of the pipeline.

This discussion has examined the option of using a suction-cutter dredge as the primary tool for excavating the Liberty pipeline trench. While the Corps of Engineers states that the use of a suction-cutter dredge can create an order of magnitude less suspended sediments than the use of a backhoe excavator during excavation, other considerations make the use of this technology questionable as the primary excavation tool. This method, using seafloor disposal, is workable only in water depths greater that 20 feet (less than 20% of the pipeline trench length); therefore, surface disposal of the excavated slurry would be required in shallow water. Seafloor disposal also would contribute to the excess suspended sediments during operation.

The added complexity of surface disposal using either on-ice containment areas or water-removal methods would add both considerable expense and the potential for breakdowns. Also, water-quality issues would need to be addressed. There also is the question of whether the method could be used in areas of bottomfast ice, which would need further evaluation. In addressing the contention that this method would provide a shorter trenching time, we have shown that this method would require 28 day using the same number of excavators as the Proposal. Based on this discussion, we see no advantage to using the suction-cutter dredge over the backhoe excavator for trenching the Liberty pipeline.

c. Other Potential Gravel Source Alternatives

We considered several potential gravel sources; however, they have either technical or environment problems or provide less potential for positive rehabilitation, which eliminates them from further consideration as alternatives in the EIS. The BPXA Environmental Report (BPXA, 1998a:Sec.2.6) discusses each of the following alternatives in greater detail and provides additional information and rationale about the problems associated with each the alternatives.

(1) Use the Kadleroshilik River Oxbow Site

Mining this site could disturb an increased amount of tundra vegetation and habitat and cause greater environmental impacts than the Proposal. This suggestion is not as environmentally sound as the Proposal.

(2) Use the Sagavanirktok River Site

Fish already overwinter in this river. If used the proposed mine site, once rehabilitated, would provide new fish-overwintering sites to the Kadleroshilik River, which currently has none. This suggestion is not as environmentally sound as the Proposal.

(3) Use Tern Island as a Gravel Site

Much of this gravel is unsuitable, and most mining would have to occur in the summer and over several seasons. BPXA's assessment of this alternative in their Environmental Report (BPXA, 1998a) indicates blasting would be required, which is not practical during the winter period. Blasting during the summer could have an adverse affect on fish and marine mammals if they are in the immediate area. The sediment plume here would cause more adverse effects than those expected from the proposed site. This suggestion is not as environmentally sound as the Proposal.

d. Potential Alternatives to Ocean Water Disposal of Dredged Material

Ocean dumping is the preferred disposal method because of the salt content of the dredged material. Disposal on uplands is not possible, because almost the entire land surface up to 60 miles (97 kilometers) inland is wetlands. Adverse impacts to wetlands from saline trench spoil are substantially greater than the temporary impacts associated with ocean disposal. Consideration also was given to backhauling the excess trench material to the gravel mine site, located on the Kadleroshilik River floodplain, where it would be used for mine-site rehabilitation. This potential alternative was dropped from detailed consideration, because the salt content of the material could affect the rehabilitation goal of providing overwintering fish habitat within the freshwater Kadleroshilik River. A disposal site located in deeper waters is not practical or reasonable because of safety and transportation difficulties in multiyear sea ice and the distance to such a site. Environmental impacts also could be greater there than at the nearshore site, where seasonal bottomfast ice disrupts the benthic community annually and storms frequently redistribute sediments. This suggestion is not as environmentally sound as the Proposal.

For the reasons stated, these alternatives are not considered further in the EIS.

6. Mitigation Incorporated into the Project

The following discussion shows the mitigating efforts in two categories. (1) the mitigating actions that BPXA already has incorporated into its development plan, and (2) the MMS-required mitigation, including the Sale 144 lease stipulations.

a. BPXA's Mitigating Actions

In planning for construction and design, BPXA has attempted to minimize impacts and to incorporate mitigating measures into the Liberty Project design. Table I-3 shows the mitigation BPXA incorporated into their project to protect the resources and lifestyles of the residents. The first column of the table shows the various BPXA designs and construction actions, and the second column notes the benefits of each action.

b. Mitigation Required by the MMS

The project also includes stipulations that are part of the lease for OCS-Y-01650. This mitigation reflects the efforts of people of the North Slope and their tribal and local governments working with MMS and other Federal and State agencies. The full text for these stipulations is found in Appendix B, part B. BPXA is required to comply with these stipulations. We note how they are meeting that obligation in the following text.

Stipulation No. 1, Protection of Biological Resources. The Liberty Prospect would be located near the Stefansson Sound Boulder Patch, a special biological resource. The drilling and production island locations and pipeline routing have been selected to avoid impacts to the Boulder Patch.

Stipulation No. 2, Orientation Program. Site personnel would receive training on at least an annual basis, and full training records would be maintained for at least 5-years.

Stipulation No. 3, Transportation of Hydrocarbons. Pipelines are the preferred mode to transporting hydrocarbons.

Stipulation No. 4, Industry Site-Specific Bowhead Whale Monitoring Program. Not applicable, because this stipulation applies to exploratory operations.

Stipulation No. 5, Subsistence Whaling and Other Subsistence Activities. BPXA proposes measures that include ongoing community liaison, development of a Cooperation and Avoidance Agreement with the Alaska

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Eskimo Whaling Commission, major construction activities planned for the winter season, and limiting vessel transit to the island to routes inside the barrier islands. An ongoing consultation process will be used to identify any concerns not addressed by BPXA's proposed mitigation and potential measures to be considered.

Stipulations 6 and 7 are part of the lease-stipulation package but are administrative in nature.

Stipulation No. 6, Agreement Between the United States of America and the State of Alaska

Stipulation No. 7, Agreement Regarding Unitization

c. Mitigation and Traditional Knowledge

The above mitigating measures incorporate traditional knowledge and the cooperative efforts between the MMS, the State, and the people of the North Slope and their Tribal and local governments to development of effective mitigating measures into our leasing program. The concerns of the North Slope residents to protect their subsistence and cultural heritage are incorporated in the Orientation Program, the Industry Site-Specific Whale Monitoring Program, and the Subsistence Whaling and other Subsistence Activities stipulations. The Transportation of Hydrocarbons stipulation reflects the concerns of the North Slope residents to require that the transportation of oil and gas be done in a safe manner. The subsistence and sociocultural sections of this EIS highlight and note the information, concerns, and traditional knowledge the North Slope residents have provided. The Northstar EIS provides another source of traditional knowledge information and is incorporated by reference. Chapter 2 of the Northstar EIS provides a good background discussion and general description of traditional knowledge.

Based on traditional Native and Inupiat testimony and concern, a conflict resolution process was included in existing mitigation measures developed for MMS Lease Sales 144 and 170 is a requirement of Lease Y-01650.Stipulation 5, Subsistence Whaling and Other Subsistence Activities, requires industry to avoid unreasonable conflict with subsistence activities during operations, especially the bowhead whale hunt. Before submitting a plan, the lessee must consult with the subsistence communities of Barrow, Nuiqsut, and Kaktovik; the North Slope Borough; and the Alaska Eskimo Whaling Commission about the proposed operations. These consultations ensure that they coordinate siting and timing with subsistence whaling and other subsistence-harvest activities. We restrict uses under the lease, if necessary, to prevent unreasonable conflicts. However, subsistence whalers and industry have been able to negotiate agreements that work for both parties. An example is the recent agreement coordinating the timing of seismic activity for the Northstar Project and the subsistence whale hunt. BPXA and the North Slope Borough, Alaska Eskimo Whaling Commission, and the city of Nuiqsut worked out this agreement.

BPXA has committed to a dialogue with Native whalers and is now working on a Conflict Avoidance Agreement that would cover Liberty production activities. This agreement would limit major construction activities to the winter season, and generally limit vessel transit to the Liberty Island to routes inside the barrier islands. The Alaska Eskimo Whaling Commission prefers to negotiate a Conflict Resolution Agreement with industry on an annual basis using a regional rather than a project specific approach so as to address potential impacts from all ongoing development projects. The Commission and BPXA are actively pursuing such an agreement at the present time. An ongoing consultation process with subsistence whalers would be used to identify any concerns not addressed by BPXA proposed mitigation, as well as identifying additional mitigating measures to be considered, such as monitoring of bowhead whales for effects from development and operations noise (See Sec. I.H.6., Mitigation Analyzed in this EIS). Industry also is required to consult with subsistence communities when activities may affect the availability of polar bears for subsistence use and to develop a Plan of Cooperation as part of the Incidental Take Program.

7. Potential Mitigation

Other mitigating measures may be identified during the public hearing process, and they will be considered in the final EIS The MMS expects to develop other mitigation in response to issues and comments received from the draft EIS.

The MMS has been participating in meetings convened by the National Marine Fisheries Service and the Alaska Eskimo Whaling Commission, with the North Slope Borough, the Inupiat Community of the Arctic Slope, and the oil and gas seismic operators concerning monitoring cumulative effects from offshore activity especially related to subsistence resources used by the communities. The group is working toward measures to address the needs of the subsistence communities, if the bowhead whale subsistence hunt were to be affected by development activities; for example, by noise or in the unlikely event of an oil spill. Existing laws and regulations cover many of the issues. For example, rules for oil spill financial responsibility, the oil spill liability trust fund, and oil spill contingency plans have very specific actions that are required. But the group seeks to identify in advance how the subsistence users could be compensated if monitoring shows that subsistence resources are affected. These discussions could identify measures to apply to all development activities, including Liberty.

Five possible mitigating measures were proposed during the scoping process. Three of the measures are described and discussed in Section I.H.8 that follows. Two proposed mitigating measures, Seasonal Drilling Restriction and Recovery and Reuse of Gravel, are described below and evaluated in Sections III.C.2.n and III.D.2.n, respectively.

a. Seasonal Drilling Restriction

The purpose of this mitigation is to provide protection to resources by eliminating the potential for a blowout during periods of broken ice during the development phase of the project. This mitigating measure is similar to the measure required the State of Alaska for the Northstar Project. BPXA is prohibited from drilling the first development well into targeted hydrocarbon formations during the defined broken ice periods for the site location; drilling subsequent development wells into previously untested hydrocarbon formations during defined broken ice periods and imposition of additional restrictions on a case-by-case basis. The spring broken ice period shall commence 15 days prior to the reported early breakup date of June 28 and proceed until the ice concentrations remain at less than 30% for a period of 48 continuous hours and for a distance of 0.5 miles as viewed in all directions adjacent to the production facility during breakup. The fall period shall commence on the earliest date after September 15, when ice concentrations of 30% or more for a period of 48 continuous hours for a distance of 0.5 miles as viewed in all directions adjacent to the production facility and proceed until the ice is aggregated and contiguous with shore based ice with an ice thickness of 18 inches or more in each of the four cardinal compass directions adjacent to the production facility. This type of stipulation was applied to exploratory drilling activity in early outer continental shelf lease sales in the Beaufort Sea. The effectiveness of this mitigating measure is evaluated in Section III.C.2.n.

b. Recovery and Reuse of Gravel

The purpose of this mitigation is to offset the reduction in wetlands that would result from onshore mining activities and gravel pad construction (for example, shore crossing pad and pipeline tie-in pad). This mitigation would recover gravel from abandoned gravel facilities and rehabilitate those sites to useable wetland habitats in an amount equal to or greater than the area lost from gravel mining and pad construction. The permittee would be required to recover and reuse available gravel from abandoned pads, roads, and airstrips within the immediate project area and/or within the Prudhoe Bay oil field complex and to rehabilitate the site.

This mitigation would require the permittee to assess abandoned onshore gravel sites near the Liberty Prospect and/or within the Prudhoe Bay oil field and develop gravel recovery and rehabilitation plans for abandoned site(s). These plans would need to include: the location, amount, and type of gravel; the areal extent of the gravel site (size); the current owner and any ownership issues; any potential gravel contamination concerns and a proposal to deal with those concerns; the proposed timing for obtaining applicable local, state, and Federal permits; and a rehabilitation plan, including timetable. If potential gravel contamination or travel costs prohibit the use of the recovered gravel for this offshore project, the gravel could be stockpiled in nonwetland or currently filled areas and used in other ongoing or future projects by the permittee.

This mitigation is based on the recently permitted onshore oil and gas developments (for example, Northwest Eileen and Northstar). The effectiveness of this mitigation is evaluated in Section III.D.2.n.

8. Other Potential Mitigation

Scoping is an ongoing process. Subsequent to the initial scoping as reported in the Scoping Report, members of the Interagency Team requested additional mitigating measures be considered in the EIS. We describe below the three potential mitigating measures proposed and provide an evaluation of the potential effectiveness of each mitigating measure. However, we did not consider these mitigating measures for further evaluation and consideration.

a. Seasonal Operating Restrictions

This proposed mitigation would halt oil production during seasonal periods of broken ice, when oil-spill cleanup-response capability is limited. During freezeup and breakup, all drilling and production operations would stop. These periods would be defined by the ice conditions and not by specific dates. Operations could resume after reaching solid ice cover (winter) or open-water (summer) conditions. This mitigating measure is intended to reduce the potential for an oil spill by suspending operations and removing all oil from the sales-oil pipeline during periods of broken ice.

Periodic starting and stopping of oil production is not a standard operating procedure. Occasionally, oil production is stopped for short periods of time (hours to a few days), and short shut-in periods usually do not result in significant problems. In the Arctic, however, cold temperatures would dictate the length of time that production can be stopped before the oil becomes too viscous to flow. Starting and stopping oil production could cause numerous other problems and increase the overall risk of an oil spill.

The first big problem involves the recovery efficiency of oil from the subsurface reservoir. The withdrawal of oil by production wells alters the pressure regime in the reservoir. Careful planning directs oil movement through the subsurface reservoir towards the production wells. This altered pressure regime is in delicate balance with the physical forces that tend to trap oil in the small pore spaces of the reservoir rock. The pressure regime is carefully monitored and managed by the sequence of well completions, by controlling oil flow rates, and by replacing recovered volumes with gas and water injection. The overall efficiency of oil recovery is very dependent on maintaining this dynamic pressure balance. If drilling or production is stopped for long periods (weeks to months), a significant volume of the potential oil reserves could be trapped in the reservoir. Extracting this trapped oil often requires additional wells or other enhanced recovery techniques. Higher development costs, lower oil recoveries, and intermittent cash flow from production sales would negatively affect the economics of the field.

A secondary problem is that natural gas is recovered as a by-product of oil production and it is used as fuel for facilities and equipment. Natural gas would not be available during production shut-in periods, and alternative fuels (such as diesel) would be needed. More diesel fuel storage tanks may require an enlargement in the size of the island. The transport of diesel to the island and its storage would increase the chance of a diesel spill, negating some of the potential benefits of seasonal shutdowns.

A more desirable option from a reservoir management standpoint would be to continue oil production from wells and store the production in tanks. However, large storage tanks would be needed and probably would require an increase in the size of the gravel island. This strategy would add more expenses associated with equipment and safety systems. The risks of a spill associated with large, aboveground storage tanks on the island would introduce additional oil-spill risks.

We assume that the production facilities would need to be kept in a "warm" standby status. If not, then equipment degradation as a result of not being used also is likely to occur. Gaskets and seals typically are designed to operate continuously. Intervals of use and nonuse likely would reduce the life of some of these components and could increase the potential for a later spill. This aspect of facilities equipment also negates some of the potential benefits from seasonal shutdowns.

The next big problem with seasonal production shutdowns is related to pipeline operations. Because the pipeline is designed to carry warm oil (sales oil is about 130 degrees Fahrenheit), stopping the oil flow would require displacing the oil in the pipeline, cleaning (pigging), and replacing it with a noncorrosive liquid until flow resumed. The displacing fluid (glycol typically is used) would have to be transported to the island and stored in tanks. New storage tanks could require a larger size for the island. Then there would be a new risk factor associated with the spilling of glycol during transport and/or storage. Glycol is a poisonous chemical used in antifreeze. The only known chemical spill on the North Slope that resulted in a dead polar bear was the result of a glycol spill, but it was not associated with oil industry operations. When production resumes following the shutdown, the glycol in the pipeline would be displaced by oil. Additional facilities would need to be constructed onshore to collect, separate, and store the glycol. If used glycol can be reclaimed, it would then be transported back to the island for future seasonal shutdowns. Transportation would require boats during open-water conditions and trucks on ice roads during the winter. The transport and storage of glycol increases the risk of a glycol spill, and this would negate some of the benefits of oil production shutdowns.

The costs of operations associated with seasonal shutdowns would increase while the reserve volumes could decrease, thus affecting the overall economics of the Liberty project. Another problem with seasonal shutdowns is the increase in the potential for human error, which could result in an oil or chemical spill. Human error ultimately is responsible for most accidents, including oil spills. When complexity is added to operations, the chances for human error are increased.

Considering the problems associated with lost oil recovery, additional storage tanks on the island, a larger footprint for the island, the increased potential for human error, and the large negative economic impact, seasonal shutdowns are likely to create more problems and have greater risks for oil or chemical spills than simply continuing normal oil production activities through the seasonal broken-ice periods. Because of the technical difficulties noted and the additional risk associated with periodically shutting down production, MMS feels this mitigating measure is not feasible.

b. Silt Curtains

Members of the Interagency Team meeting suggested that silt curtains could be used during construction of Liberty Island to reduce turbidity to surrounding areas. This includes the Boulder Patch area, which is about 1.25 kilometers to the west and northwest of the Liberty Island site. A variety of flora and fauna inhabit the Boulder Patch area. Silt curtains are flexible barriers that hang down from the water surface and are used when it may be desirable to limit the spread of fine-grained material introduced into the water column as the result of dredging operations and disposing of dredged materials. The curtains confine material suspended in the water within the area defined by the configuration of the silt curtain. They often are used during dredging of contaminated sediments, but Beaufort Sea sediments are not contaminated.

Most, if not all, of the dredging activities using silt curtains have been in ice-free waters. Silt curtains use a series of floats on the surface and a ballast chain or anchors along the bottom. They have been used at many locations with varying degrees of success (Environmental Protection Agency, 2000). The effectiveness of silt curtains is primarily based on the conditions at the site. They are most effective in relatively shallow, quiescent waters. Conditions that would reduce the effectiveness of the curtains include:

- strong currents (greater than 50 centimeters per second, about 1 knot)
- high winds
- changing water levels
- excessive wave heights
- drifting ice and debris
- curtain and seafloor interactions

The most common failure of silt curtains is silt buildup that reaches the bottom of the curtain, continues to build upward, and causes the curtain to be drawn down and buried (Johanson, 1976). Another of the operational concerns about using silt curtains is the flow through an opening in the curtain of highly turbid water that has built up inside the curtained area. This flow could cancel any benefits from the use of the curtain if the flow reaches the area to be protected. Openings may be the result of hydrodynamic forces causing the seams to part or ripping the material. Most of the dredged material suspended in the water column sinks to the seafloor and spreads out as a mud flow (Johansen, 1976). In some cases, the mud has flowed under the curtains.

Liberty Island would be constructed in Foggy Island Bay in the winter by dumping gravel through openings in the ice. The gravel would be mined from a site on the floodplain of the Kadleroshilik River in the winter. River gravel usually contains a small percent of particles small enough to be suspended in the water; river currents usually are fast enough to prevent fine particles from settling in gravel areas. Also, the gravel would be frozen and the ice bonding between particles would reduce the amount of material that could separate from the gravel mass as it falls though the water at the construction site. Water depth is about 22 feet at the Liberty Island site and the gravel would settle very quickly to the seafloor; water temperatures would be below 0 degrees Celsius (32 degrees Fahrenheit). In the winter, suspended-sediment concentrations may range from about 2-70 micrograms per liter.

At the time Liberty Island would be constructed, the ice at the site would be about 6 or 7 feet thick. Currents under the ice are caused mainly by tidal motion and rejection of brine from the ice. In Stefansson Sound, which is located just to the west of Foggy Island Bay, the currents generally are perpendicular to the shoreline. Currents generally are about 0.02-0.04 knots, with maximum velocities of about 0.2 knots.

Given their sensitivity to high winds, waves, and drifting ice, a silt curtain, if used during the construction of Liberty Island, probably would have to be installed through and removed from the ice when the ice is thick and stable enough to support the equipment required to transport the curtain, cut the trench in the ice and lower or raise the curtain. Monitoring of the curtain for effectiveness and integrity also would have to be done through the ice. The upper part of the curtain would be frozen into the ice and, if the ice moves, the curtain could tear below the ice and compromise containment.

Gravel dumped into the water would fall quickly to the seafloor and generate currents that spread laterally from the dump site. These currents would have the capacity to resuspend loose, fine-grained particles on the seafloor and carry them away from the dumping area. Silt curtains typically are suspended in the water and do not touch the seafloor. Some resuspended material could be carried under a silt curtain, if one were used during Liberty Island construction. If the curtain extended from the surface to the seafloor, there could be a buildup of material on the curtain. Such a buildup would anchor the curtain to the seafloor and might cause the curtain to tear, especially if there were any ice movement.

Any fine-grained particles that settles to the seafloor inside the silt curtain could be exposed to resuspension during the open-water season when the winds can generate waves and stronger nearshore currents. Thus any reduction in turbidity around the construction area that might be realized in the winter could be offset by the resuspension of the particles in the summer, which would add to the natural turbidity in Foggy Island Bay. Suspended-sediment concentrations in the nearshore waters may range from 30 to more than 300 micrograms per liter in the summer. Foggy Island Bay is a dynamic area, as shown by coastal erosion, which contributes to the natural turbidity in the water and the southwesterly migration of the barrier islands that lie north of the Liberty Development Project area.

The curtain would probably have to be removed before the ice breakup. If the removal cannot be done before breakup, the curtain would have to remain in the water through at least the first part of the breakup period. In an environment with moving ice masses there is a risk of tearing the curtain, and pieces of material could be left in the water and not recovered. There is a concern that pieces of fabric in the water torn from the gravel bags used to protect the slopes of previously built exploration drilling or production islands would affect navigation or the environment. The concerns about gravel-bag fabric in the environment has resulted in the suggestion to use steel sheetpile instead of gravel bags to protect the Liberty Island (see Alternative V - Use Sheetpile to Protect the Upper Slope of the Island).

A silt curtain that surrounded the island could be more than a mile long. The seafloor dimensions of Liberty Island are approximated 635 by 970 feet. If the curtain is placed 300 feet away from the bottom of the island, the perimeter for this configuration would be 5,610 feet.

The technological feasibility of using a silt curtain to reduce the amount of turbidity in the area surrounding Liberty Island during construction should be considered in the context of the existing environment and experiences associated with silt curtain use. Environmental considerations include:

- the natural turbidity of the waters in Foggy Island Bay;
- the gravel used to construct Liberty Island would be frozen and contains only a small fraction of fine-grained particles; and
- the composition of the seafloor sediments in Foggy Island Bay includes silt- and clay-size particles that could be resuspended by currents generated from dumping gravel and carried into the area surrounding the island site.

Silt curtain use considerations include:

- the effectiveness in containing fine-grained particles suspended during open water (ice free) dredging has varied;
- the experience in dredging under ice is limited and may be nonexistent;
- the deployment, recovery, and monitoring strategies and technologies most likely would have to be developed;
- the deployment technique does not prevent water, which could contain suspended sediments, from flowing under the curtain and into the surrounding area; and
- the possible tearing of the fabric and pieces of fabric drifting in the water.

In summary, the use of silt curtains during construction of Liberty Island is not being analyzed further as a mitigating measure because the benefits of reducing turbidity to surrounding areas are expected to be small and temporary when considered along with the environmental conditions. Also, feasibility is questionable due to limitations associated with silt curtain effectiveness, lack of experience in solid-ice conditions, the need to develop strategies and technologies, and the risk to the integrity of the curtain.

c. 1-Mile Polar Bear Buffer

This mitigating measure was proposed by the Fish and Wildlife Service, and it is normally included as part of their Letter of Authorization. This is a standard buffer suggested by the Fish and Wildlife Service to protect denning polar bears from certain mobile operations. However, the proposed Liberty Project would have fixed locations and ongoing operations at those locations. Potential denning polar bears would know about those activities when choosing a denning site. BPXA is not proposing additional seismic or other exploratory work that would require mobile operations. BPXA already is using this standard buffer zone when laying out and constructing ice roads for this or other North Slope operations. BPXA must obtain a Letter of Authorization from the Fish and Wildlife Service and, in that letter, the Fish and Wildlife Service can establish the principles and conditions for coordinating with BPXA to protect polar bears.

For the reasons stated, these possible mitigating measures are not considered further in the EIS.

SECTION II

DESCRIPTION

OF THE

ALTERNATIVES

CONTENTS OF SECTION II

Contents

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II. Description of the Alternatives

In this EIS, we have placed special meaning on several words and terms related to the alternatives in this EIS.

We use the phrases “component,” “component alternative,” and “set of component alternatives” to give them important specific meanings. In describing the Liberty Project and various alternatives, we use the word “component” when referring to one of a few specific project elements. Examples of components are type of slope protection, pipeline design, and gravel mine site.

A “component alternative” is used to identify a specific alternative. Each “component alternative” evaluated in this EIS focuses on a single project component. Examples of component alternatives are “Use the Kadleroshilik River Mine Site” and “Use the Duck Island Mine Site.” These two component alternatives are grouped together as a “set of component alternatives” called “Alternative Gravel Mine Sites.”

In Sections I.F and H, we introduced the five “sets of component alternatives” that we analyze. We describe them in detail in Section II.C and evaluate them, one at a time, in Section IV. This description and analysis provides the decisionmakers and readers with a good understanding of the impacts that would be expected to occur for the component alternatives in each set. We also identified a second category of alternatives, the “combination alternative.” The “combination alternative” is reflective of the real-world decision process. If the Liberty project is approved, the decisionmakers will need to chose one component from each of the five sets of “component alternatives.” The project will need a drilling and production island location and pipeline route; a pipeline design; an upper slope protection system; a gravel mine source, and a pipeline burial depth.

To aid the decisionmakers and readers in understanding how to make tradeoffs in selecting among the component alternatives, the Liberty Interagency Team developed three “combination alternatives” that we compare to each other and to the BPXA Proposal to understand their relative merits. These three combination alternatives also were introduced in Sections I.F and H, are described in detail in Section II.D, and evaluated in Section IV.D. Together, these three combination alternatives do not reflect any agency’s (or agencies’) preferred alternative or preliminary decision. They are included to provide additional information and understanding.

A complex project like the Liberty Development and Production Plan is comprised of many different elements. Most of the project elements that describe Alternative I (Liberty Development and Production Plan) are common to (the same for) all of the alternatives. These common elements, such as the configuration of a gravel island, and the specific equipment on the island, include some very precise elements, such as a production island working surface that is 345 feet by 680 feet with an elevation that is 15 feet above sea level.

Other elements, such as island footprint on the seafloor, change for each island location. Such elements are not the same for all alternatives.

In the analysis of effects in Section III, we have identified two types of impacts. The first impact type, “general effects,” is general and applies to all of the alternatives. It is the result of developing the hydrocarbon resources in the Liberty Prospect and is the same for all alternatives. The effect on caribou of constructing an offshore gravel island in the winter is an example of a “general effect.” That is, for all alternatives in this EIS, we cannot determine any difference in effects among the alternative island locations to caribou from construction of a gravel island in the winter.

We also identify “specific effects” in Section III of the EIS. These are effects that may vary among the alternatives. For example, the transport of sediment from pipeline trenching and its potential impact on the boulder patch may be different for each island location/pipeline route. Therefore, these effects are identified as “specific effects.” Note that the EIS does not repeat the “general effects” analysis identified in Section III again and again in the alternative analysis in Section IV. If the reader wants to refresh his or her understanding of the general effects on a resource, then the reader will need to refer back to the “general effects” analysis provided in Section III.

The alternatives for this EIS were drawn primarily from the results of our extensive scoping process (see Sec. I.G and Appendix E). The alternatives are described in Sections II.A through II.D, which follow immediately in keeping with our approach of quickly getting to the issues and alternatives. Readers who first would like to refresh their understanding of the basis for the selection and structure of the alternatives should re-read Sections I.F-H. before reading the remainder of Section II describing the alternatives.

As indicated in Section I.F, at the completion of this EIS process, the decisionmakers will have three options:

- Approve the Project as proposed in the Liberty Plan (Alternative I)
- Disapprove the Project (No Action - Alternative II
- Approve a modified project by choosing one alternative from each of the five sets of component alternatives or one of the combination alternatives, and/or any proposed mitigating measures.

In Sections II.A and B, we describe Alternative I (the Liberty Development and Production Plan) and Alternative II (the No Action Alternative) and all of the component alternatives. In Section III, we analyze the effects of Alternative I. In the first part of Section IV, we analyze Alternative II and all of the component alternatives. Table II.A-1 provides a comparison of the component alternatives. In Section II.D, we describe the three combination alternatives, and in Section IV.D, we summarize their effects.

Section IV devotes extensive text to the effects of the component alternatives but only includes the highlights of the effects of the combination alternatives. Our rationale for this is that the component alternatives are the building blocks for the combination alternatives. With a thorough understanding of the building blocks, the reader or decisionmaker can easily review the combination or use the blocks to construct whatever combination is preferred. The relationship between component alternatives and combination alternatives is shown in Table I-1.

As mentioned previously, development of the Liberty Prospect requires the integration of many elements. These are all described in the EIS, and most are common to (the same for) each combination alternative. Therefore, regardless of the combination alternative we are describing or evaluating, all of the following project components are assumed to be part of each combination alternative:

- The planned construction process would occur over 2 years.
  - During Year 1, the project would be approved and ice-road construction would start in late November or December.
  - The gravel island would be constructed in 1 year (Year 2), and the offshore pipeline would be constructed the next year (Year 3). To the extent possible, construction would occur during the winter.
  - If construction is delayed, all construction would occur a single season in Year 3.
- Drilling and production would occur from an offshore manmade gravel island.
  - Regardless of location, the island would be designed to operate safely in arctic offshore conditions and would have the capability to safely handle potential ice and wave events. The lower portions of the island would be protected with interconnect concrete blocks.
  - Gravel would be mined onshore and transported by trucks using ice roads to the island location.
- A drill rig would be transported to the island by a barge in the summer of Year 2 or moved over an ice road in winter of Year 3.
- The infrastructure module would be sealifted to the island in July/August of Year 2.
- Process modules would be sealifted to the island in July/August of Year 3.
- Oil would be transported offshore through a 12-inch buried pipeline that would be constructed. Oil shipment would start in the fourth quarter of Year 3.
  - Pipeline construction would use conventional construction equipment, the same as the process used for the Northstar Project. Construction and fabrication of the pipeline would occur on the surface of the ice.
  - The LEOS leak-detection system would be installed along the pipeline regardless of its route under water.
  - In addition to the LEOS system, pressure-point analysis and mass-balance leak detection would be installed.
  - Excess trenching material would be disposed of at approved ocean dumping sites.
  - An onshore aboveground pipeline would be installed on vertical support members with a minimum 5-foot clearance.
  - Two small gravel pads would be installed: one pad at the shore crossing and a second gravel pad at the Badami Pipeline tie-in location.
- The Liberty Prospect would be developed using 23 wells.
  - All of the drilling waste material (muds and cuttings) would be reinjected into a disposal well.
  - Water flood and gas reinjection would be used to maintain reservoir pressure and increase ultimate recovery during production of the field.
  - Drilling would start in the first quarter of Year 3.
  - Production would start in the fourth quarter of Year 3.
  - The economic life of the field is estimated at about15 years.

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- Production processing facilities and camp facilities would be constructed on the production gravel island.
- Diesel generators would be used to provide power for drilling until production facilities on the island are completed and operational. Then natural gas would be used to fuel all activities.
- Ice roads would be constructed annually during the winter to provide access to the island. During open-water conditions, helicopters and marine vessels would be used to transport personnel and materials to the island. During broken ice conditions helicopters would be used.
- Waste materials from the island and produced waters would either be reinjected into the disposal well or disposed at approved sites. At the completion of the project, BPXA would need to submit an abandonment plan to MMS. The plan would be evaluated at that time and a separate environmental assessment would be prepared.
- The same oil-spill response plan would apply to all alternatives.

A. DESCRIPTION OF THE LIBERTY DEVELOPMENT AND PRODUCTION PLAN - ALTERNATIVE I, THE PROPOSED PLAN

The following discussion of the development of the proposed Liberty Prospect is condensed from the proposed Development and Production Plan (BPXA, 2000a), the design basis for pipelines submitted in support of the right-of-way applications, and the Oil Discharge Prevention and Contingency Plan (BPXA, 2000a) that were submitted to us by BPXA and are incorporated here by reference. Please see Table II.A-1 for an overview of key elements for the five sets of component alternatives. The Oil Discharge Prevention and Contingency Plan is described and summarized in Section II.A.4 of this EIS.

The project as proposed by BPXA and described in their Development and Production Plan (BPXA, 2000a) is presented in the EIS and is being evaluated by the MMS and other permitting and regulatory agencies. Construction of the project will not take place unless these agencies approve the project or approve the project with modification.

BPXA's proposed Liberty Project would be a self-contained offshore drilling operation with processing facilities on an artificial gravel island with a buried pipeline to shore (Fig. II.A-1). The island would be located in Foggy Island Bay in 22 feet of water about 6 miles offshore and 1.5 miles west of the abandoned Tern Island (Map 1).

1. Description of the Liberty Project

a. Hydrocarbon Resources

BPXA estimates that the target reservoir may contain 120 million barrels of recoverable oil. This estimate is based on analyzing data from seismic surveys, the Liberty Exploration Well OCS-Y-01650 #1 and related wells (Tern Island No's. 1, 2, and 3 OCS-Y-0195, 0196, and 0197), and development experience from the adjacent Endicott field. The Liberty development would produce from the Zone 2 Kekiktuk Formation sands, the same high net-to-gross sands found to be productive at BPXA's Endicott Development. The Liberty Zone 2 sands have comparable reservoir characteristics, porosity (+20%) and permeability (+100's md), as encountered in the Endicott reservoir. As stated in Section 3 of the Plan, both the Endicott and Liberty fields are structural-stratigraphic traps involving the northwest trending Mikkelsen Bay/Tigvariak fault system and truncation of the reservoir by the northeast-dipping Lower Cretaceous Unconformity. Where the Endicott reservoir lays south of the Tigvariak fault, the Liberty reservoir lays to the north in the upthrown side of the fault. The proposed Liberty gravel island would be centered above the Liberty reservoir. This location would minimize the number of high-departure wells needed to develop the reservoir and maximize the total oil recovered. The location of the island was selected also to maximize the assessment and development of other potential productive formations.

b. Project Development, Production Scheme, and Abandonment

The following section describes the different activities associated with the development (Fig. II.A-2), production, and eventual abandonment of the project. Seismic exploration for the Liberty Project was conducted in 1996. No additional seismic activity is proposed for the Liberty Project.

Drilling activities would start in February of Year 3, beginning with the disposal well. After an adequate number of wells are drilled, production would begin. Drilling would continue until the reservoir is developed. All personnel involved in project construction would receive job orientation and safety and environmental training. This training would include the information required by MMS Lease Stipulation No. 2, Orientation Program. (See Appendix B for more information about the stipulation.)

(1) Liberty Gravel Island Design and Construction

The proposed Liberty gravel island would be constructed in 22 feet of water. Figures II.A-3 and II.A-4 present a schematic overview of Liberty Island's design and the expected complement of facilities. The proposed Liberty gravel island is designed to provide adequate space for development wells and production and other facilities. A helicopter landing pad and dock would be available for access by helicopters and vessels. Ice roads would provide seasonal vehicular access to the island. BPXA has designed the island taking into account the environmental conditions expected at the proposed location. The dimensions of the island would be as follows:

- A 345-foot by 680-foot working surface 15 feet above sea level.
- A 635-foot by 970-foot designed bottom dimension, with a maximum permitted footprint at the seafloor of 835 feet by 1,170 feet (22.4 acres). Actual experience in the placement of fill material has demonstrated that expansion of the footprint is required to accommodate for fill material falling outside the designed footprint due to the construction method.
- The perimeter berm rises to 23 feet above sea level, which is 8 feet above the working surface.

The island would be constructed with the following materials:

- 773,000 cubic yards of gravel fill for the island,
- filter fabric placed from the top of the island slope to the seafloor,
- 4,200 polyester gravel bags (4 cubic yards) placed on the upper slope of the island from 7-23 feet above sea level using an additional 17,000 cubic yards of gravel,
- 17,000 interlinked concrete mats placed from the base of the gravel bags to the seafloor, which would use about 7,600 cubic yards of gravel,
- the total gravel volume for the construction of the gravel island, including upper and lower slope protection is 797,600 cubic yards of gravel ,and
- steel sheetpile around an approximate 150-foot by 160-foot dock/helipad area

The slope-protection measures proposed for Liberty include polyester design gravel bag and interlocking concrete blocks, the same as those used at Endicott. The Liberty gravel island incorporates many features not common to previous exploration islands or to Endicott. These features would provide an additional level of safety and accommodate the longer life expectancy of the island (see Sec. III.C.1.b(5) for additional information). The proposed Liberty Island side-slope-protection system incorporates interlocking concrete mat armor (17,000 concrete mats, 4 feet x 4 feet x 9 inches), with overlapping 4-cubic yard gravel-filled bags (4,200 bags) from the bench to the top of the berm. These gravel bags would be about four times stronger than the polyethylene bags used in the 1980's construction of exploration islands. The bags would be made of a polyester material that would sink in seawater if the material entered the marine environment. MMS would require each bag is marked, so if a gravel bag is found in the marine environment we can determine if it originated at the Liberty Island. The proposed concrete mats are composed of individual concrete blocks (Fig. II.A-5) linked together with stout chain and shackles (Fig. II.A-6) and secured with anchors placed in the island gravel fill. Underlying the concrete matting and gravel bags would be a permeable filter fabric that covers the island side-slope areas. BPXA likely would install conductor pipes for each well, which would be a source of additional noise. These conductor pipes would be driven into the island using impact hammers, in a period of 1-2 consecutive weeks in June or July of Year 2. (BPXA, 2000a). The proposed island location had no observed permafrost to a minimum of 50 feet below the site.

Construction during Years 2 through 4, would be staged from existing or onsite facilities. BPXA would house the majority of the summer workforce in existing onshore facilities until the infrastructure sealift could provide onsite facilities in the summer of Year 2. As an option, a construction barge may be moored near the island during the summer of Year 3. It would be about 150 feet by 380 feet (possibly two connected barges), and would have camp facilities mounted on the barge deck. It could house between 125 and 200 persons and would be used to support construction and possibly drilling. The camp could be overwintered at the site and remain there until summer of Year 4. Any fuel stored on board would be stored in accordance with U.S. Coast Guard Regulations (33 CFR Subpart C) and best industry standards. Wastewater from the camp would be treated onboard and discharged in accordance the Arctic General National Pollutant Discharge Elimination System permit. Camp solid waste likely would be hauled back to Prudhoe Bay for recycling, treatment, or disposal in existing approved facilities.

Diesel fuel would be used for power generation for construction activities and drilling until fuel gas is available on the island. There would be a permanent 3,000-barrel diesel storage tank on the island. Two other tanks, a 2000-barrel and a 5,000-barrel tank would be used for diesel storage until the fuel gas is available. After fuel gas is available, these tanks would be converted to other uses, such as a produced water tank or a slop-oil tank. After Year 3, they would no longer be used for diesel storage. Seventeen smaller, temporary diesel fuel tanks would be used during construction and drilling and removed after gas from the project is available. All tanks would be double-walled with 10% containment capacity in the interstitial space. Fuel gas would be available in the fourth quarter of Year 3 after the facilities have been installed. The temporary tanks would be located in a lined, gravel-bermed area with a containment capacity of 550 barrels. The permanent 3000-barrel tank would be located on a raised platform with a seal-welded floor and a seal-welded 6-inch-high toeboard that would provide in excess of 100 barrels of containment. The 2,000-barrel and 5,000-barrel tanks would be located outside on a timber mat foundation on a geotechnical liner for additional containment. The berm around the island, in combination with the grading of the gravel island and the 3 sump pumps provide containment for over 5000 barrels of oil.

(a) Gravel Island Protection

The proposed working surface elevation of 15 feet was selected to ensure that the elevation of the island would be higher than the potential 100-year-wave height (12.2 feet) and adequate to handle the 100-year ice-rideup event (49 feet). The total mass of the island (gravel fill and production facilities) is intended to provide sufficient resistance to lateral movement under maximum ice loads. A gravel bench covered with concrete mats extending more than 40 feet from the base of the gravel bags to the sea surface would dampen wave energy approaching the island and induce natural formation of ice rubble. The island design will be reviewed by MMS under regulations contained in 30 CFR 250 Subpart I, Platforms and Structures, to ensure that the design has taken into account the physical forces that may impact the island. This review would be conducted by a third party and would verify that the design is adequate for use in the area.

Gravel bags would be used in the upper portion of the island slope starting at 7-8 feet above sea level and continuing to the top of the berm, which is 23 feet above sea level and 8 feet above the working surface of the island. The bags provide additional frictional resistance in the unlikely event of ice rideup past the 40-foot bench. The gravel bags would be used only in the upper portion of the island to avoid direct forces from ice or wave action, to lessen potential damage and dislocation, and to protect the surface of the island from the unlikely event of further ice rideup. Interlinking concrete mats would be placed on the lower slope of the island from the base of the gravel bags down to the seafloor to provide stability and protection against erosion. Filter-cloth material placed underneath the gravel bags and concrete matting would prevent the gravel fill material from washing out but would not itself, be susceptible to washing away.

BPXA's proposed use of gravel bags for this project is quite different from previous exploration island construction. The bags proposed for use in the Liberty Island construction are made from a polyester material, which does not float. The gravel bags for the proposed Liberty slope-protection system would be used only on the upper slope (above the concrete lined bench, approximately 7 feet above the water line), which makes them less likely to be torn by an ice event. BPXA would monitor ice events at or near the island and repair or replace any torn or ripped bags as part of their ongoing maintenance program. Major ice events usually happen during freezeup and in winter, and major wave events occur during the open-water season. With the proposed BPXA maintenance, it would be highly unlikely that a gravel bag would be ripped or torn during an ice event and not be repaired before a wave event that could wash the bag into the ocean. In the unlikely event a bag or part of a bag is washed into the marine environment, the bag would not float but sink to the bottom. BPXA also has agreed to remove all of the gravel bags that would be used in the upper slope-protection system at project abandonment.

The oblong shape of the island would be oriented so that the narrower end of the island would be facing north to lessen exposure to potential ice and wave forces. Production modules and wells would be positioned away from the north face of the island and towards the center of the island to further lessen potential exposure to ice override onto the working surface of the island. The surface of the island would be contoured, so that runoff flows into sumps away from production facilities.

(b) Gravel Mining Design, Operation, and Rehabilitation

BPXA proposes using mainly the winter seasons to construct Liberty Island and the pipelines. BPXA proposes to start constructing an ice road to the Kadleroshilik River mine site in December of Year 1, so they can access the mine site, haul gravel, and construct the island. Ice roads would be reconstructed in December of Year 2 to support pipeline construction. Construction of the ice roads (Map 1) would be much faster when the air temperatures are lower (best at subzero degrees Fahrenheit). Work on the Kadleroshilik River mine site would start in January of Year 2. The proposed mine site is approximately 1.4 miles south of Foggy Island Bay, with a ground surface elevation of 6 to 10 feet above mean sea level. (BPXA, 2000a). Figures II.A-7a, II.A-8, and II.A-9 show the locations and cross sections for Phases I and II of the mining plan. This mine site is in a region of riverine barrens and alluvial floodplain. BPXA has estimated the proposed site is about 40% dry dwarf shrub/lichen tundra, 10% dry barren/dwarf shrub, forb grass complex, and 50% river gravel (BPXA, 2000b); see Figure II.A-7b.

The proposed development mine site is approximately 31 acres, with the primary excavation area developed in two cells (PBXA, 2000b). The first cell would be approximately 19 acres and developed in Year 2; it would support construction of the gravel island.(BPXA, 2000b) The second cell is approximately 12 acres and would support pipeline construction activities in Year 3. In preparation for mining, snow, ice, and unusable overburden (organic and inorganic materials) would be removed from the mine site. For Cell 1, up to 100,000 cubic yards of overburden would be stockpiled temporarily on a 5-acre portion of the Cell 2 mine area just south of Cell 1. Cell 2 overburden (up to 13,000 cubic yards) plus about 2,500 cubic yards of excess spoil from the onshore pipeline transition trench would be placed either directly into the Cell 1 pit or on an ice pad in a temporary stockpile area (about 0.5 acres) located just south of the Cell 2 pit.

Mining would not extend into the active river channel; a dike approximately 50 feet wide would be left in place between the mine site and the river channel while mining operations are under way. Gravel would be excavated by blasting, ripping, and removing materials in two 20-foot lifts to a total depth of 40 plus feet below the ground surface. Some portion of the lower 20-foot lift may be left in place, if all gravel available from the site would not be needed to meet island requirements.

The activities listed above would take place in both Years 2 and 3. (See Sec. III.D.2 of this EIS and Sec. 5.1.10 of the Liberty Environmental Report [BPXA, 1998b] for more detailed information about the proposed gravel mine site.) The mining plan also includes a reserve area of approximately 22 acres. Approximately 31 acres of the total 53 acres of the planned mine site would be disturbed. (BPXA, 2000b).

After useable gravel has been removed from the mine, materials unsuitable for construction (for example, unusable materials stockpiled during mining) would be placed back into the mine excavation. Stockpiled snow and ice also would be pushed back into the pit to minimize effects on natural drainage patterns during spring breakup. These backfilled materials would be used to create a shelf (approximately mean water level) along one side of the mine to improve future habitat potential. The access ramp down into the mine would form the foundation of the constructed shelf, maximizing new surface area created. To complete construction, the adjacent edge of the pit would be beveled back a distance of 10-20 feet, creating a gradual slope to the shelf. The backfilled area would provide substrate and nutrients to support revegetation and improve future habitat potential of the constructed shelf along the mine wall.

After Phase I mining is complete and the pit edge contoured, the dike between the mined site and the active channel of the Kadleroshilik River would be breached to approximately 6 inches below mean low water in the channel. During spring breakup, the mine site would flood with freshwater, forming a deep lake adjacent to the river. To avoid stranding fish in the lake during periods of low water, a short section of the breach would be lowered to match the river's bottom level.

The proposed development of the Phase 2 cell is expected to begin in Year 3 to support construction of the offshore pipeline, the shoreline transition, and pipeline valve pads. The Phase 2 mine would disturb approximately 12 acres, to provide the estimated volume of gravel needed for pipeline and pad construction. An approximately 15-foot wide dike would be left between the two cells until mining has been completed.

Mining and rehabilitation plans for Phase 2 are similar to those described for Phase 1 (see Figs II.A-10 and II.A-11) After Phase 2 mining is completed, the dike separating the two mine cells would be breached, expanding the original flooded site to create a larger lake. Some portion of the breach would be at least as low as the river's bottom to avoid stranding fish during periods of low water. Backfill (materials stockpiled during Phase 2 mining and excess material from onshore pipeline construction) would be used to enhance the shallow area created during Phase 1 to improve the future habitat potential of that site.

Remnants of the dike between Phase I and Phase II cells would form islands (0.4 plus acres) in the deep lake, diversifying the aquatic habitat. The shelves constructed along the side of the mine (estimated to be 0.5-2.0 acres) should evolve into shallow water habitat over time in conjunction with flooding the mine site. After a thaw season, it is expected that irregular settlement of the material comprising the shelf would create a surface mosaic of small, shallow ponds, humps, and flats.

During fall Year 3 or spring-summer Year 4, the plan would be implemented to encourage revegetation of the shelf areas. Depending on the extent and pattern of thaw settlement, the areas would be seeded, likely with a combination of salt-tolerant (and disturbance-tolerant) seed stock, as well as other seed stock, as conditions dictate. Depending on access to appropriate sites, ambient moisture, and salinity (both current and predicted), some plugging and/or sprigging also may be done.

After rehabilitation, the flooded mine site would provide several benefits. Deepwater sources connected to streams and rivers are uncommon in this area. The excavation would create potential overwintering habitat for fish in an area where this type of habitat is limited. It also would be possible that the lake could be a source of water for future ice-road construction, although over time, coastal storm surges could make the lake water too brackish for this purpose.

(c) Placement of Gravel Fill Material

Gravel would be hauled over the ice road for about 45-60 days but should be in place at the island construction site by the end of April of Year 2. The process of placing gravel involves using conventional ditch witches (chain trenchers) and backhoes to cut and remove blocks of ice from the construction site. The hole left by the removed ice blocks would be enlarged and filled with gravel hauled in by conventional belly-dump trucks. This process would continue until the total volume of gravel fill material has been placed, including stockpiling excess gravel necessary to fill the gravel bags to be used for slope protection. Once the majority of the island is completed, materials for foundations and sheetwalls would be transported to the island by ice road or barge. The precast concrete mats would be constructed offsite and trucked to the island.

Once the gravel fill is in place, the workers would grade and reshape the island to the final design. This work would continue through ice breakup. Following breakup, the filter cloth and slope protection (concrete mats and gravel bags) would be installed. This would continue into July. Gravel bags would be filled from excess gravel at the island construction site. By the end of May, the pile-driven sheetwall for the dock would be installed. Next, the concrete foundations would be installed. Foundation installation would take about 30 days and be completed by mid-August. All other remaining island construction work would be completed in early to mid-August before the arrival of the sealift in Year 2.

(2) Drilling Activities

A drill rig and consumables would be mobilized to the site by barge in the summer of Year 2, from the Prudhoe Bay Area. Drilling would start using diesel-generated power. Diesel would be used until natural gas-fired electrical power from the plant is available. Development drilling would begin in the first quarter of Year 3 and finish in February Year 5. BPXA has collected 3-dimensional seismic data over the entire prospect and has used this information to determine the target location for each of the proposed wells. At least 23 wells would be drilled: 1 disposal, 14 producing, 6 water-injection, and 2 gas-injection wells, at a wellhead spacing of 9 feet. The disposal well would be drilled first. Muds and cuttings from the disposal well initially would be stored onsite and then injected into the disposal well. As an alternative, these drilling wastes may be hauled to existing disposal facilities onshore. Subsequent muds and cuttings from development wells would be injected down the disposal well. Production and injection wells would be drilled in specific sequence and as necessary to ensure the reservoir is depleted in the most efficient way. Workover operations (operations conducted in the well bore to improve the performance of the well) would be conducted periodically and as necessary.

Because the injection well is located on outer continental shelf lands, it is not subject to the Environmental Protection Agency's 40 CFR 146 Subpart B jurisdictions. The MMS has regulatory oversight for all facets of the injection well operations, from development through abandonment. The MMS will require BPXA to develop and operate the disposal well in accordance with MMS regulations. The MMS also intends to apply the same principles from the Environmental Protection Agency's 40 CFR 146 regulations in managing the types and volumes of waste disposed. In accordance with BPXA's Development and Production Plan, disposal wastes would be limited to nonhazardous industrial wastes, domestic wastewater, stormwater and RCRA-exempt oil and gas exploration, development and production wastes as defined in 40 CFR 261(b)(5).

(3) Construction of a Single-Wall Steel Pipeline

For the offshore pipeline, BPXA proposes a single-wall steel pipeline system that would be constructed with a 12.75-inch outside diameter pipe with a 0.688-inch wall thickness. The system would be protected from corrosion by a dual-layer fusion-bonded epoxy coating and sacrificial anodes. The system would be buried with a minimum burial depth of 7 feet (Fig. II.A-12). Cover is defined as the vertical distance between the top of the pipe and the original undisturbed seafloor. Periodic smart pigging would monitor pipeline integrity. Leaks would be detected by a combination of three systems: pressure-point analysis, mass-balance line-pack compensation, and the Siemens LEOS leak-detection system.

Map 1 shows the proposed routes for onshore and offshore pipelines. The offshore route would go nearly straight from the Liberty Island to a landfall about 6.1 miles to the south-southwest. The overland route would be about 1.5 miles long and extend south to tie in with the proposed Badami oil pipeline about 1.5 miles west of the Kadleroshilik River. The overland route would avoid major lakes and would intersect the Badami pipelines at a new gravel pad. BPXA would plan to construct the pipeline in winter of Year 3, starting in January and finishing by May.

The pipeline system would be constructed during the winter within a temporary right-of-way (250 feet wide onshore, 1,500 feet wide offshore). For welding strings of offshore pipeline, workers would need a site close to shore on grounded sea ice artificially thickened, as needed, and usually in water less than 5.5 feet deep. The site would be east of the right-of-way and would hold a welding pad 6,000 feet long by 750 feet wide.

(a) Pipeline Construction

Pipeline design, an issue and concern for this EIS, is discussed at some length in the document. This section is described in more detail than other sections, because construction is an integral part of any pipeline. We hope the additional detailed information will help the reader better understand some of issues.

Various methods of pipeline construction, including both summer and winter construction, were studied in the BPXA INTEC report (INTEC, 2000). Through-ice winter construction was selected as the most feasible construction method for installation of the single-wall steel pipeline system. This type of construction uses techniques that are similar to those used onshore. Trenching would use conventional excavation equipment, such as backhoes. Hydraulic dredging may be used for final smoothing of the trench bottom. (See Section I.H.5.b(11) for additional information and discussion about hydraulic dredging). Construction activities include:

- mobilizing equipment, material, and workforce,
- constructing the ice road and thickening the ice,
- slotting the ice,
- trenching (including temporary storage and disposal of excess material),
- preparing the pipeline makeup site,
- welding pipe strings,
- attaching anodes,
- attaching LEOS,
- transporting pipe string and welding tiein,
- island transition,
- shoreline transition,
- installing pipeline,

- backfilling the trench,
- hydrostatic testing, and
- demobilizing equipment.

A brief discussion of each of these activities and the variations particular to each pipeline system alternative follows. More detailed information relating to the construction methods to be used on the single-wall pipeline and the costs of these activities can be found in Sections 4.4 and 4.5 of the INTEC (2000) report.

1) Mobilizing Equipment, Material, and Workforce

This is the stage when the equipment, personnel, and supplies are transported to the work location. Mobilizing for the single-wall steel pipeline system is estimated to take 3 days.

2) Constructing Ice Road and Thickening Ice

Ice roads are built to provide transportation routes across the sea ice and tundra and the sea ice is thickened so that it would be able to support the weight of the construction activities. A total of 47 days would be required for constructing the ice road, thickening the ice, and maintenance. See Section II.A.1.b(5) for additional information about freshwater needs for ice-road construction.

3) Slotting the Ice

After the ice has been thickened, a slot has to be cut through the ice to allow a trench to be dug and the pipeline to be placed in the trench. Ice slotting for this system would require about 11 days.

4) Trenching

A trench must be excavated in the seafloor that the pipeline can be placed in it. The trench must be dug to fairly tight tolerances so that the pipeline would be supported along its entire length and not have high spots that would contribute to upheaval buckling. A hydraulic dredge may be used to help smooth the trench. The amount of excavation in the various water depths for this system is shown in Table II.A-2.

5) Preparing the Pipeline Makeup Site

If pipeline construction uses the drag and lay process, a pipeline makeup site needs to be prepared nearshore in the bottomfast-ice zone. This site would be used to assemble the pipeline strings before transporting them to the side of the ice slot for final tie-in welds and lowering into the trench. The size of the site required would be 416,500 square yards, about 86 acres. An estimated 37 days would be required for this activity.

6) Welding Pipe Strings

There are two methods that may be used for welding the pipeline together. Either the pipeline can be laid out along side the ice slot and welded on the ice, or it can be prepared at a makeup site and transported in strings approximately 3,000 feet long and tied together alongside the ice slot. During this stage the welds are tested to ensure there are no welding flaws, anodes are attached to the pipeline, and the welds are coated to protect against corrosion. It is estimated that approximately 17 welding-crew days are needed to weld the pipe strings together.

7) Transporting Pipe String and Welding Tie In

After the pipeline system is put together in strings at the makeup site they would be transported along the ice slot for final tie in. A total of 10 days is estimated for transporting the pipeline and welding the tie ins.

8) Installing the Pipeline Offshore

After the pipeline is welded together it would be lifted from the ice and placed in the trench. Installation of the single-wall steel pipeline system is estimated to take a total of 35 days.

9) Installing the Pipeline Onshore

Conventional techniques for constructing an onshore pipeline on the North Slope would be used to install the onshore portion of the pipeline. The pipeline would be installed during the winter from an ice road along the pipeline right-of-way. The pipeline would be installed on vertical support members to allow wildlife to travel beneath the pipeline.

10) Transitioning the Pipeline at the Gravel Island

BPXA proposes to place a pull tube in the island during island construction so that the pipeline can be pulled through to tie into the island facilities when it is installed (Fig.II.A-13).

11) Transitioning the Pipeline at the Shoreline and Constructing the Shore Pad

Near the coastline, the pipeline would begin a transition from being buried to being elevated. About 100 feet of the transition trench would be seaward of the shoreline, and about 150 feet would be landward of mean low-lower water (Figs. II.A-14 and II.A-15). The onshore transition point was located to provide protection from coastal erosion expected during the designed life of the pipeline plus a safety factor. The buried portion of the pipeline would be at the same depth below sea level as the offshore portion of the pipeline, and the elevated portion would be installed in accordance with the North Slope Borough's requirements for pipeline construction. After laying the pipeline, the trench would be refilled primarily with gravel for stability and organic layers from the original surface of the trench would be replaced on the surface. Coarser, granular material from the gravel mine or the excavation would be used as needed at the coastal bluff to achieve erosion resistance similar to the adjacent undisturbed material. This plan minimizes any increase in erosion caused by construction through coastal bluffs and is intended to replicate the natural strength and character of the landform. The cap would overlap the trench only slightly, and the entire onshore transition pipeline would disturb up to 0.3 acres. The cap would be seeded to promote revegetation across disturbed tundra, using methods that are established for the North Slope. Spoil remaining from construction and rehabilitation of the onshore trench would be used for mine site rehabilitation.

Automated pipeline isolation valves for the sales oil pipeline would be located at the landfall and the Badami pipeline tie-in point and on the island. The landfall pad would be approximately 135 feet by 97 feet (0.3 acres), requiring approximately 2,400 cubic yards of gravel (Figs. II.A-16 and II.A-17). Gravel would be obtained from the Liberty mine site.

BPXA currently is considering using an vertical loop in lieu of the landfall isolation valve; if implemented this option probably would reduce the size of the landfall pad.

12) Backfilling the Trench

The pipeline trench would be backfilled with the material removed during excavation using conventional equipment (backhoes, dump trucks, etc.). If trenching occurs several days in advance of the backfilling operation, the trench material is stored temporarily on the ice surface near the trench, and would be frozen when it is placed back in the trench. The ice bonds of any frozen material used for backfill would be broken up into smaller pieces mechanically before it is placed back in the trench. If the trenching, installing the pipeline, and backfilling occur simultaneously as part of a continuous operation, the native backfill material would not be frozen. The backfill is used to help control upheaval buckling and also to help protect the pipeline from external damage. Backfilling can proceed very quickly but cannot be done until the pipeline has been installed in the trench. Therefore, the rate of backfilling is limited by the rate of pipeline installation, which is constrained by the rate of excavation.

a) Burying Gravel-Filled Bags to Hold Down the Pipeline

Additional weight would be necessary to prevent the vertical movement of the pipelines that results from excessive axial compressive force in the pipe during thermal expansion. If there is not enough vertical downward force on the pipe to resist the instability, then vertical motion of the pipe occurs. Once an upheaval buckle begins and the pipeline starts to move upwards out of the trench, the axial force is relieved and the pipeline would expand and feed into the buckle. The axial force comes from the thermal expansion of the pipeline from about 28 degrees Fahrenheit during installation to about 150 degrees Fahrenheit operating temperature. The weight would come from the gravel-filled geotextile bags placed across the pipelines at intervals to cover approximately 50% of the pipeline route. Approximately 4,000 gravel-filled bags would be necessary. These gravel bags would be placed on top of the pipeline and buried below the seafloor (Fig. II.A-12). The bags would not be exposed to ice or erosional forces. The estimated quantity of gravel includes the gravel material (16,000 cubic yards) contained within the 4-cubic-yard bags that would be placed over the entire pipeline before placing the backfill material. Backfilling is estimated to take 36 days.

b) Methods of Backfilling

An estimated 17,000 cubic yards of gravel fill material would be required as pipeline-bedding material in various locations within the trench between the gravel island and the 3-mile limit. Approximately 50,000 cubic yards of gravel fill would be required as pipeline-bedding material in various locations within the Territorial Seas (shoreward of the 3-mile limit). These estimates include the gravel material contained within the 4-cubic-yard bags (about 4,000 bags) that periodically would be placed over the entire pipeline before placing the backfill material. The bags would cover approximately 50% of the pipeline route. Backfill material would consist of material dredged from the trench. Between the Liberty Island and the 3-mile limit, approximately 162,000 cubic yards of trench-dredged material would be used as backfill. Between the 3-mile limit and the shoreline, about 495,000 cubic yards of trench-dredged material would be used as backfill. A minimum of 7 feet of fill material would cover the pipeline. In water up to 8 feet deep, the cap of the backfill would be close to the original seafloor, not to exceed 1 foot higher than the surrounding seafloor. In water deeper than 8 feet, the trench cap would not exceed 2 feet higher than the surrounding seafloor. The affected footprint would be 18.2 acres beyond the 3-mile limit and 55.4 acres within the limit. This includes the trench cap, which could overstep the limits of the trench excavation.

c) Handling Excess Trenching Material (Ocean-Water Disposal of Dredged Material)

Any dredged/excavated material that could not be placed back into the trench would require disposal into ocean water. One case is where there is more excess spoil than can be placed into the trench without overmounding. The amount of mounding over the pipeline would not affect pipeline integrity but would be an environmental concern. In the area of grounded ice (water 8 feet deep or less), the cap of the backfill would be close to the original seafloor—not more than 1 foot higher than the original seafloor. In deeper water, mounding would not exceed 2 feet.

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Two locations are designated for temporary storage (on the ice surface) and as disposal sites of excess dredged materials (Zone 1 and Zone 2) (Fig. II.A-18).

Zone 1 is located on the west side of the pipeline right-of-way on grounded sea ice outside the 5-foot isobath. Maximum dimensions of the site would be 5,000 by 2,000 feet (230 acres). Zone 1 would serve as the primary temporary storage location of all excavated materials that cannot be directly transported for backfill along the pipeline. Excess trench material that cannot be used as backfill (Zone 2) would be transported to the Zone 1 (see the following description for Zone 2). Zone 1 is the primary and preferred ocean disposal site.

Excess trench material placed in Zone 1 would be groomed to a height not to exceed 1 foot to minimize the potential for mounding on the seafloor. The size of the site was selected to provide operational flexibility, and the entire site would not be used for disposal. Material would be stacked on portions of the site over deeper water first and then over shallower water. The maximum quantity of spoils stockpiled or left for disposal on this site at any one time would not exceed 100,000 cubic yards. Assuming this maximum quantity is placed in stacks 1 foot high, about 27% of Zone 1 (about 62 acres) would be used for actual disposal.

Zone 2 is a 200-foot-wide section along the west side of the pipeline trench from the island to shore. Zone 2A is located in water depths less than approximately 16 feet; Zone 2B is located on floating ice in water depths greater than 16 feet. About 24,400 feet of Zone 2 is within the Territorial Seas (shoreward of the 3-mile limit), while 8,000 feet is seaward of the 3-mile limit.

Zone 2 is a temporary storage area (on the ice). It also is the contingent disposal location for excess trench materials, should weather or ice conditions cause operations to be abandoned before completion. The maximum quantity of excess trench materials stockpiled or left for disposal on this site at any one time would not exceed 10,000 cubic yards. Excess trench material in Zone 2A normally would be stacked or groomed to maintain an approximate depth of less than 1 foot. Excess trench material placed in Zone 2B would be stacked or groomed to a height not to exceed 2 feet. BPXA intends to clear Zone 2 of all excess dredged material/spoils by spring breakup. This would be done by scraping the ice with heavy equipment, leaving at most a veneer of dirty ice (a very small amount of sediment remaining in the frozen matrix).

13) Hydrostatic Testing

Hydrostatic testing of the pipeline is done to ensure pipeline integrity after construction but before placing the pipeline in service. Hydrostatic testing may use seawater, glycol, or a water/glycol mixture. If any glycol is used, the test fluids would be recovered and returned to the vendor for future use or recycling or disposed of at an approved disposal site. If the seawater is used, it would be discharged in accordance with the terms of the General National Pollutant Discharge Elimination System permit. The process would take approximately 5 days. A geometry pig also would be sent through the pipeline to determine the as-built alignment of the pipeline; this data would be used as a baseline for future pig runs.

14) Demobilizing Equipment

After site cleanup, all equipment, excess materials, and personnel would be demobilized. Demobilization would take 2 days.

15) Temporary Abandonment

If weather or ice conditions dictate a temporary or seasonal abandonment of the pipeline before the completion of the pipeline, the following plan would be used. An abandonment head would be welded to the end of the pipe, and a cable attached to the head. The pipeline would be laid into the trench, with tension applied to the cable until the pipeline rests on the bottom of the trench. For seasonal abandonment, the cable would be lowered into the trench. The following season, divers would retrieve the cable and excavate any soil covering the pipeline, using hand-jetting equipment. The end of the pipeline would be lifted back onto the ice surface, and construction could resume.

(b) Leak-Detection Systems

1) Pressure-Point Analysis and Mass-Balance Line-Pack Compensation

Pressure-point analysis is the continuous monitoring of the pipeline to alert the operator to any pressure variances that leaks would induce and variances in measured volumes of oil at the inlet and outlet of the Liberty oil pipeline. Mass-balance line-pack compensation measures the volumetric throughput at both the island and the Badami tie in. The accuracy of the meters would be such that the threshold for the leak-detection system would be 0.15% of flow. Operating procedures require periodic calibration of the meters. If the crude oil meters are above or below 100 barrels or more per day for 2 days, the meters would be checked and calibrated. If there are volume discrepancies after the meters have been checked and there is no apparent operational reason, the pipelines would be shut in.

This system has been used extensively on the North Slope and is considered as part of the best available and safest technology.

2) Leak-Detection and Location System (LEOS)

BPXA plans to incorporate the LEOS system (Fig. II.A-19) as part of the leak-detection system for the pipeline. Based on continued evaluation of technologies, an alternative but equivalent system could be used. Such a system would need to meet or exceed the detection rates and reliability criteria that has been identified by the LEOS system. Siemens developed the LEOS leak-detection system about 30 years ago. It detects leaks by means of a low-density polyethylene tube, which is highly permeable to oil and gas molecules. The tube is pressure tight and contains air at atmospheric pressure when installed. In the event of an oil leak, some of the leaking oil diffuses into the tube due to the concentration gradient. The air in the tube is tested every day, when a pump at the island pulls the air at a constant speed through the tube into a detector unit. The detector unit is equipped with semiconductor gas sensors that can detect very small amounts of hydrocarbons. An electrolytic cell onshore injects a specific amount of hydrogen gas into the tube just before each daily test. This gas is transported through the tube at each test and generates a "marking peak" that not only notes the test is complete, but helps to verify that the equipment is functioning and properly calibrated. The LEOS system can detect a leak when the total volume of the leak reaches 0.3 barrels within 24 hours. For smaller leaks, the LEOS system may not detect the leak until the accumulated size of the leak exceeded 0.3 barrels. (Franklin, 2000, pers. commun.). For purposes of analysis, the leak-detection threshold of LEOS is assumed to be 0.3 barrels.

Because the air moves through the tube at a specific rate, it can accurately determine within meters the location of a pipeline leak. Should a leak be detected, it sets off an alarm. The system automatically stores more than 100 days' worth of data on a personal computer.

This system has been installed in underground pipelines and in aquatic environments, mostly in Europe. In two instances where pipeline leaks have occurred, the system was able to detect them. (INTEC, 1999b:3). It also has been installed as part of the Northstar pipeline leak-detection system. The LEOS system would be bundled to the pipeline before the pipeline was laid in the trench (INTEC, 2000).

Although the LEOS was successfully installed as part of the Northstar development its' long term effectiveness in the Arctic has not been demonstrated. Therefore a contingency plan has been developed should the LEOS system become inoperable during the period of solid ice when visual detection of a leak cannot be performed. If the LEOS systems is determined to be inoperable for some period during solid-ice conditions, BPXA would conduct monthly over ice monitoring until the LEOS system is brought back into operation, repaired, or replaced. Holes would be bored through the ice at predetermined spacing, so equipment can be lowered to search for hydrocarbons. The hole spacing was not specified by BPXA in the Development and Production Plan. The amount of time needed to detect oil through the ice is related to the spacing of the holes in the ice, which is dependent upon several specific factors, including the properties of the oil to spread and the type of ice. Liberty oil is different than Northstar oil, so new models would be needed to determine the proper hole spacing required to detect an oil leak under the ice in 30 days with 95% confidence level. If the project is approved, MMS will obtain sufficient oil for testing from the first oil well, and MMS will develop a requirement for through-ice detection to detect an oil leak of 2,956 barrels (a 97.5-barrel-per-day leak for 30 days) with monthly through-ice testing at the 95% confidence level. The distances between holes would be determined by MMS, in consultation with the Fish and Wildlife Service and the National Marine Fisheries Service, and the procedures would be in place prior to any transportation of oil in the pipeline.

(c) Pipeline Operations, Maintenance, and Repair

BPXA has designed a monitoring program that includes both pre- and post installation monitoring, aimed at reducing the risk of a pipeline failure. Visual surveillance flights to search for oil sheens on the water would occur weekly during open-water and broken-ice conditions. Aerial surveys for river overflooding would be conducted during the initial years of operation. The shoreline would be inspected annually for erosion. A check of the pipeline integrity would occur every 5 years. Visual inspection of overland pipe and values would occur monthly. Process operators would continuously monitor the automated control systems for pipeline leaks.

The key aspects of this monitoring program are Non-Destructive Examination during pipeline construction and hydrostatic testing and smart pigging the pipeline after installation. BPXA also has outlined generic repair scenarios for each of the pipeline alternatives. Although an actual pipeline repair would require its own detailed plan, these generic scenarios can give an estimate of the amount of work and level of difficulty of repairing the pipeline system.

1) Non-Destructive Examination

BPXA would conduct Non-Destructive Examination, including x-ray and ultrasonic tests, of all welds to ensure that they are sound. The Non-Destructive Examination testing would be performed on the welds during construction and on any welds that are part of a pipeline repair. Any weld that has a defect larger than the maximum acceptable level would be cut out and replaced. This would minimize the probability of a weld failing after installation. BPXA would also conduct hydrostatic testing of the pipeline after construction or a repair to ensure pipeline integrity before placing the pipeline into service. (See Sec. II.A.1.b.(3)(a)13) for a description of hydrostatic testing.)

2) Pipeline Smart Pigging

BPXA would use smart pigging to monitor the condition of the pipeline. This plan includes smart pigging the pipeline at startup to establish the initial condition of the pipeline and establish a baseline against which future pigging results can be compared. The pigging program would consist of running three different types of pigs on various

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schedules—a caliper pig, a pipeline geometry pig, and a wall-thickness pig. A more detailed discussion of these pigs follows.

a) Caliper Pig

This pig measures any internal deformation of the pipeline, such as dents and buckling. It would always be run before running either of the other two pigs to ensure that there are no internal blockages that would prevent the other pigs from passing through the pipeline.

b) Geometry Pig

This pig records the configuration of the offshore pipeline system. It can be used to determine the amount of displacement in the pipeline due to thaw settlement, upheaval buckling, strudel scour, ice gouging, or any other force that causes the pipeline to move. This information can be evaluated to determine if the pipeline's allowable strains have been exceeded, or if the amount of displacement exceeds the design parameters. This pig would be run after the pipeline has been constructed to measure its baseline condition, then once a year for the first 5 years, and then once every 2 years for the life of the pipeline. It also would be run after extreme ice gouging or strudel scouring is observed or suspected to have occurred.

c) Wall-Thickness Pig

This pig measures the thickness of the pipeline wall to determine the amount of corrosion that has occurred and to determine if the pipeline has been gouged. This pig can provide an early warning of potential pipeline failures that would allow them to be repaired before a leak could occur. This pig would be run at startup and then every 2 years. The pig would be run in early winter, so that any needed repairs can be carried out that same winter after the ice has thickened sufficiently to be safe to work on.

3) Pipeline Repairs

The probability of needing to repair the pipeline during its design life is very minimal, no matter which design is selected. We have included a description of the various types of repair methodologies so that a comparison can be made among the pipeline design alternatives. Several types of pipeline repairs are available for this system based on the nature of the damage that has occurred. These repair methods include welded repair with cofferdam, hyperbaric welded repair, surface tie-in repair, tow out of replacement string, rigid spool piece with mechanical connectors, and split-sleeve repair. INTEC (1999a:Table II.B-5) provides a matrix that can be used to evaluate the appropriateness of the various repair techniques for a given application. Appendix E of the BPXA Intec Report. (INTEC, 2000) provides details on each repair method. Below are additional details related to using each of the six repair methods on this pipeline system.

a) Welded Repair with Cofferdam

This repair method is applicable only to minor (less than 40 feet) damage. This repair method would require excavating approximately 1,150 cubic yards of soil, which would take an estimated 2-3 days. The entire repair, including damage assessment and mobilization, would take approximately 35 days. Once completed, this repair would return the pipeline to its original integrity.

b) Hyperbaric Weld Repair

This method is suitable only for minor repairs, where the pipeline has not been significantly deflected. This repair method would require excavating approximately 1,150 cubic yards of soil, which would take an estimated 2-3 days. The entire repair, including damage assessment and mobilization, would take approximately 35 days. Once completed, this repair would return the pipeline to its original integrity.

c) Surface Tie-in Repair

This repair method can be used for any type of damage. The information that follows is for repairing minor (less than 40 feet) damage in deepwater. Repairs conducted in shallower water would require less soil to be excavated and could be completed in less time. Major repairs would require significantly more soil to be excavated and would take more time. This repair method would require excavating approximately 6,490 cubic yards of soil to raise the pipeline to the surface and an additional 3,150 cubic yards for a layover area when the pipeline is lowered back into the trench. The entire repair, including damage assessment and mobilization, would take approximately 35 days, with 10-15 days being required to perform the excavation. Once completed, this repair would return the pipeline to its original integrity and a zero-stress condition.

d) Tow Out of Replacement String

This method is most applicable when the damage to the pipeline is severe (more than 100 feet). The amount of time required and volume of excavation for this type of repair is highly dependent on the length of pipeline to be replaced. The information to follow assumes that a 400-foot replacement string is used. This method of repair can be either permanent (if welded ends are used) or temporary (if mechanical connectors are used).

This repair method would require excavating approximately 6,480 cubic yards of soil. The entire repair, including damage assessment and mobilization, would take approximately 40 days. Once completed, the pipeline would be returned to its original integrity, if the end connections were welded.

e) Rigid Spool Piece With Mechanical Connectors

This method of repair would be considered only for minor repairs, less than 40 feet of pipe to be replaced, because of the temporary nature of the end fittings. This repair method would require excavating approximately 1,150 cubic yards of soil. The entire repair, including damage assessment and mobilization, would take approximately 35 days. Because this is a temporary repair method, the pipeline would not be returned to its original integrity.

f) Split-Sleeve Repair

This method of repair would be considered only for minor repairs, less than 40 feet of pipe to be replaced, and is considered to be a temporary repair method. This repair method would require excavating approximately 850 cubic yards of soil to install a 20-foot split sleeve. The entire repair, including damage assessment and mobilization, would take approximately 25 days. Because this is a temporary repair method, the pipeline would not be returned to its original integrity.

(d) Offshore Pipeline Damage and Oil Spills

As noted earlier, not all types of pipeline damage result in a release of oil into the environment. Pipeline damage has been divided into two different types: (1) functional failures that prevent the pipeline from operating as designed and would require remediation and (2) containment failures that allow oil to enter the environment. The pipeline may be displaced or bent (buckled) without resulting in a leak, which is defined as a functional failure. If the displacement is minor, the appropriate action would be increased monitoring and the pipeline could remain operational. In other circumstances, repairs may be necessary. However, some types of damage can result in a leak, a containment failure, and they were identified as a major issue concern for this EIS. The spill volumes evaluated in this EIS are based on the Response Planning Standard calculations. The probability of such a pipeline spill is low, as discussed in Section II.A.4 and Appendix A.

Two different sizes of leaks potentially could occur in the pipeline:

- a 1,580-barrel spill that would trigger the pressure-point analysis and the mass-balance line-pack compensation leak-detection systems, and
- a 125-barrel or less leak that would be below the detection threshold of these systems but would be detected by the supplemental leak-detection system, LEOS, or a LEOS-equivalent system.

A chronic leak could occur, but it would have to be below the 0.3-barrel-per-day detection limit of the LEOS system, (and it would be detected visually before it ever exceeded the 125-barrel volume. The Fleet Report (Fleet, 2000) determined oil spill volumes that are slightly different than those indicated in the INTEC Report (INTEC, 2000), but they are within the range of spill volumes analyzed for effects in this EIS.

1) Pipeline Damage That Does Not Result in a Spill (Functional Failures)

Some pipeline damage can occur that would result in a functional failure but would not release oil into the environment and, therefore, might not require immediate action. A displacement of the pipeline could occur that exceeded the design parameters but left the integrity of the pipeline intact. Some type of remedial action would be required to return the pipeline to its original design parameters, or the operator would have to prove that the pipeline was safe for continued operation. In either case, the cause of the damage to the pipeline would not cause a direct release of oil into the environment. The pipeline could buckle but not rupture. In this case, the pipeline would not leak but may become unusable. The pipeline would have to be repaired before it can resume delivering oil to shore. Because this type of damage would not result in oil being released into the environment, it might be possible to flush the oil out of the pipeline, shut it in, and make the necessary repairs. If the damage occurred during freezeup, it would be possible to leave the pipeline shut in until after freezeup, when conditions would be more favorable to repair the pipeline.

2) Oil Spills (1,580 Barrels)

For purposes of analysis, a containment failure happens when an event occurs that causes a leak of more than 97.5 barrels of oil per day (0.15% of 65,000 barrels of oil per day), the leak-detection threshold of the pressure-point analysis and the mass-balance line-pack compensation leak-detection systems. A containment failure of this magnitude is the least likely failure mode for this system. Potential causes of a leak this size include ice gouging, thaw settlement, strudel scour, and upheaval buckling.

The greatest release of oil into the environment for the proposed pipeline would result from a guillotine break, where the pipeline is severed in half. Under this scenario, the leak-detection system would detect the rupture within 30 seconds. During this detection time, the pipeline would leak about 23 barrels of oil. After the leak-detection system indicated the possibility of a containment failure, it would take the operator approximately 5 minutes to confirm the containment failure and begin the emergency shutdown process. During this reaction time, the pipeline would leak an additional 226 barrels of oil. An additional loss that would occur at this time would result from the decrease in pipeline pressure associated with the ruptured pipeline. This would result in an additional 27 barrels of oil entering the environment. After confirmation of the containment failure and the start of the shutdown process, it would take up to 8.5 minutes for the shore-crossing valve to close. **Note:** Because of the pressure used for this pipeline, valves are set to close slowly so that the pressure along the pipeline can adjust and not cause another problem. During this time, it would be possible for 170 barrels of oil from the onshore portion of the pipeline to drain into the ruptured subsea pipeline and be released to the environment. Water intrusion could result in an additional 1,130 barrels of oil entering the environment. The maximum combined volume of oil that could be released into the environment from a guillotine break would be about 1,580 barrels of oil. This type of pipeline failure event would result in a release to the environment.

3) Oil Spills (125 Barrels)

For purposes of analysis, this type of containment failure is defined as a leak with a rate between 0.3 barrels of oil per day, the leak-detection threshold of the LEOS system, and 97.5 barrels of oil per day, the leak-detection threshold of the pressure-point analysis and the mass-balance line-pack compensation systems. This type of a containment failure leak is more likely to occur than a containment failure that would release 1,580-barrels to the environment. The most probable cause of this type of containment failure is corrosion. A flaw from welding or corrosion could, in combination with ice gouging, thaw subsidence, strudel scour, or upheaval buckling, result in a small leak. We estimate that a small pinhole leak, approximately 0.069 inches in diameter (about the size of a pencil lead) could result in a leak of 97.5 barrels per day.

The maximum spill size that could result from a containment failure of this type is where the leak rate is just below the detection threshold of the pressure-point analysis and mass-balance line-pack compensation systems and is not detected for 24 hours. Under this scenario, 97.5 barrels of oil could be released into the environment before the containment failure is detected. During the time it takes to confirm that a containment failure is probable and to shut down the line, it is possible that another 0.4 barrels of oil could be released into the environment. As the pressure in the pipeline is released through the leak, it is possible that another 27 barrels of oil could be released into the environment. Because the pipeline would still flow oil until it is shut in, it would be unlikely for any oil to drain from the shore portion of the pipeline into the subsea portion and then be released to the environment. It also is unlikely that much, if any, oil would be released from the pipeline due to water intrusion, because the leak rate is so slow and the line can be purged fairly quickly. Therefore, the maximum size of a spill that could be released into the environment from a leak below the pressure-point analysis and mass-balance line-pack compensation detection rates, assuming the LEOS system is operating as planned, is 125 barrels of oil.

The LEOS, or a LEOS-equivalent system, would detect a leak, within 24 hours, when 0.3 barrels of oil has accumulated outside of the pipeline. Because of this capability, it is unlikely that a chronic leak would exceed a few barrels before it is detected.

4) Analysis of Potential Spills If the LEOS Leak-Detection System Becomes Inoperable

LEOS has been used successfully in Europe for more than 20 years and it has been successfully installed with the Northstar pipelines and preliminary testing was completed successfully. During testing prior to the commission of the Northstar gas pipeline in the fall of 2000, it detected background hydrogen generated from the anodes attached to the pipeline (Franklin, 2000, pers. commun.). The system generates a “hydrogen spike” at the end of each daily test, which verifies the system is still operational and properly calibrated. However, LEOS has not been used in an Arctic environment, or offshore before and its’ long term reliability in these conditions is unknown. If the daily LEOS test indicated a failure of the LEOS system or another system failure was suspected to have occurred, alternative leak-detection measures would be implemented. Weekly inspections already are required, and they are considered effective during open-water and in broken-ice conditions. During the winter, BPXA would need to implement monthly over-ice monitoring program, as discussed in Section II.A.1.b.(3)(b) if LEOS were inoperable for a 30-day period. The weekly pipeline inspections and monthly over-ice inspection create two other sizes of offshore pipeline oil spills, which we evaluate in the EIS. They could occur only if the LEOS leak-detection system, or equivalent, is inoperable or does not perform as well as expected.

The sizes for these spills assume that an oil leak occurs that is below the pressure-point analysis and mass-balance line-pack compensation detection level (97.5 barrels) and the LEOS system is inoperable. If a leak occurred during the summer when the pipeline is inspected weekly, the spill could last for up to 7 days before being detected, leaking about 715 barrels total. This assumes only the weekly pipeline inspection flights discover the leak and none of the other 3 helicopter flights a week detect a spill. If a leak occurred during the winter when the pipeline is inspected monthly, the spill could last for up to 30 days before being detected, which could result in a spill of about 2,956 barrels.

(e) Onshore Pipeline Construction and Construction of the Badami Pipeline Tie-in Pad

The onshore part of the pipelines would be elevated at least 5 feet above the tundra and have polyurethane-foam insulation and L-shaped expansion loops placed approximately 3,300 feet apart. The expansion loops allow the pipeline to expand and contract as the steel in the pipeline expands or contracts with the heat from the oil or from the exterior weather conditions. An automated shutdown for the pipelines would be located on Liberty Island and at the tie in to the Badami pipelines. (See Sec. II.A.1.b(3)(a)11) for a description of the onshore pad). The Liberty-Badami pipeline tie-in pad (Figs. II.A-16 and II.A-17) would be approximately 170 feet by up to 155 feet (0.5 acres), requiring approximately 3,500 cubic yards of gravel.

The onshore pipeline would be built using conventional construction techniques for the North Slope. Cuttings from the installation of vertical support members likely would contain organic materials and would be used either in reclamation of the onshore transition pipeline trench or in mine reclamation. Gravel would be obtained from the Liberty mine site.

Near the coastline, the pipeline would begin a transition from the buried mode to an elevated mode. About 100 feet of the transition trench would lie seaward of the shoreline (mean lower low-water line), and about 150 feet would lie landward. After laying the pipeline, the transition trench would be backfilled with 2,500 cubic yards of thaw stable gravel material. The 0.3-acre onshore transition area would be capped with 400 cubic yards of native overburden excavated from the site. Excess excavated material from onshore trench construction would be used as fill material for the gravel mine site rehabilitation.

(4) Production Activities

After the production facilities (Fig. II.A-1) become operational, gas produced from the reservoir would be used as fuel gas for generating electrical power for the island facilities and the drilling rig.

- Production would start in Year 4 (Fig. II.A-20). The economic field life currently is estimated to be approximately 15 years. The facilities/pipeline would have a minimum operational economic life of 20 years.
- Production would start at 30,000-35,000 barrels per day, rapidly increasing to the plateau production rate of 65,000 barrels per day, as additional production wells are drilled. Average peak production would be 65,000 barrels per day, with the possibility of intermittent production rates of up to 75,000 barrels per day to maintain the average production level. Peak production of 65,000 barrels (annual average) per day is expected to be reached by Year 3 and continue for 3 years, followed by a steady decline until abandonment.
- Waterflood and gas reinjection would start in the early life of the field to maintain the reservoir pressure and maximize oil recovery.
- Produced water and treated seawater would be used in waterflood injection. Up to 86,000 barrels per day of seawater would be drawn and treated at the site for injection.
- Some of the produced gas would be used for facility operations. The remaining gas would be compressed and used for pressure maintenance of the reservoir to enhance recovery and for artificial lift in the production wells to increase production rates.
- Discharge treated seawater and other waste management.

Although only 23 wells are proposed to develop the target reservoir, the Liberty gravel island is designed to accommodate up to 40 well slots. These well slots provide for infill drilling, should any of the original wells become unusable during the life of the project. As information on the reservoir performance is evaluated during the life of the project, additional wells may be determined necessary to properly develop the target reservoir. BPXA indicated that exploration wells might be drilled in the future to assess the potential for other productive formations. Any production resulting from additional wells into the target formation or other productive formations would be processed through the existing facilities and pipeline. No additional processing facilities, pipelines, or structures are proposed to accommodate potential future production. Additional future production, if any, could extend the operating life of the Liberty Island, processing equipment, and pipelines and would be subject to engineering and environmental assessment at that time.

(5) Transportation

(a) Helicopters and Vessels

Helicopters and barges or supply boats would transport personnel, material, and facilities to Liberty Island. Helicopters could reach the Liberty Island all year long, weather permitting (see Table V.B-8).

Helicopters generally would be used to transport personnel and food and for the emergency transport of supplies or equipment. Helicopters would avoid Howe Island (near the Endicott facility) by at least 1 mile, while snow geese are nesting and rearing their broods. Helicopters would fly at an altitude of at least 1,500 feet except for takeoffs and landings and when safety is an issue.

Seagoing barges would carry large modules and other supplies and equipment from Southcentral Alaska. Barges would be in the Point Barrow area only from mid-August through mid- to late September and would dock at the island to offload modules. Vessel traffic, except for emergency traffic, outside the barrier islands would be scheduled to avoid interference with subsistence whaling. Vessels from Prudhoe Bay or Endicott would travel shoreward of the barrier islands.

(b) Ice Roads

Ice roads would be built through the life of the project to provide vehicle access to the island during solid-ice conditions. During construction, ice roads would extend in corridors (see Map 1):

- along the coast from the Endicott Causeway to the shore-crossing location in Foggy Island Bay
- from the gravel island to the Badami pipeline
- from Point Brower to the gravel island, and
- from the Kadleroshilik River mine site to the gravel island.

Additional spur roads may be constructed to interconnect the major corridors. Trunk roads built on grounded sea ice and onshore would have a travel surface approximately 40 feet wide. The road from the mine site to the gravel island would be about 50 feet wide. Typically, ice roads constructed on the tundra would be 6 inches thick. Offshore, the ice roads would need to be sufficiently thick to support the construction equipment that would be using the road. Typically offshore in the floating ice, the ice would be thickened to about 8 feet.

In Year 4 and following, segments of ice roads would be built to support drilling and production operations on the island.

Four ice pads also are planned. Two of the ice pads are the stockpile/disposal zones 1 and 2. The Zone 2 pad is part of the ice road system used for construction of the pipeline. The third pad would be a pipeline construction or staging area. The fourth pad, approximately 350 feet by 770 feet, would be built on the sea ice on the eastside of the island for storage of drilling tubular material (pipe) and other clean materials.

Map 3c identifies more than 30 different existing permitted water sources that may be used for ice-road construction and other water needs. These sources include existing and abandoned gravel mine sites and other tundra lakes and ponds. BPXA estimates the freshwater needs during construction would be approximately 120 million gallons per year. After construction, the annual freshwater needs for ice roads would be reduce to about 20 million gallons.

Vehicle traffic can access the island by ice road to support construction and operations. The ice roads would be used to transport, people, materials, equipment, and supplies from onshore to the gravel island.

(c) Typical Transportation for the Project

During Liberty construction (beginning in December of Year 1 and continuing through project startup in November of Year 3), offshore and onshore ice roads would provide winter access for constructing the island and pipelines. During January through April or May of Year 2 and Year 3, construction workers would travel to the project over existing gravel roads and ice roads. About 400 round trips over the roads are forecast for each season during drilling. After drilling, this number would drop to 100 each season. Construction vehicles would be staged at the construction site. Helicopters might operate during these months.

By spring breakup in Year 2, materials needed for continuing light construction would be on the island; barges or helicopters would bring the rest. Personnel would travel by helicopter (10-20 flights/day) during breakup. During summer, they would continue traveling by helicopter or crew boat averaging a total of 10-20 flights or trips per day. Fixed-wing aircraft also may be used for aerial surveillance.

During breakup and summer, helicopters would access the pipeline and tie-in area for final pipeline tests—about one or two flights per week. However, during the broken-ice period when there is no other access, possibly one trip per day is anticipated to transport personnel to equipment at the pipeline tie in. Approved tundra vehicles would be used to access the site. Barges would carry drilling equipment and consumables to the island from Prudhoe Bay while the water is open during summer of Year 2 and Year 3. After that, access to the drilling site would be by barge (summer) or ice roads (winter).

During production, two to three helicopter trips per week would transport personnel to and from the island. Each winter, vehicles would make about 100 trips on ice roads to resupply equipment, parts, food, and materials, and to haul waste from the island as needed. During summer, an estimated five barge trips would be required to resupply the island from Prudhoe Bay or Endicott. Helicopters or vessels would handle emergency evacuations, based on a detailed plan that BPXA would complete before operations begin.

During production, BPXA plans to use helicopters at least once a week to survey offshore and onshore pipelines. Helicopter visits to the tie-in pad should average no more than once a week for routine operations.

(6) Waste Management

BPXA proposes to use a waste-disposal underground-injection well for the management of waste products generated by drilling, production, and operational activities associated with the Liberty Project. The disposal-well permit would be reviewed for MMS approval. The disposal-well is designed to meet Environmental Protection Agency Class I industrial waste-disposal well standards. The waste stream, as defined by the Resource Conservation and Recovery Act, would consist of all exempt and nonexempt nonhazardous-waste materials. The waste-disposal well would be the first well permitted and drilled; it is the key component in BPXA’s environmental waste-management plan for the handling of waste products.

The majority of wastes generated during construction and developmental drilling would be drill cuttings and spent muds. Some waste also would be generated during operations from well-workover activities. These also would be disposed of through onsite injection into the disposal well or would be transported offsite to permitted disposal wells. BPXA proposes zero discharge of drilling waste to lessen discharges into the Beaufort Sea.

BPXA would dispose of cuttings in onsite or offsite disposal wells. Onsite, they would run cuttings through a portable grinding unit and inject them into the disposal well with spent muds. Cuttings taken offsite would go through the grinder and into a permitted disposal well at Prudhoe Bay. Drilling wastes, including those from the first wells, would remain in temporary storage onsite until disposal. Produced waters would be reinjected.

In addition to drilling wastes, domestic wastewater and solid waste would be generated during the project. Workers at the site would haul burnable and recyclable scrap, including

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scrap metal, to an approved offsite location. Nonhazardous solid waste (trash, food wastes, construction debris) would be either burned onsite, with the ash hauled offsite, or hauled to an approved offsite disposal facility. For additional information on waste-management plans, see the Liberty Development Project Development and Production Plan (BPXA, 2000a).

A system would be used to treat sanitary and domestic wastewater. BPXA would chlorinate effluent before placing it into the injection-well waste stream. BPXA has applied to the Environmental Protection Agency for a National Pollutant Discharge Elimination System permit to discharge effluent from sanitary and domestic wastewater into the sea whenever the injection well is unavailable. Under the waste-management plan, BPXA does not plan to discharge domestic waste effluent or storm water (coming from rain and snowmelt collected in surface sumps) to the sea. However, to ensure compliance with any potential waste-management discharge scenarios, BPXA would acquire an Environmental Protection Agency National Pollutant Discharge Elimination System permit for discharging these and other wastes. An outfall line would be used for the outflow from the "reject stream" of the Seawater Treatment Plant, the backwash from the desalination unit, treated domestic wastewater, and water used to test the fire-protection and suppression systems. For additional information on permitted discharges, see the Ocean Discharge Criteria Evaluation in Support of the Liberty Development Project National Pollutant Discharge Elimination System Permit Application (URS Greiner Woodward Clyde, 1998) or Section III.D.1.l (Effects of Discharges on Water Quality).

Wastes would be shipped offsite over ice roads in winter or shipped on barges or boats in summer. During spring and fall breakup and freezeup when transportation by ice road or barge is not available, waste products would be stored in appropriate containers until workers could haul them to other locations for disposal.

The quantity of waste materials for disposal in the injection well would be about 6,000,000 barrels for the 15-20-year life of the Liberty Project. This is broken out as follows:

- 700,000 barrels of rig muds and other liquids
- 70,000 barrels of rig drill cuttings and other solids
- 100,000 barrels of flush waters for cuttings disposal
- 900,000 barrels of camp sewage and gray water
- 2,700,000 barrels of wastes from wells, processing units, etc.
- 1,500,000 barrels of storm-water runoff
- 20,000-40,000 barrels of nonhazardous industrial wastes

The waste volumes of the injection well also break out as follows:

- 44% industrial waters consisting of seawater, brine from produced oil reservoirs, freshwaters, and water gel
- 12% water-based drilling mud
- 1% water-based drill cuttings
- 15% domestic wastewater (camp sewage)
- 25% storm water
- 3% well workover fluids, crude oil, vessel sludge/sand, diesel, methanol
- less than 1% spent acid, cement, agents used to fracture formations, and other minor waste streams
- less than 1% nonhazardous industrial wastes

(7) Employment Related to the Project

BPXA expects this project should generate about 450 jobs: 300 for construction, 100 for drilling, and 50 for maintenance and operations. BPXA states that they prefer hiring Alaskan workers and contracting with Alaskan firms and have an ongoing joint venture with the Arctic Slope Regional Corporation aimed at job recruitment and training for North Slope residents. BPX has made a commitment to hire local workers on the North Slope and within Alaska. If Alaskan workers and firms are used, it could boost Alaska's economy.

Normally, BPXA would buy from the lower 48 States only what equipment is not manufactured or available in Alaska (generators, separators, pumps, compressors, process heaters, etc.).

We do not expect the onshore population to increase permanently because of the Liberty Project. Activities on the North Slope would be in shifts, with one shift at the worksite and one out on break.

Drilling should be continuous for about 2 years. Two crews would be on the island at any time, working 12-hour shifts and rotating with new crews every 14 days. About 25 workers would be part of the drilling operation at any given time, and each drilling position would employ 4 full-time workers. Drilling for initial development should last about 19 months.

Once production starts, one operations crew would be on the island at any time, with one out on break; most would work the day shift, with a few on the night shift. Operations would require crews for the life of the field (about 15-20 years).

Direct economic benefits from Liberty (more jobs and money) would occur mostly on the North Slope and in Southcentral Alaska. Historically, the oil industry has employed few villagers. BPXA is trying to change this pattern of employment by committing to an ongoing joint venture with the Arctic Slope Regional Corporation to improve recruitment of Native workers. However, the Liberty Project is small and would create relatively few permanent jobs. The overall change of Native employment in permanent positions in the oil and gas industry on the North Slope would not change significantly due to this project. This small size also means Liberty would not employ many more Alaskan contractors or vendors except for the initial construction.

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(8) Abandonment Activities

BPXA would submit an abandonment plan at the end of the project. The applicable Federal, State, and local agencies would review and evaluate BPXA's abandonment plan and the environmental effects of the plan, in keeping with regulations and permit requirements in force at the time. The goal of abandonment is to restore the areas to their original condition while minimizing the environmental effects of abandonment. For example, after removing all topside facilities and island slope protection, it may be environmentally preferable to abandon the island in place and let it erode naturally over time rather than require mechanical removal of the island. At the time of abandonment, the environmental analysis would need to include whether a habitat has been established on the concrete mats.

For purposes of analysis, we assume that after the field is depleted, BPXA would plug and abandon the wells and remove production and other surface facilities. At a minimum, we would expect that the portion of the pipeline contained in the island would be removed. The rest of the subsea pipeline may be removed or abandoned in place after an evaluation is made of the impacts of the options at the time of abandonment. Based on conditions at the time, BPXA would either remove the gravel from the island or let the island erode naturally. The gravel bags used for island slope protection would be removed at the same time that other island abandonment activities occur, in keeping with regulations and permit requirements in force at the time of project abandonment. A possible technique might be to open the bags, deposit the gravel, and remove the polyester bag material from the site; another could be to remove the gravel-filled bags from the site. The onshore portion of the pipeline, the vertical support members, and other surface equipment would be removed. For analysis purposes, we assume abandonment of the landfall and Badami tie-in gravel pads in place.

c. Mitigation Incorporated into the Project

Two types of mitigation are already built into this project. The first is the mitigation BPXA has built into the project as part of its Plan (see Sec. I.H.6.a). The second is mitigation required by MMS that is part of the lease (see Sec. I.H.6.b and Appendix B).

2. Safety Systems for Development and Production Systems and Oil-Spill Prevention

In accordance with regulatory requirements and industry standards, the Liberty Project must be designed and would be operated to prevent potential accidents and oil spills. Safety and pollution-prevention equipment would be installed, tested, and maintained according to MMS requirements and other applicable Federal and State requirements.

a. Development Wells and Disposal Well

Each well to be drilled would be designed according to the intended use of the well. Four types of wells (oil producers, gas injectors, water injectors, and disposal) would be drilled. The design basis for each of these wells is discussed in Section 7.3 and Appendix A of the Development and Production Plan. The final design of each well would be submitted to MMS before drilling begins and would be reviewed to ensure that it meets MMS requirements found in 30 CFR Subpart D. The following is a list of essential components for well safety:

- multiple blowout preventors used during drilling
- redundant power sources used to activate blowout preventors and other safety equipment during drilling
- casing programs designed to contain subsurface formation pressures
- cementing programs designed to support casing and to containing formation fluids and pressure outside the casing
- drilling-fluid programs designed to control formation pressures and to provide a stable borehole environment in the open hole during drilling, completion, and workover operations
- well completions designed to ensure well control during production
- well control training and drills completed by all personnel
- following completion of the well, subsurface safety valves installed that would shut in the well automatically to prevent formation fluids from flowing to the surface
- additional redundant safety valves installed at the surface

b. Production Equipment

Production equipment would be designed for the maximum pressures that could be encountered. Automatic and manual shutoff valves would be installed between each piece of processing equipment and pressure vessels, so the flow can be isolated and stopped at any point in the production stream. Equipment would be installed with sensors to shut in the facility and stop the flow before operating pressure exceeds design pressures. Pressure sensors and shutoff valves would be tested and maintained on a scheduled basis, according to MMS requirements. Production equipment would meet design and operating specification, according to MMS requirements. The production stream would be connected to an automated shutdown system to be activated

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should there be a pipeline leak or other process upset. All production equipment and safety systems would be tested before startup. Process operators would be trained and certified to operate and maintain production safety systems, according to our requirements.

A more detailed discussion of the production system and safety equipment is included in BPXA's Plan. Production and processing equipment and safety systems would be designed to comply with MMS requirements. We would approve the production systems before production starts. Additional details on our regulatory program for safety and pollution prevention are available in Appendix A, Oil-Spill-Risk Analysis.

3. Pipeline Safety

The Liberty pipeline is required to be designed and constructed to safely transport oil from the gravel island to the Badami pipeline. The design goal for this or any pipeline is zero discharge of oil and must be in compliance with U.S. Department of Transportation pipeline safety regulations.

Leases issued from Sale 144 require using pipelines as the environmentally preferred transportation system. Lease Stipulation No. 3, Transportation of Hydrocarbons, states:

> Pipelines will be required: (a) if pipeline rights-of-way can be determined and obtained; (b) if laying such pipelines is technologically feasible and environmentally preferable; and (c) if, in the opinion of the lessor, pipelines can be laid without net social loss, taking into account any incremental costs of pipelines over alternative methods of transportation and any incremental benefits in the form of increased environmental protection or reduced multiple-use conflicts. The lessor specifically reserves the right to require that any pipeline used for transporting production to shore be placed in certain designated management areas. In selecting the means of transportation, consideration will be given to recommendations of any advisory groups the Federal, State, and local governments and industry.
>
> Following the development of sufficient capacity, no crude oil production will be transported by surface vessel from offshore production sites, except in the case of emergency. Determinations as to emergency conditions and appropriate responses to these conditions will be made by the Regional Supervisor, Field Operations.

BPXA is proposing to use a pipeline consistent with this provision. The proposed Liberty pipeline system would include an offshore pipeline buried in a trench from the Liberty Island to shore and an elevated onshore pipeline from shore to the existing Badami pipelines

BPXA submitted a Pipeline Design Summary (*BP Liberty Project, Preliminary Engineering*) dated February 1998 to the MMS and the State Pipeline Coordinator's Office in support of the Right-of-Way applications. This document provided a description of the design basis for the single-walled pipelines, including operating pressures, flow rates, external loads (ice gouging), and monitoring. This technical engineering document is separate from the EIS. Review of this document by the MMS and the State Pipeline Coordinator's Office was suspended by BPXA while they investigated alternative pipeline designs.

BPXA contracted with INTEC Engineering to prepare, with input from the Interagency Team, conceptual engineering designs for four pipeline alternatives. Each of these four designs is based on the same functional, safety and project specific requirements. These conceptual designs are the basis for the alternatives presented and analyzed in the EIS. More detailed designs will have to be prepared for the pipeline system that is chosen for this project. The MMS and the State Pipeline Coordinator's Office will then conduct a very thorough technical evaluation of the pipeline design before making a decision on the pipeline right-of-way application. After the review is completed the MMS and the State Pipeline Coordinator's Office will decide whether to approve, disapprove, or approve with modifications our respective pipeline right-of-way applications.

The reader is advised that additional and more detailed review will be done under the right-of-way review processes, which may result in technical changes to the design basis. However, we consider that the design basis of the four pipeline designs evaluated in this EIS is appropriate. It is unlikely that any major changes to the pipeline designs that are being evaluated in this EIS will occur as a result of evolving technology. Any changes to the design basis would be small and would not affect the scope or nature of the environmental effects already being analyzed in this EIS. In the unlikely event that significant design changes do occur and if they could significantly change the type and level of effects analyzed in this EIS, a supplemental National Environmental Policy Act document would be prepared. Alternative III also evaluates different pipeline routes.

Any offshore pipeline system in the Beaufort Sea would be designed according to the following codes, standards, and specifications:

- American Petroleum Institute
  - API STD 1104: Welding of Pipelines and Related Facilities
  - API Spec 5L: Specification of Line Pipe
  - API RP 2N: Recommended Practice for Planning, Designing, and Constructing Structures and Pipelines for Arctic Conditions

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- American Society of Mechanical Engineers
  - ASME B31.4, 1992 Ed.: Pipeline Transportation System for Liquid Hydrocarbons and Other Liquids
  - ASME B31.8, 1992 Ed.: Gas Transmission and Distribution Piping Systems
- American Institute of Steel Construction
  - AISC, 1994: LRFD Manual of Steel Construction, 2nd ed., Volume 1
- American Society of Civil Engineers
  - ASCE 7-95-1995: Minimum Design Loads for Buildings and Other Structures
- Det norske Veritas
  - Rules for Submarine Pipelines, 1996
  - RP B401: Cathodic Protection Design, 1993
- U.S. Department of Transportation
  - 49 CFR Part 195: Transportation of Hazardous Liquids by Pipeline
- U.S. Department of the Interior
  - 30 CFR 250 Subpart J: Pipelines and Pipeline Rights-of-Way
- British Standard
  - PD6493: Guidance on methods for assessing the acceptability of flaws in fusion welded structures, 1991
- 8 AAC 7S Alaska Prevention Standards

The proposed pipeline would be designed for a maximum allowable operating pressure of 1,415 pounds per square inch gauge. After installation, the pipeline would be hydrostatically tested at 1,775 pounds per square inch gauge for a minimum of 8 hours.

All steel pipelines need cathodic protection. Cathodic protection uses an electrical current to prevent external corrosion. The electromagnetic field produced from this pipeline would be very small.

4. Description of BPXA's Oil-Spill-Response Plan

BPXA submitted the *Oil Discharge Prevention and Contingency Plan* (BPXA, 2000b) that identifies the potential oil spills that could occur from the Liberty Project and the equipment, strategies, and personnel that would be available to respond to a spill event. The plan includes an inventory of the equipment that will be available on the gravel island as well as other equipment available through Alaska Clean Seas. The *Oil Discharge Prevention and Contingency Plan*, which references the Alaska Clean Seas Technical Manual, is a part of the Development and Production Plan and is incorporated by reference into this EIS. The *Oil Discharge Prevention and Contingency Plan* describes BPXA's oil-spill-response capabilities and specific spill scenarios for this project as well as how the equipment referenced in the plan will be used in the event a spill occurs.

a. Oil-Spill-Response Capability

Through Alaska Clean Seas, BPXA has acquired, or is in the process of acquiring, additional response equipment to enhance their offshore spill-response capability. These acquisitions would provide BPXA with an improved capability to respond in broken-ice conditions. The equipment includes a more powerful tug for the second barge, four purpose-built 42-foot fast-response vessels capable of handling boom, skimmers, minibarges for offshore response, and additional Lori skimmers for responding in broken ice. In addition, BPXA has committed to the acquisition of an additional ice-strengthened barge to be made available under contract through Alaska Clean Seas. This barge, along with the existing ice-breaking barge and the ice-reinforced barge, would extend the capability to respond to a spill during the spring and fall broken-ice periods. With the addition of this new equipment, the response capability on the North Slope would exceed the broken-ice capability that existed during exploratory operations in the 1980's.

Table II.A-3 is a summary of the response planning standards from the Liberty Oil Discharge Prevention and Contingency Plan. Details on how these numbers were developed are included in the Section 1.0 of that plan.

The oil-spill-response plan includes detailed scenarios that outline the equipment, response tactics, and logistics necessary to clean up these volumes of oil under different environmental conditions—open water, solid ice, and broken ice. The scenarios describe a set of specific response tactics (a description of how oil would be contained and recovered) that would be used. Each tactic is based on a specific type and number of systems that include containment boom(s), oil skimmers, and vessels needed to contain and recover a specific volume of oil. More than 100 specific tactics are detailed in Volume 1 of the Alaska Clean Seas Technical Manual (Alaska Clean Seas, 1998). These tactics include cleanup and recovery in open water, solid ice (both over and under), broken ice (freezeup and breakup), the shoreline, and onshore. The Alaska Clean Seas Tactics also address storage, tracking and surveillance, in situ burning of oil, shoreline cleanup, wildlife and sensitive area response, disposal, and logistics.

For example, one of the tactics BPXA proposes for the containment and recovery of higher concentrations of oil near the source of the release during open water (Tactic R-19) would use two weir-type skimmers, two 1,500-foot sections of open-ocean boom deployed from the surface of a deck barge. Two workboats would be used to establish the necessary boom configuration, and two tugs would be used to maneuver the barge. This tactic is estimated to achieve a

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combined recovery rate of 427 barrels per hour (8,540 barrels of oil per day, based on two 10-hour shifts).

To address broken-ice conditions, the preceding tactic would be modified to include using an ice-reinforced barge and two additional boom/skimmer systems. These systems would be deployed either from behind the deck barge or to either side of the barge, depending on the ice concentrations. These two systems can add an estimated additional 434 barrels per hour to the original 427 barrels recovered. This system is sensitive to the amount of ice found in the recovery area. The response plan explains that containment efficiencies are decreased by 30%, 60%, and 80%, in ice concentrations of 30%, 50%, and 70%, respectively. The barge system has the added advantage that in the event conditions become unsafe due to ice concentrations, the boats could be loaded onto the deck barge for safe passage through the ice.

The capability of the equipment and tactics detailed in the Alaska Clean Seas Manual to recover specific volumes of oil are based on guidance developed by the North Slope Spill Response Advisory Team. This team consists of representatives from the State of Alaska, Department of Environmental Conservation; the U.S. Coast Guard; the Environmental Protection Agency; the North Slope Borough; the MMS; and industry. These guidelines establish quantitative criteria for specific parameters affecting oil-spill response, including estimated spill size and duration, realistic (maximum) environmental conditions (wave height and wind speed and direction), equipment efficiencies, utilization time of the system (actual in-service time), and the holding capacity of the storage barge (taking into account transit times and decanting times). Table II.A-4 contains these guidelines.

The *Evaluation of Cleanup Capabilities for Large Blowout Spills in the Alaskan Beaufort Sea During Periods of Broken Ice* (S.L. Ross Environmental Research Ltd., D.F. Dickens and Associates Ltd., and Vaudrey and Associates Ltd., 1998) concluded that cleanup of an oil spill from a blowout would range from about 10% to more than 45%, depending on ice conditions. That report also concluded that well-site ignition of the blowout could achieve a reduction in the spill volume of from 74-99%. The differences between the response capabilities outlined in the Liberty oil-spill-response plan and the observed cleanup capabilities referenced in the EIS and evaluated by S.L. Ross Environmental Research Ltd., D.F. Dickens and Associates Ltd., and Vaudrey and Associates Ltd. (1998) can be rationalized based on a difference in the projected day-to-day ice variations used in the scenario development.

Additionally, the S.L. Ross report characterizes the oil plume as being derived from a high-velocity jet, which would result in a fine mist that is easily carried downwind for long distances. While BPXA accepted this characterization of the spill in developing the response plan, the probability of this type of unconstrained flow is low. Some form of obstruction—the well derrick, blowout-preventer stack, subsurface-safety valve, or production Christmas tree—likely would provide an obstruction to the well flow, thereby reducing the height and nature of the blowout jet.

We acknowledge that arctic conditions, particularly broken ice, are more challenging, and that cleanup capability would fall somewhere between BPXA's assessment in the oil-spill-response plan and S.L. Ross Environmental Research Ltd., D.F. Dickens and Associates Ltd., and Vaudrey and Associates Ltd. (1998) independent assessment. The actual effectiveness of the cleanup effort would be based on actual conditions at the time of the spill. We are reviewing the overall response capability discussed in the response plan for the Liberty Project, along with the extended equipment inventories and support structure that is proposed, to determine if they provide a level of response that meets current MMS regulatory requirements. See Section IX for the analysis of impacts from a blowout. Section IX also describes two cleanup scenarios and evaluates the impacts.

The probability of an oil spill from a blowout is small. Since 1971, more than 24,000 exploratory and development wells have been drilled on the outer continental shelf, and there has never been a significant oil spill from a blowout at any of these wells. Only one 100-barrel spill was associated with an exploratory well blowout in 1992. A review of blowouts (Kato and Adams, 1991) indicated that gas blowouts are the predominate blowouts encountered, and that these do not result in oil spills. Additionally, the probability of a blowout from development drilling is significantly less than exploratory drilling. This is due to the increased knowledge of geologic conditions from one or more exploratory wells, the acquisition of additional 3-dimensional geophysical data, better correlation between well and geophysical data, correlation with analogous reservoirs, and continuity with each subsequent development well. Also, we have a stringent set of regulatory standards in place to ensure that operators maintain control of drilling and production operations. These requirements are discussed in Section II.A. The evaluation of impacts from a very unlikely blowout spill can be found in Section IX.

Another possible source for an oil spill is from a pipeline. To ensure that the chance of such a spill occurring is small, we review the pipeline construction and operations to ensure that they are conducted in a safe and prudent manner. These safeguards are discussed in Section II.A.

b. Scenario Summaries

The oil-spill-response plan contains a number of scenarios that address the various possible spill events that could occur during the life of the Liberty Project. Two scenarios will be evaluated in this section; an under-ice pipeline leak of 2,956 barrels and a broken-ice leak from a pipeline rupture of 1,580 barrels. See Section II.A.1.b.(3)(d) for a description of how these oil volumes were determined. Section IX evaluates two blowout scenarios that assume a spill of 180,000 barrels: one is on solid ice and the other is during broken ice. See Section IX for a description of those scenarios and the EIS analysis of impacts. These scenarios are included in Section 1of the response plan and are based on the guidance provided by the North Slope Spill Response Advisory Team. These scenarios are refined further using site-specific environmental and oceanographic conditions expected at the Liberty Project site. The tactics used in these scenarios can be found in the Alaska Clean Seas Technical Manual and address the conditions at the Liberty location. Because of the concern associated with oil releases from blowouts or pipelines, we summarize the scenarios that specifically deal with these events.

(1) Under Ice (2,956-Barrel Pipeline Leak)

Containment and recovery involves drilling/trenching holes in the ice and using oleophilic skimmers, absorbents, and light vehicles (trucks/snowmachines) to recover oil that rises to the surface through the holes/trenches.

Initially, five recovery teams would be mobilized to the site to construct a series of recovery sumps throughout the contaminated area. Three to five holes within each sump would allow recovery of almost all of the trapped oil in the vicinity of the sump. Recovery sumps would be cut throughout the entire spill area. In each sump, oleophilic-skimming systems having a combined estimated recovery capacity of 99 barrels of oil per day would be deployed. The total number of oleophilic skimmers would be increased in proportion to the size of the spill and the length of the solid-ice season available. Excavated ice that is oiled would be removed and taken to lined storage pits for disposal. Oil entrained in the ice could be left in place until spring, when it would migrate up through brine channels in the ice and pool on the surface. Once pooled, the oil could be removed using skimmers or in situ burning.

(2) Broken Ice, Breakup (1,580-Barrel Pipeline Rupture)

Containment and recovery involves ocean-containment booms, storage barges, weir- and oleophilic-skimming devices, and support tugs and boats.

Initial response would consist of a barge-based recovery system having an estimated combined capacity of 17,360 barrels during open-water conditions. The response team would use the barge *Endeavor* to deploy equipment identified in Alaska Clean Seas Tactic R-19A (Alaska Clean Seas, 1998). From the barge, up to 400 feet of containment boom would be deployed on each side of the barge, and oleophilic skimmers would be placed in the apex of each boom to recover oil. As conditions permit, workboats are placed in the water from the barge to deploy two additional boom and skimming systems. At 70% ice concentration, the recovery rate would be 3,500 barrels per day, and at 50% coverage, the recovery rate is 6,944 barrels per day. These recovery rates depend on the ice concentrations in the area being worked. If ice coverage increases, tactics would be modified to maintain a safe operation. Workboats would be pulled from the water and placed on the deck of the barge until conditions permit continued safe operation. The oil spill would be tracked using visual observation and remote-sensing techniques. Tracking buoys would be deployed, and an airplane using forward-looking infrared-detection equipment would locate oil within the ice leads. In situ burning could be used if oil concentrations are adequate to support burning.

The actual effectiveness of the cleanup effort would be constrained by wind, wave, and ice conditions at the time of the spill. These scenarios are based on an examination of the actual environmental conditions found at the site and represent a reasonable effort to consider the average conditions that can occur during cleanup activities. The effects from oil-spill-cleanup activities are evaluated in Section III, IV, and IX.

B. DESCRIPTION OF NO ACTION – ALTERNATIVE II

Under this alternative, the Liberty Development and Production Plan would not be approved. None of the potential 120 million barrels of oil would be produced, and none of the environmental effects that would result from the proposed development would occur. There would be no potential oil spills and no effects to the physical, biological, or human environment in the Foggy Island Bay area. The economic benefits, royalties, and taxes to the Federal and State governments would be forgone.

To replace the potential 120 million barrels of oil not developed from Liberty, a large portion of the oil likely would be imported from other countries. The associated environmental impacts from producing oil and transporting it to market still would occur. These imports have attendant environmental effects and negative effects on the Nation’s balance of trade (see Sec. IV.B).

C. DESCRIPTION OF THE COMPONENT ALTERNATIVES

(If an explanation of component alternatives is desired, please refer back to the introduction to Section II and to Sections I.F and H.)

Some of the alternatives (Island Location and Pipeline Route and/or Pipeline Design), if chosen, may result in delays in the Liberty Project of 18-24 months to collect additional engineering data and allow time for specific

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design and testing work. This information would be necessary for technical approval of the project but is not expected to change the environmental effects. For purposes of analysis in the EIS, we have not adjusted the timelines for starting the different alternatives. Therefore, all the alternatives are on the same footing for the analysis of environmental effects.

1. Drilling and Production Island Locations and Pipeline Routes

This set of alternatives evaluates three different island locations and pipeline. Alternatives III.A and III.B evaluate the potential impacts of using different island locations (Liberty Island, Southern Island, and Tern Island) and corresponding pipeline routes (Liberty, eastern, and Tern).

Although both Alternatives III.A and III.B have different offshore pipeline routes that start at different locations (see Map 1), they share the same shore-crossing and onshore pipeline route to the Badami pipeline. They also share an ocean disposal site. The onshore pipeline for both Alternatives III.A and B is about 3.1 miles long. Key components of these alternatives are summarized in Table II.A-1. Table II.A-2 provides information about pipeline trenching, excavation, and backfill quantities for different pipeline routes and pipeline designs for Alternatives III.A , III.B, IV.A, IV.B, IV.C, and for Alternative I (Liberty Development and Production Plan). This table separates the different quantities of excavation and backfill material into two different pipeline zones: from land to the 3-mile limit and from shore to the 3-mile limit. Table II.C.1 provides information about the maximum seafloor dimensions, the number of concrete blocks needed for the lower island slope-protection system, and the total volume of gravel needed for construction of the island.

a. Project Elements Shared by All Drilling and Production Island Location and Pipeline Route Alternatives

All of the alternatives in this set of component alternatives share the following elements.

The gravel island would be constructed during Year 2 (the first construction season), and the offshore pipeline would be constructed the next year. If construction of the gravel island were to be delayed for some reason, construction of both the island and pipeline would occur at the same time in Year 3. To the extent possible, construction of the gravel island and pipeline would occur during the winter.

All gravel islands, regardless of location, would have a working surface size of 345 feet by 680 feet. The working surfaces would be 15 feet above sea level. A helicopter landing pad and dock would be constructed with steel sheetpile. The dock/helipad would be approximately 150-feet by 160-feet. All islands would be designed to operate safely in Arctic offshore conditions, including potential ice and wave events. Figure II.A-4 presents a schematic overview of the expected complement of facilities that would be on all the islands. The total mass of the island (gravel fill and production facilities) is intended to provide sufficient resistance to lateral movement under maximum ice loads.

Ice roads would provide seasonal vehicular access to the island during the winter months. Boats or vessels may be used during open-water periods. Helicopters may be used year-round as needed.

Gravel would be mined onshore and transported by trucks using ice roads to the island location. The process of placing gravel involves using conventional ditch witches (chain trenchers) and backhoes to cut and remove blocks of ice from the construction site. The hole left by the removed ice blocks would be enlarged and filled with gravel hauled in by conventional belly-dump trucks. This process would continue until the total volume of gravel fill material has been placed.

Once the gravel fill is in place, workers would grade and reshape the island to the final design. This work would continue through ice breakup. When the majority of the island is completed, materials for foundations and sheetwalls would be transported to the island by ice road or barge. The precast concrete mats would be constructed offsite and trucked to the island. Following breakup, the filter cloth and slope protection (concrete mats) would be installed, and then the concrete foundations would be installed. All other remaining island construction work would be completed in early to mid-August before the arrival of the sealift in Year 2. During construction of the island, conductor pipes would be installed for each well, which would be a source of additional noise. These conductor pipes would be driven into the island using impact hammers, during a consecutive 1-2-week period in June or July of Year 2 (BPXA, 2000a).

The bottom part of the island would be protected by interconnect concrete blocks (4 feet by 4 feet by 9 inches)(Fig. II.A-5). These blocks would line the island from the seafloor to 5 feet above sea level. These concrete blocks would protect the berm of the island. Steel sheetpile would be placed around the dock and helicopter area (150 feet by 160 feet).

The 40-foot gravel bench on the island (Fig. II.A-3) would be covered with concrete mats. These concrete mats would extend from the base of the gravel bags to the sea surface. These mats dampen wave energy approaching the island and induce the natural formation of ice rubble. Overlapping gravel bags would be used in the upper portion of the island slope starting at 7-8 feet above sea level and continuing to the top of the berm, which is 23 feet above sea level and 8 feet above the working surface of the island. These bags provide additional frictional resistance in the unlikely event of ice rideup past the 40-foot bench. The gravel bags would be used only in the upper portion of the island to avoid direct forces from ice or wave action.

For analysis of this set of component alternatives, the EIS assumes the trenching, excavation, and backfill quantities for a 7-foot minimum burial depth. Other alternatives (IV.A., IV.B, IV.C, and VI) evaluate effects of different burial and trench depths.

All gravel islands would be oblong and oriented so that the narrower end of the island would be facing north to lessen exposure to potential ice and wave forces. Production modules and wells would be positioned away from the north face of the island and towards the center of the island to further lessen potential exposure to ice override onto the working surface of the island. The surface of the island would be contoured, so that runoff flows into sumps away from production facilities.

The individual concrete blocks (Fig. II.A-5) on the gravel island would linked together with stout chain and shackles (Fig. II.A-6) and secured with anchors placed in the island gravel fill.

Construction of the islands would occur during Years 2 through 4 and would be staged from existing or onsite facilities. The majority of the workforce willwould be housed in existing onshore facilities until the infrastructure sealift could provide onsite facilities in the summer of Year 2. A construction barge may be moored near the island during the summer of Year 3. It would be about 150 feet by 380 feet (possibly two connected barges) and would have camp facilities mounted on the barge deck. It could house between 125 and 200 persons and would be used to support construction and possibly drilling. The camp could be overwintered at the site and remain there until summer of Year 4. Any fuel stored on board would be stored in accordance with U.S. Coast Guard Regulations (33 CFR Subpart C) and best industry standards. Wastewater from the camp would be treated onboard and discharged in accordance the Arctic General National Pollutant Discharge Elimination System permit. Solid waste from the camp likely would be hauled back to Prudhoe Bay for recycling, treatment, or disposal in existing approved facilities.

Diesel fuel would be used for power generation for construction activities and drilling until fuel gas is available on the island. . All tanks would be double-walled with 10% containment capacity in the interstitial space. There would be a permanent 3,000-barrel diesel storage tank on the island. The permanent 3000-barrel tank would be located on a raised platform with a seal-welded floor and a seal-welded 6-inch-high toeboard that would provide in excess of 100 barrels of containment. Two other tanks, a 2000-barrel and a 5,000-barrel tank, would be used for diesel storage until the fuel gas is available. After fuel gas is available, these tanks would be converted to other uses, such as a produced water tank or a slop-oil tank. After Year 3, they would no longer be used for diesel storage. The 2,000-barrel and 5,000-barrel tanks would be located outside on a timber mat foundation on a geotechnical liner for additional containment. Seventeen smaller, temporary diesel fuel tanks would be used during construction and drilling and removed after gas from the project is available. The temporary tanks would be located in a lined, gravel-bermed area with a containment capacity of 550 barrels. Fuel gas would be available in the fourth quarter of Year 3 after the facilities have been installed.

b. Alternative I - Use the Liberty Island Location and Liberty Pipeline Route

This alternative (see Map 1) is the Liberty Island location and Liberty pipeline route proposed by BPXA. Liberty Island is in about 22 feet of water. The proposed Liberty gravel island would be centered above the Liberty reservoir. This location would minimize the number of high-departure wells needed to develop the reservoir and maximize the total oil recovered. The present island location had no observed permafrost to a minimum of 50 feet below the island location.

The Liberty Island is about 5 miles from shore (BPXA, 2000a) in water about 22 feet deep. The distance for hauling the gravel is about 7 miles. This location is about 1 mile southeast of the Boulder Patch. Liberty pipeline route would go southwest to shore. For purposes of analysis, we assume a trench with a 7-foot minimum burial depth. In addition to the construction elements shared by all alternatives in this component set, as noted in Section I.A, construction of the Liberty Island and pipeline would include the following:

- 773,000 cubic yards of gravel fill would be needed for the island.
- 17,000 interlinked concrete mats (4 feet x 4 feet x 9 inches) (Figs. II.A-5 and II.A-6) placed from the base of the gravel bags to the seafloor (Fig. II.A-3) and secured with anchors placed in the island gravel fill. About 7,600 cubic yards of gravel are needed to make the concrete mats.
- 4,200 polyester gravel bags (4 cubic yards) placed on the upper slope of the island from 7-23 feet above sea level using an additional 17,000 cubic yards of gravel (Fig.II.A-3).
- Gravel bags would be filled from excess gravel at the island construction site.
- 797,600 cubic yards of gravel would be needed for constructing the island.
- Gravel would be hauled over the ice road for about 45-60 days but should be in place at the island construction site by the end of April of Year 2.
- A maximum footprint would be 835 feet by 1,170 feet, which is about 22.4 acres. The perimeter berm rises to

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23 feet above sea level, which is 8 feet above the working surface.

The 40-foot gravel bench on the island would be covered with concrete mats (Fig. II.A-3). These concrete mats would extend from base of the gravel bags to the sea surface. These mats dampen wave energy approaching the island and induce the natural formation of ice rubble. Overlapping gravel bags would be used in the upper portion of the island slope starting at 7-8 feet above sea level and continuing to the top of the berm, which is 23 feet above sea level and 8 feet above the working surface of the island. These bags provide additional frictional resistance in the unlikely event of ice rideup past the 40-foot bench. The gravel bags would be used only in the upper portion of the island to avoid direct forces from ice or wave action.

The overall pipeline length from the Liberty island to the Badami tie in would be 7.6 miles (12.2 kilometers), compared to 7.3 miles (11.7 kilometers) for Alternative III.A and 8.6 miles (13.8 kilometers) for Alternative III.B. Table II.A-2 shows the trenching, excavation, and backfill quantities for this alternative.

This pipeline would use two ocean disposal sites, Zone 1 and 2 (Fig. II.A-18). Zone 1 is a temporary on-ice storage area. It is a contingent disposal location for excess trench materials, should weather or ice conditions cause operations to be abandoned before completion. The maximum quantity of excess trench materials stockpiled or left for disposal on this site at any one time would not exceed 10,000 cubic yards. Excess trench material in water depths greater than 16 feet would be stacked or groomed to maintain an approximate depth of less than 1 foot. Excess trench material placed where the water depths are less than 16 feet, would be stacked or groomed to a height not to exceed 2 feet. During pipeline construction, the plan is to clear excess material stacked in Zone 1 of all excess dredged material/spoils by spring breakup. This would be done by scraping the ice with heavy equipment, leaving at most a veneer of dirty ice (a very small amount of sediment remaining in the frozen matrix).

c. Alternative III.A - Use the Southern Island Location and Eastern Pipeline Route

Alternative III.A (see Map 1) assumes the drilling and production island location is moved to the southeast edge of the lease, where it would be in shallower water (18 feet) and farther from both the Boulder Patch and the bowhead whales' fall migration than either Alternatives III.B or I. The island would be about 2.5 miles (4 kilometers) from areas of dense boulders and kelp in the Boulder Patch.

This alternative was developed in response to scoping comments requesting analysis of island locations in shallower water to eliminate or reduce effects to bowhead whales.

The island location would be about 1.5 miles (2.4 kilometers) south-southeast of BPXA's proposed location (Alternative I) (BPXA, 2000a). The pipeline route would follow BPXA's alternate eastern route, extending south-southeast from the Southern island location to shore and then to the Badami pipeline (BPXA, 2000a). For analysis purposes, we assume a trench with a 7-foot minimum burial depth. See Sec. IV.C.1.c for a full description of the trench size and characteristics.

In addition to the construction elements shared by all alternatives in this component set, as noted in Section II.A, construction of the Southern Island and Eastern pipeline would include the following:

- 661,000 cubic yards of gravel fill for the island.
- 16,000 interlinked concrete mats (4 feet x 4 feet x 9 inches)(Figs.II.A-5 and II.A-6) placed from the base of the gravel bags to the seafloor and secured with anchors placed in the island gravel fill. About 7,600 cubic yards of gravel would be used to make the concrete mats.
- 4,200 polyester gravel bags (4 cubic yards) placed on the upper slope of the island from 7-23 feet above sea level using an additional 17,000 cubic yards of gravel.
- Gravel bags would be filled from excess gravel at the island construction site.
- 684,800 cubic yards of gravel would be needed for constructing the island.
- Gravel would be hauled over the ice road for about 42-55 days but should be in place at the island construction site by the end of April of Year 2.
- A maximum footprint would be 825 feet by 1,155 feet, which is about 21.9 acres. The perimeter berm rises to 23 feet above sea level, which is 8 feet above the working surface.

The overall pipeline length from the Liberty island to the Badami tie in would be 7.3 miles (11.7 kilometers), compared to 8.6 miles (13.8 kilometers) for Alternative III.B and 7.6 miles (12.2 kilometers) for Alternative I. Table II.A-2 shows the trenching, excavation, and backfill quantities for this alternative.

While the offshore pipeline routes start at different locations (see Map 1), they share the same shore-crossing and onshore pipeline route to Badami. The rate of shore erosion for the shore crossing for these alternatives is higher (2.7 feet per year) than the rate of erosion at the shore-crossing location for the Proposal (2.0 feet per year). The onshore gravel pad has been moved farther inland and is located 205 feet from the shoreline. This would increase the length of the shore-crossing trench by 55 feet more than the Proposal, and it would increase by one-third the shoreline area disturbed.

Pipeline construction would require using temporary storage sites for excess trenching material. This requires an Ocean Water Disposal of Dredged Material permit. Each pipeline route would need two on-ice disposal sites, one nearshore and one along the side of the pipeline. Both pipeline routes

(Eastern and Tern) would use the same nearshore site, Zone 3 (Fig. II.C-1). Zone 3 is comparable in size, bathymetry location, and purpose to Zone 1 in the Proposal (see Sec. II.A.1.b.(3)). Zone 3 is located on the west side of the pipeline right-of-way on grounded sea ice outside the 5-foot isobath. Maximum dimensions of the site would be 5,000 by 2,000 feet (230 acres). Zone 3 would serve as the primary temporary storage location of all excavated materials that cannot be directly transported for backfill along the pipeline. For excess trench material that cannot be used as backfill, Zone 3 would serve as the designated disposal site. Table II.A-2 shows the trenching, excavation, and backfill quantities for this alternative.

Excess trench material placed in Zone 3 would be groomed to a height not to exceed 1 foot to minimize the potential for mounding on the seafloor. The entire site would not be used for disposal. Material would be stacked on portions of the site over deeper water first and then over shallower water. The maximum quantity of spoils stockpiled or left for disposal on this site at any one time would not exceed 100,000 cubic yards. Assuming this maximum quantity is placed in stacks 1 foot high, about 27% of Zone 3 (about 62 acres) would be used for actual disposal (see Fig. II.C-1).

The Eastern Pipeline has a second disposal site, Zone 4 (Fig. II.C-1), which is comparable in purpose to Zone 2 in the Proposal (see Sec. II.A.1.b.(3)). Zone 4 is 4.2 miles long; for comparison, Zone 2 in the Proposal is 6.1 miles long. Zone 4 is 200 feet wide on the west side of the pipeline trench from the island to shore. About 0.1 mile of Zone 4 is seaward of the 3-mile boundary, and the remaining 4.1 miles are shoreward of the 3-mile boundary.

Zone 4 is a temporary on-ice storage area. It also is a contingent disposal location for excess trench materials, should weather or ice conditions cause operations to be abandoned before completion. The maximum quantity of excess trench materials stockpiled or left for disposal on Zone 4 at any one time would not exceed 10,000 cubic yards. Excess trench material in water depths greater than16 feet would be stacked or groomed to maintain an approximate depth of less than 1 foot. Excess trench material placed where the water depths are less than 16 feet would be stacked or groomed to a height not to exceed 2 feet. During pipeline construction, the plan is to clear excess material stacked in Zone 4 of all excess dredged material/spoils by spring breakup. This would be done by scraping the ice with heavy equipment, leaving at most a veneer of dirty ice (a very small amount of sediment remaining in the frozen matrix).

d. Alternative III.B - Use the Tern Island Location and Tern Pipeline Route

Alternative III.B (see Map 1) assumes the location of the drilling and production island is moved about 1.5 miles east to the abandoned Tern Exploration Island. The Tern Island location is in about 23 feet of water, on Outer Continental Shelf Lease Y-01585. BPXA is a part owner of this lease. This location, about 2.5 miles southeast of the Boulder Patch, was used to drill the exploratory well from an ice cap on top of the remnants of the abandoned island. The Tern pipeline route would go directly south to shore. It would have the same shore-crossing location and onshore pipeline route to the Badami Pipeline as the eastern pipeline route in Alternative III.A. About 230,000 cubic yards of gravel remain from the exploration island, which would reduce the gravel needs to construct the island to about 599,500 cubic yards.

In addition to the construction elements shared by all alternatives in this component set, as noted in Section II.A, construction of the Tern Island and pipeline would have the include the following:

- 574,500 cubic yards of gravel fill for the island.
- 18,000 interlinked concrete mats (4 feet x 4 feet x 9 inches) (Figs. II.A-5 and II.A-6) placed from the base of the gravel bags to the seafloor and secured with anchors placed in the island gravel fill. About 8,000 cubic yards of gravel would be used to make the concrete mats.
- 4,200 polyester gravel bags (4 cubic yards) placed on the upper slope of the island from 7-23 feet above sea level using an additional 17,000 cubic yards of gravel.
- Gravel bags would be filled from excess gravel at the island construction site.
- 599,500 cubic yards of gravel would be needed for constructing the island.
- Gravel would be hauled over the ice road for about 35-45 days but should be in place at the island construction site by the end of April of Year 2.
- A maximum footprint would be 850 feet by 1190 feet, which is about 23.3 acres. The perimeter berm rises to 23 feet above sea level, which is 8 feet above the working surface.

The overall pipeline length from the Liberty island to the Badami tie-in would be 8.6 miles (13.8 kilometers), compared to 7.3 miles (11.7 kilometers) for Alternative III.A and 7.6 miles (12.2 kilometers) for Alternative I. Table II.A-2 shows the trenching, excavation, and backfill quantities for this alternative.

In addition to the Zone 3 disposal site described in Section II.D.1 a second site would be needed along the west side of the Tern pipeline (Fig. II.C-2). Zone 5 (See Fig. II.C-2) is comparable in purpose to Zone 2 in the Proposal (see Sec. II.A.1.b.(3)). Zone 5 is 5.5 miles long (for comparison, Zone 2 in the Proposal is 6.1 miles long). Zone 5 is 200 feet wide and extends from the island to shore. A 1.8-mile long portion of Zone 5 is seaward of the 3-mile boundary, and the remaining 3.7 miles are shoreward of the 3-mile.

As stated, Zone 5 is a temporary on-ice storage area. It is a contingent disposal location for excess trench materials, should weather or ice conditions cause operations to be

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abandoned before completion. The maximum quantity of excess trench materials stockpiled or left for disposal on this site at any one time would not exceed 10,000 cubic yards. Excess trench material in water depths greater than16 feet would be stacked or groomed to maintain an approximate depth of less than 1 foot. Excess trench material placed where the water depths are less than 16 feet, would be stacked or groomed to a height not to exceed 2 feet. During pipeline construction, the plan is to clear excess material stacked in Zone 5 of all excess dredged material/spoils by spring breakup. This would be done by scraping the ice with heavy equipment, leaving at most a veneer of dirty ice (a very small amount of sediment remaining in the frozen matrix).

All other aspects of the project description are the same as those for all alternatives, as noted in Section II.A (see Secs. I.A and II.A and Table II.A-1). Comparison of the key components for all of the alternative are shown in Table II.A-1.

2. Pipeline Designs

a. Project Elements Shared by All Pipeline Design Alternatives

Pipeline design and secondary containment of oil were identified as key issues by some members of the Interagency Team. This alternative describes and evaluates the environmental effects of different pipeline designs (Fig. II.C-3), including pipelines that offer the potential of secondary containment. This set of alternative components evaluates four different pipeline designs (the first two address the issue of secondary containment): (1) a steel pipe-in-steel pipe system, Alternative IV.A; (2) a steel pipe-in-HPDE (high-density polyethylene) system, Alternative IV.B; and (3) flexible pipeline, Alternative IV.C. The alternative evaluation will include a summary of the analysis of effects for the single-wall steel pipeline component proposed in Alternative I. Key components of the alternatives are summarized in Table II.A-1.

The following subsection describes the basic design characteristics of each of the alternative pipeline design system. The information presented in this section is from *Pipeline Systems Alternative. Liberty Development Project Conceptual Engineering* (INTEC, 2000).

Many of the features associated with pipeline construction, operation, maintenance, leak detection, failure modes, and repair are the same or similar for the three alternative pipelines designs. These characteristics are described in the following subsections. The discussion of each activity begins with a description of those features that are common to each pipeline system; differences in features also are noted. The pipeline systems have different activity levels; these include time requirements to perform certain tasks and/or quantities of material moved. The changes in activity levels between the alternatives are shown in Table II.C-2. Also, the activity level for the construction of the pipeline for the Proposed Action is shown for comparison.

(1) General Pipeline Design, Construction, and Operation Information

The pipeline systems in this alternative are designed to withstand the environmental conditions that can be expected to occur along the Liberty, Eastern, or Tern pipeline routes. All designs can be constructed and operated safely (Stress, 2000).

It is expected that all of these designs would be constructed in a single construction season. It is possible that a second construction season may be needed if there are problems with construction or weather. The more complex the construction process, the higher the potential for multiple-year construction. All offshore pipeline systems evaluated in this Section would be constructed the third year of the project and the second winter construction season. This pipeline would be constructed using conventional construction equipment, the same as the process used for the Northstar Project. Construction and fabrication of the pipeline would occur on the surface of the ice. The LEOS, or a LEOS equivalent, leak-detection system would be installed with all pipelines. In addition to the supplemental leak-detection system, pressure-point analysis and mass-balance line-pack compensation systems would be installed for leak detection. Excess trenching material would be disposed at approved ocean dumping sites.

A pipeline makeup site needs to be prepared on the ice surface in the bottomfast-ice zone. This site would be used to assemble the pipeline strings before transporting them to the side of the ice slotted trench for final tie-in welds and lowering into the trench. The size of the site required depends on the amount of materials necessary for pipeline makeup. Table II.C.2 provides information on the size of the makeup sites and number of days required for construction of those sites. It also provides information about the number of days required to make up the pipeline strings, transport the strings to the trench, install the pipeline in the trench, and to backfill the trench. Table II.A-2 provides a comparison of the quantities of trench excavation and backfill for the four alternatives in this component set.

The pipeline designs were optimized by Intec to provide the best overall design in terms of safety, ease of construction, operation and maintenance, leak detection, and costs. All four pipeline systems evaluated in this section are designed for a maximum allowable operating pressure of 1,415 pounds per square inch gauge. After installation the pipelines would be hydrostatically tested at 1,775 pounds per square inch gauge for a minimum of 8 hours.

For comparative purposes in this EIS, the same pipeline route (Liberty Pipeline Route/Alternative I) was assumed

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for each of the pipeline systems evaluated in this alternative, with a length of 6.1 miles (32,314 feet). The length of the pipeline is 14,877 feet in water 0-8 feet deep, 12,473 feet in water 8-18 feet deep, and 3,964 feet in water 18-22 feet deep.

All of the pipeline systems would be constructed in winter of Year 3, starting in January and finishing by May. The pipeline system would be constructed within a temporary right-of-way (250 feet wide onshore, 1,500 feet wide offshore). For welding strings of offshore pipeline, workers would need a site close to shore on grounded sea ice artificially thickened, as needed, and usually in water less than 5.5 feet deep. The site would hold a welding pad 6,000 feet long by 750 feet wide.

All of the pipelines would be constructed through the ice in winter and use techniques that are similar to those used onshore and at Northstar Project. Trenching would use conventional excavation equipment, such as backhoes. Hydraulic dredging may be used for final smoothing of the trench bottom. (See Sec. I.H.5.b(11) for additional information and discussion about hydraulic dredging.)

Construction activities include the following (see Sec. II.A.1.(3)(a) for a more detailed description of each activity):

- mobilizing equipment, material, and workforce;
- constructing the Ice road and thickening the ice;
- slotting the ice;
- trenching (including temporary storage and disposal of excess material);
- preparing the pipeline makeup site;
- welding pipe strings;
- attaching anodes;
- attaching LEOS;
- transporting pipe string and welding tie in;
- island transition;
- shoreline transition;
- installing pipeline;
- backfilling the trench;
- hydrostatic testing; and
- demobilizing equipment.

All of the pipelines systems evaluated in this section would use the following three leak-detection systems:

- Pressure-Point Analysis
- Mass-Balance Line-Pack Compensation
- Leak-Detection and Location System (LEOS) or an equivalent system

Pressure-point analysis is the continuous monitoring of the pipeline to alert the operator to any pressure variances that leaks would induce and variances in measured volumes of oil at the inlet and outlet of the Liberty oil pipeline. Mass-balance line-pack compensation measures the volumetric throughput at both the island and the Badami tie in. The accuracy of the meters would be such that the threshold for the leak-detection system would be 0.15% of flow.

Operating procedures require periodic calibration of the meters. If the crude oil meters are above or below 100 barrels or more per day for 2 days, the meters would be checked and calibrated. If there are volume discrepancies after the meters have been checked and there is no apparent operational reason, the pipelines would be shut in. Combined, these systems have been used extensively on the North Slope and are considered as part of the best available and safest technology.

The LEOS system is described in greater detail in Section II.A.1.b.(3)(b)2). The LEOS system can detect a leak within 24 hours when the total volume of oil released reaches 0.3 barrels. Because the air moves through the tube at a specific rate, it can accurately determine within meters the location of a pipeline leak. Should a leak be detected, it sets off an alarm. The system automatically stores more than 100 days' worth of data on a personal computer.

(2) Pipeline Oil-Spill Information

The EIS evaluates four offshore pipeline oil-spill sizes: less than 125 barrels, 715 barrels, 1,580 barrels, and 2,956 barrels. These are described in Section III.C.1 in more detail. Because all of the carrier pipelines in the alternatives have the same diameter and transport the same volumes of oil, these spill sizes are evaluated for all pipeline alternatives.

All pipeline systems would have a monitoring program that includes both pre- and postinstallation monitoring aimed at reducing the risk of a pipeline failure. Visual surveillance flights to search for oil sheens on the water would occur weekly during open-water and broken-ice conditions. Aerial surveys for river overflooding would be conducted during the initial years of operation. The shoreline would be inspected annually for erosion. A check of the pipeline integrity would occur every 5 years. Visual inspection of overland pipe and valves would occur monthly. Process operators would continuously monitor the automated control systems for pipeline leaks. Monthly on-ice inspections would monitor for possible oil leaks during the winter, if the LEOS leak-detection system were suspected of not operating properly.

All pipeline systems would periodically monitor the status of the pipelines using smart-pig tools. Smart pigging of the pipeline at startup would be used to determine the initial condition of the pipeline and establish a baseline against which future pigging results can be compared. Smart pigging would involve three different types of pigs:

- A caliper pig would measure any internal deformation of the pipeline, such as dents and buckling. It would always be run before running either of the other two pigs to ensure that there are no internal blockages that would prevent the other pigs from passing through the pipeline.
- A geometry pig would record the configuration of the offshore pipeline system. It can be used to determine

the amount of displacement in the pipeline due to thaw settlement, upheaval buckling, strudel scour, ice gouging, or other event that may cause the pipeline to move. This information can be evaluated to determine if the pipeline's allowable strains have been exceeded, or if the amount of displacement exceeds the design parameters. This pig would be run after the pipeline has been constructed to measure its baseline condition, then once a year for the first 5 years, and then once every 2 years for the life of the pipeline. It also would be run after extreme ice gouging or strudel scouring is observed or suspected to have occurred.

- A wall-thickness pig would measure the thickness of the pipeline wall to determine the amount of corrosion that has occurred and to determine if the pipeline has been gouged. This pig can provide an early warning of potential pipeline failures that would allow them to be repaired before a leak could occur. This pig would be run at startup and then every 2 years. The pig would be run in early winter, so that any needed repairs can be carried out that same winter after the ice has thickened sufficiently to be safe to work on.

(3) Pipeline Operation, Maintenance, and Repair

Pipeline operations and maintenance essentially are the same for all pipeline systems, except as noted in the following. See Section II.A.1.b.(3)(c) for a complete description of pipeline monitoring, including pigging.

Several types of pipeline repairs are available, based on the nature of the damage that has occurred. These include welded repair with cofferdam, hyperbaric weld repair, surface tie-in repair, tow-out of replacement string, rigid spool piece with mechanical connectors, and split sleeve repair. A matrix for evaluating the appropriateness of the various repair techniques is given in Table II.C-6. Details on each repair method (INTEC, 2000:Appendix E) are provided in Section II.A.1.b.(3)(c)3) and summarized in Table II.C-7.

The exact type of repair would depend upon the type of leak, the season of year, weather conditions, and many other variables. Any analysis of the environmental assessment associated with the repair of the pipeline would be driven by the assumptions and may not reflect the actual environmental conditions. A small area of the pipeline trench surface area would need to be excavated and backfilled after the repair work was completed. Those effects would be considerably smaller than the construction of the pipeline and would be short-term in nature. The repair area would be contained with oil boom and oil response equipment would be stationed on site to remove any oil that may be released during the repair, although the goal of the pipeline repair would be zero release. The effects of any oil spill would be similar to those evaluated in Section III.C and III.D.3.

Automated pipeline isolation valves for the sales oil pipeline would be located at the landfall and the Badami pipeline tie-in point and on the island. BPXA currently is considering using a vertical loop in lieu of the landfall isolation valve; if implemented this option probably would reduce the size of the landfall pad.

b. Alternative I – Use a Single-Wall Steel Pipeline System (Liberty Development and Production Plan)

Section II.C.2.a describes the common elements shared by all alternatives in the set of component alternatives. Those common elements, plus the following alternative components specific to this particular pipeline design, complete the description of this alternative. For the offshore single-wall steel pipeline, BPXA proposes a single-wall steel pipeline system that would be constructed with a 12.75-inch outside diameter pipe with a 0.688-inch wall thickness. The system would be protected from corrosion by a dual-layer fusion-bonded epoxy coating and sacrificial anodes. The system would be buried with a minimum burial depth of 7 feet (Fig. II.A-12). The estimated cost of the pipeline system is $31 million. (INTEC, 2000).

A detailed description of the activities involved in constructing a pipeline are in Section II.A.1.b.(3)(a). Table II.C-2 provides information about the number of days required to construct the pipeline. All of the pipeline welds would undergo x-ray and ultrasonic tests to ensure that they are sound. Any weld that has a defect larger than the maximum acceptable level would be cut out and replaced.

The amount of excavation in the various water depths for this system is shown in Table II.A-2. The size of the pipeline makeup site required would be 416,500 square yards, about 86 acres. An estimated 17,000 cubic yards of gravel fill material would be required as pipeline-bedding material in various locations within the trench between the gravel island and the 3-mile limit. Approximately 50,000 cubic yards of gravel fill would be required as pipeline-bedding material in various locations within the Territorial Seas (shoreward of the 3-mile limit). These estimates include the gravel material contained within the 4-cubic-yard bags (about 4,000 bags) that periodically would be placed over the entire pipeline before placing the backfill material. The bags would cover approximately 50% of the pipeline route. Backfill material would consist of material dredged from the trench. Between the Liberty Island and the 3-mile limit, approximately 162,000 cubic yards of trench-dredged material would be used as backfill. Between the 3-mile limit and the shoreline, about 495,000 cubic yards of trench-dredged material would be used as backfill. The pipeline would be buried with a minimum 7-foot burial depth. In water up to 8 feet deep, the cap of the backfill would be close to the original seafloor, not to exceed 1 foot higher than the surrounding seafloor. In water deeper than 8 feet, the trench cap would not exceed 2 feet higher than the surrounding seafloor. The affected footprint would be 18.2 acres beyond the 3-mile limit and 55.4 acres within the 3-mile limit. This includes the trench cap, which could overstep the limits of the trench excavation.

Any dredged/excavated material that could not be placed back into the trench would require disposal into ocean water. See Sections IV.C.2 and II.A.1.b.(3)(a)12)c) for more a detailed description of disposal Zones 1 and 2 (Fig. II.A-18).

Table II.C-5 provides information about the functional and containment failure rates for this pipeline. Section III.C.1.c provides information about the different sizes of oil spill that may occur. This pipeline system does not offer any secondary containment should the pipe develop a leak.

c. Alternative IV.A - Use Pipe-In-Pipe System

Section II.C.2.a describes the common elements shared by all alternatives in the set of component alternatives. Those common elements, plus the following alternative components specific to this particular pipeline design, complete the description of this alternative. The pipe-in-pipe system (Fig. II.C-3) would be constructed with a steel inner pipe with an outside diameter of 12.75 inches and a wall thickness of 0.500 inch. The inner pipe would be placed in a steel outer pipe with an outside diameter of 16.00 inches and a wall thickness of 0.844 inch. The inner pipe would be supported in the outer pipe with annular spacers or centralizers. The outer pipe would be protected from external corrosion by a dual-layer fusion-bonded epoxy and sacrificial anodes. The inner pipe would be protected from corrosion by a dual-layer fusion-bonded epoxy. For the EIS analysis we assume the double-wall pipeline design can be built in a single winter construction season, although its complexity increases the risk that it may require a two-season (2 winters) construction. The system would be buried with a minimum burial depth of 5 feet. Table II.A-1 provides a comparison of key components for the different alternatives being analyzed.

A detailed description of the activities involved in constructing a pipeline are in Section II.A.1.b.(3)(a). Table II.C-2 provides information about the number of days required to construct the pipeline. All of the pipeline welds on the carrier pipe would undergo x-ray and ultrasonic tests to ensure that they are sound. Most welds on the outer pipe would also be x-rayed and ultrasonically tested; some welds, the tie-in welds, can only be tested by ultrasonically because the inner pipe of the pipe-in-pipe configuration would interfere with the x-ray test. Any weld that has a defect larger than the maximum acceptable level would be cut out and replaced.

The amount of excavation in the various water depths for this system is shown in Table II.A-2. The size of the pipeline makeup site required would be 533,000 square yards, about 110 acres. No select backfill material would be needed. Between the Liberty Island and the 3-mile limit, approximately 137,000 cubic yards of trench-dredged material would be used as backfill. Between the 3-mile limit and the shoreline, about 419,700 cubic yards of trench-dredged material would be used as backfill. The pipeline would be installed with a minimum 5-foot burial depth. In water up to 8 feet deep, the cap of the backfill would be close to the original seafloor, not to exceed 1 foot higher than the surrounding seafloor. In water deeper than 8 feet, the trench cap would not exceed 2 feet higher than the surrounding seafloor. The affected footprint would be 15.4 acres beyond the 3-mile limit and 47.1 acres within the 3-mile limit. This includes the trench cap, which could overstep the limits of the trench excavation.

Any dredged/excavated material that could not be placed back into the trench would require disposal into ocean water. See Sections II.A.1.b.(3)(a)12)c) and IV.C.2.k for more a detailed description of disposal Zones 1 and 2 (Fig. II.A-18).

This alternative could provide secondary containment capabilities in the unlikely event of a functional failure that allows oil to escape from the carrier pipeline. The outer pipe in this pipe-in-pipe system can handle the full operating pressure that could occur if the inner pipe leaked, but the outer pipe did not.

For the Liberty pipeline route, MMS calculated that 1,325 barrels would be the maximum volume that may be contained in the annulus (the space between the two pipes) for the pipe-in-pipe design system. It is possible that the pipe-in-pipe system could suffer a functional failure, where oil is released from the inner pipe and contained in the annulus. If this type of functional failure occurs, one step of the repair process would be to remove the oil from the annulus and clean the annular space before the pipeline could be returned to service. If this pipeline design is selected additional work and testing would be needed to develop a procedure for cleaning the annular space should a leak occur. All other aspects of the project description are the same as those in Alternative I (the Proposal) (see Secs. I.A and II.A and Table II.A-1).

The pipe-in-pipe system is subject to another type of functional failure that likely would require immediate attention and repair, although it would not result in a release of oil to the environment. Conditions relating to this type of failure are discussed Table II.C-4. The outer pipe could be damaged or corroded, which would allow seawater to enter the annulus space. The pipeline may continue operating for a limited time until it could be repaired, if pigging and other tests show the integrity of the carrier pipeline has not been adversely affected.. Similar to the case of oil entering the annulus, a procedure would need to be developed to remove the seawater from the annulus and dry the annulus before the pipeline is placed back in service following a repair.

The caliper pig would not be able to determine if the outer pipe has buckled or is dented for the pipe-in pipe system, unless the damage to the outer pipe was so extensive that it affected the inner pipe. The geometry pig cannot directly measure the outer pipe of the pipe-in-pipe systems, but inferences from the shape of the inner pipe could be applied to the outer pipe. The wall-thickness pig cannot investigate the outer pipe of a pipe-in-pipe system. Due to the limitations of smart pigging it would be difficult, if not impossible, to predict if the outer pipe was in danger of leaking.

BPXA proposes, as a supplemental leak detection for the pipe-in-pipe system, to sample the entire annulus as if it were a large LEOS tube. This system would need to be able to detect seawater in the annulus or another system would need to be installed that could detect seawater in the annulus. Seawater in the annulus would mean that the outer pipe has failed and is no longer able to provide secondary containment. Seawater in the annulus also raises the concern of corrosion of the inner pipe.

d. Alternative IV.B - Use Pipe-In-HDPE System

Section IV.C.2.a describes the common elements shared by all alternatives in the set of component alternatives. Those common elements, plus the following alternative components specific to this particular pipeline design, complete the description of this alternative. The pipe-in-HDPE system (Fig. II.C-3) would be constructed with a steel inner pipe with an outer diameter of 12.75 inches and a wall thickness of 0.688 inch. The inner pipe would be placed in a high-density polyethylene (HDPE) outer pipe with an outer diameter of 16.25 inches and a wall thickness of 0.75 inch. The inner pipe would be placed in the high-density polyethylene outer pipe without the use of spacers or centralizers. Because the outer pipe is made of high-density polyethylene, it would not require any corrosion protection. The inner pipe would be protected from corrosion by a dual-layer fusion-bonded epoxy. The EIS assumes this pipeline could be constructed in a single winter construction, although the complexity would increase the possibility that the construction could take 2 years. The system would be buried with a minimum burial depth of 5 feet. Table II.A-1 provides a comparison of key components for the different alternatives being analyzed.

The amount of excavation in the various water depths for this system is shown in Table II.A-2. The size of the pipeline makeup site required would be 416,500 square yards, about 86 acres. An estimated 17,000 cubic yards of gravel fill material would be required as pipeline-bedding material in various locations within the trench between the gravel island and the 3-mile limit. Approximately 50,000 cubic yards of gravel fill would be required as pipeline-bedding material in various locations within the Territorial Seas (shoreward of the 3-mile limit). These estimates include the gravel material contained within the 4-cubic-yard bags (about 4,000 bags) that periodically would be placed over the entire pipeline before placing the backfill material. The bags would cover approximately 50% of the pipeline route. Backfill material would consist of material dredged from the trench. Between the Liberty Island and the 3-mile limit, approximately 162,000 cubic yards of trench-dredged material would be used as backfill. Between the 3-mile limit and the shoreline, about 495,000 cubic yards of trench-dredged material would be used as backfill. The pipeline would be buried with a minimum 6-foot burial depth. In water up to 8 feet deep, the cap of the backfill would be close to the original seafloor, not to exceed 1 foot higher than the surrounding seafloor. In water deeper than 8 feet, the trench cap would not exceed 2 feet higher than the surrounding seafloor. The affected footprint would be 18.2 acres beyond the 3-mile limit and 55.4 acres within the 3-mile limit. This includes the trench cap, which could overstep the limits of the trench excavation.

This alternative could provide secondary containment capabilities in the unlikely event of a functional failure that allows oil to escape from the carrier pipeline. The high density polyethylene outer pipe is not capable of withstanding the operating pressure of the inner pipe; therefore, the ends of the annulus would have to be equipped to allow the pressure to escape or the high density polyethylene pipe could burst and allow oil to enter the environment. Because of the pressure relief capability of the annulus, it is possible that a leak from the inner pipe could flow through the annulus and out the end of the annulus. The shoreline crossing is at a lower elevation than the island and, therefore, the transition pad would need to be designed to contain a possible oil spill of up to 2,000 barrels.

For the Liberty pipeline route, MMS calculated that 1,725 barrels would be the maximum volume that could be contained in the annulus (the space between the two pipes) for the pipe-in HDPE system. It is possible that the pipe-in-HDPE system could suffer a functional failure where oil is released from the inner pipe and contained in the annulus. If this type of functional failure occurs, one step of the repair process would be to remove the oil from the annulus and clean the annular space before the pipeline could be returned to service. If this pipeline design is selected additional work and testing would be needed to develop a procedure for cleaning the annular space should a leak occur. All other aspects of the project description are the same as those in Alternative I (the Proposal) (see Secs. I.A and II.A and Table II.A-1).

The pipe-in-HDPE system is subject to another type of functional failure that likely would require immediate attention and repair, although it would not result in a release of oil to the environment. Conditions relating to this type of failure are discussed in Table II.C-4. The outer pipe could be damaged, which would allow seawater to enter the annular space. The pipeline may continue operating for a limited time until it could be repaired, if pigging and other tests show the integrity of the carrier pipeline has not been adversely affected. Similar to the case of oil entering the annulus, a procedure would need to be developed to remove the seawater from the annulus and dry the annulus before the pipeline were placed back in service following a repair.

The caliper pig would not be able to determine if the outer pipe has buckled or is dented for the pipe-in HDPE systems, unless the damage to the outer pipe was so extensive that it affected the inner pipe. The geometry pig cannot directly measure the outer pipe of the pipe-in HDPE systems, but inferences from the shape of the inner pipe could be applied to the outer pipe. The wall-thickness pig cannot investigate the outer pipe of a pipe-in-HDPE system. Due to the limitations of smart pigging, it would be difficult, if not impossible, to predict if the outer pipe was in danger of leaking.

BPXA proposes, as supplemental leak detection for the pipe-in-pipe system, to sample the entire annulus as if it was a large LEOS tube. This system would need to be able to detect seawater in the annulus or another system would need to be installed that could detect seawater in the annulus. Seawater in the annulus would indicate that the outer pipe has failed and is no longer able to provide secondary containment. Seawater in the annulus also raises the concern of corrosion of the inner pipe.

e. Alternative IV.C – Use Flexible Pipe System

Section II.C.2.a describes the common elements shared by all alternatives in the set of component alternatives. Those common elements, plus the following alternative components specific to this particular pipeline design, complete the description of this alternative. Table II.A-1 provides a comparison of key components for the different alternatives being analyzed.

The flexible pipe system (Fig. II.C-3)would be constructed with an internal diameter of 12 inches of and a wall thickness of 1.47 inches. The flexible pipe is a nonbonded pipe made of thermoplastic layers and steel strips. The plastic layers provide fluid containment, and they transfer the pressure loads to the steel strips, which provide the strength to withstand the operating pressure of the pipeline. The pipe has eight layers: an inner interlocked steel carcass; a pressure thermoplastic sheath; two layers of armor wires; fabric tape; and a polyethylene external sheath (INTEC, 2000). The pipe is typically supplied on a reel, and each reel holds about 0.75 miles of flexible pipe. Each of the sections terminates with a fitting that can be welded to the next section. The flexible pipe itself does not require cathodic protection, but the butt-weld connectors joining the segments would have anticorrosion coating and possibly sacrificial anodes. This system could be constructed in a single season, and construction would start in Year 3, which is the second winter construction season. The system would be buried with a minimum burial depth of 5 feet. Periodic smart pigging would monitor the system’s integrity.

A detailed description of the activities involved in constructing a pipeline are in Section II.A.1.b.(3)(a). Table II.C-2 provides information about the number of days required to construct the pipeline. All of the pipeline tie-in welds would undergo x-ray and ultrasonic tests to ensure that they are sound. Any weld that has a defect larger than the maximum acceptable level would be cut out and replaced.

The amount of excavation in the various water depths for this system is shown in Table II.A-2. The size of the pipeline makeup site required would be 533,000 square yards, about 110 acres. An estimated 17,000 cubic yards of gravel fill material would be required as pipeline-bedding material in various locations within the trench between the gravel island and the 3-mile limit. Approximately 50,000 cubic yards of gravel fill would be required as pipeline-bedding material in various locations within the Territorial Seas (shoreward of the 3-mile limit). Backfill material would consist of material dredged from the trench. Between the Liberty Island and the 3-mile limit, approximately 123,200 cubic yards of trench-dredged material would be used as backfill. Between the 3-mile limit and the shoreline, about 375,760 cubic yards of trench-dredged material would be used as backfill. The pipeline would be buried with a minimum 5-foot burial depth. In water up to 8 feet deep, the cap of the backfill would be close to the original seafloor, not to exceed 1 foot higher than the surrounding seafloor. In water deeper than 8 feet, the trench cap would not exceed 2 feet higher than the surrounding seafloor. The affected footprint would be 14.7 acres beyond the 3-mile limit and 44.9 acres within the 3-mile limit. This includes the trench cap, which could overstep the limits of the trench excavation.

Any dredged/excavated material that could not be placed back into the trench would require disposal into ocean water. See Sections II.A.1.b.(3)(a)12)c) and IV.C.2.k for more a detailed description of disposal Zones 1 and 2 (Fig. II.A-18).

Technically, flexible pipe offers secondary containment, but the volume is very small, and the annular space is very different from the annuli of Alternatives III.A and III.B. This space cannot be monitored or cleaned effectively, although it may be possible to monitor one of the layers that contain steel strips for the presence of hydrocarbon vapors. For analysis purposes in this EIS, we assume any leak in the flexible pipe system would result in a leak to the environment. Flexible pipe systems have been used offshore in applications where strength and flexibility are needed, such as flexible risers for floating production facilities.

3. Upper Island Slope-Protection Systems

a. Project Components Shared by All Upper Island Slope-Protection System Alternatives

This alternative resulted from scoping meetings in Nuiqsut, where concerns were raised that gravel bags might be damaged by ice events and enter the sea, affecting navigation and the environment. Previous exploration used plastic bags (polyethylene) for the total island slope-protection system. These bags were in contact with the ice at the seawater level and, if they were torn by the ice, they could be washed into the ocean environment. These plastic bags often floated at or near the surface of the water, causing a navigation hazard. Comments recommended the EIS evaluate the use of steel sheetpile for the upper slope-protection system the same as the system being used for the Northstar Project. For this component set, the EIS will evaluate using steel sheetpile (Alternative V) and using gravel bags (Alternative I).

The proposed working surface elevation of island alternatives would be 15 feet to ensure that the elevation of the island would be higher than the potential 100-year-wave height (12.2 feet) and adequate to handle the 100-year ice-rideup event (49 feet). The total mass of the island (gravel fill and production facilities) is intended to provide sufficient resistance to lateral movement under maximum ice loads. Interlinking concrete mats would be placed on the lower slope of the island from the base of the upper slope-protection system (steel sheetpile or gravel bags) down to the seafloor to provide stability and protection against erosion. Filter-cloth material placed underneath the gravel bags and concrete matting would prevent the gravel fill material from washing out but would not itself be susceptible to washing away.

The oblong shape of the island is oriented so that the narrower end of the island would be facing north to lessen exposure to potential ice and wave forces. Production modules and wells would be positioned away from the north face of the island and towards the center of the island to further lessen potential exposure to ice override onto the working surface of the island. The surface of the island would be contoured, so that runoff flows into sumps away from production facilities.

The island design, which would include the upper slope-protection system (steel sheetpile or gravel bags) would be reviewed by MMS under regulations contained in 30 CFR 250 Subpart I, Platforms and Structures, to ensure that the design has taken into account the physical forces that may impact the island. This review would be conducted by a third party and would verify that the design is adequate for use in the area.

b. Use Gravel Bags (Liberty Development and Production Plan)

Gravel bags would be used in the upper portion of the island slope starting at 7-8 feet above sea level and continuing to the top of the berm, which is 23 feet above sea level and 8 feet above the working surface of the island (see Fig. II.A-3). This alternative would use 4,200 polyester gravel bags (4 cubic yards) placed on the upper slope of the island from 7-23 feet above sea level using an additional 17,000 cubic yards of gravel. The gravel would be hauled to the island location during construction of the island. The bags would be placed in an overlapping pattern. A gravel bench covered with concrete mats extending more than 40 feet from the base of the gravel bags to the sea surface would dampen wave energy approaching the island and induce natural formation of ice rubble. The bags provide additional frictional resistance in the unlikely event of ice rideup past the 40-foot bench. The gravel bags would be used only in the upper portion of the island to avoid direct forces from ice or wave action, to lessen potential damage and dislocation, and to protect the surface of the island from the unlikely event of further ice rideup.

BPXA's proposed use of gravel bags for this project is quite different from previous exploration island construction. The bags proposed for use in the Liberty Island construction are made from a polyester material, which does not float. The gravel bags for the proposed Liberty slope-protection system would be used only on the upper slope (above the concrete lined bench, approximately 7 feet above the water line), which makes them less likely to be torn by an ice event. BPXA would monitor ice events at or near the island and repair or replace any torn or ripped bags as part of their ongoing maintenance program. Major ice events usually happen during freezeup and in winter, and major wave events occur during the open-water season. With the proposed BPXA maintenance, it is highly unlikely that a gravel bag would be ripped or torn during an ice event and not be repaired before a wave event that could wash the bag into the ocean. In the unlikely event a bag or part of a bag is washed into the marine environment, the bag would not float but sink to the bottom. MMS would require each bag to be marked identifying the bag to be from Liberty Island, so if a bag is found the marine environment, MMS can determine whether or not it originated at the Liberty Island. BPXA would remove all of the gravel bags used in the upper slope-protection system at project abandonment.

c. Alternative V – Use Steel Sheetpile

Under this alternative, steel sheetpile would protect the upper part of Liberty Island; no gravel-filled bags would be on the island (see Fig. II.C-4). The sheetpile would be similar to that proposed for Seal Island in the Northstar Development Project (U.S. Army Corps of Engineers, 1999:Fig. 4-17). This alternative would eliminate the need

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for gravel bags as upper slope protection, which would eliminate the possibility of damaged bags entering the environment as a result of a storm or ice event. It would be designed to carry the surface loads. The sheetpile would protect the island above the concrete blocks used for slope protection and would weather to a natural rust color.

The seafloor footprint would be 905-feet by 1,240-feet, which is about 25.8 acres. This footprint is about 15% larger than Alternative I, 18% larger than Alternative III.A, and 11% larger than Alternative III.B. On the lower slope of the island, 18,000 concrete mats (see Table II.C-1) and filter fabric still would protect the slope up to 5-feet above the seawater level. The concrete block would be placed on filter fabric, which is put in place prior to laying the concrete blocks to help keep the gravel from washing away.

On the sides of the island where a storm's effects would be most intense, the wall would rise to at least 27 feet (8.8 meters) above sea level (mean lower low-water level). On the other sides, the wall would rise to an elevation of at least 21 feet (6.4 meters) above sea level. Open-cell sheetpile would be used on the south side of the island and for the dock area. The top portion of the sheetpile along a section of the dock face would be 7 feet (2 meters) above sea level. The sheetpile would extend about twice the height of the gravel bag armor in Alternative I to accommodate direct wave action (gravel bags dissipate wave energy where vertical steel walls do not). A gravel bench covered with concrete mats extending more than 75 feet from the base of the gravel bags to the sea surface would dampen wave energy approaching the island and induce natural formation of ice rubble. The wider bench would be required for the large cranes needed to install the concrete mat that would protect the side slope. This alternative would use approximately 1,900 linear feet of sheetpile for the four sides, excluding the dock. The dock would use about 470 linear feet of sheetpile.

The sheetpile would be shipped by ice road or barge. The sheetpile around the dock would be installed before the open-water period. The installation of the remainder of the sheetpile would take place during open water and would be installed before the start of the fall bowhead whale migration.

Under this alternative, steel sheetpile would be installed using vibrator equipment, which reduces noise to the marine environment. The installation of the steel sheetwall around the perimeter of the whole island probably would continue into August. During abandonment, BPXA would be required to remove the sheetpile wall with all other steel and hardware.

Key components of this alternative are summarized in Table II.A-1.

4. Gravel Mine Sites

a. Project Elements Shared by All Gravel Mine Site Alternatives

This set of component alternative evaluates two different gravel mine sites (Fig. II.C-5). Alternative VI evaluates the potential impacts of using the existing Duck Island Mine Site. Alternative I evaluates the effects of creating a new mine site at the Kadleroshilik River. Key components of these alternative are summarized in Table II.A-1.

Both of the alternatives in this set of component alternatives share the following elements.

Ice roads to support gravel mines extraction activities and gravel island construction would start in December of Year 1, so they can access the mine site, haul gravel, and construct the island. The gravel extraction process would start in January of Year 2. Similar activities would be needed in Year 3 to support construction of the pipeline. Gravel hauling would be completed by the end of April of both years. Gravel would be excavated by blasting, ripping, and removing materials in 20-foot lifts. Gravel would be hauled from the mine site to the gravel island location or pipeline site via ice road or existing gravel road.

b. Alternative I – Use Kadleroshilik River Mine Site (Liberty Development and Production Plan)

The Kadleroshilik River mine site (Fig. II.C-5) is approximately 1.4 miles south of Foggy Island Bay, with a ground surface elevation of 6-10 feet above mean sea level. (BPXA, 2000a). The mine site is in a region of riverine barrens and alluvial floodplain. BPXA has estimated the proposed site is about 40% dry dwarf shrub /lichen tundra, 10% dry barren/dwarf shrub, forb grass complex, and 50% river gravel (Noel and McKendrick, 2000).

The development mine site is approximately 31 acres (Figs. II.A-7a and II.A-8), with the primary excavation area developed in two cells (Noel and McKendrick, 2000). The first cell would be approximately 19 acres and developed in Year 2; it would support construction of the gravel island.(Noel and McKendrick, 2000). The second cell (Fig. II.A-9) is approximately 12 acres and would support pipeline construction activities in year 3. In preparation for mining, snow, ice, and unusable overburden (organic and inorganic materials) would be removed from the mine site. For Cell 1, up to 100,000 cubic yards of overburden would be stockpiled temporarily on a 5-acre portion of the Cell 2 mine area just south of Cell 1. Cell 2 overburden (up to 13,000 cubic yards) plus about 2,500 cubic yards of excess spoil from the onshore pipeline transition trench would be placed either directly into the Cell 1 pit or on an ice pad in a temporary stockpile area (about 0.5 acres) located just south of the Cell 2 pit.

Mining would not extend into the active river channel; a dike approximately 50 feet wide would be left in place between the mine site and the river channel while mining operations are under way. Gravel would be excavated by blasting, ripping, and removing materials in two 20-foot lifts to a total depth of 40 plus feet below the ground surface. Some portion of the lower 20-foot lift may be left in place, if all gravel available from the site is not needed to meet island requirements.

The activities listed above would take place in both Years 2 and 3. (See Sec. II.A.1.b.(1)(b) of this EIS and Sec. 5.1.10 of the Liberty Environmental Report [BPXA, 1998a] for more detailed information about the proposed gravel mine site.) The mining plan also includes a reserve area of approximately 22 acres. Approximately 31 acres of the total 53 acres of the planned mine site would be disturbed. (Noel and McKendrick, 2000).

After useable gravel has been removed from the mine, materials unsuitable for construction (for example, unusable materials stockpiled during mining) would be placed back into the mine excavation. Stockpiled snow and ice also would be pushed back into the pit to minimize effects on natural drainage patterns during spring breakup. These backfilled materials would be used to create a shelf (approximately mean water level) along one side of the mine to improve future habitat potential. The access ramp down into the mine would form the foundation of the constructed shelf, maximizing new surface area created. To complete construction, the adjacent edge of the pit would be beveled back a distance of 10-20 feet, creating a gradual slope to the shelf. The backfilled area would provide substrate and nutrients to support revegetation and improve future habitat potential of the constructed shelf along the mine wall.

After Phase I mining is complete and the pit edge contoured, the dike between the mined site and the active channel of the Kadleroshilik River would be breached to approximately 6 inches below mean low water in the channel. During spring breakup, the mine site would flood with freshwater, forming a deep lake adjacent to the river. To avoid stranding fish in the lake during periods of low water, a short section of the breach would be lowered to match the river's bottom level.

Development of the Phase 2 cell is expected to begin in Year 3 to support construction of the offshore pipeline, the shoreline transition, and pipeline valve pads. The Phase 2 mine would disturb approximately 12 acres, to provide the estimated volume of gravel needed for pipeline and pad construction. An approximately 15-foot wide dike would be left between the two cells until mining has been completed.

Mining and rehabilitation plans for Phase 2 are similar to those described for Phase 1 (Figs. II.A-10 and II.A-11). After Phase 2 mining is completed, the dike separating the two mine cells would be breached, expanding the original flooded site to create a larger lake. Some portion of the breach would be at least as low as the river's bottom to avoid stranding fish during periods of low water. Backfill (materials stockpiled during Phase 2 mining and excess material from onshore pipeline construction) would be used to enhance the shallow area created during Phase 1 to improve the future habitat potential of that site.

Remnants of the dike between Phase I and Phase II cells would form islands (0.4 plus acres) in the deep lake, diversifying the aquatic habitat. The shelves constructed along the side of the mine (estimated to be 0.5-2.0 acres) should evolve into shallow water habitat over time in conjunction with flooding the mine site. After a thaw season, it is expected that irregular settlement of the material comprising the shelf would create a surface mosaic of small, shallow ponds, humps, and flats.

During fall of year 3 or spring-summer of year 4, the plan would be implemented to encourage revegetation of the shelf areas. Depending on the extent and pattern of thaw settlement, the areas would be seeded, likely with a combination of salt-tolerant (and disturbance-tolerant) seed stock, as well as other seed stock, as conditions dictate. Depending on access to appropriate sites, ambient moisture, and salinity (both current and predicted), some plugging and/or sprigging also may be done.

After rehabilitation, the flooded mine site would provide several benefits. Deepwater sources connected to streams and rivers are uncommon in this area. The excavation would create potential overwintering habitat for fish in an area where this type of habitat is limited. It also is possible that the lake could be a source of water for future ice-road construction, although over time, coastal storm surges could make the lake water too brackish for this purpose. However, information indicates the Kadleroshilik River may not flow year around, therefore the ability of the lake to support fish habitat is unknown.

c. Alternative VI - Use Duck Island Gravel Mine

Under Alternative VI, the existing Duck Island Gravel Mine (Fig. II.C-6) would be mined to provide gravel for the project (see Map 1). To get the required gravel for the project from the Duck Island mine site, BPXA would need to deepen a portion of the gravel pit by 20-40 feet (6-12 meters). This site does not require any overburden to be removed, and it would reduce the snow and ice removal cost by about half. Eventually, BPXA would need to rehabilitate the site (Figs. II.C-7, II.C-8, II.C-9), but the Liberty Project would share a portion of the total costs.

Under this alternative, BPXA also would need to remove water from the mine before extracting the gravel. At the current permitted rate, it would take more than 400 days to remove the estimated 600 million gallons of water from the mine site. This water could be pumped under the current General National Pollutant Discharge Elimination System Permit. However, BPXA's preferred construction method would be to obtain a modified General National Pollutant Discharge Elimination System Permit to increase appreciably the discharge rate (5-6 million gallons per day) to avoid a delay in the construction schedule. If permitted, this dewatering activity would need to start in the summer of year 1, before the decisions are made for many of the other permits. At a pump rate of 5 million gallons per day, it would take at least 120 days to remove the water from the site. The water would be removed using four different pumps. Each pump would use a temporary pipeline systems to transport the water to the Sagavanirktok River. These temporary pipelines would be relocated periodically so the tundra would not be affected. The removal of the water from the gravel mine also would temporarily preclude BPXA and other companies in the area from using the pit as a source of freshwater for the construction of ice roads supporting this and other projects. If the National Pollutant Discharge Elimination System permit or if the necessary State permits are not approved, dewatering the pit at the current approved rate of 1.5 million gallons a day would delay the project a year. (**Note:** BPXA has not consulted with the regulatory and permitting and resource agencies regarding the feasibility of mining from this location. It is unknown at this time, whether the permitting agencies would require additional mitigation or if they would even permit the higher dewatering rate.)

The Duck Island mine site is about 17.4 miles (28 kilometers), or about 2.7 times farther from the Liberty Island construction sites than the proposed Kadleroshilik mine. For purposes of analysis, the EIS assumes the use of two different sizes of vehicles and the use of a temporary dumping site. The larger of the vehicles (B70's) would haul the gravel from the mine site to a temporary site near the base of the Endicott Causeway. The gravel would be reloaded at the temporary site into smaller trucks (Maxhauls), which would haul the gravel to the island location. A 7.9-mile (12.7-kilometer) long ice road from the base of Endicott to the gravel island would need to be constructed and maintained. From there, the distance to any of the three island locations (Liberty, Southern, and Tern) is approximately the same.

Key components of this alternative are summarized in Table II.A-1.

5. Pipeline Burial Depths

a. Introduction

This alternative was suggested during scoping meeting on the North Slope, because they are concerned about the safety of the pipeline from ice gouging events. The trench depth and burial depth are among the many factors that will be considered in this evaluation.

For the purpose of this draft EIS, burial depth is defined as the distance between the top of the installed pipeline and the original seafloor, and trench depth is defined as the depth of the trench in relation to the original seafloor. Burial depth will always be less than trench depth. In various locations in this draft EIS and some of the pipeline studies, the term depth of cover is used and has the same meaning as burial depth.

This set of alternatives evaluates two different pipeline burial depths (Fig. II.C-10). Alternative VII – Use a 15-Foot Trench Depth and Alternative I – Use a 7-Foot Burial Depth.

The MMS and the State Pipeline Coordinator's Office would conduct an engineering evaluation of the pipeline design, independent of the EIS process, before issuing their respective pipeline rights-of-way, which would allow construction to begin. This alternative would allow the MMS and the State Pipeline Coordinator's Office to require a deeper burial depth should the technical analysis show a deeper depth is warranted.

There are several factors that affect pipeline integrity for a buried subsea pipeline in the Beaufort Sea. Among them are strudel scour, ice gouging, thaw settlement, and upheaval buckling. For a pipeline to maintain its integrity, all of these factors, along with other construction-related factors, must be considered when selecting a burial depth. If a pipeline is not buried deep enough, it would not be adequately protected from ice gouging, strudel scour, and upheaval buckling. If a pipeline is buried too deep, it would increase the cost of the project and also increase the stresses applied to the pipeline during thaw settlement. Following is a brief discussion of how a deeper burial depth would affect these factors.

(1) Strudel Scour

Strudel scour occurs during the springtime when floodwaters from the rivers overflood the sea ice. The floodwater would flow through holes in the sea ice and, given the right conditions, can scour the seafloor. The size of the strudel scour that can occur is controlled by many different factors, including amounts of floodwater and water depth. In general, both the size and frequency of strudel scouring are greater just beyond the bottomfast ice zone and diminishes as water depth increases. Strudel scour is a potential hazard to pipelines, because it can remove soil from around a pipeline and cause an unsupported span. If the size of the unsupported span is large enough, it is possible that the pipeline could be damaged. Burying a pipeline deeper would help provide additional protection from strudel scour.

(2) Ice Gouging

The keels of icebergs and ice-pressure ridges contacting the seafloor and plowing through the soil cause ice gouging. A pipeline could be affected by ice gouging in two ways: an ice keel could directly contact the pipeline or an ice keel could displace the soil around the pipeline. The size of an ice gouge is a function of many different factors, including water depth. In general, the potential depth of an ice gouge increases with water depth. Burying a pipeline deeper would help to protect it from an ice keel.

(3) Thaw Settlement

Thaw settlement occurs when the heat from the product flowing through a pipeline causes the ice in ice bonded soil to melt and soil to subside. Ice bonded soil exists along the pipeline route onshore and a short distance (about 300 feet) offshore. The temperature of the pipeline and soil conditions affect the amount of thaw settlement. The higher the temperature of the pipeline the larger the thaw bulb that would develop around the pipeline over its life. The soil conditions around a pipeline dictate whether subsidence would occur and to what degree. If thaw subsidence is consistent along the pipeline, it does not pose a risk to structural integrity. Thaw subsidence is a concern when there is differential settlement. Under this condition, one portion of the pipeline would not be supported by the underlying soil and would have to support the overburden by itself. Burying a pipeline deeper would increase the risk of pipeline loading due to the additional overburden placed on the pipeline, if thaw settlement occurs.

(4) Upheaval Buckling

Pipeline heating after installation could cause upheaval buckling to occur. When warm product heats a pipeline, the pipeline expands in length. If there is insufficient overburden on a pipeline, it is possible that the forces in the pipeline would cause the pipeline to push up through the soil and become exposed. The amount of upheaval buckling is controlled by the difference in temperature between installation and operation and the composition of the pipeline. The higher the differential temperature, the more the pipeline would want to expand. The type of material controls the amount of expansion. For example, plastics expand about 100 times more than steels. Burying a pipeline deeper would provide greater weight over the pipeline, which would reduce the risk of upheaval buckling.

(5) Determination of Pipeline Burial Depth

The ideal burial depth for a pipeline is one that will minimize construction costs and provide adequate protection against strudel scour, ice gouging, thaw settlement, and upheaval buckling. Each of these conditions requires a different burial depth. The condition that requires the deepest burial depth, as determined by the engineering criteria, determines the minimum burial depth needed for that pipeline. For example, upheaval buckling might determine the minimum burial depth for the single-wall pipe design (Alternative I); whereas, for the pipe-in-pipe design (Alternative IV.A) along the same pipeline route, ice gouging might determine the minimum burial depth.

b. Project Elements Shared by both Pipeline Burial Depth Alternatives

Both alternatives in this set of component alternatives share the following elements.

The pipeline system would be constructed on thickened ice during the winter within a temporary right-of-way (250 feet wide onshore, 1,500 feet wide offshore). For welding strings of offshore pipeline, workers would need a site close to shore on grounded sea ice artificially thickened, as needed, and usually in water less than 5.5 feet deep. The site would be east of the right-of-way and would hold a welding pad 6,000 feet long by 750 feet wide.

All of the pipelines would use through-ice winter construction and use techniques that are similar to those used onshore and at Northstar Project. Trenching would use conventional excavation equipment, such as backhoes. Hydraulic dredging may be used for final smoothing of the trench bottom. (See Sec. I.H.5.b(11) for additional information and discussion about hydraulic dredging.)

Construction activities include the following (see Sec. II.A.1.(3)(a) for a more detailed description of each activity):

- mobilizing equipment, material, and workforce;
- constructing the Ice road and thickening the ice;
- slotting the ice;
- trenching (including temporary storage and disposal of excess material);
- preparing the pipeline makeup site;
- welding pipe strings;
- attaching anodes;
- attaching LEOS;
- transporting pipe string and welding tie in;
- island transition;
- shoreline transition;
- installing pipeline;
- backfilling the trench;
- hydrostatic testing; and
- demobilizing equipment.

c. Alternative I – Use a 7-Foot Burial Depth (Liberty Development and Production Plan)

For this alternative, the pipeline trench would average 10.5 feet (3.2 meters) deep (BPXA, 2000a). The trench depth may vary between 8 and 12 feet (2.4-3.7 meters). The trench would be dug using conventional trenching equipment and constructed from the ice surface. The minimum burial depth would be 7 feet. The trench at the seafloor would be 61-132 feet (18.5-40 meters) wide for this alternative. This alternative would require excavating and backfilling approximately 724,000 cubic yards of soil (See Table II.A-2). Trenching is estimated to take about 58 days.

Any excess trenched material likely would be placed in a 5,000-foot by 2,000-foot disposal site (Zone 1). This site would be along the construction right-of-way, outside the 5-foot isobath (see Figs. II.A-18 and II.C-3).

Key components of this alternative are summarized in Table II.A-1.

d. Alternative VII – Use a 15-Foot Trench Depth

For this alternative, the pipeline trench would be 15 feet (4.6 meters) deep rather than the proposed 10.5 feet (3.2 meters) (BPXA, 2000a:Sec. 8.3 and BPXA, 1998a:Sec. 3.9.3). This alternative assumes the trench would be dug using the same equipment and constructed on the ice surface, the same as for the other alternatives. For purposes of analysis, we assume an 11-foot minimum burial depth, regardless of the pipeline route or pipeline design. The trench at the seafloor would be 120-200 feet (36.5-61 meters) wide. This greater width would be needed for the 6.1 miles (9.8 kilometers) of offshore pipeline route. Table II.C-3 provides information about the trench excavation and backfill quantities for this alternative in combination with the three pipeline routes evaluated in this EIS.

This would require excavating approximately 1,438,560 cubic yards of soil, which almost doubles (98%) the quantity the amount of soil excavated in Alternative I. For the three alternative pipeline designs, the increases in quantity of trench material excavated would be 158% for Alternative IV.A, 113% for Alternative IV.B, and 188% for Alternative IV.C. The additional excavation work would add trenching time of about 30 days. Increasing the number of days needed for trenching also increases the number of days required for ice maintenance. This alternative would add to the risk of not completing the installation of the pipeline in a single winter construction season because of increased excavation and backfill handling.

Excavating and backfilling the deeper trench would produce a larger amount of excess trenched material. This trenched material likely would be placed in a 5,000-foot by 2,000-foot disposal site (Zone 1). This site would be along the construction right-of-way, outside the 5-foot isobath. A wider trench could mean a slightly larger disposal site. Zone 1 is a large enough disposal site to handle the additional volume of trench material (see Fig. II.A-18).

Using the techniques for excavating the trench described in Section II.B.3, this alternative might require more use of a hydraulic dredge to clean out the trench. See Section I.H.5.b(11) for additional information about hydraulic dredging.

Key components of this alternative are summarized in Table II.A-1.

D. COMBINATION ALTERNATIVES

The preceding five sets of component alternatives each looked at one component at a time. However, a decisionmaker wanting to approve the Liberty Project with modifications would choose one component alternative from each set of component alternatives. That means, the decisionmaker can choose among the 96 different combinations from the five sets of component alternatives.

The Liberty Interagency Team recommended, and the EIS includes, a summary analysis in Section of the effects for three combination alternatives. The three combination alternatives formulated by the Liberty Interagency Team and Alternative I do not reflect any agency's (agencies') preferred alternative or preliminary decision. They are included to provide additional information about the possible range of effects should the decisionmaker chose to modify the proposal by selecting one or more of the EIS alternatives. For a more detailed rationale for the use of combination alternatives, please refer back to the beginning of Section II and to Section I.F and G.

1. Review of the Component Alternatives

The Liberty Interagency Team developed three combination alternatives by selecting one component from each of the five sets of component alternatives below.

The first component set, **Alternative Island Locations and Pipeline Routes,** has three potential choices:

- Use Southern Island and Eastern Pipeline Route (Alternative III.A)
- Use Tern Island and Tern Pipeline Route (Alternative III.B)
- Use Liberty Island and Pipeline Route (Alternative I, Liberty Development and Production Plan).

The second component set, **Alternative Pipeline Design,** has four potential choices:

- Use Steel Pipe-in-Steel Pipe (Alternative IV.A)
- Use Steel Pipe-in-HDPE (Alternative IV.B)

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- Use Flexible Pipe (Alternative III.C)
- Use Single Walled Steel Pipe (Alternative I, Liberty Development and Production Plan).

The third component set, **Alternative Upper Island Slope Protection Systems**, has two potential choices:
- Use Steel Sheetpile (Alternative V)
- Use Gravel Bags (Alternative I, Liberty Development and Production Plan).

The fourth component set, **Alternative Gravel Mine Site,** has two choices:
- Use Duck Island Gravel Mine (Alternative VI)
- Use Kadleroshilik River Mine (Alternative I, Liberty Development and Production Plan)

The fifth component set, **Alternative Pipeline Burial Depth**, has two choices:
- Use a 15-Foot Trench Depth (Alternative VII), or
- Use a 7-Foot Burial Depth (Alternative I, Liberty Development and Production Plan).

Each pipeline design alternative has a designed burial depth unique to that design and those different minimum burial depths are not repeated in this alternative. Table I-1 provides a visualization for the grouping of key components for the four combination alternatives evaluated in this section.

2. Description of Combination Alternatives

All of the alternatives in this EIS share project elements. These shared elements include the basic elements for developing the reservoir; production activities; transportation activities, including ice roads; waste management; abandonment activities; safety systems; oil-spill prevention systems; production systems; pipeline safety systems' and the Oil Discharge Prevention and Contingency Plan (BPXA, 2000b). They are important parts of every alternative, including Alternative I. They are described in Section II.A, but they will not be repeated in the description of each combination alternative.

In addition to the following descriptive information, each of these combination alternatives shares common elements that were described for each set of component alternatives. Those common elements will not be repeated in this text; the following references are provided to aid the reader in recalling those descriptions:
- Island Location and Pipeline Route, Section II.C.1
- Pipeline Design, Section II.C.2
- Upper Island Slope-Protection Systems, Section II.C.3
- Gravel Mine Site, Section II.C.4
- Pipeline Burial Depth, Section II.C.5

The four combination alternatives (A, B, C, and Alternative I) are as follows:

a. Combination Alternative A

The five components selected for this alternative are as follows:
1. Use Liberty Island and Liberty Pipeline Route (Alternative I) for the island location and pipeline route
2. Use Pipe-in-Pipe (Alternative IV.A) for the pipeline design
3. Use Steel Sheetpile (Alternative V) for upper island slope protection system
4. Use Duck Island Gravel Mine (Alternative VI) for the mine site for gravel
5. Use a 7-foot burial depth (Alternative I) for the pipeline burial depth.

This combination has the following key features:
- The pipeline design reduces the probability of a containment failure, relative to a single-wall pipeline, and offers secondary containment. The probability of a functional failure is increased compared to a single wall pipeline. The probability of an oil-spill greater than 1,000 barrels, as calculated in the Fleet Report, is estimated at 0.00234 during the life of the project.
- It eliminates all potential effects at the Kadleroshilik River mine site, both beneficial and adverse. There would be no surface disturbance at the Kadleroshilik River mine site. The potential for a new fish overwintering site in the Kadleroshilik River would be lost. The haul distance of the gravel from the mine site to the gravel island would be about 20 miles. The amount of equipment needed to transport the gravel would be increased.
- This alternative eliminates the potential for gravel bags to enter the marine environment. The placement of the steel sheetpile would increase the amount of noise during the construction of the upper slope protection system, which would occur during open water. However, construction of the steel sheetpile should be completed prior to the fall bowhead whale migration.
- Construction of gravel island at the Liberty Island location would require about 855,000 cubic yards. The maximum footprint of the gravel island on the seafloor is 25.8 acres. The Liberty Island is about 1 mile from the Boulder Patch area.
- The minimum burial depth for this pipeline design is 7 feet. The amount of excavation and backfill needed for this pipeline route and pipeline design is 724,000 cubic yards of material.

Table IV.D-1, provides a comparison of key project elements among the combination alternatives.

b. Combination Alternative B

The five components selected for this alternative are as follows:

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1. Use Southern Island and Eastern Pipeline Route (Alternative III.A) for the island location and pipeline route.
2. Use Pipe-in-HDPE Design (Alternative IV.B) for the pipeline design.
3. Use Gravel Bags for Upper Island Slope Protection (Alternative I) for upper island slope-protection system.
4. Use the Kadleroshilik River Mine Site (Alternative I), for the mine site for gravel.
5. Use the 6-foot burial depth (Alternative IV.B) as designed for the Steel Pipe-in-HDPE pipeline design for the pipeline burial depth.

This combination has the following key features the following:

- Construction of gravel island at the Southern Island location would require about 684,800 cubic yards. The maximum footprint on the sea floor is about 21.9 acres. It about 2.5 miles from the Boulder Patch area.
- The offshore portion of the Eastern Pipeline Route is 4.2 miles long. The onshore route is 3.1 miles long. For those who feel a shorter offshore pipeline is a safer pipeline, this alternative's pipeline is 1.9 miles shorter than Alternative I, although the length of pipeline in 8 feet or more of water is about the same. The onshore pipeline is 1.6 miles longer. The combined onshore and offshore pipeline is 7.6 miles long.
- The pipeline design reduces the probability of a containment failure, relative to the single-wall pipeline, and offers secondary containment. The probability of a functional failure is increased relative to a single wall pipeline. However, the pipe-in-HDPE pipeline is not capable of handling the operating pressure in the carrier pipeline; therefore, it is important to monitor the annular space oil and seawater and shut down the pipeline if a contaminated annulus is suspected.. The probability of an oil-spill greater than 1,000 barrels, as calculated in the Fleet report, is estimated at 0.0138 during the life of the project.
- The minimum burial depth for this pipeline design is 6 feet. The amount of excavation and backfill needed for this pipeline route and pipeline design is 463,590 cubic yards of material, a reduction of 224,975 cubic yards.

c. Combination Alternative C

The five components selected for this alternative are as follows:

1. Use Tern Island and Tern Pipeline Route (Alternative III.B)) for the island location and pipeline route.
2. Use Steel Pipe-in-Steel Pipe Pipeline Design (Alternative IV.A) for the pipeline design.
3. Use Steel Sheetpile for Upper Slope Protection (Alternative V) for upper island slope protection system.
4. Use Duck Island Mine Site (Alternative VI) for the mine site for gravel.
5. Use a 15-foot trench depth (Alternative VII).

This alternative has all five components that are different than Alternative I. This combination has the following key features:

- The Tern Island location would require about 659,200 cubic yards of gravel. The island would use the 230,000 cubic yards of existing gravel from the Tern exploration island. The maximum island footprint on the seafloor is about 26.4 acres. This island is located about 2.5 miles from the Boulder Patch.
- The pipeline has a reduced probability of containment failure, compared to the single-wall pipeline, and offers secondary containment. The probability of a functional failure is increased relative to a single wall pipeline. The probability of an oil-spill greater than 1,000 barrels for INTEC's design of a steel pipe in steel pipe at a 7-foot burial depth, as calculated in the Fleet report, is estimated at 0.00234 occurrences during the life of the project. The 11-foot minimum burial depth would not significantly affect this value, because operational failures are by far the most significant hazard, and these would not be affected by burial depth (Fleet, 2000).
- The offshore portion of the Tern Pipeline Route is 5.5 miles long. The onshore route is 3.1 miles long. For those who feel a shorter offshore pipeline is a safer pipeline, this alternative's pipeline is 0.6 miles shorter, although the length of pipeline in 8 feet or more of water is about 0.4 miles longer. The onshore pipeline is 1.6 miles longer. The combined onshore and offshore pipeline length is 8.6 miles.
- This alternative eliminates all potential effects, both beneficial and adverse, at the Kadleroshilik River mine site. There would be no surface disturbance at the Kadleroshilik River mine site. The potential would be lost for a new fish-overwintering site in the Kadleroshilik River. The distance to haul gravel from the mine site to the gravel island would be about 20 miles. The amount of equipment and/or time needed to transport the gravel would be increased.
- This alternative eliminates the potential for gravel bags to enter the marine environment. The placement of the steel sheetpile would increase the amount of noise during the construction of the upper slope-protection system, which would occur during open water. However, construction of the steel sheetpile should be completed prior to the fall bowhead whale migration.
- This alternative buries the pipe in a 15-foot trench. It increases the amount of sediment excavated to 1,298,095 cubic yards.

d. The BPXA Proposal (Liberty Development and Production Plan)

The five components included in the BPXA Proposal (Liberty Development and Production Plan - Alternative I) are as follows:

1. Use Liberty Island and Liberty Pipeline Route for the island location and pipeline route.
2. Use Single-Wall Pipeline Design for the pipeline design.
3. Use Gravel Bags for upper island slope-protection system.
4. Use Kadleroshilik River Mine for the mine site for gravel.
5. Use a 7-foot burial depth) for the pipeline burial depth.

Alternative 1 has the following key features:

- The single-wall steel pipeline system has a higher containment failure probability than the other combination alternatives and does not offer any secondary containment. The single-wall pipeline has a lower functional failure probability than the other combination alternatives. The probability of an oil-spill greater than 1,000 barrels, as calculated in Fleet (2000), is estimated at 0.0138 occurrences during the life of the project.
- The offshore portion of the Liberty pipeline route is 6.1 miles long. The onshore route is 1.5 miles long. The combined length of the pipeline is 7.6 miles.
- Construction of the Liberty gravel island would require about 797,600 cubic yards. The maximum footprint of the gravel island on the seafloor is 22.4 acres. The Liberty Island is about 1 mile from the Boulder Patch area.
- There is the potential for the gravel bags to enter the marine environment, but these gravel bags would not float in the water.
- There would be surface disturbance activities at the Kadleroshilik River mine site and the potential for a new fish-overwintering site in the Kadleroshilik River. The distance to haul gravel from the mine site to the gravel island would be about 6 miles.
- The minimum burial depth for this pipeline design is 7 feet. The amount of excavation and backfill needed for this pipeline route and pipeline design is 724,000 cubic yards of material.

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SECTION III

EFFECTS
OF THE
LIBERTY DEVELOPMENT
AND
PRODUCTION PLAN
(ALTERNATIVE I,
THE PROPOSED ACTION)

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III. Effects of the Liberty Development and Production Plan (Alternative I, The Proposed Action)

Section III analyzes how the Proposal (Alternative I) would affect the resources in or migrating through the Liberty Project area. Section III.A is an overview of the analyses that follow. In Section III.A.1, we summarize the most important effects of the project to each resource. Each summary provides references to the location of the detailed analyses, which follow. We hope these bottom-line summaries will be helpful to reviewers to focus their time and attention. We encourage readers who would like or need more information to go to the appropriate analyses in Section III.C and D for the complete and full evaluation. Section III.C analyzes the effects of oil spills and disturbances in detail, and Section III.D analyzes the effects of other issues (such as discharges, gravel mining) in detail. The text of the detailed analysis for each resource in both of these sections (III.C and D) first describes the general effects of developing the Liberty Prospect and then the specific effects of BPXA's proposed Liberty Development and Production Plan. The general effects would occur no matter which alternative is chosen. The specific effects would occur if the Liberty Prospect were developed based on BPXA's proposed Development and Production Plan.

The effects of the alternatives developed for this EIS are described in Section IV. Section V evaluates the cumulative effects of oil and gas activities on the North Slope and in the Beaufort Sea and identifies the Liberty portion of the overall cumulative effect. Section VI describes the affected environment.

Each analysis of effects in this EIS evaluates the following key resource topics that were identified during scoping:

- threatened and endangered species: bowhead whales and spectacled Steller's eiders
- seals and polar bears
- marine and coastal birds
- terrestrial mammals
- lower trophic-level organisms
- fishes
- vegetation-wetland habitats
- subsistence-harvest patterns
- sociocultural systems
- archaeological resources
- economy
- water quality
- air quality

Precision of Oil-Spill Estimates: In Sections III and IV, we present information from engineering studies and MMS oil-spill models. The precision of the engineering calculations for the oil-spill sizes we analyze do not express the uncertainty associated with our estimating the size of an oil spill that might occur in the future. Typically, we round the assumed oil-spill volumes to the nearest hundred or thousand to represent the uncertainty in our estimating the spill size that could occur over the life of the project. However, for the Liberty EIS, where engineering calculations are made, we have kept the exact calculations to maintain consistency between documents related to the project and reduce confusion.

Significance Thresholds: The Council on Environmental Quality National Environmental Policy Act regulations (40 CFR 1508.27) define the term "significantly" in terms of both context and intensity. "Context" considers the setting of the Proposed Action, what the affected resource may be, and whether the effect on this resource would be local or more regional in extent. "Intensity" considers the severity of the impact, taking into account such factors as whether the impact is beneficial or adverse; the uniqueness of the resource (for example, threatened or endangered species); the cumulative aspects of the impact; and whether Federal, State, or local laws may be violated. The analysis in this document uses terminology that is consistent with that definition. Impacts may be beneficial or adverse. Impacts are described in terms of frequency, duration, general scope and/or size and intensity. The analysis in this EIS also considers whether the mitigation that is proposed as part of the project can reduce or eliminate all or part of the potential adverse effects.

As directed by the Council on Environmental Quality National Environmental Policy Act regulations (40 CFR 1502.16), we discuss direct and indirect impacts (effects) and their significance on the previously listed physical, biological, and human social resources.

Our EIS impact analysis addresses the significance of the impacts on the above resources considering such factors as the nature of the impact (for example, habitat disturbance or mortality), the spatial extent (local or regional effect), temporal effect and recovery times (years, generations), and the effects of mitigation (for example, implementation of the oil spill-response plan). Bowhead whales, for example, are an endangered species, and the analysis considers the possible effects of a large oil spill in terms of:

- lethal and nonlethal effects;
- habitat affected;
- seasonality and spatial extent of the effect;
- what part of the population may be affected;
- oil-spill-cleanup mitigation;
- the likelihood of such a spill; and
- if such a spill occurred, the likelihood of the oil contacting whales.

For impacts on water quality from construction disturbance, the analysis considers:

- the increases in suspended particles and turbidity relative to acute (toxic) criteria;
- the seasonal, temporal, and spatial extent of the effect; and
- the contribution of this relative to naturally occurring turbidity.

Some impacts may be measurable, but their effects may be minimal and/or short-term in duration; therefore, they may not require avoidance or mitigation.

Adverse impacts that are reduced by mitigation below the “significance thresholds” that are incorporated into the project, or that are demonstrated to be acceptable because the risk of the impact occurring is small, are not identified in this EIS as “significant.”

For this EIS, we have defined a “significance threshold” for each resource as the level of effect that equals or exceeds the adverse changes indicated in the following impact situations:

- **Threatened and Endangered Species** (bowhead whale, spectacled and Steller’s eider): An adverse impact that results in a decline in abundance and/or change in distribution requiring one or more generation for the indicated population to recover to its former status.
- **Biological Resources** (seals, polar bear, marine and coastal birds, terrestrial mammals, lower trophic-level organisms, fishes, and vegetation-wetland habitats): An adverse impact that results in a decline in abundance and/or change in distribution requiring three or more generations for the indicated population to recover to its former status and one or more generations for polar bears.
- **Subsistence-Harvest Patterns:** One or more important subsistence resources would become unavailable, undesirable for use, or available only in greatly reduced numbers for a period of 1-2 years.
- **Sociocultural Systems:** Chronic disruption of sociocultural systems occurs for a period of 2-5 years, with a tendency toward the displacement of existing social patterns.
- **Archaeological Resources:** An interaction between an archaeological site and an effect-producing factor occurs and results in the loss of unique, archaeological information.
- **Economy:** Economic effects that will cause important and sweeping changes in the economic well-being of the residents or the area or region. Local employment is increased by 20% or more for at least 5 years.
- **Water Quality:** A regulated contaminant is discharged into the water column, and the resulting concentration outside a specified mixing zone is above the acute (toxic) State standard or Environmental Protection Agency criterion more than once in a 1-year period and averages more than the chronic State Standard or Environmental Protection Agency criterion for a month. Turbidity exceeds 7,500 parts per million suspended solid concentration outside the mixing zone specified for regulated discharges more than once in a 3-year period and averages more than chronic State standards or Environmental Protection Agency criteria for a month. The accidental discharge of crude or refined oil in which the total aqueous hydrocarbons in the water column exceeds 1,500 micrograms per liter (1.5 parts per million)—the assumed acute (toxic) criteria—for more than 1 day and 15 micrograms per liter (0.015 parts per million)—the assumed chronic criteria and the State of Alaska ambient-water-quality standard—for more than 5 days.
  Violating the effluent limits of the National Pollution Discharge Elimination System Permit (Appendix I-2) might cause an adverse effect and could result in an enforcement action by the Environmental Protection Agency. Violations would be caused by exceeding an effluent limit or creating an oil sheen. The accidental discharge of a small volume of crude or refined oil also might cause an adverse impact and could result in concentrations of hydrocarbons that are greater than the acute criteria in a local area (less than 1 square mile) for less than a day and concentrations that are greater than the chronic criteria in a larger area (less than 100 square miles) for less than 5 days. However, an action of violation or accidental discharge of a small volume crude or refined oil would not necessarily constitute a significant environmental impact as defined in 40 CFR 1508.27 and discussed previously in this section of the EIS.
- **Air Quality:** Emissions cause substantial increases in concentrations over more than half of the Federal attainment are (regional effect), resulting in the

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consumption of at least 50%, but not all of the available Prevention of Significant Deterioration criteria for nitrogen dioxide, sulfur dioxide, or total suspended-particulate matter, or National Ambient Air Quality Standards concentration for particulate mater less than 10 micrometers in diameter, carbon monoxide, or ozone; readily identifiable adverse long-term effects on human health or vegetation. No significant decrease in onshore visibility as determined by Environmental Protection Agency visibility-analysis guidelines.

A. SUMMARIES OF EFFECTS BY RESOURCE

We provide a summary of the effects by resource, of the overall effects we think might occur from the proposed Liberty Project without first considering any oil-spill cleanup. For this EIS, we analyze the effects to the resources of a large oil spill greater than or equal to 500 barrels. In Section II.A.4, we describe BPXA's Oil Discharge Prevention and Contingency Plan (BPXA, 2000b) and the types of actions, tactics, and cleanup effort that would be applied in the unlikely event of an oil spill. The effectiveness of cleanup and spill containment is considered, but this depends on many variables such as weather and ice cover. Under certain weather and ice conditions, cleanup efforts may be delayed or be ineffective. The mitigative effects of the Oil Discharge Prevention and Contingency Plan's (BPXA, 2000b) cleanup efforts are uncertain and range from minimal to substantial removal of spilled oil. (See Appendix K for a summary of the effects of BPXA's Oil Discharge Prevention and Contingency Plan). In this EIS, we keep our analyses of the effects of an oil spill to the resources conservative and assume minimal oil-spill cleanup when we determine the effects. In addition to evaluating the impacts of a possible oil spill in Section III.C.2, we also evaluate the effects associated with oil-spill cleanup and provide a qualitative assessment of the mitigation provided by the contingency plan (BPXA, 2000b). (See Appendix K for a summary of the impacts and potential benefits that may result from oil-spill cleanup.) In the unlikely event of an oil spill, the permitting agencies would require BPXA to undertake the appropriate efforts to contain and clean up an oil spill.

1. Significant Impacts To Resources From The Proposed Action

The MMS does not expect any significant impacts to result from any of the planned activities associated with the Proposal (Alternative I, Liberty Development and Production Plan) or any of the alternatives. Significant adverse impacts to spectacled eiders, common eiders, long-tailed ducks, and to local water quality would occur in the unlikely event of a large oil spill. However, the very low probability of such an event occurring (a less than 1% chance of oil entering the environment), combined with the seasonal nature of the resources inhabiting the area, make it highly unlikely that an oil spill would occur and contact eider and sea duck resources. Eiders and sea ducks are present in the Liberty area for only about 4 months out of the year. Also, a resource may be present in the area but may not necessarily be contacted by the oil. Furthermore, the Proposal and alternatives include mitigation, such as extra-thick-walled pipelines, pipeline burial depth that is more than twice the maximum 100-year ice-gouging event, and an advanced leak-detection system (LEOS). Together, they reduce the likelihood of an oil spill, detect very small volumes of oil, and limit the size of potential chronic leaks to about 100 barrels of oil.

As noted in Section V (cumulative analysis), the potential for significant adverse effects to subsistence, spectacled and common eiders, and the long-tailed duck and the potential adverse effects to other key resources (bowhead whales, the Boulder Patch, polar bears, and caribou) are of primary concern and warrant continued close attention. Effective mitigation practices (winter construction, advanced leak-detection system, thick-walled pipeline designs, etc.) also should be consider in future projects.

Cumulative Effects and the potential contribution of effects from this project to cumulative effects are provided in Section V.

2. Summary of Effects by Resource

In this section, we identify our best estimate of the overall effects the proposed Liberty Project could have on each resource. The following evaluation is meant to provide readers with information that will help them to focus on issues and concerns regarding particular natural resources and species. This is a summary and does not contain in-depth analyses or references, which are found in Sections III.C, III.D, and V.

a. Threatened and Endangered Species

(1) Bowhead Whales

The chance of an oil spill greater than or equal to 500 barrels occurring from either the Liberty pipeline or the island facility and entering the offshore waters is on the order of 1%. If a spill occurred, the chance of it contacting bowhead whale habitat is relatively low. The highest chance of an oil spill contacting bowhead habitat is a 16% chance of contact to Environmental Resource Area 39 (northeast of McClure Island) within a 360-day period from a summer spill at Liberty Island. There is a less than 0.5% chance that an oil spill would contact the spring lead system within a 360-day period during either summer or winter. If a spill did occur and contact bowheads, some whales could experience temporary, nonlethal effects from getting oil on their skin, inhaling hydrocarbon vapors, ingesting oil-contaminated prey, fouling of their baleen, loss of food source, or temporarily having to leave feeding areas. A few whales could die from prolonged exposure to freshly spilled oil; however, with such a low chance of contact, we expect that number to be very small.

Bowhead whales may be affected by noise from drilling and production, vessel and aircraft traffic, construction, and oil-spill-cleanup activities. Underwater industrial noise, including drilling noise measured from artificial gravel islands, has not been audible in the water more than a few kilometers away. Because the main bowhead whale's migration corridor is 10 kilometers or more seaward of the barrier islands, noise from drilling and production operations at Liberty Island likely would not reach many migrating whales. Whales are not usually found near Liberty Island. The few whales that may be in lagoon entrances or inside the barrier islands also are unlikely to be affected, because industrial sounds tend to decrease rapidly in shallow water. Subsistence whalers have stated that noise from some drilling activities displaces whales farther offshore away from their traditional hunting areas.

Vessel traffic outside the barrier islands probably would be limited to barges transporting equipment and supplies to the Liberty location between mid-August and mid- to late September. Barge traffic that continues into September could disturb some bowheads. Whales may avoid being within 1-4 kilometers of barges. Fleeing behavior usually stops within minutes after a vessel has passed but may last longer. Some bowhead whales in lagoon entrances or inside the barrier islands may avoid noise-producing activities associated with Liberty.

No seismic surveys are planned for Liberty. Bowhead whales are not likely to be affected by discharges, gravel mining, small oil spills, or abandonment activities.

It is unlikely that the bowhead whale population would be adversely affected by the Liberty Project. (See Secs. III.C.2.a(1), III.C.3.a(1),. III.D.1.a(1), III.D.2.a(1), III.D.3.a(1), and III.D.6.a(1) for detailed effects and references on bowhead whales.)

(2) Eiders

Mortality from a spill that moves into offshore areas and contacts spectacled eiders staging before nesting or migration currently would be difficult to estimate. Aerial surveys conducted by the Fish and Wildlife Service located few spectacled eiders offshore in all but two subareas, thus a model developed by the Fish and Wildlife Service estimates very low mortality from an oil spill for this species. However, because many "unidentified" eiders could have been spectacled, and the limited aerial surveys may not accurately represent use of the entire area, these observations may underestimate numbers expected to be present. Recovery of the relatively small, local eider population from even small losses is not likely to occur quickly. Any substantial spill-related losses could have serious consequences for this population and would be considered a significant impact. Small oil spills are expected to cause few deaths among nesting, broodrearing, or staging eiders. Reduction of local prey populations that are oiled could reduce eider foraging success, although relatively little information concerning spectacled eider food habits is available. Helicopter flights to Liberty Island or spill-cleanup activities may displace spring migrant, nesting, broodrearing, postbreeding or staging spectacled eiders from preferred habitats, all of which have either depleted their stored energy reserves or need to build up reserves for future activities, potentially decreasing survival and/or productivity. Most effects from the Liberty Project to eiders are expected to result from disturbance factors, although there is a potential for mortality from collision of low-flying eiders with Liberty Island structures. Mortality from any large oil spill is likely to be more substantial than that from other factors, although collisions also could result in substantial losses. Although Fish and Wildlife Service survey data do not show a significant decline in the coastal plain spectacled eider population, the potential exists for a significant adverse effect on this population from factors associated with the Liberty Project, particularly that segment nesting in the eastern portion of the range. (See Secs. III.C.2.a(2), III.C.3.a(2), III.D.1.a(2), III.D.2.a(2), III.D.3.a(2), III.D.6.a(2), and VI.A.1.a(2) for detailed effects and references on eiders.)

b. Seals and Polar Bears

The main potential effect would be the loss of small numbers of ringed seals, bearded seals, and polar bears from a large oil spill occurring anywhere in the Liberty Project area. Amstrup, Durner, and McDonald (2000) estimated that a large spill is likely to affect fewer than 12 polar bears. The project is not likely to have population-level effects on ringed seals, bearded seals, or polar bears (see Sec. III.C.2.b). These species are not likely to be significantly affected by small spills or discharges associated with Liberty (see Sec. III.D.3.b). Island and pipeline construction; gravel mining; and aircraft, vessel, and ice-road traffic likely would displace some seals and a few polar bears within less than 1 mile of these activities, but they would not affect overall distribution or abundance in the Foggy Island Bay-Liberty area (see Secs. III.C.3.b and III.D.2.b). The project is not likely to affect seal and polar bear populations.

c. Marine and Coastal Birds

Mortality of molting long-tailed ducks from an oil spill that enters lagoons or other protected nearshore areas is estimated to exceed 1,200 birds (equivalent to about 1% of the average coastal plain population). Total kill potentially could exceed 10 times this number, if oil were to contact areas of high bird density. A model developed by the Fish and Wildlife Service estimates mortality exceeding 1,400 individuals at average bird densities (Stehn and Platte, 2000). Such losses would result in a significant adverse effect on population numbers and productivity, especially if many of those molting in this area come from declining subpopulations. The estimated loss of loons and eiders in spring open water, migrant shorebirds in coastal habitats, and staging eiders offshore also could be substantial, if oil entered these habitats. Because Beaufort Sea king and common eider populations apparently have undergone major declines in the past 20 years, and long-tailed ducks have declined in some areas, substantial mortality is likely to hinder their recovery. Small oil spills could cause the death of up to several hundred individuals among nesting, molting, broodrearing, or staging waterfowl and shorebirds in aquatic inland or coastal habitats. If prey populations decline because of oiling, shorebirds and sea ducks that depend on this energy source could be adversely affected. For example, postbreeding female eiders and other waterfowl, shorebirds, and seabirds require high quality foraging habitat to replace energy reserves depleted during nesting and incubation, and long-tailed ducks require abundant food to offset increased demands of metabolism, temperature regulation and protein synthesis associated with molt.

Helicopter flights to Liberty Island, vessel traffic in summer, or spill-cleanup activities, may displace loons, waterfowl, and shorebirds from preferred habitats, potentially decreasing survival and/or productivity. The Liberty Project is expected to cause insignificant habitat loss from construction and gravel mining activities.

The potential exists for a significant overall adverse effect from all factors associated with the Liberty Project for long-tailed ducks and common eiders. Losses of king eiders and loons of the magnitude estimated by a Fish and Wildlife Service model, whose populations are declining and/or with a limited capacity for population growth, would represent substantial effects. For all other species, effects are likely to be inseparable from natural variation in population numbers. Most of the potential effects are expected to result from an oil spill. (See Secs. III.C.2.c, III.C.3.c, III.D.1.c, III.D.2.c, III.D.3.c, and III.D.6.c for detailed effects and references on marine and coastal birds.)

d. Terrestrial Mammals

The main potential effect would be the loss of fewer than 100 caribou and a few muskoxen, grizzly bears, and arctic foxes from a large oil spill occurring anywhere in the project area (see Sec. III.C.2.d). We expect normal reproduction to replace these losses within about 1 year. Helicopter and ice-road traffic, encounters with people, and mining and construction operations would disturb individual or small groups of these mammals for a few minutes to a few days, or no more than about 6 months within about 1 mile of these activities. These disturbances would have no effect on populations (see Secs. III.C.3.d and III.D.2.d). Small onshore spills are likely to have local effects on less than 1 to a few acres of tundra habitat at the spill sites but negligible effects on caribou, muskoxen, and other terrestrial mammals (see Sec. III.D.3.d). The project is not likely to affect terrestrial mammal populations on the North Slope.

e. Lower Trophic-Level Organisms

Lower trophic-level organisms would be affected by a large oil spill. It would have only short-term effects on plankton, including phytoplankton, zooplankton, and epontic species on the bottom of the ice cover, but longer term effects on coastlines that might be fouled. As documented in Section III.C.2.e and Appendix A, up to 15% of the Stefansson Sound coastline would be affected by a large spill. The coastal waters are inhabited by only mobile, seasonal invertebrate species such as amphipods, and the populations would recover within a year. However, traces of the oil would persist in the sediments for about 5 years in most areas and could persist up to a decade in areas where water circulation is reduced. The viscous Liberty crude oil probably would not be mixed down deep enough in Stefansson Sound to affect deep benthic communities, such as the Boulder Patch at about 6 meters. However, diesel oil, which would be occasionally barged to the island for emergency fuel, is more soluble and could be mixed down to the seafloor by currents. In the unlikely event of a 1,500 barrel spill of diesel from a fuel barge during the open-water season, the concentration would be toxic within an area of about 18 square kilometers (7 square miles), as noted in the water quality section below (III.A.2.l). Such toxicity probably would stunt the seasonal growth of some kelp plants and reduce the population size of attached invertebrates for several years. Oil-spill responses in general would have both beneficial effects for some and adverse effects on other lower trophic-level organisms, as described in Section IX.A.6.e.

The Liberty Project would disturb lower trophic-level organisms in three primary ways: (1) island construction would bury 23 acres of typical benthic organisms; (2) pipeline trenching would disturb additional benthos, burying up to 14 acres of kelp, boulders, and suitable substrate that has very low (1%) coverage; and (3) sediment plumes would reduce Boulder Patch kelp production by up to 6% during 1 year. The buried 14 acres would equal less than 0.1% of the Boulder Patch area. The density of the kelp, boulders, and suitable substrate in the pipeline corridor is very low, averaging about 1% coverage, and the lost kelp biomass and production probably would be less than .01% of the Boulder Patch totals. Plumes of suspended sediment from pipeline trenching and island construction would drift over other parts of the Boulder Patch, reducing light penetration and kelp production during 1 year. The reduction is estimated to be less than 6%, about one-third of which would be due to the proximity to the Boulder Patch of the excess sediment disposal zone. However, in relation to the large range of natural variability, all of these disturbance effects on lower trophic-level organisms would be barely detectable.

The island's concrete slope 6 feet below sea level would temporarily benefit kelp and other organisms that need a hard substrate for settlement. Within a decade, this portion of the concrete slope would become a home for colonies of species similar to those of the Boulder Patch area. If abandonment of the island requires removal of the cement blocks, the kelp habitat would be eliminated.

f. Fishes and Essential Fish Habitat

(1) Fishes

The likely effects on fishes from a large oil spill primarily would depend on the season and location of the spill, the lifestage of the fishes (adult, juvenile, larval, or egg), and the duration of the oil contact. Because of their very low numbers, no measurable effects are expected on fishes in winter. Effects would be more likely to occur from an offshore spill moving into nearshore waters during summer, where fishes concentrate to feed and migrate. Based on the Oil-Spill-Risk Assessment (Table A-13), the probability of an offshore oil spill contacting nearshore waters in summer ranges from less than 1% to 26%. Only land segments in Foggy Island Bay (Land Segments 25-27) would have a greater than 10% chance of contact within a year. Nevertheless, if an offshore oil spill did occur and contact the nearshore area, some marine and migratory fish may be harmed or killed. However, it would not be expected to have a measurable effect on fish populations, and recovery of the number of fish harmed or killed would be expected within 5 years.

Based on the Oil-Spill-Risk Assessment, the probability of a large diesel fuel spill contacting nearshore waters in summer ranges from less than 1% to 3%. Nevertheless, if a spill did occur and contact a small waterbody supporting fish (for example, ninespine stickleback, arctic grayling, and Dolly Varden char) with restricted water exchange, it would be expected to kill or harm most of the fish within the affected area. Recovery would be expected in 5-7 years. However, due to the small amount of oil or diesel fuel likely to enter freshwater habitat, the low diversity and abundance of fish in most of the onshore area, and the unlikelihood of spills blocking fish migrations or occurring in overwintering areas or small waterbodies (containing many fish or fish eggs), an onshore spill of this kind is not expected to have a measurable effect on fish populations on the Arctic Coastal Plain.

Treated seawater would be the primary discharge from Liberty. The discharged water would contain dissolved salts, higher concentrations of suspended sediments, and chemicals and would be warmer and more turbid than Beaufort Sea water. Fishes in the vicinity of these discharges from Liberty Island are expected to avoid them and be unaffected. Noise and discharges from dredging, gravel mining, island construction, island reshaping, and pipeline trenching associated with Liberty are expected to have no measurable effect on fish populations. While a few fish could be harmed or killed, most in the immediate area would avoid these activities and would be unaffected. Effects on most overwintering fish are expected to be short term and sublethal, with no measurable effect on overwintering fish populations. Liberty's proposed seawater-intake structure (Fig. III.D-1) likely would harm or kill some young-of-the-year arctic cisco during the summer migration period and some eggs and fry of other species in the immediate vicinity of the intake. However, less than 1% of the arctic cisco in the Liberty area are likely to be harmed or killed by the intake structure. Hence, the intake structure is not expected to have a measurable effect on young-of-the-year arctic cisco in the migration corridor. Because of the wide distribution/low density of the eggs and fry of other fishes in the area, the intake structure is not expected to have a measurable effect on their populations.

(2) Essential Fish Habitat

Salmon are rare in the Liberty area and, to the limited extent that they occur there, they are most abundant in the Colville River and its tributaries. Populations of salmon apparently do not exist in the Beaufort Sea or its watersheds and, thus, are not expected to be harmed by the Liberty development. The most likely potential threat to salmon would occur if spilled oil came in contact with spawning areas or migratory pathways. However, salmon are not believed to spawn in the intertidal areas or near the mouths of streams or rivers of the Beaufort Sea. If spilled oil concentrated along the coastline at the mouths of streams or rivers, the only direct effect on salmon would be that the potential movements of small numbers of salmon could be disrupted during migrations.

Zooplankton and fish are potential salmon prey and are a component of essential fish habitat that could be adversely affected by spilled oil. Zooplankton populations could be subjected to short-term, localized reductions as a result of contact with spilled oil. Spilled crude or diesel oil could cause the lethal or sublethal effects to limited numbers of fish of a variety of species that are potential prey for salmon in the Beaufort Sea. Oil spilled in wetland habitat, including saltmarshes, could kill vegetation and associated insect species and small fish that are potential food for salmon, and thus, adversely affect salmon essential fish habitat. Although essential fish habitat could be altered, lasting from less than 10 years to several decades, any changes would not have an influence on salmon or their populations. As a result of Liberty Island construction and operation, prey populations might experience other short-term, localized, but unmeasurable effects. This would include potential adverse effects from noise during construction and operations; from discharge of treated seawater during Liberty operations; and from increased turbidity and sedimentation as a result of dredging, gravel mining, island construction, and pipeline trenching.

Kelp and other marine plants are a component of salmon essential fish habitat, because they provide food and shelter for various lifestages of a variety of potential prey in the Boulder Patch and elsewhere in the Beaufort Sea. Marine plants could be subjected to localized, negative effects due to mechanical removals and sedimentation resulting from pipeline trenching and island construction. Juvenile lifestages of salmon inhabit fresh or estuarine waters and generally feed on insects. Clean water is an important component of salmon essential fish habitat that could be adversely affected by the Liberty development, if water quality is degraded. Water quality could be degraded by the dispersion of hydrocarbons in the water column from spills of crude or diesel oil and increased turbidity from construction of the gravel island and pipeline, abandonment of Liberty Island, and reclamation of the gravel mine reclamation. Moreover, temperature, turbidity and salinity of seawater discharged from the Liberty Island production facility are expected to be slightly higher than waters in the surrounding Foggy Island Bay. The spatial scale of these disturbances is expected to be fairly localized, and effects are expected to range from short-term to the life of the project, or longer.

g. Vegetation-Wetlands Habitats

The main potential effect would come from a large spill occurring anywhere in the project area. An oil spill contacting wetland habitat would foul, smother, asphyxiate, and poison plants and associated insects and other small animals. Complete recovery of moderately oiled wetland of the Sagavanirktok River east to Mikkelsen Bay would take perhaps 10 years or longer. Wetland also would be disturbed by cleanup activities. Complete recovery of oiled coastal wetland from these disturbances and oil could take several decades (see Sec. III.C.2.g). Other disturbances mainly would come from constructing gravel pads and ice roads and installing the onshore pipeline and tie in with Badami, gravel mining, and abandonment-removal of pipeline facilities. These activities would destroy some local vegetation at the mining site, gravel pads, and along the onshore pipeline but would not affect the tundra ecosystem. Construction of ice roads would compress tundra under the roads but would not kill vegetation, and recovery is expected within a few (3) years. Small spills would cause very minor ecological harm, and recovery is expected within a few (3) years to no more than perhaps 20 years. The overall effect likely would be local to vegetation and wetland habitats along the pipeline route (see Secs. III.C.3.g, III.D.2.g, and III.D.3.g).

h. Subsistence-Harvest Patterns

The chance of an oil spill greater than or equal to 500 barrels occurring from the Liberty pipeline and the island facility and entering the offshore waters is on the order of 1%. If a spill occurred, the chance of it contacting bowhead whales and other marine mammals and important marine subsistence resources and harvest areas for Nuiqsut and Kaktovik is low. The highest chance of an oil spill contacting bowhead habitat is a 16% chance of contact to Environmental Resource Area 58 (McClure Islands) over a 360-day period from a summer spill at Liberty Island. The same low risk also would apply to onshore traditional subsistence-harvest areas and resources. In general, oil spills periodically could affect subsistence *resources* in the communities of Nuiqsut and Kaktovik. In the unlikely event an oil spill occurred and contacted any part of the bowhead whale’s migration route, oil could taint this subsistence resource that has primary cultural importance to the Inupiat. Even if whales were available for the subsistence hunt, tainting could make bowhead whale products less desirable and disturb or stop the subsistence hunt. Concerns about tainting also would apply to polar bears and seals. A large oil spill could have short-term but serious adverse effects on oldsquaw and king and common eiders. Polar bear losses from a spill could reduce their availability to Nuiqsut subsistence hunters, although they are not a locally preferred resource. No harvest areas or resources, except possibly bowhead whales, would become unavailable for use. Some resources could suffer losses and bowhead whales could become culturally unavailable due to tainting. Subsistence practices for harvesting, sharing, and processing resources should continue.

Disturbances periodically could affect subsistence resources in the communities of Nuiqsut and Kaktovik, but no resource or harvest area would become unavailable and no resource population would experience an overall decrease. Disturbances could alter or reduce subsistence-hunter access to subsistence resources, alter or extend the normal subsistence hunts, and displace subsistence species; but disruptions to subsistence resources should not displace traditional practices for harvesting, sharing, and processing resources. Subsistence species potentially affected by disturbance and noise would include bowhead whales, seals,

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polar bears, caribou, fish, and birds. Disturbances from oil-spill cleanup could increase disturbance effects. Beluga whales rarely appear in the Liberty Project area, and we do not expect them to be affected by noise or other project activities; neither do we expect changes in Kaktovik's subsistence harvest of beluga whales.

i. Sociocultural Systems

Effects on the sociocultural systems of communities of Nuiqsut and Kaktovik could come from disturbance from oil-spill cleanup activities; small changes in population and employment; and periodic interference with subsistence harvest patterns from oil spills and oil-spill cleanup. Effects from these sources would not displace ongoing sociocultural systems, community activities, and traditional practices for harvesting, sharing, and processing subsistence resources. For potential effects from food tainting, see the discussion on Environmental Justice in Section III.C.3.i.(6).

Alaskan Inupiat Natives, a recognized minority population, are the predominant residents of the North Slope Borough, the area potentially most affected by Liberty development. Inupiat Natives may be disproportionately affected because of their reliance on subsistence foods, and Liberty development may affect subsistence resources and harvest practices. Disproportionately adverse effects on Alaskan Natives could result from Liberty development under the Proposal. Effects will focus on the Inupiat community of Nuiqsut, and possibly of Kaktovik, within the North Slope Borough. Effects to subsistence resources and subsistence harvests are expected to be mitigated substantially though not eliminated.

j. Archaeological Resources

(1) Summary and Conclusion for Effects of an Oil Spill on Archaeological Resources

The geography, prehistory and history of the Liberty Project area is very different from that of Prince William Sound, where the effects of the *Exxon Valdez* oil spill were concentrated; therefore, direct analogies cannot be drawn regarding the numbers and types of sites that may be affected should such a spill occur in the Liberty Project area. However, general findings and conclusions regarding the types and severity of impacts to archaeological sites present within the *Exxon Valdez* oil spill area are applicable to the Liberty Project area. The most important understanding that came from the *Exxon Valdez* oil spill was that the greatest effects to archaeological sites were not from the oil itself, but from the cleanup activities (Bittner, 1993, Dekin, 1993). The effects from cleanup activities were due both to physical disturbance of sites from cleanup equipment and due to vandalism by cleanup workers. Regardless, researchers concluded that less than 3% of the archaeological resources within the spill area suffered any significant effects (Mobley et al., 1990; Wooley and Haggarty, 1993), and that level of effect would be expected in the unlikely event that an oil spill occur from the Liberty development.

k. Economy

The proposed Liberty Project would generate approximately:

- $100 million in wages and 870 full-time equivalent construction jobs in Alaska during 14-18 months of construction
- $4.2 million in wages and 50 jobs annually for operations for 16 years in Alaska
- 1,248 indirect full-time equivalent jobs during the 14-18 months of construction
- 78 indirect full-time equivalent jobs each year for 16 years of operations
- $480 million capital expenditure, $240 million operating expenditures
- $344 million total Federal revenue
- $63 million total State revenue
- $5 million ad valorem tax to the North Slope Borough
- $114 million net present value of receipts to Federal and State governments
- 5 to 125 jobs for 6 months to clean up possible 125 to 2,956-barrel oil spills
- 52 jobs for 2 years and $12 million in wages and $6 million for other during abandonment

(See Secs. III.C.2.k, III.C.3.k, III.D.1.k, III.D.2.k, III.D.3.k, III.D.5, III.D.6.k, V.C.11, for detailed effects and references on the economy.)

l. Water Quality

During open water, hydrocarbons dispersed in the water column from a large (greater than or equal to 500 barrels) crude oil spill could exceed the 0.015-parts per million chronic criterion for 10-30 days in an area that ranges from 30-45 square kilometers (11.6-17.4 square miles) to 51-186 square kilometers (19.7-71.8 square miles). Hydrocarbons in the water could exceed the 1.5-parts per million acute (toxic) criterion during the first day in the immediate vicinity of the spill. A large crude oil spill in broken sea ice or when the sea ice melts could exceed the chronic criterion for several days in an area of about 7.6 square kilometers (2.9 square miles). Hydrocarbons from a 1,283-barrel diesel oil spill during open water could exceed the acute (toxic) criterion for about 7 days in an area of about 18 square kilometers (7 square miles). During broken sea ice or melting ice conditions, a 1,283-barrel diesel spill could exceed the acute (toxic) criterion for about 1 day in an area of about 1 square kilometers (0.4 square miles) and the

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chronic criterion for more than 30 days in an area of about 103 square kilometers (39.8 square miles). The effects from a spill occurring under the ice would be similar to those described for broken ice or melting conditions; the oil would be trapped and essentially remain unchanged until breakup occurred and the ice began to melt. A large crude or refined oil spill (greater than or equal to 500 barrels) would have a significant effect on water quality by increasing the concentration of hydrocarbons in the water column to levels that greatly exceed background concentrations; however, the chance of a large spill occurring and oil entering the offshore waters is estimated to be about 1%. Also, regional (more than 1,000 square kilometers [386 square miles]), long-term (more than 1 year) degradation of water quality to levels above State and Federal criteria because of hydrocarbon contamination is very unlikely.

The greatest effect on water quality from gravel island and pipeline construction would be additional turbidity caused by increases in suspended particles in the water column. Increases in turbidity generally are expected to be considerably less than the 7,500 parts per million suspended solids used in the analysis as an acute (toxic) criterion for water quality (Sec. III.C.3.l(2)); exceptions may occur within the immediate vicinity of the construction activity. Turbidity increases from construction activities generally are temporary and expected to occur during the winter and end within a few days after construction stops. Material excavated from the pipeline trench but not used for backfill most likely would be left in an area where active erosion of sediment particles could occur during breakup and open water. This material would be similar in composition to seafloor sediments in the trenching and disposal areas, and its contribution to future turbidity from waves and currents is expected to be about the same as the sediments existing at the seafloor surface before pipeline construction. Construction activities are not expected to introduce or add any chemical pollutants.

Treated seawater would be the primary discharge from the Liberty Island production facility. The discharged waters will be a few degrees warmer and contain higher concentrations of suspended sediments and dissolved salts when compared to the water in Foggy Island Bay. Increases in turbidity generally are expected to be considerably less than the 7,500 parts per million suspended solids used in the analysis as an acute (toxic) criterion for water quality. The water also will contain some chemicals that have been added to prevent biofouling, scaling, and corrosion. Mixing in the receiving waters of the bay is estimated to dilute the effluent waters by a 50:1 ratio within about 6 meters (20 feet) of the island.

Planned reclamation of the gravel mine site may increase the turbidity in the river downstream from the site and in the coastal waters off the mouth of the Kadleroshilik River in the spring, when the water from the river floods the mine site. The gravel mining and reclamation activities are not expected to introduce or add any chemical contaminants.

Hydrocarbons from small oil spills (3 barrels) could exceed the 0.015-parts per million chronic criterion for less than a day or two in an area less than 2 square kilometers (0.8 square miles)—perhaps only a few tens of square kilometers. Small oil spills, as represented by a 3-barrel spill, are not expected to have any long-term degradational effects on the overall water quality of Foggy Island Bay.

Abandonment of Liberty Island and removal of the slope-protection system would expose the fill material to erosion by ice, waves, and currents. Exposed fine-grained particles would be suspended and increase the turbidity in the water column downcurrent from the island. Increases in turbidity generally are expected to be considerably less than the 7,500-parts per million suspended solids used in the analysis as an acute (toxic) criterion for water quality. The abandonment activities are not expected to introduce or add any chemical contaminants.

(See Secs. III.C.2.l, III.C.3.l, III.D.1.l, III.D.2.l, III.D.3.l, and III.D.6.l for detailed effects and references on water quality.)

m. Air Quality

The proposed Liberty Project would affect air quality in several ways, but the overall effects would be very low. An oil spill could cause an increase in hydrocarbon air pollutants, as discussed in Section III.C.2.m. The overall effects on air quality would be minimal. (See Sec. III.C.2.m for details of oil-spill effects on air quality.)

The most noticeable effects on air quality are caused by emissions from equipment. This is discussed in detail in Section III.D.1.m. That section concludes that the Liberty Proposal would cause a small, local increase in the concentrations of criteria pollutants. Concentrations would be within the Prevention of Significant Deterioration Class II limits and National Ambient Air Quality Standards. Therefore, the effects would be low.

B. ENVIRONMENTAL STUDIES PROGRAM AND ENGINEERING STUDIES

1. Environmental Studies Program

The purpose of our Environmental Studies Program is to define information needs and implement studies to assist in assessing, predicting, and managing potential effects on the human, marine, and coastal environments of the outer continental shelf and coastal areas that may be affected by gas and oil development. To attain program goals, data are required on specific environmental, social, and economic concerns arising from offshore development. The Environmental Studies Program monitors effects during and after oil exploration and development.

The Alaska Environmental Studies Program was initiated by the U.S. Department of the Interior in 1974 in response to the Federal Government's decision to propose areas of Alaska for offshore gas and oil development. The Outer Continental Shelf Lands Act requires the Secretary of the Interior to conduct environmental studies to obtain information pertinent to sound leasing decisions and to monitor the human, marine, and coastal environments (Outer Continental Shelf Lands Act Amendment, 1978 [Public Law 95-372, Sec. 20]). One of the goals of the Outer Continental Shelf Lands Act is to provide for both the development of the oil and gas resources and adequate protection of the renewable resources of the outer continental shelf.

In addition, the National Environmental Policy Act of 1969 requires that all Federal Agencies use a systematic, interdisciplinary approach that will ensure the integrated use of the natural and social sciences in any planning and decisionmaking that may have effects on the environment. Federal laws impose additional requirements on the offshore leasing process, including the Coastal Zone Management Act; Federal Water Pollution Control Act Amendments; Marine Mammal Protection Act; Endangered Species Act; and Marine Protection, Research, and Sanctuaries Act.

Beaufort Sea coastal communities expect increased involvement in exploration and development project reviews and decisions that may affect their subsistence lifestyle. The indigenous Inupiat people of these communities rely on resources of the marine and terrestrial environment. They are especially concerned about industrial activities that may directly or indirectly affect their subsistence activities or the habitats of subsistence species. Local people also desire to participate in project-level decisionmaking related to research activities that seek to understand the interactions of human activities and the natural environment.

Over the years, our Environmental Studies Program has involved Alaskans and others in its research planning and execution in a number of ways. One way of doing this has been the practice of submitting the proposed Alaska Annual Studies Plans for public review and comment. Traditional knowledge of the Inupiat people also has been incorporated into specific study planning, fieldwork, and interpretation of results over the years of the Environmental Studies Program. Incorporating traditional knowledge into these activities varies from project to project, but the outcome of better information for decisionmaking is a common goal. In all MMS field-oriented studies, researchers coordinate directly with local communities to discuss their plans, seek advice, and ensure that interested persons learn about the project and its results.

The Alaska Environmental Studies Program also seeks to coordinate plans and ongoing studies with other programs and research to ensure optimal studies management, reduce costs, enhanced use of existing information, shared logistics and equipment, and enhanced team approaches to interdisciplinary projects. Currently, a major portion of the studies program is conducted on a cooperative basis. In 1993, we developed the Coastal Marine Institute to take advantage of environmental scientific expertise at local levels. Under a 5-year Cooperative Agreement, we committed $1,000,000 per year for studies to be conducted by the Coastal Marine Institute, if the Institute can obtain matching funds. The Cooperative Agreement was renewed for another 5 years in 1998. The University of Alaska, Fairbanks, School of Fisheries and Ocean Sciences, nationally recognized for its coastal and marine scientific expertise, administers the Coastal Marine Institute.

Several other cooperative projects have been initiated recently, including a cooperative agreement with Canadian entities to perform a study of tagging and tracking beluga whales in the Beaufort Sea, a cooperative agreement with the Alaska Department of Fish and Game to jointly perform a multiyear monitoring study of ringed seals in the Beaufort Sea, and a cooperative agreement with the Alaska Department of Fish and Game to jointly perform a multiyear study of social consequences of Alaska outer continental shelf activities.

Preparation of the environmental impact statements for proposed oil and gas lease sales and development projects requires environmental information. Although much information exists for certain Alaska outer continental shelf lease areas, changes in types or levels of activities and the area in which these activities occur often require that past studies be updated so that information contained in the environmental impact statement is current and accurate.

In addition, not all information needs can be obtained before a lease sale or the start of a development activity. In accordance with mandates of Section 20(e) of the Outer Continental Shelf Lands Act, as amended, postlease studies will be needed to address environmental concerns and

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monitoring related to specific development projects. We will acquire additional information for development- and production-phase environmental analyses. Thus, future study plans have become more closely related to development schedules and monitoring and evaluation needs rather than leasing schedules.

Postlease activities that raise issues and require environmental data and assessment are:

- geophysical surveys
- exploration drilling
- development, construction, and production activity
- oil transportation, including pipelines and tankers
- exploration and development site abandonment

The MMS-sponsored studies being conducted in or adjacent to the Beaufort Sea Planning Area or studies applicable to the planning area are shown in Table III.B.-1. Additional information on these studies is presented in Appendix F. The Alaska Annual Studies Plan Final FY 2001-2002 contains additional information on the Alaska Environmental Studies Program (USDOI, MMS, Alaska OCS Region, 1999).

2. Pipeline Design Studies

Pipeline design, including the advantages and problems associated with single-wall and double-wall construction, have been an issue among the Federal Agencies. Several engineering efforts have been developed to provide additional information about the issues.

The first project was prepared by INTEC Engineering, Inc., and delivered to BPXA in November 1999. This report, *Pipeline System Alternatives, Liberty Development Project Conceptual Engineering* (INTEC, 1999a) contains conceptual engineering designs for the four pipeline systems, including a single-wall pipeline, a steel-in-steel pipe-in-pipe system, a steel pipe-in-HDPE system, and a flexible pipe system. After comments were received from Federal Agencies and a third-party peer review was completed by Stress Engineering Services, Inc., INTEC prepared responses to the comments and an addendum to the report with all four pipeline designs buried with the same 7-foot burial depth. In April 2000 the report was reissued in its final stage (INTEC, 2000). The four designs are described as the pipeline design alternatives in Section II and evaluated in Sections III and IV.C.2. The Executive Summary of this report can be found in Appendix D-5.

In the summer of 1999, MMS also contracted with the Centre for Cold Oceans Resource Engineering (C-CORE) for a generic pipeline study (*An Engineering Assessment of Double Wall verses Single Wall Designs for Offshore Pipelines in an Arctic Environment*) comparing the advantages and disadvantages of pipe-in-pipe and single-wall pipe designs. The information contained in this C-CORE report (C-CORE, 2000) is provided in Section IV.C.2. The Executive Summary of this report can be found in Appendix D-2.

In December 1999, Stress Engineering Services, Inc. (Stress) was contracted to perform a study titled *Independent Evaluation of Liberty Pipeline System Design Alternatives*. The purpose of the Stress study was to provide an independent review of the INTEC Report. They delivered the final report in April 2000 (Stress, 2000). The findings from that study are incorporated into Section IV.C-2. The Executive Summary from this report can be found in Appendix D-4.

In April 2000, the MMS awarded a contract to Fleet Technology Limited titled *Independent Evaluation of Liberty Pipeline Failure Assessment and Risk Analysis*. This study calculated failure probabilities for each of the four alternative pipeline designs at both the original depths of cover contained in the body of the INTEC report and the 7-foot burial contained in the addendum to the report. The final report (Fleet, 2000) was delivered in September 2000. The Executive Summary from this report can be found in Appendix D-6.

a. Summary of the Pipeline Engineering Studies

The four studies mentioned all generally concurred with or concluded that:

- All four pipeline designs proposed by INTEC could be constructed and operated safely;
- The probability of a spill is low for any of the four pipeline designs;
- The pipe-in-pipe designs can provide secondary containment that would prevent oil from entering the environment for certain types of failures; and
- The pipe-in-pipe designs would be more complex to construct and repair than the single-wall designs.

b. The MMS Conclusion for Offshore Pipelines

The outer continental shelf historical database would estimate a 15% chance of an oil spill from an offshore pipeline. Adjusting for anchor and trawler events for a buried pipeline would reduce the chance from other events to about 5%. The CONCAWE (Conservation of Clean Air and Water in Europe) and S.L. Ross estimates range around a 1-2% chance of a spill occurring from the offshore pipeline. The pipeline engineering studies concluded low, less than 1.5%, likelihood of a spill.

The BPXA Proposal includes detailed design, testing, quality assurance, mitigation, and monitoring to ensure the safety of the pipeline. These measures are beyond what is done for most of the pipelines on which the historical data are based. If a chance of a spill occurring must be given, our best professional judgment, given the above, is that the chance of a significant oil spill from the Liberty offshore pipeline is less than 1%. See Section III.C.2 for additional information about large oil spills for this EIS.

C. MAJOR ISSUES CONCERNING THE LIBERTY PROJECT

Within the context of the National Environmental Policy Act and the EIS, some concerns cannot be "analyzed." The EIS is not intended to, nor can it, serve as a technical review to determine the adequacy of BPXA's Oil Discharge Prevention and Contingency Plan (BPXA, 2000b),their proposed pipeline (including leak detection), or their proposed platform designs. Each of these is subject to separate and additional technical review processes that is independent of the EIS and that will include separate and additional public review. Within each of these technical reviews, the contingency plan, the pipeline, and the platform designs will be evaluated against specific engineering and technical standards and criteria. The EIS cannot substitute or replace the scope and purpose of these other required technical reviews. However, because of the high level of public concern expressed about these topics, the MMS believes it is prudent and reasonable to include an assessment of each of these elements of the Liberty Project. Sections III.C.1.a, b, and c provide a "first-level" technical review of BPXA's contingency plan, their proposed pipeline, and their proposed platform designs, respectively, for the Liberty Project.

The adequacy of BPXA's contingency plan and pipeline and island designs is of paramount importance to the MMS. If this project moves forward, MMS will require BPXA to have the best available and safest technology to prevent potential oil spills, to detect spills should they occur, and to clean up any spills. This will be ensured through our stringent regulatory requirements and through the separate technical reviews of these documents.

Sections III.C.2 and III.C.3 provide analyses of the effects of large oil spills and disturbances. Other effects from sources such as discharges, gravel mining, and abandonment can be found in Section III.D. Detailed analyses of the effects of possible platform and pipeline oil spills are found in Section III.C.2. Analyses and references for disturbances, such as noise, are found in Section III.C.3. These analyses properly provide a full discussion of potential effects regardless of and independent to the capability to contain and clean up a spill, as described in BPXA's Oil Discharge Prevention and Contingency Plan (BPXA, 2000b) (see Appendix K) or the safety of the pipeline and design of the island to prevent spills.

A cumulative effects analysis can be found in Section V. The effects of a low probability but very large oil-spill event can be found in Section IX.

1. Project Integrity

This section provides basic information about oil-spill-response capability, gravel island design and slope protection, and pipeline safety for the Liberty Project.

a. Discussion of BPXA's Proposed Liberty Oil Discharge Prevention and Contingency Plan

The BPXA Oil Discharge Prevention and Contingency Plan (BPXA, 2000b) for Liberty was developed to comply with multiple regulatory standards. These include the MMS (30 CFR 254), the U.S. Coast Guard (33 CFR 154), the U.S. Department of Transportation (49 CFR 194), and the Alaska Department of Environmental Conservation (18 AAC 75). Each agency reviews the plan to ensure compliance with their regulatory authority and responsibilities (i.e., outer continental shelf facility, offshore segment of pipeline, onshore segment of the pipeline, and diesel storage and transfer). These reviews of the contingency plan are conducted independent of the EIS process and, depending on the agency, also will have a separate public and coastal zone management review process.

The discussion presented in this section is not intended to represent a comprehensive evaluation of BPXA's contingency plan to meet individual agency requirements or to substitute for each agency's independent technical and public review process to determine if the plan is adequate. However, because of the high level of public concerns regarding oil-spill response offshore during broken-ice conditions, this section provides an analysis of these aspects of the contingency plan. Additionally, this discussion is not a review or analysis of the administrative (i.e., reporting, notification) aspects of the contingency plan.

Our regulations are the principal response-planning requirements for outer continental shelf facilities and pipelines such as those proposed by BPXA. As described below, the North Slope Spill Response Advisory Team, which is composed of representatives from the State of Alaska, Department of Environmental Conservation; the U.S. Coast Guard; the Environmental Protection Agency; the North Slope Borough; the MMS; and industry has developed additional guidance and criteria for response plan development on the North Slope. The guidelines (detailed in Table II.A-4) establish quantitative criteria related to oil-spill response, including estimated spill size and duration, realistic (maximum) environmental conditions (wave height and wind speed and direction), equipment efficiencies, utilization time of the system, actual in-service time, and storage-barge holding capacity (taking into account transit times and decanting times). This guidance also is considered in this analysis, where appropriate. It is important to note that BPXA also used site-specific data to provide realistic environmental information in refining the spill scenarios in their contingency plan.

Our review has determined that in several areas, BPXA's Oil Discharge Prevention and Contingency Plan has exceeded the parameters that MMS established in 30 CFR 254. For the calculation of the blowout flow rate (spill size), MMS regulations (30 CFR 254.47) link the highest flow rate of a well to the expected changes in the reservoir flow rate. We do not expect a well to continue to flow at a constant rate for an extended period of time. The MMS has established in 30 CFR 254.47 that the worse-case spill size is determined by multiplying the total volume of oil released from a single well in a 24-hour period by four (for Liberty, this results in multiplying 15,000 barrels times 4, which equals 60,000 barrels). BPXA's approach to defining the flow rate and resulting total spill volume (180,000 barrels) does not take into consideration pressure depletion and the resulting reduction in flow. BPXA's approach provides a more conservative estimate of the worst-case spill size with regard to a blowout from the Liberty Project.

The efficiency of response equipment to operate under anticipated environmental conditions is one of the most important components in evaluating response capabilities. We require that the manufacturer's rated throughput capacity of recovery equipment be reduced by 80% over a 24-hour period to represent the oil-recovery capacity of the equipment. For example, a skimmer with a rated throughput of 270 barrels per hour (6,480 barrels/day), would be credited with an oil-recovery capability of 1,296 barrels per day (6,480 x 0.2). The 20% criteria takes into account the limitations of the recovery operations due to the available daylight, the sea state, the air temperature, and the viscosity and emulsification of the oil. Table III.C-1 is a list of skimmers in the Alaska Clean Seas inventory and their derated recovery capacity.

The information detailed in Table II.A-4 provides a more comprehensive and conservative approach for estimating oil spills than the MMS regulations. In particular, the guidelines limit equipment use to a 20-hour day (versus 24). (This change would result in the same piece of equipment described above as being credited with a total daily recovery of 1,080 barrels instead of 1,296 barrels.) The guidelines also provide more detailed characterization of the nature of the oil spill (spreading, thickness) and provide for quantitative assessment of the associated encounter rates with containment and recovery equipment. This provides for the development of an equipment list that will exceed the amount needed to address a spill calculated under our criteria. The tactics developed for broken-ice conditions and included in the BPXA's contingency plan also identify and provide for additional reductions in containment and recovery in broken-ice conditions based on decreasing encounter rates with changing ice coverage (freezeup and breakup). These tactics are described in Volume I of the Alaska Clean Seas Technical Manual (Alaska Clean Seas, 1998). Tactics center around using an ice-breaking barge, two ice strengthened barges and various other vessels as platforms for on-water oil recovery and storage operations. Depending on the ice conditions, responders have a number of options for deploying equipment in varying configurations to maximize their ability to clean up oil in the environment.

In addition to our review of BPXA's contingency plan, the U.S. Coast Guard is the Federal On-Scene Coordinator for offshore spills and the Regional Response Team will oversee BPXA's efforts to respond to a spill. The Regional Response Team, which is composed of Federal, State, and local governments and representatives of the Native community, has developed a series of guidelines for conducting cleanup activities. This includes the assessment of shoreline cleanup, preapproval guidelines for in situ burning, methods of wildlife protection, approval of dispersant use, and development of an environmental sensitivities atlas for the North Slope. The U.S. Coast Guard will consult with land managers of the areas that could be impacted by the spill to ensure that sensitive environmental sites are protected from the impact of the spilled oil. In addition, the individual in charge of the spill response will coordinate with the State of Alaska and local communities to ensure that areas of local concern are adequately protected. Our review of BPXA's contingency plan will include seeking input from the responsible Federal, State, and local government representatives and the public to ensure, as much as possible, that areas requiring special attention are considered in the contingency plan.

BPXA's contingency plan includes Regional Contingency Field Maps, which indicate locations of sensitive resources (BPXA, 2000b). This information will assist the Federal On-Scene Coordinator in prioritizing actions and deploying the response team and equipment. The use of this information can help mitigate effects of an oil spill to both the habitat and the resource that use these sensitive area

We also reviewed BPXA's contingency plan for compliance with the special mitigation, provisions, Information to Lessees Clauses, adopted in the Sale 144 lease-sale notice. There were several Information to Lessees clauses that were relevant to the development of BPXA's contingency plan. These Information to Lessees clauses have been addressed by BPXA in their contingency plan.

ITL (m) advises lessees that certain areas are valuable due to their environmental sensitivity or biological resource potential. It directs the lessee to identify these areas through consultation with the resource agencies and the local communities. It further directs lessees that these areas should be considered when they are developing the response portion of BPXA's Oil Discharge Prevention and Contingency Plan (BPXA, 2000b). The contingency plan properly identifies the known sensitive areas. If additional areas are identified as a result of the EIS analysis, BPXA will be expected to include them in their contingency plan along with proper protection methods.

ITL (n) advises lessees that they must demonstrate their capability to detect, clean up, and dispose of spilled oil in broken ice. The lessee is advised that additional field testing to verify the response capability described in the plan may be required. Substantial field tests were conducted in the early 1980's on existing technology. We determined that industry had demonstrated the capacity to cleanup oil in broken-ice conditions. As a result of the review of the Northstar oil-spill-contingency plan, field testing of the barge-based systems was conducted during fall 1999, summer 2000 and fall 2000. The results of these trials are currently being reviewed by Federal, State and local regulatory agencies.

ITL (o) advises lessees that they must be prepared to respond to any oil spill that occurred as a result of the activities being conducted on the lease. This preparation is to be detailed in an oil-spill-contingency plan submitted before, or as a part of, an exploration or development and production plan. The lessees also are informed of the need to conduct a spill-response drill to verify the abilities outlined in the oil-spill-contingency plan. Both local and State agencies will be invited to witness these response drills as they occur.

There are several items that we will address in the final review of BPXA's Oil Discharge Prevention and Contingency Plan. These include procedural corrections such as verifying telephone numbers and agency contacts and reviewing the additional characterization of the Liberty oil, which is being completed. The results of this chemical analysis will enable a better assessment of the susceptibility of the oil to the various response strategies, including in situ burning. (See Appendix K for a summary of effects of BPXA's Oil Discharge Prevention and Contingency Plan.)

In addition to BPXA's Oil Discharge Prevention and Contingency Plan, a North Slope Subarea Contingency Plan provides the Federal/State-expected response criteria to an accidental release. The plan, which provides the umbrella structure under which the North Slope Borough, village governments, and local population are brought into an oil-spill-response action, is being developed; once completed, we expect that the Liberty contingency plan will be revised to recognize the areas addressed in the subarea plan. The subarea plan also conforms to the Alaska Federal/State Preparedness Plan for Response to Oil and Hazardous Substance Discharge/Releases Plan. Also, existing guidelines for preapproval of in situ burning by the Federal On-Scene Coordinator are being revised by the Regional Response Team to facilitate in situ burn-response actions; following revisions of these guidelines, we will expect them to be incorporated into BPXA's Oil Discharge Prevention and Contingency Plan for Liberty.

We provided an assessment of cleanup capability in the Sale 170 Final EIS (USDOI, MMS, 1998). This assessment included discussion on the various techniques and processes that could be employed in the event an oil spill occurred. It included discussion on the uses and limitations of in-situ burning, how containment and recovery would be affected by various environmental conditions, and various techniques for addressing shoreline response. The Sale 170 EIS also discussed detection and tracking, use of alternative responses (dispersants and other chemicals), and how the recovered materials would be handled. It concluded that based on experience, the historical cleanup ranged from 5-15% of the oil spilled.

As the EIS and public review process continue, we will fully consider any additional relevant information on BPXA's contingency plan to ensure that the capability to contain and recover the oil spill and to protect sensitive resources and habitat is maintained to the maximum extent practicable.

In addition to the required elements of the response plan, as discussed, several additional initiatives have been undertaken to improve oil-spill-response capabilities in the Beaufort Sea. These include the following:

- Establishing Alaskan Clean Seas as a responder organization rather than a storehouse of equipment. We believe that this centralized core of experienced personnel and equipment and logistical support fundamentally will improve overall response on the North Slope.
- Taking additional new initiatives. Field trials conducted in the 1980's (TIER II demonstrations) and associated research led to significant improvement in arctic response capability (notably the Helitorch and fire-resistant boom). Since then, additional new initiatives have been identified and are in progress. These include:
    - Testing a prototype mechanical-recovery system for recovering oil in high concentrations of ice (MORICE); we currently are participating in a joint industry project to build and test this system in controlled test-tank conditions. Additional full-scale testing is the next proposed phase of the project.
    - Operating a test tank. Alaska Clean Seas has constructed and is operating a test tank on the North Slope. This test tank has been used most recently for additional in situ burn tests to confirm the emissions and suitability of this technology for arctic conditions.
    - Using additional field trials to demonstrate and verify barge transit and logistical capabilities that have been requested by the State of Alaska. These trials were conducted in the fall 1999, the spring 2000 and the last round in fall 2000. The trials have demonstrated the need to revise broken ice response tactics to meet conditions unique to breakup and freezeup. They have also been useful in establishing maximum operating limits for boom, skimmers and vessels in various ice conditions and provided a basis for modifying

tactics and equipment requirements for those different conditions.

- Conducting large mutual aid drills annually on the North Slope. These drills mobilize and enact multiple levels of industry, Federal and State Government, and local coordination for a simulated major oil spill. The 1998 drill included an offshore spill component from the Alpine Project. The State of Alaska, Department of Environmental Conservation, and the U.S. Coast Guard concluded that this drill was successfully conducted. The 2000 mutual aid drill was successfully conducted in November and simulated a loss of well control at the Northstar offshore facility during fall freeze up conditions. This mutual aid drill was limited to a tabletop drill because the on-water response elements had been exercised during the fall 2000 trials.

b. Gravel Island Design and Slope Protection

Artificial gravel islands are not new technology for the Beaufort Sea. Five gravel islands have been constructed for exploratory drilling operations in the Beaufort Sea outer continental shelf. The Endicott Development Project, which includes two gravel islands and a causeway to shore, is located less than 7 miles from the Liberty gravel island site. The experience from these projects shows that field measurements of ice forces and movement recorded during these and other exploration activities, as well as the results of research and development over the last 15-20 years, make it possible to design a safe gravel island.

The adequacy of the Liberty gravel island design will be verified through our platform-verification process. Through this program, all aspects of the island design and construction will be reviewed by an independent third-party engineering firm(s) that we approve. The review will include the following:

- **Design criteria:** ice loads; wave, current, and storm conditions; working surface elevation; facility setback; and soil conditions and foundation stability
- **Construction materials:** gravel type, density, and size distribution; slope armor/defense materials
- **Performance:** movement, compaction and settlement, ice rideup and override
- **Construction:** verify as-built meets design specifications

(1) Design of Safe Gravel Islands

Gravel islands are not complex structures. The basic design considerations for a gravel island are:

- **mass** to resist lateral movement from ice forces
- **working surface elevation** to extend above potential wave and ice rideup and override
- **slope angle** to dampen wave energy, resist ice rideup, and induce natural ice-rubble formation
- **slope protection (armor)** to resist ice and wave forces and provide additional resistance to rideup and override
- **filter fabric** to prevent washout of the gravel material

The proposed Liberty Island design compares to other gravel islands that have been successfully used for exploratory drilling in the Beaufort Sea outer continental shelf. Table III.C-2 is a comparison of the design basis between the proposed Liberty gravel island and the Tern and Mukluk exploratory islands. Tern Island is located less than 2 miles from the proposed Liberty gravel island site in similar water depths and also is located inside the protective barrier islands. By contrast, the Mukluk gravel island, constructed by BPXA (previously SOHIO) in 1983, was located in Harrison Bay in 49 feet of water outside the barrier islands. Table III.C-2 also shows the Northstar Project, which is being constructed in Gwydyr Bay about 50 miles northwest of Liberty, and the Endicott main production island, located 7 miles to the west of the Liberty location.

Table III.C-2 shows that gravel island designs share many common features, and that the same basic design can be used in different water depths and locations. The principal difference in the island designs is the slope-protection material. The proposed Liberty Island includes an additional design element not used in the exploration islands or Endicott. A gravel bench with concrete slope protection extends 40 feet from the base of the gravel-bag-protected slope to the sea surface. The bench provides additional dampening of wave energy and to further induce natural formation of ice rubble.

Ice conditions, oceanographic conditions (waves and storm surges), soil conditions, specifications for gravel-fill material, and construction methods are integral parts of the island design. Because of concerns expressed about the ice and wave conditions, these two topics are addressed in more detail below.

(2) Information on Wave and Ice Conditions

There is a substantial amount of public and proprietary information on oceanographic (waves) and ice conditions in the Beaufort Sea. One of the best summaries of oceanographic information is the *Climactic Atlas of the Outer Continental Shelf Water and Coastal Regions of Alaska, Volume III, Chukchi-Beaufort Sea* (Climatic Atlas) (Brower et al., 1988). The principal summary of ice conditions and methods for determining potential ice forces is the American Petroleum Institute Recommended Practice 2N (API RP2N). Additional public and proprietary data also have been collected for different portions of the Beaufort Sea. At least 3 years of oceanographic data have been collected in the Liberty area in conjunction with previous exploratory activity.

(3) Oceanographic Conditions

The major oceanographic conditions addressed in the Liberty Island design are maximum and significant wave heights and storm surges. The island must be designed to avoid wave rideup and overtopping of the island working surface. The slope-protection material must be able to withstand damage from wave energy acting against the island slope.

Based on hindcasting and design criteria developed for previous offshore gravel islands, maximum wave heights and storm surges for the area of the Liberty Island are expected to be on the order of 20 feet and 4 feet, respectively. The specific design criteria to address the potential oceanographic conditions BPXA used to design the Liberty Island will be verified by a third party during the technical platform verification process. Although the historic data for the Liberty site are relatively short (3 years), this will not prevent an exhaustive and valid assessment of oceanographic design criteria for the Liberty Island for the following reasons:

- Oceanographic forces and processes are well understood.
- Bottom contours, water depth, fetch distance (the uninterrupted distance traveled by a wave), and other features that will influence oceanographic forces at Liberty are known and can be used to model and predict oceanographic conditions for the Liberty site.
- Hindcasting methodologies are extensive and will take into account all available information.
- Other gravel islands and other offshore drilling structures have been designed using similar hindcasting methods and successfully operated in the Beaufort Sea.
- Hindcasting methods will provide conservative values for maximum events.
- Design criteria can be selected based on longer return events (typically, design criteria are based on a 100-year return period) to further increase conservative design.

The proposed Liberty Island design is similar to the Tern gravel island. The Tern gravel island experienced no wave rideup or override events during exploratory operations. This suggests that the Liberty design is appropriate for these similar conditions. Whereas the Tern Island was used for temporary exploratory activities and the proposed Liberty Island will be for longer-term development and the design criteria must account for the longer operating life of the island. The methodologies, data, and proposed design criteria for the Liberty Island will be reviewed and verified during the platform verification process.

(4) Ice Conditions

Ice poses two major risks to the island—direct forces acting against the structure that can cause lateral movement, and rideup and overriding the slope of the island to potentially damage surface equipment or injure personnel. The island must be designed with sufficient mass to resist lateral forces and with appropriate design features (for example, slope angle and slope-protection material) to prevent ice rideup and override.

The following considerations suggest that the proposed Liberty design is safe for ice loads against the island.

- There has never been a failure as a result of ice loads of an artificial gravel island or other artificial structures used for oil and gas activities in the Beaufort Sea.
- The most likely ice forces to be experienced at the Liberty location will be from first-year ice. Ice forces from other types of ice such as multiyear, consolidated rubble, or pack ice, would be larger, but these conditions are not expected inside the barrier islands.
- Other gravel islands with similar designs have successfully operated in more significant ice conditions than those expected at Liberty.
- Operating experience, field studies, and research on ice mechanics that have been conducted in association with earlier islands has demonstrate that natural rubble piles formed at the base of the island/sea level interface provide additional resistance to ice loads on the island. Measured ice loads have been minimal compared to the design loads.
- Tern Island, the design of which is comparable to the Liberty Island design, was used to drill three exploratory wells during multiple seasons without incident. Although a temporary exploratory drilling island, the design basis was characteristic of a longer term production island; ice loads were based on a floating consolidated rubble field and a 100-year return event.
- The design criteria used for Liberty Island were based on the conservative methodologies and calculations found in API RP 2N. Although evidence supports the use of methodologies for calculating lower ice loads, the API RP 2N continues to use a conservative approach in its calculations.

Preventing ice movement up the island slope and override onto the working surface of the island is important to safety of personnel and protection of production equipment. Testimony from local residents confirms that significant ice rideup/override events occur along the coastline and the barrier islands. The following considerations suggest that the proposed Liberty Island can be safely designed for ice rideup and override.

❖ The design slope angle of 1:3 is greater than the natural slope where override has occurred along the coast/barrier islands.

❖ The slope angle of 1:3 is designed to resist ice rideup. The most susceptible time for ice rideup is in early freezeup when the ice is thin. The greater the angle of the slope, the more force necessary to push the ice up the slope; with a 1:3 slope, thin ice will buckle before rideup.

- The 1:3 slope has been used in other gravel island designs. There have been no incidents of ice override on pervious gravel islands used on the outer continental shelf.
- The proposed Liberty Island is located inside the barrier islands. Wind- or wave-induced movement of ice is limited by the short fetch distance.
- The island provides three additional design features for defense against potential ice rideup and override:
  - an extended gravel bench between the main slope and the sea surface to further dampen wave- and wind-induced energy that could drive the ice up the slope, and to facilitate natural rubble pile formation;
  - use of overlapping gravel bags on the upper portion of the slope to provide frictional resistance against ice movement up the slope; and
  - a 5-foot gravel bag berm above the height of the working surface and around the perimeter of the working surface, to provide additional frictional resistance and to cause the ice to break under its own weight at the berm, rather than extend farther onto the island surface.

(5) Slope Protection

The Liberty design includes 4-cubic-yard bags of gravel and interlinking concrete as slope protection In addition, filter cloth will be layered under both the gravel bags and the concrete mats to prevent the leaching of sediment into the water column. The following considerations suggest that the slope-protection methods, including the use of gravel bags proposed for the Liberty gravel island are appropriate.

- Gravel bags and concrete mats have been successfully used as slope protection for other gravel islands and other structures subjected to wave action and ice forces.
- There has never been a compromise of a gravel island that threatened safety of the island or facilities as a result of damage to slope-protection armor.
- Gravel bags proposed for Liberty will be 4-cubic-yard bags, larger than the 2-cubic-yard bags used in earlier gravel island designs, to provide greater mass against possible disorientation from wave or ice action.
- Gravel bags will be constructed from polyester material, which is a stronger and heavier material than the polypropylene used in earlier islands. The bags will sink in water rather than float removing them from possible interaction with boat-propellers.
- Gravel bags will be located only on the upper 8 feet of the island slope and 7-10 feet above the splash zone to minimize exposure to direct wave and ice action.
- Gravel bags are separated from the water surface by a 40-foot gravel bench, which is designed to provide further protection from direct wave and ice action.

The design of the Liberty gravel island is not susceptible to the release of gravel-bag fabric into the water, as was experienced for previous gravel islands. Earlier gravel islands included gravel bags placed below sea level. When these islands were permanently abandoned, recovery of the bag fabric was hampered in deeper water due to poor visibility to direct recovery operations and by the reworking of the bag fabric into the body of the island. Following abandonment and over time, subsequent erosion and reworking of the gravel fill exposed remnants of the bag fabric. Although annual monitoring and recovery activities were undertaken to retrieve exposed fabric, some fabric was released. BPXA has stated that maintenance procedures designed to prevent the loss of any gravel-bag fabric will be implemented for the Liberty Project. We will review these maintenance procedures to ensure that they are adequate to prevent the loss of the bag fabric to the water, and that they are conducted as stated. The location of the bags above the splash zone will make recovery at the time of abandonment easier and more thorough than on the predecessor islands.

A number of other slope-protection methods have been considered for Liberty. Rip-rap (layered stones), concrete blocks, concrete grout mats, and vertical steel sheetpiling are possible alternative types of slope armor. These alternative methods have been used on the North Slope except for rip-rap (due to lack of source material). Any of these alternatives, or combination of one or more, could be viable for Liberty Island.

Vertical sheetpiling is being used for the Northstar gravel island. There has been considerable public concern that the Liberty Island design is less safe than the Northstar design because it uses gravel bags instead of sheetpiling. The principal reason for using steel sheetpiling is to reduce the volume of gravel fill and the size of the footprint of the island that would be needed to achieve the same effective defense against wave and ice rideup and override provided by bag/concrete armored slopes. Vertical sheetpiling requires less gravel-fill to achieve the same working surface elevation. Because of the deeper water depth and higher design wave heights and ice-override potential at the Northstar location, a significant decrease in the footprint of the island could be achieved using sheetpiling. Because of the shallower water depths at Liberty, the savings would not be as great. Alternative V in the EIS evaluates the use of steel sheetpile instead of gravel bags for the upper island slope-protection system.

c. Pipeline Safety

The following provides information concerning pipeline safety. Essential components of the applicant's Proposal that contribute to pipeline safety are:

- a design basis that meets or exceeds engineering design standards and regulatory requirements;
- extra thick steel pipe;
- specially formulated steel to accommodate arctic conditions;

- pipeline burial depth of at least 7 feet, which is more than three times deeper than the deepest detected ice gouge in the project area;
- pipeline routed to avoid areas of highest strudel-scour concentration;
- pipeline designed to accommodate smart pigs;
- proactive smart- pigging program to assess pipeline integrity throughout the life of the project, which will allow for identification of potential problems before pipeline failure; and
- three independent state-of-the-art leak-detection systems designed to detect leaks as low as 0.3 barrels from the pipeline.

BPXA postponed the Liberty Project so that lessons learned from the Northstar Project could be incorporated. Experience gained from the Northstar pipeline construction increases our confidence that the pipeline can be constructed safely.

A more detailed description of components of the applicant's Proposal that contribute to pipeline safety can be found in Section II.A.3.

(1) Pipeline Concerns

Effects to the environment from oil released during a pipeline failure are a major concern. Potential environmental effects of the proposed pipeline on the biological resources are analyzed in Section III.C.2 , III.C.3, and III.D. As part of the right-of-way leasing process, MMS and the State Pipeline Coordinator's Office for the State of Alaska will rigorously review BPXA's proposed design. If the agencies determine that additional measures are required for environmental protection or design integrity to ensure safety, the design could be modified, approval could be denied, or approval could be based on conditions or stipulations to address areas of concern. It is not expected that any modifications to the design that may be required by the State Pipeline Coordinator's Office and the MMS will be outside of what is analyzed in this EIS. However, if a significant change is required that is outside of what has been analyzed, a supplemental National Environmental Policy Act document will be prepared.

(2) Description of the Noise Level Generated by Oil Flowing Through the Pipeline

When the 12-inch oil pipeline is flowing at 65,000 barrels per day, the linear velocity of the oil is about 4 miles per hour. There are no restrictions (valves or openings) in the buried pipeline to create noise. If you placed your ear directly against the pipe, you probably would hear the oil flowing; however, with soil covering the buried pipelines and insulation covering pipelines on the island and onshore, any sound would be muffled, making it inaudible.

d. Estimates of the Chance of an Oil Spill Occurring Considering Historical Records and Oil-Spill Prevention Designed into the Liberty Project

(1) The Uncertainty of Estimating the Chance of an Oil Spill Occurring Using Historical Spill Records

The uncertainty attached to estimating the chance of an event occurring usually fits into one or more of the following five categories. Ideally the data should fall into Category 1, but such an ideal rarely exists for most applications.

1. Good, direct statistical evidence on the process of interest is available.
2. The process can be desegregated with analytical tools, such as fault tree, event trees, and various stochastic models, into subprocesses, for which good, statistical evidence is available. Aggregate probabilities can be constructed.
3. No good data are available for the process under consideration, but good data are available for a similar process; and these data may be adapted or extended for use either directly or as part of a desegregated model.
4. The direct and indirect evidence that is available is poor or incomplete and it is necessary to rely to a very substantial extent on the physical intuition and subjective judgment of technical experts.
5. There is little or no available evidence, and even the experts have little basis on which to produce a subjective judgement.

Unfortunately, a very substantial portion of the problems that society must deal with falls into categories 3, 4, or 5. For Liberty, the analysis of the chance of an oil spill occurring, from historical spill records, falls into categories 3 and 4, because the only offshore production that occurs anywhere in the Arctic is at the Endicott Unit. To gain insights, we look for similar historical data sets about oil spills from production in different regions of the world, although we expect they might have different engineering requirements due to their locations.

We review several historical oil-spill datasets and analytical methods to provide insight and understanding about the chance of a spill occurring from Liberty. These datasets do not fully match conditions at Liberty, but they do represent some similar factors. We use the results carefully, understanding their limitations, and what the information implies.

Therefore, we also must use professional judgment to factor in all the engineering features applied to the Liberty Project that are designed to prevent an oil spill. The engineering data generally fall into categories 1 and 2, because direct tests have been done on Northstar materials and pipe, and information is available on external environment factors. We expect that the Liberty pipe will behave similarly to

Northstar, but at this time no specific tests have been completed.

We recognize that for the Liberty Project, there is a great temptation to use quantitative techniques from historical records to get a chance of an oil spill occurring as "the answer." This is not an appropriate use, because there is not enough direct statistical information. Quantitative assessment on similar processes can provide understanding and insight, but it can never capture all the factors, such as engineering risk abatement, that are important to this problem, and it should never become a substitute for careful human judgement (Morgan, 1981). The likelihood of a spill from a particular gravel island or pipeline really depends on how well the island or pipeline are designed, maintained, managed, and monitored, plus the external factors relevant to the location (for example, whether the pipelines could be punctured by anchors or be subject to hurricanes or ice forces).

(2) Spill Sizes for Estimating the Chance of an Oil Spill Occurring Using Historical Spill Records

As might be expected, small spills (typically on the order of less than 5 barrels) are more common than larger spills. However, for estimating the chance of a spill occurring from historical datasets, larger spills generally are the focus. Such spills are better investigated and documented and are more likely to cause environmental damage. In addition, larger spills often persist long enough to impact areas far removed from the original spill site; the transport mechanisms are frequently ocean currents and winds. For this EIS, only spills larger than 500 barrels are considered. From a numerical perspective, spills from U.S. outer continental shelf platforms and pipelines greater than or equal to 500 barrels account for a very small fraction (0.06%) of the total number of U.S. outer continental shelf spills; however, such spills represent most (82%) of the volume spilled, as based on 1971-1999 U.S. outer continental shelf Gulf of Mexico and Pacific spill data.

(3) Estimating the Chance of an Oil Spill Occurring Using Spill Rates using Historical Spill Records

For us to successfully estimate the chance of an oil spill occurring from historical spill records, we must properly develop and validate the database. Ideally, the database should include a wide range of spill volumes over a long period of time from oil developments resembling the prospective project. Because no databases exactly match the Liberty Project in engineering scope or location, we use the available databases but evaluate project-specific considerations for Liberty.

In addition to a properly developed and validated database, the computation of an oil-spill rate requires an exposure variable. The purpose of an exposure variable is to balance equally different oil developments that should have similar probabilities for an oil spill for a fixed size of spills. Such a variable is required, because oil developments rarely resemble each other. Two basic criteria for the selection of an exposure variable are (1) it should be defined simply, and (2) it should be a quantity readily estimated. The verification of a potential exposure variable includes a demonstration that the exposure variable generates equal values, in a statistical sense, for oil developments with similar oil spill histories.

For oil spills, numerous such variables are in use, including historic volumes of oil produced/transported, number of wells drilled, well-years, and pipeline mile-years. Each of these exposure variables has an assigned application; for example, "wells drilled" would be used to compute the chance of a gas blowout during development drilling. Moreover, two different variables may be used for computing the chance of a spill from the same segment of an oil development; for example, both historic volumes of oil produced/transported, and pipeline mile-years are used to estimate the chance of a spill from the same pipeline. However, in this latter case, caution must be exercised, because different databases often are used when developing exposure variables.

We review several historical oil-spill datasets and analytical methods to provide insight and understanding about the chance of a spill occurring from historical oil-spill records applied to the Liberty Project. This EIS summarizes the information that we use to evaluate the chance of an oil spill occurring from historical spill records and includes all oil-spill records available to us at the time of this draft EIS. This information includes MMS, CONCAWE, and Alaska North Slope data. The MMS oil-spill data is from the Gulf of Mexico and Pacific Outer Continental Shelf. The CONCAWE oil-spill data is from onshore European pipelines, and the Alaska North Slope oil-spill data is from onshore Alaska North Slope facilities and pipelines.

Table III.C-3(a) shows the datasets and the exposure variables used to estimate the probability (expressed as percent chance) of an oil spill occurring from historical oil-spill records. The exposure variables used are either volume of oil produced or pipeline miles or well years. None of these exposure variables will produce differences in spill occurrence between any of the alternative pipeline designs. Because the pipelines for the alternatives are all of similar length or the same amount of oil will be produced regardless of pipeline design. Estimates of an oil spill occurring from spill rates derived from historical oil spills can not be used to differentiate spill occurrence among the alternative pipeline designs. With the exception of the single wall pipe there are no historical oil spill data for the alternative pipeline designs. The reader is referred to Table II.C-5 for information on pipeline failure probability by pipeline design. In the following sections all the probabilities are all expressed as percent chance.

(a) The MMS Outer Continental Shelf Spill Rate Based on Volume

We (MMS) base our spill rates on historical U.S. outer continental shelf platform and pipeline spill data we derive principally from Gulf of Mexico and Pacific coast oil developments. We use the Gulf of Mexico and Pacific spill data because we have a high confidence in the integrity of the spill data set. We require these spill data from industry and verify each spill through Federal investigation with regard to occurrences, volumes, and causes. Other datasets are not as comprehensive, may contain voluntary information, and have not always undergone the quality assurance that the MMS outer continental shelf data have. Thus, comparisons among datasets are difficult, because one cannot ensure they were gathered in the same way. Because the database is for the outer continental shelf, the platforms are marine and the pipelines are submarine. Platform spills include blowouts, platform damage/accidents, and spills from storage tanks on or near the platform. We use volumes of oil produced as the exposure variable on which we base our spill estimates. Our rationale for selecting this exposure variable is that the volume of oil produced is a readily available and verifiable number. It also meets the linear relationship between expected number of spills and the exposure variable. The combined Gulf of Mexico and Pacific outer continental shelf spill rates for oil spills greater than or equal to 1,000 barrels are:

- 0.32 platform spills per billion barrels of oil developed and
- 1.33 pipeline spills per billion barrels of oil transported.

These U.S. outer continental shelf oil-spill statistics represent cumulative activity on the outer continental shelf. They are not meant to be predictive for a particular platform or pipeline segment or give "the answer" for a specific project. As noted earlier, they can provide some insight. What they say is that on a historical basis, we would tend to see a spill somewhere along the 24,000 miles of pipeline in the Gulf of Mexico and Pacific for every 750 million barrels of oil that flows through all the lines. We cannot say where that spill would occur.

Likewise, we would expect to see a spill from one of the nearly 4,000 platforms for every 3.1 billion barrels produced. They do not tell us which platform would have the spill. The likelihood of a spill from a particular platform or pipeline segment really depends on how well the island or pipeline are designed, constructed, maintained, and monitored, plus the external factors relevant to the location (for example, hurricanes, ice forces, amount of other vessel traffic, whether pipelines could be punctured by anchors). For perspective, few platforms have had spills greater than 1,000 barrels—11 of the nearly 4,000 platforms since 1964. All but two of these occurred more than 24 years ago, with the last platform spill occurring in 1980. Sixteen pipeline spills greater than 1,000 barrels have occurred over the 24,000 miles of pipeline since 1964.

Using the combined Gulf of Mexico and Pacific outer continental shelf data as it is and volume as an exposure variable, we estimate a 4% chance of one or more spills greater than or equal to 1,000 barrels occurring for the Liberty production island, and a 15% chance for the 6-mile offshore pipeline (Table III.C-3b). Another way of saying this is that there is a 96% chance of no spills greater than or equal to 1,000 barrels occurring from the Liberty facilities and an 85% chance of no spills from the Liberty offshore pipeline. BPXA proposes to use an extensive set of engineering design parameters to prevent oil spills from occurring in the Liberty Project. We discuss these parameters in Section III.C.1.d(4).

(b) Alaska North Slope Spill Rate Based on Volume

Drilling procedures for Liberty will be the same as on the onshore Alaska North Slope, and the geologic characteristics are similar. Thus, drilling and spill data from the Alaska North Slope provide insights for Liberty.

Hart Crowser (2000) compiled a spill database for the North Slope of Alaska from 1968-1999 using as may sources of information as were made available. The following organizations made information available to either Hart Crowser for this study or the MMS Alaska OCS Region previously:

- The State of Alaska, Department of Environmental Conservation;
- The U.S. Department of the Interior and the Alaska Department of Natural Resources Joint Pipeline Office;
- The Alyeska Pipeline Service Company;
- USDOI, MMS, Alaska OCS Region;
- BPXA;
- ARCO Alaska Inc.; and
- Oil Spill Intelligence Newsletter.

The oil-spill data were collated and evaluated for completeness and comprehensiveness. Private industry provides oil-spill information to the Department of Environmental Conservation according to the State of Alaska Regulations 18 AAC 75. The totals are based on initial spill reports and may not contain updated information. We obtained written oil-spill reports on most of the spills greater than or equal to 500 barrels. Based on the information obtained, we believe the database is most complete for the years 1985-1998 for spills greater than or equal to 500 barrels. We cannot validate that the spill records are complete before 1985 due to missing or incomplete documentation.

The Alaska North Slope oil-spill analysis includes onshore oil and gas exploration and development spills from the Point Thompson Unit, Badami Unit, Kuparuk River Unit, Milne Point Unit, Prudhoe Bay West Operating Area, Prudhoe Bay East Operating Area, and Duck Island Unit (Endicott). The Alaska North Slope data include spills from onshore pipelines and onshore facilities.

The compiled database has no crude oil spills on the North Slope resulting from well blowouts and no facility or onshore pipeline spills greater than 1,000 barrels for the years 1985-1998. Thus, we turn to data on spills greater than or equal to 500 barrels.

The Alaska North Slope rates for crude oil spills greater than or equal to 500 barrels from 1985-1998 are

- 0.48 facility spills per billion barrels of oil developed and
- 0.12 pipeline spills per billion barrels of oil transported.

Strictly using the Alaska North Slope data as it is from 1985-1998, we estimate a 6% chance of one or more spills greater than or equal to 500 barrels occurring for the Liberty production island, and 1% chance for the 6-mile offshore and onshore pipeline (Table III.C-3c). Given the estimated rates for spills greater than or equal to 500 barrels, we know that spill rates for spills greater than or equal to 1,000 barrels must be lower, because the distributions always have a logarithmic relationship between the increase in spill category and the decrease in the number of spills from each category.

These spill occurrence rates for spills greater than or equal to 500 barrels could be conservative, i.e., higher spill rates than could be estimated using the entire North Slope spill record. The spill rate above is based on 1985-1998 data (excluding the record from 1969-1984) because of uncertainties as to whether the lack of crude oil spills (greater than or equal to 500 barrels) before 1985 indicated a failure to report or maintain records of such spills. However, other spills were reported before that time, and it is possible that no crude spills of 500 barrels or more occurred before 1985.

Using the entire North Slope record of 12.221 billion barrels of production from 1969-1998, with the same five crude oil spills greater than or equal to 500 barrels as 1985-1998, the overall rate drops to 0.41 spills per billion barrels (0.33 from facilities, 0.08 from pipelines). The estimated chance of one or more crude oil spills greater than or equal to 500 barrels occurring as a result of producing 0.120 billion barrels from Liberty is 5%, 4% for facility spills, and 1% for pipeline spills

Using both spill rates as a range the estimated chance of occurrence of one or more crude oil spills greater than or equal to 500 barrels is 5-7%, with a 4-6% chance of one or more from the facility, and the chance of one or more pipeline spills of the same magnitude as 1%.

For context, the following compares actual oil-spill data from the Endicott Unit to what we would estimate the chance of a spill greater than or equal to 500 barrels occurring using Alaska North Slope spill rates from 1985-1998. The only offshore facility and pipeline in the Arctic is Endicott. The Hart Crowser (2000) study compiling spills on the Alaska North Slope found no spills greater than or equal to 100 barrels from Endicott. The Endicott facility is the first offshore production in the Beaufort Sea. Endicott began production in 1986 and has produced 388 million barrels through 1998. Based on State of Alaska, Department of Environmental Conservation spill records from 1986-1998, there were approximately 24 crude oil spills of 1 gallon or greater. The 24 crude oil spills range from 1-420 gallons (0.02-10 barrels).

Using the Alaska North Slope oil-spill rate and 388 million barrels of produced oil from Endicott, we would estimate a 17% chance of one or more spills greater than or equal to 500 barrels from the Endicott Facility, or an 83% chance of no spills greater than or equal to 500 barrels occurring., For the pipeline we would estimate a 5 % chance of one or more spills greater than 500 barrels occurring or a 95% chance of no spills occurring . In fact our estimates would be correct. It is more likely that no spills greater than or equal to 500 barrels, would occur while producing 388 million barrels. In reality, no spills greater than or equal to 500 barrels have occurred at the Endicott Unit while producing 388 million barrels.

(c) European Onshore Pipeline Spill Rate based on Mile-Year

The Northstar EIS (U.S. Army Corps of Engineers, 1999) uses CONCAWE data to estimate the chance of a spill for onshore and offshore pipelines. The CONCAWE database covers crude oil and petroleum product pipelines that run cross-country in Western Europe. It includes estuary crossings but not submarine sections running cross-sea. The CONCAWE exposure variable is length dependent. The CONCAWE method was used to compare the relative differences among the Northstar EIS alternatives, which had varied pipeline lengths offshore and onshore, and was applied to the offshore and onshore pipeline segments separately.

The CONCAWE spill rate for spills greater than or equal to 1,000 barrels is 1.8 spills per year for 10,000 miles of pipeline (or 0.00018 spills per mile-year).

By this method, we estimate the chance of one or more spills greater than or equal to 1,000 barrels for the Liberty offshore pipeline length is 1.1-1.6%. For the onshore pipeline, we estimate 0.4-0.8% (Table III.C-3d).

(d) Outer Continental Shelf Spill Rate Based on Mile-Year and Well-Year

The Canadian firm of S.L. Ross Environmental Research Ltd. estimated the chance of a blowout or a spill for Liberty (S.L. Ross Environmental Research Ltd., 1998). The S.L. Ross exposure variables are well-years and pipeline mile-years. They base their analysis on MMS outer continental shelf data from the Gulf of Mexico and Pacific. Lanfear and Amstutz (1983) express caution about using spills per pipeline mile-year from the MMS outer continental shelf data without further statistical study.

The S.L. Ross spill rate for spills greater than or equal to 1,000 barrels is:

- 0.000036 spills per well-year and
- 0.00025 spills per pipeline mile-year.

For the sake of comparison, S.L. Ross uses 0.00025 spills per pipeline mile-year, whereas CONCAWE provided 0.00018 spills per pipeline mile-year. These values are similar.

By this method, S.L. Ross estimates the chance of one or more spills greater than or equal to 1000 barrels for the offshore pipelines between 4.2 and 6.1 miles in length is 1.6-2.3%. For the onshore pipelines between 1.5 and 3.1 miles in length, S.L. Ross estimates a 0.6-1.2%. For the gravel island, S.L. Ross estimates 0.0008% (Table III.C-3e).

(e) U.S. Petroleum Product Pipeline Spill Rate based on Mile-Year

Hovey and Farmer (1993) conducted an analysis of U.S. petroleum product pipelines from 1982-1991. The exposure variable was pipeline mile years. They base their analysis on pipeline accidents reported to the U.S. Department of Transportation. These pipelines are onshore and offshore and carry other petroleum products in addition to crude oil.

The Hovey and Farmer rate was 0.000888 spills per pipeline mile-year for spills greater than or equal to 5 or 50 barrels depending of the reporting requirement. In a followup article, Hovey and Farmer (1999) indicate that the rate at which pipeline accidents occur show no significant change over the last sixteen years. The U.S. Department of Transportation spill rate for spills greater than or equal to 1,000 barrels from 1986-1998 is 0.0002312 spills per mile-year. By this method, we estimate the chance of one or more spills greater than or equal to 1,000 barrels for the Liberty offshore pipeline length is 1.4-2.1%. For the onshore pipeline, we estimate 0.5-1.1%.

(4) Consideration of Oil-Spill Prevention Designed into the Liberty Project

As suggested by Morgan (1981), it is important to look at what may be the cause of spills and to see that the project has accounted for these potential events. The use of Gulf of Mexico and Pacific data has drawn criticism due to obvious differences in habitat, climate, boat and barge traffic, and other conditions. On the one hand, it has been argued that the different operating conditions in the Arctic increase the chance compared to the Gulf of Mexico or the Pacific. On the other hand, the main causes of pipeline oil spills in the outer continental shelf database (anchor and trawl dragging) are not present for a buried pipeline in the Arctic, which suggest a lower chance.

(a) The Liberty Gravel Island

Significant spills from outer continental shelf platforms, on which the 4% chance of a gravel island spill is based, were due to blowouts, storage tank ruptures or leaks, vessels collisions with offshore platforms or hurricanes. The four spills greater than or equal to 500 barrels on the Alaska North Slope from 1985-1998 were due to tank leaks or corrosion and an explosion.

All five of the blowout events with an oil spill greater than or equal to 500 barrels occurred between 1964 and 1970. Following the Santa Barbara blowout in 1969, amendments to the Outer Continental Shelf Lands Act and implementing regulations significantly strengthened safety and pollution prevention requirements for offshore activities. Well-control training, redundant pollution prevention equipment, and subsurface safety devices are among the provisions that have been adopted in the regulatory program. The absence of an oil spill greater than or equal to 500 barrels from an exploration or development well blowout since 1970 reflects the success of a more stringent and rigorous regulatory program. Likewise, there have been no such blowout spills from all the North Slope drilling operations onshore and in State waters. Drilling procedures are comparable on the Alaska North Slope and in the Gulf of Mexico, and the data support each other.

The chance of an oil spill occurring from a blowout on either an exploration or a development well is extremely small. Better geologic knowledge from exploratory drilling results, additional and more comprehensive 3-dimensional seismic analysis, and correlation with similar reservoirs provide for even better well control for development drilling. Industry has drilled four exploratory wells into the Liberty Prospect. This information provides substantive understanding of the geologic and engineering considerations for safe drilling activity. Additional 3-dimensional seismic data have been collected and analyzed, which further improves understanding and knowledge of the reservoir. The Liberty Project will produce from the Kekiktuk formation, which is the same formation that has been producing for over 14 years at the nearby Endicott Field.

The nearly 4,000 platforms and the level of vessel traffic in the Gulf of Mexico is orders of magnitude higher than that in the Beaufort Sea. The chance of a spill from a vessel collision with the Liberty production island is negligible.

The prime cause of spills on outer continental shelf platforms and the Alaska North Slope is leaks from or damage to storage tanks. The last significant outer continental shelf platform spill was in 1980 from a tank overflow. The storage tanks at Liberty include a 3,000-barrel diesel storage tank, a 2,000-barrel slop-oil tank, a 5,000-barrel produced water tank, and 17 diesel storage tanks, each with a capacity of 9,350 barrels total (BPXA, 2000b). The design and nature of the Liberty gravel island does not lend itself to damage of storage tanks from causes that are external to the island and that would result in a spill entering the ocean.

This conclusion is based on several facts. The working surface of the island is set back more than 60 feet from the water's edge. The island has a 40-foot wide bench that is 6 feet above sea level and a 24-foot wide 8-foot high berm of gravel bags. All diesel storage tanks at Liberty will be constructed in accordance with American Petroleum Institute Standard 650. As such, they may not be riveted or bolted and must have a cathodic protection system or other approved corrosion protection where soil conditions warrant. They must be equipped with a leak-detection system that an observer can use from outside the tank to detect leaks in the bottom of the tank. All hydrocarbon storage tanks at Liberty will be double walled, which would contain any leaks and spills from the inner tank. The volume of this containment space is 10% of the maximum capacity of the storage tank. All tanks at Liberty will have secondary containment, as required in 30 CFR 250.300(b)(5). The permanent 3,000 barrel diesel storage tank is located on a raised platform with a seal-welded floor and a seal-welded 6-inch high toe board providing an additional 100 barrels of containment. Secondary containment for the diesel storage tanks consists of a diked, lined area with a total containment capacity of 550 barrels, the volume of the largest tank in the diked area. If a spill were to occur from a storage tank at Liberty, secondary containment would keep it from reaching the marine environment. If secondary containment failed, the gravel island's working surface is sloped to direct surface runoff to drainage swales located along the edges of the island surface (BPXA, 2000a:Fig.12-1). These swales direct liquids to stormwater sumps located on the north, south, and east sides of the island. Each sump has storage capacity of 7,660 gallons with a combined capacity of 22,980 gallons. The porosity of the gravel also would work to keep oil on the island. Taking all these pollution prevention measures into consideration, it is likely that spills from storage tanks would be contained on the island itself.

Gravel Island Conclusion: Using outer continental shelf spill rates, we estimate a 4% chance of one or more spills greater than or equal to 1,000 barrels occurring for the Liberty Island. Using Alaska North Slope spill rates we estimate a 6% chance of one or more spills greater than or equal to 500 barrels occurring for the Liberty Island. Based on the MMS outer continental shelf and Alaska North Slope spill data, leaks from storage tanks are the most prevalent cause of spills from platforms and facilities. The design factors for Liberty Island should contain these types of tank spills and/or keep them from entering the water. Taken together, pollution prevention and island design measures are in place for the most likely types of accidents. If a chance of occurrence must be estimated, we would estimate that the chance of a significant spill that occurs and then enters the water from the production island would be less than 1%.

(b) The Liberty Offshore Pipeline and Detailed Pipeline Engineering Considerations

Using the outer continental shelf database, we estimate a 15% chance of one or more spills greater than or equal to 1,000 barrels occurring from the offshore pipeline. Between 1964 and 1999, companies reported 16 spills of 1,000 barrels or more from outer continental shelf pipelines. All but one of these were caused by a force external to the pipeline. Eleven involved anchors or trawl gear, one was a mud slide and weld failure, one was due to corrosion, two were hurricane related and one was due to a jack-up barge on the pipeline.

The usual cause of pipeline breaks is from an anchor or trawler drag. Burial of the Liberty pipeline and the project's location in a remote area away from commercial shipping and fishing would eliminate this potential cause of a leak. If this principal cause of pipeline leaks is eliminated, it is reasonable to expect that the chance of an oil spill occurring for the Liberty pipeline would be reduced accordingly. Only one spill was caused by corrosion of the pipe itself, and this was in 1973. Adjusting for the anchor and trawler events, the chance of other events occurring is about 5%.

BPXA has designed the Liberty pipeline to address corrosion and other external forces that could be present in the Arctic.

The three greatest risks to the integrity of the Liberty pipeline are trauma, corrosion, and construction. Other risks also are discussed.

1) Trauma

Trauma from ice keels, strudel scour, and thaw settlement have been mitigated specifically through engineering design. The pipeline burial depth (7 feet) is more than four times the depth of the 100-year average return period ice-keel gouge (1.59 feet) and more than two times the depth of the design ice-keel gouge (3.0 feet), which has a 3,600-year average return period. For strudel scour to affect the integrity of a pipeline, it must be deep enough to cause a free span in the pipeline. A strudel scour that causes any free span at the pipeline depth has an average return period of more than 1,350 years. A strudel scour that causes a significant free span, more than 100 feet at the pipeline depth, has an average return period of more than 29,000 years. The maximum anticipated thaw settlement for the Liberty pipeline is 1-foot. The pipeline is designed to handle the pipe deformation that could occur from ice-keel loading, which is potentially much greater than can occur from thaw settlement.

The Liberty pipeline is designed to operate without leaking, even if all of the potential sources of failure (ice gouging, strudel scour, settlement) occur at the same time and same location. This is an extraordinarily conservative design basis.

2) Corrosion

Corrosion also is mitigated through engineering design.

The pipeline is designed with an extra thick steel wall, which provides extra protection against corrosion. If the design the pipeline were based strictly on pressure containment, the wall thickness of the pipeline would be less than one-half of its current design.

The pipeline has a two-layer fusion-bonded epoxy coating for corrosion protection. The first layer prevents the bare metal from being exposed, and the second layer protects the first layer.

The pipeline has a cathodic protection system, which protects the pipe from corrosion.

The pipeline will have an extensive monitoring program using smart pigs (to see what's happening to the pipeline before a leak could occur) on a pre-established frequency. This is a preventative practice. The type and frequency of pig runs proposed by BPXA are not commonly done in the Gulf of Mexico. For existing pipelines, pigging to monitor pipe integrity is rarely done and usually is in response to an indication of a problem and not as a preventative measure. Corrosion rates or pipeline deformation, if they occur at all, occur over a period of years, and frequent pigging is not necessary. However, BPXA has proposed a proactive and definitive monitoring program for the offshore portion of the pipeline that exceeds practices in the Gulf of Mexico and that will be reviewed and approved by the MMS and State Pipeline Coordinator's Office as part of the Quality Assurance Program for this pipeline.

3) Construction

Construction issues are mitigated through Quality Assurance/Quality Control programs that are used during the construction phase of the project.

Construction includes an extensive Quality Assurance Program for testing welds (100% x-ray and ultrasonic tests of all welds).

The Liberty pipeline will be of a similar design to the Northstar pipeline and should perform similarly. For the Northstar pipeline, four progressive full-scale pipe bend tests were conducted to verify that the pipeline would not leak (full-scale tests are the best method for verifying the design). Three of these tests included a purposely induced welding flaw. The loads used during the tests were many times what is expected and the pipe performed as expected, without developing any leaks. Even with the induced flaws and higher loads, the pipe tested to 10% strain without leaking; an order of magnitude greater than the expected strain and more than five times the design strain. Such full-scale tests are not commonly conducted for other outer continental shelf pipelines. We are not aware of any other offshore pipeline that has been designed and tested to this level of design.

The Liberty pipeline will be specifically designed for this application. Everything about it will be designed specifically for the Liberty Project including pipe chemistry, pipe material testing, and pipe strength properties.

4) Other Risks

In addition to the above, the following considerations contribute to reducing oil spills for the Liberty pipeline.

No subsea connectors, valves, etc., which potentially could cause small leaks, will be installed on the subsea portion of the pipeline.

The pipeline design will be subjected to extensive third-party review by individuals with expert academic and/or professional experience on all the aspects of the design (ice gouge, strudel scour, thaw settlement, shore approach, corrosion protection, welding, metallurgy, geology, mechanical engineering). The MMS and State Pipeline Coordinator's Office's engineering staffs and six third-party consultants will conduct in an independent review of the pipeline design and design basis.

BPXA will use best available technology for leak detection. BPXA is proposing to use a combination of mass-balance line-pack compensation and pressure point analysis with a detection threshold of 0.15% of throughput. This exceeds State regulatory standards by an order of magnitude. They also propose to use the LEOS leak-detection system, which will further lower the leak detection threshold to 0.0005% of throughput.

The pipeline is designed so that "smart pigs," electronic pipeline evaluation tools, can be run through the pipeline. Smart pig runs are scheduled on a regular basis to monitor the condition of the pipeline, so that remedial action can be taken before the pipeline fails. The pigs will be able to monitor the shape of the pipeline to determine if it has been bent or dented and also monitor the thickness of the pipe to determine if the pipe is corroding or has been gouged in some way.

Offshore Pipeline Conclusion: Using the outer continental shelf database, we estimate a 15% chance of an oil spill from the offshore pipeline. Adjusting for anchor and trawler events, the chance of other events occurring is about 5%. The CONCAWE and S.L. Ross estimates range from a 1.1% to a 2.3% chance of an oil spill occurring from the offshore pipeline.

The BPXA Proposal includes detailed design, testing, quality assurance, mitigation, and monitoring to ensure the safety of the pipeline. If a chance of a spill occurring must be given, our best professional judgement, given the above, is that the chance of a significant oil spill from the Liberty offshore pipeline is less than 1%.

(5) Overall Liberty Offshore Conclusions

The analysis of historical oil-spill rates using different methods provides insight, but not definitive answers, on whether oil may be spilled from a site-specific project such as Liberty. Engineering risk abatement and careful professional judgment are key in confirming whether a project will be safe.

We base our conclusion on the insights gathered from the historical spill-rate analyses and consideration of oil-spill prevention applied to Liberty. All showed a low likelihood of a spill, on the order of a less than 1% to a 6% chance. More importantly, we also base our conclusion on the engineering design factors that BPXA has included in the project, especially for the buried pipeline.

We conclude that the designs for the Liberty Project would produce a minimal chance of a significant oil spill reaching the water. If an estimate of chance must be given for the offshore production island and the buried pipeline, our best professional judgment is that the chance of an oil spill greater than or equal to 500 barrels occurring from the Liberty offshore project and entering the offshore waters is on the order of 1%.

e. Sizes of Oil Spills Analyzed in this EIS

For purposes of analysis in this EIS, we have identified several different sizes of possible oil-spills. A possible oil leak may originate from facilities or pipelines, both onshore and offshore (see Table III.C-4 and Table A-2 in Appendix A). Section II.A.1.b(3)(d) provides the rationale and information we used to determine each of the sizes of possible offshore pipeline spills. Additional rationale and information we used for determining the possible spill sizes for facility, onshore pipeline, diesel, and small operational spills are described in Appendix A. Those volumes also are used for all the alternatives, because all of the pipelines and facilities evaluated in this EIS are designed to carry the same amount of product and meet the same environmental conditions.

(1) Sizes of Possible Pipeline Spills

The sizes of possible offshore pipeline leaks are determined by several key factors:

- whether or not the spill is greater than the detection limit for pressure-point analysis and mass-balance line-pack compensation (this detection limit is 0.015% of the flow rate, which for Liberty's 65,000 barrels per day maximum production is about 97.5 barrels per day);
- whether or not the LEOS or LEOS-equivalent leak-detection system works;
- if LEOS or LEOS-equivalent leak-detection system does not work, the pipeline inspection process is implemented and detects a spill; and
- whether or not the outer pipeline contains the spill for the pipe-in-pipe and pipe-in-HDPE pipeline.

(a) Sizes of Offshore Pipeline Leaks Assuming LEOS is Working

The pressure-point analysis, mass-balance line-pack compensation, and LEOS systems are included as part of the Proposal. They are described in Section II.A.1.b(3)(b). The pressure-point analysis and mass-balance line-pack compensation detection system can detect a spill rate above 97.5 barrels per day. Although unlikely, if this type of leak happens, it probably would be caused by external forces (ice gouging, strudel scour, etc.) and could result in a leak to the environment of up to approximately 1,580 barrels, regardless of the pipeline design. See Section II.A.1.b(3)(d)2) for the description factors used to arrive at that volume.

If the possible leak is less than 97.5 barrels per day, it would be detected by the LEOS systems within 1 day or less and could result in a spill of 125 barrels or less. See Section II.A.1.b(3)(d)3) for the description of the factors used to arrive at this volume. The most likely cause for this type of leak would be corrosion, a small defect during welding, or from a defect when the pipe was manufactured. If this type of leak occurs to a single-wall pipe or to the flexible pipe system, the leak would be to the environment. If it occurs to the pipe-in-pipe or pipe-in-HDPE systems, there would be two outcomes:

- Both the inner and outer pipe could leak, and the leak, 125 barrels or less, could enter the environment.
- The carrier or inner pipe could leak, but the leak could be contained in the outer pipe and the oil does not enter the environment.

For purposes of analysis the EIS assumes the oil within the annulus between the inner and outer pipe can be removed and the annulus cleaned and dried. The details of this procedure are unknown, but if a pipe-in-pipe or pipe-in-HDPE designs is selected, cleanup and repair procedures would need to be developed. The oil and any chemicals or water used in the cleaning process would need to be disposed in an approved manner. Under this scenario, we assume the oil would not enter the environment.

(b) Sizes of Offshore Pipeline Leaks Assuming LEOS is Not Working

The description for possible spill sizes if the LEOS system is not working is more complicated. If the leak rate is above the pressure-point analysis and mass-balance line-pack compensation detection rate, it could result in a leak to the environment of up to 1,580 barrels, regardless of the pipeline design, the same as described above.

If the leak rate is below the pressure-point analysis and mass-balance line-pack compensation rate of 97.5 barrels per day, the spill would be detected by pipeline inspection. If the daily LEOS test determines the LEOS system is not functioning correctly, BPXA would rely on the visual (open water, broken ice, or solid ice) inspections. The pipeline route is visually inspected weekly year-round. However, during solid-ice conditions, visual inspections may not detect a leak under the ice, and an inspection program that makes bore holes through the ice would be implemented on a monthly basis. In addition to weekly inspections, there are an additional three helicopter trips weekly during summer and winter to the Liberty facility. Although these flights are not looking solely for oil spills, they may assist in detecting one.

Therefore, for the single-wall and flexible pipe systems, there are two possible outcomes:

- During open-water or broken-ice conditions, oil could be observed within 7 days and could result in a spill up to 715 barrels. See Section II.A.1.b(3)(d) for the description of how the volume of the spill was calculated.
- If the leak occurs during solid-ice conditions, the spill could continue for up to 30 days before the bore-hole inspection would detect the spill, which could result in a spill of up to approximately 2,956 barrels. See Section II.A.1.b(3)(d) for a description of the how the volume of the spill was calculated.

For the pipe-in-pipe and pipe-in-HDPE designs, there are three possible outcomes:

- Both the inner and outer pipe leak, and the leak enters the environment, this would be classified as a containment failure. As above, if a leak occurs during open water or broken ice, the spill size could be up to 715 barrels; if it occurs during solid ice, the spill size could be up to 2,956 barrels.
- The carrier pipe leaks, but the leak is contained inside the outer pipe, this would be classified as a functional failure. This event could result in different outcomes. As the oil fills the annulus, the pressure within the annulus will increase and the leak may be discovered in the process, or it may completely fill the annulus. The annulus for the pipe-in-pipe systems could hold about 1,325 barrels, and the annulus for the pipe-in-HDPE could hold about 1,725 barrels. For this scenario, the outer pipe contains the oil. The EIS assumes the oil within the annulus of the pipe can be removed and the pipeline can be cleaned and dried. The details of this procedure are unknown, but if pipe-in-pipe or pipe-in-HDPE design is selected, detailed cleanup and repair procedures would need to be developed. The oil and any chemicals or water used in the cleaning process would need to be disposed of in an approved manner.
- When the annulus fills with oil, the outer pipe may not be able to handle the pressure and a leak could develop. We know the outer plastic pipe in the pipe-in-HDPE alternative cannot withstand all the pressure that could develop, if the inner pipe were to leak. This would subject the outer plastic pipe to higher operating pressures used for transporting the oil, and the plastic pipe likely would fail. The outer steel pipe in the pipe-in-pipe design is stronger. However, it seems logical that both designs would have a designed pressure release or failure mechanism at the onshore gravel pad that would allow the release of pressure and oil at the onshore gravel pad, before the pressure exceeded the design criteria for outer pipeline. (Otherwise, the result would be a leak somewhere along the offshore portion of the pipeline.) This could result in a release of oil, which we estimate could be up to about 720 barrels, the same as the other onshore spills.

(c) Sizes of Onshore Pipeline Leaks

Onshore pipeline spills could be from either a pinhole leak or a guillotine cut. The spill sizes for a possible onshore pipeline spill include a pinhole leak of 720 barrels or a leak of 1,142 barrels from a guillotine cut.

(2) Sizes of Possible Gravel Island Spills

As identified in Appendix A, the EIS also evaluates several other sizes of spills that could occur from sources other than the offshore pipeline. The description and logic we use to estimate the sizes of these spills also is described in Appendix A. The EIS evaluates a possible facility spill of 925 barrels at the production island and a possible diesel fuel spill from a storage tank of 1,283 barrels.

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2. Large Oil Spills

A major concern we heard during scoping was the potential effects of oil spills. We define large oil spills as greater than or equal to 500 barrels. This introduction summarizes the assumptions we use to analyze large oil spills for each alternative. The section locations for the analysis of small and very large spills are shown under Locations of Oil Spill Analyses.

The assumptions about large oil spills are a mixture of project-specific information, modeling results, statistical analysis, and professional judgement. For details on any of these points, please read Appendix A and Sections III.C.1.d and e. We feel this is the basis for understanding discussions about the effects of oil spills on resources of concern in Sections III.C, IV.C, and IV.D.

For purposes of analysis, we assume one large spill occurs anywhere from the Liberty gravel or alternative islands or along the proposed or alternative offshore or onshore pipeline. After we analyze the effects of a large oil spill, we consider the chance of a large oil spill occurring. Even though the chance of one or more spills occurring and entering offshore waters is low (on the order of 1%), we analyze the consequences of an oil spill because it is a significant concern to all stakeholders. The analysis of these oil spills determines if such spills could cause serious environmental impact.

The analysis of a large spill represents the range of effects that might occur from a range of offshore or onshore spill sizes at Liberty facilities Table III.C-4 shows the large spill sizes we assume for purposes of analysis range from 715-2,956 barrels for crude and diesel oil. The spills are broken out as follows:

- Crude Oil
    - Gravel Island, 925 barrels
    - Offshore Pipeline, 715, 1,580, and 2,956 barrels
    - Onshore Pipeline, 720 and 1,142 barrels
- Diesel
    - Storage Tank, 1,283 barrels

For further information on how we derive the information in Table III.C-4, please read Appendix A and Sections III.C.1.d and e.

A large spill from the Liberty facilities could happen at any time during the year. We assume that the island would not contain any oil. We assume that a spill reaches the following environments, depending on the time of year:

- gravel island and then the water or ice
- open water
- broken ice
- on top of or under solid ice
- shoreline
- tundra or snow

In our analysis, we assume the following fate of the crude oil without cleanup. We summarize this information from Tables A-7 and A-8 in Appendix A.

After 30 days in open water or broken ice:

- 13-16% evaporates,
- 0.3-21% disperses, and
- 63-87% remains.

After 30 days under ice:

- nearly 100% of the oil remains in place and unweathered.

The Chance of a Large Spill Occurring: This section summarizes the conclusions from III.C.1.d, Estimates of the Chance of an Oil Spill Occurring Considering Historical Spill Records and Oil-Spill Prevention Designed into the Liberty Project. For the full discussion, please refer to that section.

The analysis of historical oil-spill rates and failure rates and their application to the Liberty Project provides insights, but not definitive answers, regarding whether oil may be spilled from a site-specific project. The engineering risk abatement and careful professional judgment are key in confirming whether a project will be safe.

We conclude that the designs for the Liberty Project would produce minimal risk of a significant oil spill reaching the water. If an estimate of chance must be given for the offshore production island and the buried pipeline, our best professional judgment is that the chance of an oil spill greater than or equal to 500 barrels occurring from the Liberty offshore project and entering the offshore waters is on the order of 1%.

We base our conclusion on the insights gathered from the several analyses done for Liberty. All showed a low likelihood of a spill, on the order of a 1-6% chance or less. More importantly, we also base our conclusion on the engineering design factors (a combination of pollution prevention measures, design, testing, quality assurance, and proactive monitoring) that BPXA has included in the project, especially for the subseabed pipeline and island containment.

Locations of Oil-Spill Analyses: Following are section locations for the analysis of oil spills and their effects throughout this document

- Sections III.C.2 and III.D.3, Alternative I BPXA Proposal, analysis of oil spills from the Proposal.
- Section V.C, Alternative I BPXA Proposal, analysis of oil spills in the cumulative case.
- Section IV.B, Alternative II, No Action assumes no spill occurs, because no action occurs.
- Sections IV.C.1, Effects of Alternative Drilling and Production Island Locations and Pipeline Routes, analysis of spills from alternative locations.

- Sections IV.C.2, Effects of Alternative Pipeline Designs, analysis of spills from the pipeline design alternatives.
- Section IV.C.3, Effects of Alternative Upper Slope Protection Systems
- Section IV.C.4, Effects of Alternative Gravel Mine Site.
- Section IV.C.5, Effects of Alternative Pipeline Burial Depths.
- Section IX, analysis of very large oil spills.
- Appendix A, supporting documentation for assumptions we use in the oil spill analysis in this EIS.

We base the analysis of effects on the following assumptions:

- One large spill occurs.
- The spill size is one of the sizes we show in Table III-C-4.
- All the oil reaches the environment, the island absorbs no oil.
- The spill starts at the gravel island or along the pipeline.
- There is no cleanup or containment.
- The spill could occur at any time of the year.
- A spill under ice does not move significantly until the ice breaks up.
- The spill area varies over time and is calculated from Ford (1985).
- The time and chance of contact from an oil spill are calculated from an oil-spill-trajectory model (Appendix A).
- The chance of contact is analyzed from the location where it is highest when determining effects.

For More Information on the Analysis of Oil Spills:

- Appendix A of this EIS
- Johnson, Marshall, and Lear (2000). Oil Spill Risk Analysis: Liberty Development and Production Plan.

Effects of a Large Oil Spill: A major concern we heard during scoping meetings was about the effects that a large oil spill would have on wildlife and subsistence activities. In the following section, we analyze, from the Proposal, the effects that a large oil spill, from either the gravel island or a pipeline, could have on individual resources.

a. Threatened and Endangered Species

(1) Bowhead Whales

(a) Summary and Conclusion for Effects of an Oil Spill on Bowhead Whales

It is unknown what effects an oil spill would have on bowhead whales, but some conclusions can be drawn from studies that have looked at the effects of oil spills on other cetaceans. If a spill occurred and contacted bowhead habitat during the fall whale migration, it is likely that some whales would be contacted by oil. It is likely that some of these whales would experience temporary, nonlethal effects, including one or more of the following symptoms:

- oiling of their skin, causing irritation
- inhaling hydrocarbon vapors
- ingesting oil-contaminated prey
- fouling of their baleen
- losing their food source
- moving temporarily from some feeding areas

Some whales could die as a result of contact with spilled oil. Geraci (1990) reviewed a number of studies on the physiologic and toxic effects of oil on whales and concluded there was no evidence that oil contamination had been responsible for the death of a cetacean. Nevertheless, the effects of oil exposure to the bowhead whale population are uncertain, speculative, and controversial. The effects would depend on how many whales contacted oil, the duration of contact, and the age/degree of weathering of the spilled oil. If oil got into leads or ice-free areas frequented by migrating bowheads, a significant portion of the population could be exposed to spilled oil. Prolonged exposure to freshly spilled oil could kill some whales, but we expect that number to be very small with such a low chance of contact.

The chance of an oil spill greater than or equal to 500 barrels from the offshore production island and the buried pipeline occurring and entering the offshore waters is estimated to be on the order of 1% (Sec. III.C.1). A spill of 715-2,956 barrels could contact areas outside the barrier islands where bowhead whales may be present. Environmental Resource Area 39 (Map A-2 in Appendix A) generally has the highest percent chance of contact by an oil spill from Liberty Island. During the summer, there is a 15% chance of contact over a 30-day period and a 16% chance of contact over a 360-day period. During the winter, there is a 3% chance of contact over a 30-day period and a 15% chance of contact over a 360-day period. During the summer, Ice/Sea Segment 11 (habitat where bowhead whales may occur during their fall migration) has an 8% chance of contact over both a 30-day and a 360-day period. During the winter, Ice/Sea Segment 10 has a 2% chance of contact over a 30-day period and a 5% chance of contact over a 360-day period.

Environmental Resource Area 39 generally also has the highest percent chance of contact by an oil spill from the offshore portion of the pipeline PP1. During the summer, there is a 13% chance of contact over a 30-day period and a 14% chance of contact over a 360-day period. During the winter, there is a 3% chance of contact over a 30-day period and a 13% chance of contact over a 360-day period. During the summer, Ice/Sea Segment 11 has a 7% chance of contact over both a 30-day and a 360-day period. During the winter, Ice/Sea Segment 10 (habitat where bowhead whales may occur during their fall migration) has a 2% chance of contact over a 30-day period and a 4% chance of contact over a 360-day period. Ice/Sea Segment 11 has a 1%

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chance of contact over a 30-day period and a 5% chance of contact over a 360-day period. The model estimated there is less than a 0.5% chance that an oil spill would contact the spring lead system (SPL1-SPL5 on Map A-2 in Appendix A) over a 360-day period during either summer or winter.

A 1,283-barrel diesel oil spill from Liberty Island during the summer would have a 1% chance of contacting Ice/Sea Segments 10 and 11, a 6% chance of contacting Environmental Resource Areas 30 and 39 (habitat where bowhead whales may occur during their fall migration), and less than a 0.5% chance of contacting the spring lead system. No diesel oil would remain after 7 days. (All the above numbers are from Appendix A, Tables A-12, 16, and 17.)

The potential for bowhead whales to be affected by spilled oil from the Liberty Project is relatively small, based on the estimated size of a spill and the relatively low chance of spilled oil reaching the main bowhead fall migration route outside the barrier islands (14% or less).

(b) Details on How a Large Oil Spill May Affect Bowhead Whales

1) General Effects from Developing the Liberty Prospect

The effects of an oil spill on bowhead whales are unknown. However, some conclusions can be drawn from studies that have looked at the effects of oil spills on other cetaceans. Several researchers (Geraci and St. Aubin, 1982; St. Aubin, Stinson, and Geraci, 1984) concluded that exposure to spilled oil is unlikely to have serious direct effects on baleen whales. Other studies (Loughlin, 1994; Dahlheim and Matkin, 1994; Dahlheim and Loughlin, 1990) either documented no effects to cetaceans from spilled oil, or the results of the studies were inconclusive. If an oil spill occurred in the bowhead whale's habitat while they were present, some whales could experience the following (Geraci, 1990):

- oiling of skin
- inhaling of hydrocarbon vapors (from a fresh spill)
- ingesting contaminated prey
- fouling of their baleen
- reduced food source
- displacement from feeding areas
- death
- other effects

The number of whales contacting spilled oil would depend on the size, timing, and duration of the spill; how many whales were near the spill; and the whales' ability or inclination to avoid contact.

a) Effects of Skin Contact

Oil first would contact a whale's skin as it surfaces to breathe. The effects of oil contacting skin are largely speculative. Although oil is unlikely to adhere to smooth skin, it may stick to rough areas on the surface. Henk and Mullan (1997) studied skin lesions on bowheads and categorized them as shallow lacerations, circular depressions, and epidermal sloughing. All lesions remain on the top layer of the skin and produce no inflammation or other response. They stated that whatever the cause or form of the lesion, a layer of cells builds up next to the affected area. This layer eventually moves to the surface and heals the lesion without scarring. The authors suggest that a layer of cells on an otherwise smooth skin surface may increase the potential for petroleum to adhere.

Haldiman et al. (1981) also describe the skin and lesions on the skin of bowheads. Haldiman et al. (1985) detail the skin's structure, finding the epidermal layer to be as much as 7-8 times thicker than that found on most whales. This study included some very simple preliminary trials to determine possible interactions between bowhead skin and crude oil. The researchers found that little or no crude oil adhered to preserved bowhead skin that was dipped into oil up to three times, as long as a water film stayed on the skin's surface. Oil adhered in small patches to the surface and vibrissae (stiff, hairlike structures), once it made enough contact with the skin. The amount of oil sticking to the surrounding skin and epidermal depression appeared to be in proportion to the number of exposures and the roughness of the skin's surface.

Albert (1981) suggests that oil would adhere to the skin's rough surfaces (eroded areas on the skin's surface, tactile hairs, and depressions around the tactile hairs). Albert (1996, as cited in U.S. Army Corps of Engineers, 1998:Appendix B) characterizes the rough areas as variable in size and shape, often 1-2 inches in diameter and 1-3 millimeters deep with hairlike projections extending up from the depths of the damaged skin surface. He theorizes that oil could irritate the skin, especially the eroded areas, and interfere with information the animal receives through the tactile hairs. Because we do not know how these hairs work, we cannot assess how any damage to them might affect bowheads. Albert (1981) is concerned that the eroded skin may provide a point of entry into the bloodstream for pathogenic bacteria, if the skin becomes more damaged. Shotts et al. (1990) found a large number of species of bacteria and yeast, both from the normal skin and from lesions on bowheads. Enzymatic assays from isolates from normal skin and skin with lesions demonstrated the production of enzymes capable of causing necrosis (tissue death). The presence of the enzymes suggests that the lesions are active sites of necrosis. The authors noted that 38% of the microorganisms in lesions contained enzymes necessary for hemolytic activity of blood cells (breaking down of red blood cells and the release of hemoglobin) compared to 28% of the microorganisms on normal skin. Many of these species of bacteria and yeast were determined to be potential pathogens of mammalian hosts. Hansen (1985) speculates that much of the oil is washed off the whale's skin as it moves through the water. However, we do not know how long spilled oil will adhere to the skin of a free-ranging whale. Oil might wash off the skin and body surface shortly after bowheads vacated oiled areas, if they left shortly after being oiled. However, oil might adhere to the skin and other surface features (such as sensory hairs) longer, if bowheads remained in these areas.

In a study on nonbaleen whales and other cetaceans, Harvey and Dahlheim (1994) observed 80 Dall's porpoises, 18 killer whales, and 2 harbor porpoises in oil on the water's surface from the *Exxon Valdez* spill. They observed groups of Dall's porpoises on 21 occasions in areas with light sheen, several occasions in areas with moderate-to-heavy surface oil, once in no oil, and once when they did not record the amount of oil. Thirteen of the animals were close enough to determine if oil was present on their skin. They confirmed that 12 animals in light sheen or moderate-to-heavy oil did not have oil on their skin. One Dall's porpoise had oil on the dorsal half of its body. It appeared stressed because of its labored breathing pattern. The authors gave no other information on effects. The 18 killer whales and 2 harbor porpoises were in oil but had none on their skin. None of the cetaceans appeared to alter their behaviors when in areas where oil was present. The authors concluded their observations were consistent with other reports of cetaceans behaving normally when oil is present. It is probable that bowhead whales would respond in a similar manner (U.S. Army Corps of Engineers, 1998:Appendix B).

Histological data and ultrastructural studies by Geraci and St. Aubin (1990) showed that long exposures to petroleum hydrocarbons produced only transient damage to epidermal cells in whales. The authors began their experiments by applying a small sponge soaked in crude oil to the skin of four species of toothed whales. Contact for up to 45 minutes had no effect. They switched to gasoline and applied the sponge up to 75 minutes. Even unrealistically long contact times could not produce a severe reaction typical of that in other mammals. Subtle changes were evident only at the cell level and, in each case, healed within a week. The authors pointed out that a cetacean's skin is an effective barrier to the noxious substances in petroleum. These substances normally damage skin by getting between cells and dissolving protective lipids. In cetacean skin, however, tight intercellular bridges, vital surface cells, and the extraordinary thickness of the epidermis impeded the damage. The authors could not detect a change in lipid concentration between and within cells after exposing skin from a white-sided dolphin to gasoline for 16 hours in vitro.

Geraci and St. Aubin also investigated how oil might affect healing of superficial wounds in a bottlenose dolphin's skin. They found that following a cut, newly exposed epidermal cells degenerate to form a zone of dead tissue that shields the underlying cells from seawater during healing. They massaged the superficial wounds with crude oil or tar for 30 minutes, but the substances did not affect healing. Lead-free gasoline applied in the same manner caused strong inflammation, but it subsided within 24 hours and was indistinguishable from control cuts. The authors concluded that the dead tissue had protected underlying tissues from gasoline in the same way it repels osmotic attack by seawater. The authors further concluded that in real life, contact with oil would be less harmful to cetaceans than they and others had proposed.

Bratton et al. (1993) synthesized studies on the potential effects of contaminants on bowhead whales. They say no published data prove oil fouling of the skin of any free-living whales, and conclude that bowhead whales contacting fresh or weathered petroleum are unlikely to suffer harm. Cetacean skin is a strong barrier to the toxic effects of petroleum.

b) Effects of Inhalation

Bowheads would be most likely to contact spilled oil as they surface to breathe. They probably would not inhale oil into the blowhole, although bowheads surfacing in a spill of lightly weathered oil could inhale some hydrocarbon vapors that might affect breathing. The most serious situation would occur if oil spilled into a lead that bowheads could not escape. In this case, Bratton et al. (1993) theorized the whales could inhale oil vapor that would irritate their mucous membranes or respiratory tract. They also could absorb volatile hydrocarbons into the bloodstream. However, they rapidly would excrete these volatile hydrocarbons, and vapor concentrations that harm whales would dissipate within several hours after a spill. Within hours after the spill, toxic vapors from oil in a lead could harm the whales' lungs and even kill them, but only a few whales likely would occupy the affected lead at any given time.

c) Effects of Ingestion

Bowheads sometimes skim the water surface while feeding, filtering a lot of water for extended periods. If oil were present, they could swallow it. Albert (1981) suggested that whales could take in tarballs or large "blobs" of oil with prey. He also said that swallowed baleen "hairs" mix with the oil and mat together into small balls. These balls could block the stomach at the connecting channel, which is a very narrow tube connecting the stomach's fundic and pyloric chambers (the second and fourth chambers of the stomach) (Tarpley et al., 1987). Hansen (1985; 1992) suggests that cetaceans can metabolize ingested oil, because they have cytochrome p-450 in their livers (Hansen, 1992). The presence of cytochrome p-450 (a protein involved in the enzyme system associated with the metabolism and detoxification of a wide variety of foreign compounds, including components of crude oil) suggests that cetaceans should be able to detoxify oil (Geraci and St. Aubin, 1982, as cited in Hansen, 1992). He also suggests that digestion may break down any oil that adheres to baleen filaments and causes clumping (1985). Observations and stranding records do not reveal whether cetaceans would feed around a fresh oil spill long enough to accumulate a critical dose of oil.

Bowheads may swallow some oil-contaminated prey, but it likely would be only a small part of their food. Some zooplankton that bowheads eat consume oil particles but apparently can quickly excrete hydrocarbons from their system. Tissue studies by Geraci and St. Aubin (1990) revealed low levels of naphthalene in the livers and blubber of baleen whales. This result suggests that prey have low concentrations in their tissues, or that baleen whales may be able to metabolize and excrete petroleum hydrocarbons.

d) Effects of Baleen Fouling

Baleen hairs might be fouled, which would reduce a whale's filtration efficiency. Braithwaite (1983, as cited in Bratton et al., 1993) used a simple system to show a 5-10% decrease in filtration efficiency of bowhead baleen after fouling, which lasted for up to 30 days. The fouled baleen allowed increased numbers of plankton to slip past the baleen without being caught. We do not know how such a reduction in food caught in the baleen would affect the overall health or feeding efficiency of these whales. Geraci and St. Aubin (1985) found that 70% of the oil adhering to baleen plates moved away within 30 minutes, and 95% within 24 hours after fouling. The study could not detect any change in resistance to water flowing through baleen after 24 hours. This study tested baleen from fin, sei, humpback, and gray whales. The baleen from these whales is shorter and coarser than that of bowhead whales, whose longer baleen have many hairlike filaments. Information from these two studies suggest that a spill of heavy oil, such as Bunker C, or residual patches of weathered oil, could interfere with feeding efficiency of the fouled plates for several days at least (Geraci and St. Aubin, 1985). Lighter oil, such as that from the Liberty Project, should result in less interference with feeding efficiency. Geraci and St. Aubin, (1985) stated that it appeared that the concern for oiled whales (baleen fouling) is becoming less defensible based on the low level immediate impact in Braithwaite's study and the rate of clearance of oil in this study. Bowheads most likely would occupy oiled waters for only a short time, and filtration efficiency could return to normal in a matter of hours as oil flushes from the baleen. Repeated baleen fouling over a long time, however, might reduce food intake and blubber deposition, which could harm the bowheads.

e) Effects of Reduced Food Source

An oil spill probably would not permanently affect zooplankton, the bowhead's major food source, and any effects are most likely to occur nearshore (Richardson et al., 1987, as cited in Bratton et al., 1993). The amount of zooplankton lost, even in a large oil spill, would be very small compared to what is available on the whales' summer-feeding grounds (Bratton et al., 1993).

f) Effects of Displacement from Feeding Areas

We have no observations through western science whether bowheads may be temporarily displaced from an area because of an oil spill or cleanup operations. However, Thomas Brower, Sr. (1980) described the effects of a 25,000-gallon oil spill at Elson Lagoon (Plover Islands) in 1944 on bowhead whales. It took approximately 4 years for the oil to disappear. For 4 years after the oil spill, Brower observed that bowhead whales made a wide detour out to sea when passing near the Elson Lagoon/Plover Islands during fall migration. Bowhead whales normally migrated close to these islands during the fall migration. These observations indicate that some displacement of whales may occur in the event of an oil spill, and that the displacement may last for several years. Based on these observations, it also appears that bowhead whales may have some ability to detect an oil spill and avoid surfacing in the oil by detouring around the area of the spill. Potential displacement because of disturbance is discussed in Section III.C.3.

Several investigators have observed various cetaceans in spilled oil, including fin whales, humpback whales, gray whales, dolphins, and pilot whales. They did not avoid slicks but swam through them, apparently showing no reaction to the oil. During one study, researchers saw humpback and fin whales, and a whale tentatively identified as a right whale, surfacing and even feeding in or near an oil slick off Cape Cod, Massachusetts (Geraci and St. Aubin, 1990). None of the observations prove whether cetaceans can detect oil and avoid it. Some researchers have concluded baleen whales have such good surface vision that they rely on visual clues for various activities. Bowhead whales have "played" with floating logs and sheens of floating dye on the sea surface, suggesting they may be able to recognize floating oil (Bratton et al., 1993).

After the *Exxon Valdez* oil spill, researchers studied the potential effects of an oil spill on cetaceans. Dahlheim and Loughlin (1990) documented no effects on the humpback whale. von Ziegesar, Miller, and Dahlheim (1994) found no indication of a change in abundance, calving rates, seasonal residency time of female-calf pairs, or mortality in humpback whales as a result of that spill, although they did see temporary displacement from some areas of Prince William Sound. It was difficult to determine whether the spill changed the number of humpback whales occurring in Prince William Sound. This study could not have detected long-term physiological effects to whales or to the humpback's prey.

g) Other Effects and Information

We know of no bowhead whale deaths resulting from an oil spill. Loughlin (1994) did necropsies on three gray whales and one minke whale (which are baleen whales) and three harbor porpoises (which are not baleen whales) after the *Exxon Valdez* oil spill. He found no indication of the cause of death and could not link the cause of death directly to the spill. He observed the carcasses of 26 gray whales, but attributed this large number to the timing of the search effort coinciding with the northern migration of gray whales, augmented by increased survey effort in the study area associated with the oil spill.

Dahlheim and Matkin (1994) observed killer whales near the *Exxon Valdez* oil spill. Before the spill, the AB pod in Prince William Sound had 36 whales. Following the spill, 14 killer whales were missing from the AB pod and presumed dead. Although there was a history of the AB pod interacting with the sablefish fishery in Prince William Sound, there was no evidence of fishery-related mortality in 1988-1990. No whales in distress were seen following the spill, nor were any carcasses found. The authors concluded that some of the whales may have died from natural causes and the rest from interactions with fisheries or the spill, or a combination of both. The whales died after and near the spill, but the cause of death is uncertain. There is a spatial and temporal correlation between the loss of whales and the spill, but there is no clear cause-and-effect relationship.

Although there is no conclusive evidence that bowhead whales would be killed as a result of contact with spilled oil, a few whales could die from prolonged exposure to oil.

In the 1980's, there was fairly limited information regarding how petroleum products, heavy metals, and other contaminants may affect bowhead whales. Information about cetacean metabolism also is inadequate. Based on the limited data available, researchers (Bratton et al., 1993) concluded that petroleum products appear not to harm bowheads or humans who eat them, but we need more work to be certain. In addition, we provided funds to the National Oceanic and Atmospheric Administration in 1987 to establish and conduct a program for collection and long-term storage of tissues from Alaska marine mammals for future contaminant analysis. This program, the Alaska Marine Mammal Tissue Archival Project, which has been managed by the National Marine Fisheries Service since 1992, contains tissue samples from bowhead whales as well as other marine mammals. Tissue samples were collected from whales landed at Barrow in 1992-1994 and 1996-1997. Initial studies of bowhead tissues (Becker et al., 1995) indicate that bowhead whales have very low levels of mercury, PCB's, and chlorinated hydrocarbons, but they have fairly high concentrations of cadmium in their liver and kidneys. Cadmium is a naturally occurring heavy metal that commonly is present at high levels in marine mammal tissues, particularly in the liver and kidney. The study concluded that high concentration of cadmium in the liver and kidney tissues of bowheads warrants further investigation.

Bratton, et al. (1997) looked at eight metals (arsenic, cadmium, copper, iron, mercury, lead, selenium, and zinc) in the kidneys, liver, muscle, blubber, and visceral fat from bowheads harvested from 1983-1990. These metals were chosen because they are the most common metals reported in the literature for cetaceans, they represent the most toxic metals to marine organisms, and they are the most likely metals to enter the Eskimo food chain. They observed considerable variation in tissue metal concentration among the whales tested. Metal concentrations evaluated did not appear to increase over time between 1983 and 1990. Based on metal levels reported in the literature for other baleen whales, the metal levels observed in all tissues of the bowhead are similar to levels in other baleen whales. None of the metals studied were high enough in muscle, blubber, or visceral fat to pose a risk to human consumers. The study concluded the tissues from bowhead whales are, in general, nutritious and safe to eat. The bowhead whale has little metal contamination as compared to other arctic marine mammals, except for cadmium, which requires further investigation as to its role in human and bowhead whale health. The study recommended limiting consumption of kidney from large bowhead whales pending further evaluation.

h) Effects of Oil-Spill Response

BPXA's Oil Discharge Prevention and Contingency Plan (BPXA, 2000b) includes detailed scenarios that outline the equipment, response tactics, and logistics necessary to clean up these volumes of oil under different environmental conditions: open water, solid ice, and broken ice. The scenarios describe a set of specific response tactics (a description of how oil would be contained and recovered) that would be used. Each tactic is based on a specific type and number of systems that include containment booms, oil skimmers, storage barges, tugboats, and other vessels needed to contain and recover a specific volume of oil. These tactics include open water, solid ice (both over and under), broken ice (freezeup and breakup), the shoreline, and onshore cleanup and recovery. The tactics also address storage, tracking and surveillance, in situ burning of oil, shoreline cleanup, wildlife and sensitive area response, disposal, and logistics. BPXA's Oil Discharge Prevention and Contingency Plan for the Liberty Project lists the *Endeavor*, an icebreaking barge, as one of the vessels to be used if an oil spill occurs. The *Endeavor* can break up to 24 inches of broken or rafted ice and up to 15 inches of solid unbroken ice offshore.

Bowhead whales would be migrating through the Beaufort Sea offshore of the Liberty Project area during their fall migration. Bowhead whales are found primarily outside the barrier islands, although a few occasionally may enter the lagoon system. If a 1,580-barrel pipeline spill occurred during the broken-ice period in the fall, some bowheads may be displaced temporarily from an area due to the large numbers of personnel, equipment, vessels, and aircraft conducting oil-spill-cleanup operations. Containment and recovery involves ocean-containment booms, storage barges, weir and oleophilic skimming devices, and support tugs and boats. Initial response would consist of a barge-based recovery system. The capability of this equipment to clean up spilled oil and estimated recovery rates are discussed in Section II.A.4. The estimated recovery rates are based on the estimated capacity of the equipment under optimum conditions. It is not likely that this rate of recovery would be realized. The actual effectiveness of the cleanup effort would be constrained by the weather, wind, wave, ice conditions, equipment failure, human error, etc.

An under-ice pipeline leak of 2,956 barrels likely would not have much effect on bowhead whales. Some of the oil could be recovered from holes or trenches cut in the ice. Oil entrained in the ice would migrate to the surface and could be cleaned up relatively easily. Cleanup of a spill under the ice would not be affected much by weather, wind, waves, etc. Any oil remaining after these cleanup efforts likely would be recovered during the open-water period before the bowhead's fall migration begins.

It is difficult to assess the effectiveness of these cleanup and response tactics in protecting bowhead whales. Response efforts to preclude oil from getting through entrances between the barrier islands and reaching the bowhead's main migration corridor would be very effective at protecting bowheads. If cleanup and response efforts were successful, no oil would reach bowhead habitat outside the barrier islands. If cleanup and response efforts were not successful and little or no oil was cleaned up, the chance of oil contacting bowhead habitat outside the barrier islands would be the same as described above without any cleanup response. If cleanup and response efforts were partially successful, the most likely scenario, the amount of oil on the water would be reduced and likely would cover a smaller area. If oil passed through the entrances and reached the main migration corridor, some bowheads would be affected. It is likely that fewer bowheads would be exposed to oil as a result of cleanup operations than without cleanup operations. The effects of oil on bowheads would be as described earlier in this section.

Oil-spill-cleanup activities during September and October could disturb bowhead whales during their fall migration. No information is available regarding bowhead disturbance from oil-spill-cleanup operations, but noise disturbance to bowheads from vessel and aircraft traffic involved with cleanup activities likely would be similar to that already described in Section III.C.3. Most oil-spill-cleanup work probably would occur inside the barrier islands, because the spill model indicates that spilled oil has a relatively low probability to reach areas outside of the barrier islands. Some whales may be disturbed by vessel or aircraft traffic and displaced seaward, if cleanup activities occurred outside the barrier islands or in the channels between the barrier islands during the whale migration. Cleanup activities could continue for multiple seasons. The icebreaking barge *Endeavor* could be used if a spill occurred during broken-ice conditions in October. Information is not available regarding how far noise can be heard from this vessel during icebreaking operations. Icebreaking activity causes substantial increases in noise levels out to at least 5 kilometers (Richardson et al., 1995). Sounds measured from icebreaking activities by icebreakers and icebreaking supply ships in deeper water have been detected at more than 50 kilometers away (Richardson et al., 1995). The icebreaking barge likely would be operating mostly in shallow water primarily inside the barrier islands, a different environment than icebreaking activity referenced by Richardson et al. (1995). If this vessel were to be used before the end of the bowhead whale fall migration, it is possible some migrating whales could hear the noise. It is likely the shallow water with ice cover and the presence of the barrier islands would greatly reduce the amount of noise reaching migrating whales. Considering this likely reduction in noise levels, the relatively low chance of an oil spill, the estimated size of the spill, the very narrow window of time in October that icebreaking vessel could affect whales, and the relatively low chance that oil would reach bowhead habitat outside the barrier islands, there is low probability that whales would be affected by cleanup activities.

2) Specific Effects of a Large Oil Spill from BPXA's Proposed Liberty Development and Production Plan

Several spill scenarios are analyzed, a pipeline crude oil spill (715-2,956 barrels), a 925-barrel platform crude oil spill, and a 1,283-barrel diesel oil spill (Table A-1). Four crude oil spill sizes are possible for a pipeline spill, depending on several variables. A complete cut through the pipeline would result in a 1,580-barrel spill. A chronic leak in the pipeline would result in spill sizes ranging from less than 715-2,956 barrels, depending on the timing aspects of the leak-detection inspection program and whether the leak-detection system was working. Crude oil-spill sizes during the open-water/broken-ice period range from a spill of 715 barrels to a 1,580-barrel spill, while crude oil-spill sizes during the solid-ice period range from a spill 715 barrels to a 2,956-barrel spill; both ranges include the chance of either a platform spill or a pipeline spill.

A spill of 715-2,956 barrels could contact areas outside the barrier islands where bowhead whales may be present. A spill during broken ice in the fall or under the ice in the winter would melt out during the following summer. Approximately 56-75% of the oil from a 715-1,580-barrel spill during the open-water period would remain after 30 days, covering a discontinuous area of 124-186 square kilometers (Table A-7). Approximately 84-87% of the oil from a 715-2,956-barrel spill during the broken-ice/solid-ice period would remain after 30 days, covering a discontinuous area of 73-150 square kilometers (Table A-7). Probabilities in the following discussion are conditional probabilities estimated by the Oil-Spill-Risk Assessment model (expressed as a percent chance) of spill contacting bowhead whale habitat within 30-360 days. Conditional probabilities are based on the assumption that a spill has occurred. During the summer, the Oil-Spill-Risk Assessment model estimates the chance of an oil spill from the Liberty Island contacting Ice/Sea Segments 6-13 (habitat where bowhead whales may be found during their fall migration) (see Maps A-2 and A-3 and Table A-10) ranges from 1-8% over both a 30-day and a 360-day period (Table A-12). Ice/Sea Segment 11 has an 8% chance of contact over both a 30-day and a 360-day period, the highest chance of contact in this group. The chance of an oil spill during the summer from Liberty Island contacting Environmental Resource Areas 14-15, 18-21, 24, 29-30, 39-41, 43, 45, or 47 (habitat where bowhead whales may be found during their fall migration) ranges from 0-15% over a 30-day period and 0-16% over a 360-day period, respectively. Environmental Resource Area 39 has a 15% chance of contact over a 30-day period and a 16% chance of contact over a 360-day period, the highest chance of contact in this group. If any bowheads migrated on the shoreward side of Cross Island (Environmental Resource Area 28) during an oil spill, there is an 11% and a 12% chance of contact with spilled oil over both a 30-day and a 360-day period, respectively. Although a few bowheads may be inside the barrier islands during the fall migration, this area is not their main habitat. During the winter, the chance of an oil spill from Liberty Island contacting these ice/sea segments ranges from 1-2% over a 30-day period and 1-5% over a 360-day period, respectively (Table A-12). Ice/Sea Segment 10 has a 2% chance of contact over a 30-day period and a 5% chance of contact over a 360-day period, respectively, the highest chance of contact in this group. The chance of an oil spill from Liberty Island during the winter contacting these environmental resource areas ranges from 0-3% over a 30-day period and 0-16% over a 360-day period, respectively. Environmental Resource Area 39 has a 3% chance of contact over a 30-day period and a 15% chance of contact over a 360-day period. Environmental Resource Area 40 has a 3% chance of contact over a 30-day period and a 16% chance of contact over a 360-day period. Environmental Resource Areas 39 and 40 have the highest chance of contact in this group The model estimated there is less than a 0.5% chance of an oil spill from Liberty Island contacting the spring lead system (SPL 1-5) over both a 30-day period and a 360-day period during either the summer or winter. Information on oil spills and the probabilities of an oil spill contacting a specific area on Maps A-2 and A-3 are in Section III.C.2.

During the summer, the chance of an oil spill from the offshore portion of the pipeline (PP1) contacting Ice/Sea Segments 6-13 (See Maps A-2 and A-3) ranges from 0-7% over a 30-day period and from 1-7% over a 360-day period (Table A-16). Ice/Sea Segment 11 has a 7% chance of contact over both a 30-day and a 360-day period, the highest chance of contact in this group. The chance of an oil spill during the summer from the offshore portion of the pipeline contacting Environmental Resource Areas 14-15, 18-21, 24, 29-30, 39-41, 43, 45, or 47 ranges from 0-13% and from 0-14% over a 30-day and a 360-day period, respectively. Environmental Resource Area 39 has a 13% chance of contact over a 30-day period and a 14% chance of contact over a 360-day period, the highest chance of contact in this group. If any bowheads migrated on the shoreward side of Cross Island (Environmental Resource Area 28) during an oil spill, there is an 9% and a 10% chance of contact with spilled oil over both a 30-day and a 360-day period, respectively. During the winter, the chance of an oil spill from the offshore portion of the pipeline contacting these ice/sea segments ranges from 0-2% over a 30-day period and 1-5% over a 360-day period, respectively (Table A-17). Ice/Sea Segment 11 has a 1% chance of contact over a 30-day period and a 5% chance of contact over a 360-day period. Ice/Sea Segment 10 has a 2% chance of contact over a 30-day period and a 4% chance of contact over a 360-day period. The chance of an oil spill from the offshore portion of the pipeline contacting these environmental resource areas ranges from 0-3% over a 30-day period and 0-15% over a 360-day period, respectively. Environmental Resource Area 39 has a 3% chance of contact over a 30-day period and a 13% chance of contact over a 360-day period. Environmental Resource Area 40 has a 15% chance of contact over a 360-day period, the highest chance of contact in this group.

The chance of an oil spill from the nearshore portion of the pipeline (PP2) contacting ice/sea segments, environmental resource areas, and spring lead systems referenced earlier is the same as or less than from the offshore portion of the pipeline and, therefore, is not analyzed here (Table A-16 and Table A-17).

A 1,283-barrel diesel spill from Liberty Island during the summer would have a 1% chance of contacting Ice/Sea Segments 10 and 11 (Table A-10). The chance of a diesel oil spill contacting environmental resource areas during the fall migration range from 0-6% over a 3-day period. Environmental Resource Areas 30 and 39 each have a 6% chance of contact, the highest in the group. There is a less than 0.5% chance of a diesel oil spill contacting the spring lead system (SPL 1-5) over the 3-day period. Approximately 2% of the diesel oil would remain after 7 days (Table A-9). Although a few bowheads may be inside the barrier islands during the fall migration, this area is not their main habitat.

The potential for bowhead whales to be affected by spilled oil from the Liberty Project is less likely than for the Northstar Project, because Liberty has a smaller volume of oil in the reservoir; a smaller estimated probability of a spill; spilled oil has a low probability of reaching areas outside the barrier islands; and the Liberty location is farther inshore of the main bowhead fall migration route.

(2) Eiders

(a) Summary and Conclusions for Effects of an Oil Spill on Spectacled and Steller's Eiders

Mortality resulting from the Liberty Project would be additive to natural mortality and would interfere significantly with recovery from any declines of the coastal plain spectacled eider population, and would be considered a take under the Endangered Species Act. An oil spill from Liberty Island or associated marine pipeline would have the highest probability of contacting nearshore and offshore areas of Foggy Island Bay and the eastern Sagavanirktok River Delta where spectacled eiders may be staging before migration. Oil could contact these eiders from early June to September. Mortality from a spill that moves offshore would be difficult to estimate. Aerial surveys conducted by the Fish and Wildlife Service located few spectacled eiders offshore in all but two subareas, thus a model developed by the Fish and Wildlife Service estimates very low mortality from an oil spill for this species. The estimated population for the Arctic Coastal Plain is about 9,500 individuals. A spill that enters open water off river deltas in spring could contact any migrant eiders present. Recovery of this population from even small losses is not likely to occur quickly. Any substantial spill-related losses would have significant adverse effects on this population. Small oil spills are expected to cause few deaths among nesting, broodrearing, or staging eiders. Potentially one or two spectacled eiders and their productivity could be lost as a result of an onshore spill. Reduction of prey populations from an oil or diesel fuel spill could have a negative effect on foraging success of eiders in the local area, especially in spring when there is limited open water. However, substantial foraging habitat is expected to be available following the breeding season, although the amount of high quality habitat in the Beaufort Sea area remains unknown, as are details of eider foraging habits.

Although Fish and Wildlife Service survey data do not show a significant decline in the coastal plain spectacled eider population, the potential exists for a significant adverse effect from an oil spill on this population, particularly that segment nesting in the eastern portion of the range. Steller's eiders are not expected to occur in the Liberty Project area.

(b) Details on How a Large Oil Spill May Affect Eiders

1) General Effects from Developing the Liberty Prospect

a) Effects of Oil or Diesel Fuel Contact

Direct oil or diesel fuel contact usually is fatal to birds, death resulting from hypothermia, shock, and drowning. This was particularly evident in Elson Lagoon in 1944 when 25,000 gallons (595 barrels) of oil was released causing birds to be blinded and suffocate on contact (Thomas P. Brower, statement at public hearing in 1978, as cited in U.S. Army Corps of Engineers, 1998). Four years passed before the oil disappeared. If birds swallow oil or fuel when preening it from their feathers or eating contaminated prey, they may experience (a) reduced endocrine gland and liver function, (b) weight loss, and (c) production of fewer young, and their surviving nestlings may grow more slowly (USDOI, MMS, 1996a). Ingestion of diesel fuel is more immediately fatal because of its greater toxicity.

b) Effect of Decreased or Contaminated Prey Populations

Bottom-dwelling prey populations may decline if contacted; if this occurred, it could decrease foraging success and increase stress on eiders that depend on these organisms as an energy source for completion of growth in young birds and migration of all individuals. Postbreeding female eiders require high quality foraging habitat to replace energy reserves depleted during nesting and incubation which will be used for migration. If prey populations decline, eiders will need to relocate in alternate foraging habitat. An examination of information from onshore habitat surveys (for example, Markon and Derksen, 1994; Walker, 1985; Walker and Acevedo, 1987) and petroleum industry offshore bottom survey video records (LGL Environmental Research Ltd., 1998) suggests that alternate foraging habitat, at least superficially similar in appearance and with similar prey organisms evident, is readily available, although the amount of high quality foraging habitat for particular species in the Beaufort Sea area remains unknown. Because limited open water is available in spring, access to such areas is likely to be more restricted than in the postbreeding period. Contaminated prey may be rejected or, if eaten, produce some of the impacts noted above and in USDOI, MMS (1996a).

c) Oil-Spill Prevention and Response

General aspects of oil-spill prevention and response, an inventory of available equipment, and containment/cleanup methods for four seasonal scenarios are summarized in Section II.A.4. Most spill-response equipment is stored in Deadhorse (Alaska Clean Seas), but some is kept on Egg Island outside Gwydyr Bay. Oil-spill prevention and response strategies would be used to mitigate significant oil-spill impacts, but specific methods would not be used if it was determined they could cause additional harm to this species.

Open-Water Spill: Most relocations of satellite-tagged spectacled eiders has been in or offshore of Harrison Bay or outside western Simpson Lagoon, where chance of contact by a spill that occurs at Liberty Island or from the subsea pipeline is low. However, if an oil spill occurred during the open-water season, these areas would need to be surveyed for eider presence to plan a response strategy for oil that entered this area. If the spill is not contained before reaching this area, the most effective response may involve hazing.

Although spectacled eiders apparently spend little time in nearshore coastal habitats, females with broods may occupy them briefly before moving to offshore staging areas. Containment, recovery, and cleanup activities for a spill of any size may involve substantial numbers of workers, boats, aircraft, and onshore vehicles operating over an sizeable area for an extended period. The presence of personnel and equipment is likely to act as a general hazing factor, displacing any eiders from the immediate area of activity, perhaps within a few kilometers, which potentially may be viewed as a positive result given birds' extreme vulnerability to oil in the environment. If a reliable system of locating eiders in a specific area can be devised, specific birds or groups in danger of oil contact could be targeted with specific hazing tactics.

Currently, no important specific foraging areas for eiders are identified in the Liberty area so displacement away from the area is not expected to significantly affect their ability to accumulate fat to fuel migration.

An estimated 10 or fewer nesting eiders are likely to be displaced and potentially lose their clutches or broods to predators as a result of disturbance by onshore cleanup operations (eiders show no attraction to areas immediately adjacent to the Beaufort Sea [TERA, 1999], and only 10 pairs were recorded within 5 kilometers of it in a recent 5-year interval of observations). Helicopter support traffic and human presence probably would be the most disturbing factors associated with oil-spill-cleanup activity. If their presence forces eiders from a marine area where oil contact is imminent, it may be considered a positive factor. However, overland flights and off-road personnel activity during the nesting season may displace females from their nests or broods and result in egg or duckling losses. During the nesting season, early June to early September, an effort should be made to route air traffic over areas where there is a low probability of eider nesting, and spill-cleanup personnel should not enter inland areas except on established roads.

2) Specific Effects of a Large Oil Spill on Eiders from BPXA's Proposed Liberty Development and Production Plan

a) Vulnerability of Eiders to Oil or Diesel Fuel Spills

The Oil-Spill-Risk Assessment model predicts relatively high probabilities of a spill from Liberty Island or from the buried pipeline contacting and entering offshore waters in Foggy Island Bay and the eastern Sagavanirktok River Delta. Spectacled eiders would be most vulnerable to such a spill from early June to September while they were staging before migration. These individuals may have low energy reserves following the breeding period, and this condition may be intensified if oil or diesel fuel enters their preferred foraging areas, causing them to relocate to uncontaminated areas. Locations determined from satellite-tagged individuals suggest that males migrate offshore a median distance of 6.6 (average = 10.1) kilometers and females a median distance of 16.5 (average = 21.8) kilometers (Petersen, Larned, and Douglas, 1999; TERA, 1999), but there also have been many returns from individuals staging in nearshore areas. The Oil-Spill-Risk Assessment model estimates that the probability of contact within 30 days for oil released at Liberty Island in the summer open-water season would range from 17% in nearshore Foggy Island Bay (Land Segment 26, Environmental Resource Areas 34 and 36) to 60% in mid-bay (Environmental Resource Area 33), and 12-22% in the eastern Sagavanirktok River Delta (Environmental Resource Area 57, Land Segment 25) (Map A-2, Table A-12). These areas range from 3-10 kilometers offshore. Farther offshore, contact declines to 15% or less (Table A-12) in Environmental Resource Areas 31, 58, 37 60, 30. 39, 8, and 9 (Map A-2), which range from 13-53 kilometers offshore. Eiders may be found at any of these distances offshore. To the west, repeated satellite transmitter locations have been recorded in the Simpson Lagoon and Harrison Bay areas (Petersen, Douglas, and Mulcahy, 1995; TERA, 1999) where spill contact probabilities for 30 days in summer (Table A-12) are less than 10% (Environmental Resource Areas 20-24 and 48-52, Map A-3) and less than 3% (Environmental Resource Areas 14-19, Map A-3), respectively. Even such low probabilities of contact suggest a potential for significant spectacled eider losses, given the apparent importance of these two areas.

b) Mortality from an Oil or Diesel Fuel Spill

An oil spill from early June to September that reaches Foggy Island Bay and areas to the east and west could contact spectacled eiders staging before migration (Petersen, 1997, pers. commun.). Because aerial surveys conducted by the Fish and Wildlife Service in 1999 and 2000 in the central Beaufort Sea area located few spectacled eiders, except in two subareas near Harrison Bay, modeling efforts by Fish and Wildlife biologists (Stehn and Platte, 2000), using modeled trajectories for assumed spill sizes of 5,912 and 1,580 barrels and bird densities derived from Fish and Wildlife Service aerial survey counts, yielded low estimates of exposure of birds to oil (assumed mortality). The authors state that the predictive value of their model was constrained by the incorporation of a number of important assumptions, and that there were other limitations of the bird density-oil-spill-trajectory overlay analysis. Factors contributing to the uncertainty of final model estimates of numbers of birds exposed to oil include errors inherent in estimating numbers of birds present in or passing through a prescribed area during aerial surveys performed at one point in time, turnover rates (duration of time a bird spends on the water at a specific site), whether the areas sampled on limited surveys accurately represents all areas occupied by eiders, and a substantial proportion of the unidentified eiders may have been spectacled. Together, these have considerable potential to influence the number of deaths predicted to result from the oil-spill scenarios analyzed. However, the relative magnitudes and patterns of exposure of birds to oil calculated by the model should have application for the management and protection of birds using this area. Using average estimated bird density and average to maximum spill-trajectory severity, the model estimates that numbers of spectacled eiders exposed to the larger spill would range from 2-52 in July, and 0 in August. Spectacled eider numbers on the coastal plain appear generally to be stable or declining at an insignificant rate. If oil or diesel fuel enters open water off river deltas (such as the Kadleroshilik) in spring, or is released into it from melting ice, migrant eiders that gather in such open areas before moving to nesting areas could contact oil. Although diesel fuel is more toxic than oil, a diesel spill (estimated 1,500 barrels) is likely to contact fewer eiders than an oil spill of the same size, because it would disperse in the water and dissipate more quickly, with less than 10% remaining after 6 days.

c) Population Effects

The relatively small loss of spectacled eiders likely to result from an oil or fuel spill in the Liberty area, where so far there is little indication of large numbers gathering in offshore waters, may be difficult to separate from natural variation in population numbers. This has been found for other waterbird populations under similar circumstances. For example, total reproductive failure of a local south polar skua population following the *Bahia Paraiso* oil spill in Antarctica generated a controversy regarding whether the oil spill or other factors caused chick mortality, or whether it was a result of natural fluctuation (Eppley, 1992). The report concluded that because of the complexity of variables influencing natural variation in population numbers, it was not possible to determine causal factor(s) with confidence, but most likely the effects of oil exposure on adults and possibly food limitation contributed. Given the difficulty of determining effects on a small, local population, attempting to demonstrate effects of the oil spill on the larger regional skua population would have been fruitless.

Regardless of the factors involved in causing mortality, recovery of the coastal plain spectacled eider population from even small losses is not likely to occur quickly, because population increase is slow or not occurring and nesting density, and probably overall productivity, is extremely low. Recruitment of individuals into the population under such circumstances is likely to be low and losses from spill mortality, intensified by decreased productivity of nesting pairs disturbed by spill-related activities or lowered survival of any age groups, is expected to increase the length of time required for recovery to former population levels. Because the level of information on parameters such as rates of productivity, survival, and recruitment currently available makes it difficult to determine the recovery rate of the local population (or entire Arctic Coastal Plain population) from incidents causing mortality, the long-term effect of oil-spill mortality is uncertain. However, we expect the overall effect of any substantial spill-related losses to have significant adverse consequences on the spectacled eider population until it recovers from its threatened status.

d) Onshore Spill

A leak in the onshore portion of the pipeline is estimated to release 720-1,142 barrels of oil. If it occurs on a pad, the extent of a spill likely would be restricted by containment berms and procedures. If the spill occurred along the off pad portion of the pipeline, the area covered is estimated to be about 2.2-3.5 acres or 0.01 square kilometer. Limited survey data for the Kadleroshilik River area in 1994 (TERA, 1995b) indicates that eider density probably is relatively low (average 0.4 birds per square kilometer, range 0.0-1.7 birds per square kilometer) throughout the area during summer. This suggests that a spill during the breeding season may result in only one bird becoming oiled, although both members of a pair could be oiled in June if a spill entered the area near a nest. If strong winds occur while oil is leaking from an elevated pipeline, oil may mist over a much larger area, although as a thinner coating, on the order of tens of acres to more than 100 acres (1 square kilometer = 247 acres), depending on the volume of oil released. Also, if the spill enters streams or lakes, a greater area could be affected as the oil spreads over a water surface or is carried down a watercourse, including areas used by broodrearing females (although no females with broods were recorded from this study area in 1994; TERA, 1995b); however, losses still are likely to be low (perhaps because of generally low bird density in the area).

b. Seals and Polar Bears

(1) Summary and Conclusion for Effects of an Oil Spill on Seals and Polar Bears

Seals and polar bears most likely would contact the spill in the Foggy Island Bay, and Mikkelsen Bay areas regardless of which spill scenario is assumed (Table A-1). An estimated 60-150 ringed seals (out of a resident population of 40,000) fewer than 50 bearded seals (based on their sparse distribution in the project area) out of a population of several thousand) could be affected by the large spill. An estimated 5 to 30 bears could be lost if the spill contacted Cross Island when and where that many polar bears may be concentrated during the whale harvest. This represents a severe event. The more likely loss from Liberty development would be no more than three to six bears. The seal and polar bear populations are expected to recover individuals killed by the spill within 1 year, and there would be no effect on the population.

Amstrup, Durner, and McDonald (2000; see Appendix J-1) estimated that a 5,912 barrel spill could contact 0 to 25 polar bears in open water conditions and 0 to 61 polar bears in autumn mixed ice conditions. The oil spill trajectories contacted small numbers of bears far more often than they contacted large numbers of bears. In October 75% of the trajectories oiled 12 or fewer bears while in September 75% of the trajectories oiled 7 or fewer polar bears (Amstrup , Durner, and McDonald; 2000, see Appendix J-1). The median of polar bears that could be affected by a 5,912 barrel spill in October was 4.2. Barring environmental degradation after such a loss, survival of young born in the year of the spill should prevent net changes in population size. These results are comparable to the estimate of 5-30 bears. A spill from Liberty is likely to affect 12 or fewer polar bears. The polar bear population is expected to recover this likely loss within one year (see (3) Specific Effects of a Large Spill).

Secondary effects could come from oil contaminating food sources. A spill might affect the abundance of some prey species in local, coastal areas of Foggy Island Bay where epibenthic food such as amphipods (small shrimp) concentrate, but a spill should not greatly decrease abundant food, such as arctic cod. Local changes in the abundance of some food sources would not affect the seal populations or, in turn, affect the polar bear population in the Beaufort Sea (see Sec. III. C.f(1)(a) Effects of a large oil spill on fishes and essential fish habitat).

(2) Details on How a Large Spill May Affect Seals and Polar Bears

(a) General Effects of Developing the Liberty Prospect

1) Effects of an Onshore Pipeline Spill

For purposes of analysis, we assume that a 720-1,142-barrel onshore pipeline spill would occur and oil less than 5 acres of vegetation along the pipeline landfall to the Badami tie in. This onshore spill is not likely to affect seals or polar bears.

2) Effects of a Large Offshore Spill

In an interview in 1978, Thomas Brower, Sr. (as cited in U.S. Army Corps of Engineers, 1998), gave an account of a 25,000-gallon (6,000-barrel) oil spill and its effects at Elson Lagoon in 1944. He saw birds and seals that were blinded and suffocating from the oil in the water. It took about 4 years for the oil to disappear and, during this time, whales avoided passing near the lagoon during fall migration. See OCS Reports MMS 85-0031 and MMS 92-0012 (Hansen, 1985; 1992) and the Sale 144 Final EIS (USDOI, MMS, 1996a) for detailed discussions of the various possible direct and indirect effects of oil and other chemical pollutants on marine mammals.

Direct contact with spilled oil may kill some marine mammals and have no apparent effect on others, depending on factors such as the species involved and the animal's age and physiological status. Some oiled polar bears and newly born seal pups in the Liberty area are likely to die from thermoinsulation loss, which could result in hypothermia. Adult ringed and bearded seals are likely to suffer some temporary effects, such as eye and skin irritation with possible infection. Such effects may increase physiological stress and perhaps contribute to the death of some individuals (Geraci and Smith, 1976; Geraci and St. Aubin, 1980; St Aubin, 1990). Oil ingestion by marine mammals when they eat contaminated prey, groom, or nurse could have pathological effects, depending on the amount ingested, species involved, and the animal's physiological state. Death would be likely to occur if they took in a lot of oil or inhaled it into their lungs. Consuming a lot of oil over a relatively short time (as in the Oritsland et al.[1981] experiment with polar bears) can concentrate hydrocarbons in the bloodstream. If these concentrations exceed the kidneys' ability to filter toxins and the liver's ability to detoxify hydrocarbons (Engelhardt, 1983), kidney failure may occur, with severe toxic reactions and an imbalance of body chemistry leading to the animal's death (Oritsland et al., 1981). Chronic oil ingestion might cause degeneration of liver and kidney tissue in marine mammals that have thick fur (which oil will adhere to) and that groom intensely, such as sea otters and polar bears.

Avoidance of Oil Spills by Seals and Polar Bears: Seals and polar bears are not likely to intentionally avoid oil spills, although they may limit or avoid further contact with oil if they experience discomfort or apprehension (Hansen, 1985; 1992). Under some circumstances, they might be attracted to the spill site, if concentrations of food organisms are nearby. During migration, they may have little choice but to move through the spill site. Polar bears might be attracted to an oil spill because of their curiosity (Adams, 1986, pers. comm.) and because birds or other animals killed by the spill are present. However, seals and bears could be scared away from the spill area by cleanup activities and by wildlife hazing intended to keep bears and other wildlife away from the spill, as covered under BPXA's oil-spill-contingency plan (Sec. II.A.4). However, poor weather conditions could prevent helicopters from hazing bears and other wildlife away from the spill.

3) Effects of Oil-Spill Response

If a large spill were to oil habitats in Foggy Island Bay containing several hundred seals and some polar bears during the spring or open-water season, hundreds of people, many boats, and several aircraft operating in the area for cleanup probably would displace some seals and polar bears from oiled areas and temporarily stress others. It is possible that cleanup operations could displace some bears and ringed seals from maternity dens during the spring, resulting in the loss of a few bear cubs and seal pups. These effects may occur during 1 or 2 years of cleanup; however, we do not expect it to greatly affect seal and polar bear behavior and movement beyond the Foggy Island Bay area or after cleanup.

A 1,500-barrel diesel spill would dissipate quickly and is not expected to persist beyond about 6 days. The number of seals and polar bears affected is likely to be less than that affected by a crude oil spill of the same size. The seal and polar bear populations are expected to recover within 1 year.

Cleanup efforts should include the removal of all oiled animal carcasses to prevent polar bears from scavenging on them. Oil-spill-contingency measures that include the aircraft hazing of wildlife away from the oil spill could reduce the chances of polar bears entering coastal waters where there is an oil slick. However, such hazing may have to be repeated to prevent polar bears from entering the oiled water or oiled shoreline area after the aircraft has left. Poor weather conditions would prevent this contingency measure from being effective.

The Alaska Clean Seas tactics (Alaska Clean Seas, 1998) for responding to spills in broken ice and pack ice could help, including the strategies for tracking of oil in pack ice (Tactics T-1, -3, and -5) and the in-situ burning of oil on ice (Tactics B-4, -5 and -6). However, poor weather conditions would prevent this contingency measure from being effective. The response plan discusses the importance of timely salvage of oiled carcasses and the required State and Federal permits (Tactics W-1 and -4).

(b) Specific Effects of a Large Oil Spill from BPXA's Proposed Liberty Development and Production Plan

The Oil-Spill-Risk Assessment model estimates a 3-23% chance of a spill starting at the Liberty Island location contacting Foggy Island Bay and Mikkelsen Bay seal and polar bear habitats (Environmental Resource Areas 27 through 40 and 57 through 59) have within 30 days during the summer (Table A-12, Maps A-1 and A-2). The Oil-Spill-Risk Assessment model estimates a 8-45% chance of that a spill occurs along the pipeline (P1 or P2) during the summer and contacts these environmental resource areas within 30 days (Table A-12).

A crude-oil spill that occurred in October is not likely to be effectively cleaned up under freezeup conditions and might contaminate the fast-ice habitats. However, once freezeup occurs in the fast-ice zone, the oil would spread very little under fast ice. A winter spill that occurred nearshore (within the 20-meter isobath fast-ice zone) would affect very few ringed seals during the pupping and breeding season, because the spill would cover only 0.75-3.0 acres or less than 1 square kilometer under the ice (Table A-7). If the spill occurred during broken ice or meltout (715-2,956-barrels), it is assumed it would spread as a discontinuous slick over 73-150 square kilometers (Table A-7). This spill could affect about 59-122 ringed seals, based on a spring density of about 0.81 seals per square kilometer (Frost et al., 1998) times the area swept by the spill. During the open-water summer season, a crude oil spill of 715-1,580 barrels could sweep over 124-186 square kilometers in 30 days (Table A-7). The number of ringed seal pups and adults contaminated is likely to be small. The ringed seals density of 0.81seals per square kilometer times the area swept by the spill 124-186 square kilometers) equals 100-151 seals exposed to the spill during summer. These numbers of ringed seals that would be contaminated and possibly killed represent a small fraction of the resident population of 40,000. If a 2,956-barrel crude oil spill were released during spring meltout or in broken ice and contacted the offshore flaw zone, more ringed and bearded seals could be contaminated because sometimes hundreds of them do aggregate in ice leads or open water. Such an event could contaminate and kill up to perhaps 300 ringed seals but probably fewer than 50 bearded seals (bearded seals have a much lower density than ringed seals).

Polar bears are most likely to be oiled or eat oiled prey at a whale carcass on Cross Island or at a concentration of seals in Foggy Island Bay. Perhaps an estimated 5-30 bears may be harmed. This estimate is based on the number of polar bears sometimes observed by the Bowhead Whale Aerial Surveys in the Cross Island area during the fall Bowhead whale harvest (Treacy 1988 through 1997). An estimated 5-30 bears could be lost to a spill, if the spill contacted Cross Island when and where that many polar bears may be concentrated during the subsistence whale harvest. This represents a severe event. However, the probability of this occurrence is low (for example, there is only a 1-7% conditional annual probability of a spill starting at the Liberty Island location or along the pipeline and contacting the Cross island Environmental Resource Area within 30 days, Tables A-12 and A-17 and Maps A-2 and A-3). The more likely loss would be no more than three to six (2.9-6 bears (assuming a bear density of one bear per 25 square kilometers [Amstrup, Durner, and McDonald; 2000] divided into 73-150 square kilometers [the area swept by the 715-2,956-barrel spill as a discontinuous slick in broken ice or meltout, Table A-7]). The seal and polar bear populations are expected to recover individuals killed by the spill within 1 year, and there would be no effect on the population.

Amstrup, Durner, and McDonald (2000) interfaced a polar bear density model with an oil-spill-trajectory model using 255 observations of 69 polar bears during "open water" from August 22-September 30 (30% or less ice cover) and 322 observations of 95 polar bears to generate the October period (1 October to 9 November). The model estimated the number of bears likely to occur in each 1.00-square kilometer cell of a grid superimposed over the surrounding Liberty Island. Oil-spill-trajectory footprints were projected for October and September, when hypothesized effects of oil on bears were assumed to be worst. Amstrup, Durner, and McDonald (2000) estimated that a 5,912-barrel spill could contact 0-25 polar bears in-open water conditions and 0-61 polar bears in autumn mixed-ice conditions. In September, the mean number of bears affected was four, while the median number was one. In October, the mean and median number of bears affected were 9.5 and 2.9 respectively. The oil-spill trajectories contacted small numbers of bears far more often than they contacted large numbers of bears. In October, 75% of the trajectories oiled 12 or fewer bears while in September, 75% of the trajectories oiled 7 or fewer polar bears (Amstrup, Durner, and McDonald; 2000). These numbers are comparable to the estimate of 5-30 bears given above. A spill from Liberty likely would affect 12 or fewer polar bears. The polar bear population is expected to recover this likely loss of 12 or fewer bears within 1 year.

The following additional information on simulated oil spills and polar bear harvest rates is provided by Taylor (2000b) in collaboration with S. Amstrup (U.S. Geological Survey, Biological Resources Division, Anchorage, Alaska) and S. Schliebe and S. Kalxdorf (USDOI, Fish and Wildlife Service, Marine Mammals Management Office, Anchorage):

> The recent subsistence polar bear harvests have been smaller than the recommend quota (Gorbics et al. 1998), and the population has shown the capacity for growth despite sometimes-higher harvests (Amstrup, 2000; Amstrup et al., 2001)…Barring environmental degradation after the spill, survival of young born in the year of the spill should prevent net changes in population size…in the years surrounding the spill event.
>
> In 25% of simulated 5912 (2956) barrel spills, losses ranged from 12-61 (10-33) bears during October. The maximum subsistence harvest level agreed upon between the North Slope Borough (Alaska) and the Inuvialuit (Canada) allows 40 polar bears to be taken per jurisdiction per year. No more than one third (n=13) of the quota may be comprised of females. Between 1988 and 1998, the Alaskan harvest of polar bears averaged 34.8 bears; however, the harvest exceeded the 40-bear quota in three years during this period (S. Schliebe, USFWS, unpubl. data). An average of 10 female polar bears was harvested during this 10-year period and the 13 female polar bear harvest limit was exceeded one time (S. Schliebe, USFWS, unpubl. data). Also, polar bears available in the near-shore areas most likely to be oiled include a high percentage of adult females, the most valuable reproductive component (Amstrup et al. 1986; Amstrup and DeMaster, 1988). Four nearshore surveys along the mainland coast and barrier islands from Cape Halkett to Barter Island were conducted during September-October, 2000 (Schliebe et al., USFWS, unpubl. data). A total of 50, 73, 72, and 38 bears were counted and of these, 40 (80%), 55 (75%), 30 (42%), and 19 (50%) were individuals in family groups (Schliebe et al., USFWS, unpubl. data). The time necessary for reproduction to compensate for larger, but less likely losses, would depend upon: the sex and age of bears actually oiled; the presence or absence of sustained environmental degradation, and the size and sex/age compositions of the subsistence harvests in the years surrounding the spill. Actual replacement of oiled, mature individuals by cubs born in the year of the spill will take 5 - 6 years (Amstrup and DeMaster, 1988). In summary, the greater the number of mature polar bears oiled and removed from the population, the more extended the expected recovery time and the more dependent the recovery will be upon an unpredictable subsistence harvest, latent environmental effects of oil, and other factors that cannot be precisely predicted in advance of a spill" (Taylor, 2000b).

If a spill (2,956 barrels) occurred during the fall freezeup or melts out of the ice during the spring breakup, a number of polar bears could be exposed to the oil. Polar bears are most likely to be oiled or eat oiled prey at a whale carcass on Cross Island or at a concentration of seals in Foggy Island Bay. Perhaps an estimated 5-15 bears or up to 30 bears could be harmed if the spill contacts Cross Island during the fall whale hunting season when perhaps as many as 30 bears could be concentrated at the remains of whales carcasses harvested from subsistence hunting. The probability of this contact is low (for example, only a 2-7 % conditional probability of a spill starting at the Liberty Island and contacting Cross and No Name islands within 30 days during the summer; Environmental Resource Area 56, Table A-12). However, the spill would not harm the Beaufort Sea population based on the following assumptions:

- The number of bears likely to be contaminated probably would be small, even in a severe situation. For example, a concentration of 5-30 bears at a whale carcass were contaminated and all the bears died or 12 or fewer polar bears were oiled based on Amstrup, Durner, and McDonald (2000).
- The current growth rate of the Beaufort Sea population of 1,800 bears is about 2.4% (USDOI, Fish and Wildlife Service, 1995a, b; Gorbics, Garlich-Miller, and Schliebe, 1998).
- We assume a sex ratio of 2:1 male to female of removed bears and a population of 1,800. In this case, the biological removal rate would be about 76 bears per year (Nageak, Brower, and Schliebe, 1991).
- We assume an Alaskan/Canadian mean subsistence harvest of about 60 bears per year (Gorbics, Garlich-Miller and Schliebe, 1998).
- We assume environmental degradation resulting from the 2,956-barrel oil spill is below the level that would alter reproduction and survival of the polar bear population.

Under these reasonable assumptions, we do not expect the additional loss of 5-30 bears (or 12 or fewer bears) to exceed the potential biological removal rate (noted above) plus the subsistence harvest. The North Slope Borough/Inuvialuit Game Council Agreement allows 80 bears to be harvested from this population (Gorbics, Garlich-Miller and Schliebe, 1998). This number is close to the maximum sustainable rate and does not factor in potential losses from oil development. However, some of the bears we assume would be killed by the spill probably would have been among the animals harvested that year. Thus, the harvest is likely to be less than the approximate 60 bears for that year.

The Fish and Wildlife Service Proposed Rule on incidental take of polar bears that may be associated with the Northstar Development project concluded that the probability of large numbers of polar bear being killed by an oil spill is low (the

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probability of 20 or more bears being killed is 0.3-1.1%) (65 *FR 16828*). The Fish and Wildlife Service believes that if a large spill occurs during fall freezeup or during spring breakup, significant effects to polar bears could occur. However, "balancing the level of impact with the probability of occurrence," they concluded that the probability of serious impacts (high mortality of bears) is low (65 *FR 16828*).

The following additional information on polar bear harvest rates is provided by Taylor (2000b) in collaboration with S. Amstrup (U.S. Geological Survey, Biological Resources Division, Anchorage) and S. Schliebe and S. Kalxdorf (USDOI, Fish and Wildlife Service, Marine Mammals Management Office, Anchorage):

> The maximum subsistence harvest level agreed upon between the North Slope Borough (Alaska) and the Inuvialuit (Canada) allows 40 polar bears to be taken per jurisdiction per year. No more than one third (n=13) of the quota may be comprised of females. Between 1988 and 1998, the Alaskan harvest of polar bears averaged 34.8 bears; however, the harvest exceeded the 40-bear quota in three years during this period (S. Schliebe, USFWS, unpubl. data). An average of 10 female polar bears was harvested during this 10-year period and the 13 female polar bear harvest limit was exceeded one time (S. Schliebe, USFWS, unpubl. data). Also, polar bears available in the near-shore areas most likely to be oiled include a high percentage of adult females, the most valuable reproductive component (Amstrup et al. 1986; Amstrup and DeMaster, 1988). Four nearshore surveys along the mainland coast and barrier islands from Cape Halkett to Barter Island were conducted during September-October, 2000 (Schliebe et al., USFWS, unpubl. data). A total of 50, 73, 72, and 38 bears were counted and of these, 40 (80%), 55 (75%), 30 (42%), and 19 (50%) were individuals in family groups (Schliebe et al., USFWS, unpubl. data). The time necessary for reproduction to compensate for larger, but less likely losses, would depend upon: the sex and age of bears actually oiled; the presence or absence of sustained environmental degradation, and the size and sex/age compositions of the subsistence harvests in the years surrounding the spill. Actual replacement of oiled, mature individuals by cubs born in the year of the spill will take 5 - 6 years (Amstrup and DeMaster, 1988). In summary, the greater the number of mature polar bears oiled and removed from the population, the more extended the expected recovery time and the more dependent the recovery will be upon an unpredictable subsistence harvest, latent environmental effects of oil, and other factors that cannot be precisely predicted in advance of a spill" (Taylor, 2000b).

c. Marine and Coastal Birds

(1) Summary and Conclusion for Effects of an Oil Spill on Marine and Coastal Birds

A large oil spill would have the highest probability of contacting nearshore and offshore areas of Foggy Island Bay and the eastern Sagavanirktok River Delta, where waterfowl and other aquatic birds may be staging before migration. Mortality from a spill contacting **long-tailed ducks** in lagoons or other protected nearshore areas is estimated to exceed 1,200 individuals (equivalent to about 1% of the average coastal plain population) at average bird densities. Total kill potentially could approach or exceed 10 times this number, if oil were to contact areas of high bird density. A model developed by the Fish and Wildlife Service estimates mortality exceeding 1,400 individuals at average bird densities in the Harrison Bay to Brownlow Point area, where these ducks concentrate during the molt period. Total kill estimate from a 5,912 barrel spill used in the Fish and Wildlife Service model (twice the spill size estimated by MMS) ranged up to 35% of this central Beaufort Sea population. The maximum estimate would result in a significant adverse effect on population numbers and productivity (out of an estimated Arctic Coastal Plain population of about 115,500 individuals), especially if many of those molting in this area come from declining subpopulations. Should long-tailed ducks be contacted by a spill outside the barrier islands, mortality is likely to be considerably lower than this number due to the lower bird density.

Flocks of staging **eiders** could contact oil in nearshore and/or offshore areas. Oil could contact flocks of **king** and **common eiders** offshore from early June to September, although mortality from a spill that moves offshore would be difficult to estimate. **King** and **common eider** populations have declined 50% in the past 20 years (Suydam, et al., 1997), and substantial oil-spill mortality would aggravate this effect. For most species, the relatively small losses likely to result from a spill may be difficult to separate from the natural variation in population numbers, but their populations are not expected to require lengthy recovery periods (see the discussion in Sec. III.C.2(a)(2), Threatened and Endangered Species, Eiders, population effects). Because much of the information needed to determine the recovery rate of bird populations from incidents causing mortality is only superficially known for most species (for example, accurate values for population size, breeding rate and success, age- and sex-specific survival), the long-term effect (i.e., rate of recovery) of oil-spill mortality on such populations is uncertain. Species that are declining in numbers, such as **king** and **common eiders** and **red-throated loon**, or have limited capacity for population growth, such as (**loons** and **seaducks** in general), are expected to recover from oil spill mortality slowly. In particular, because of historic or current declines in common eiders and long-tailed ducks and the estimated mortalities of an assume oil spill, a large offshore spill could result in impacts to these species.

A spill that enters open water off river deltas in spring could contact migrant **loons, swans**, **long-tailed ducks, eiders**, and **glaucous gulls**. Some of the several hundred broodrearing, molting, or staging **brant** and **snow geese** could contact oil in coastal habitats. Also, several thousand **shorebirds** could encounter oil in shoreline habitats, and the rapid turnover of migrants during the migration period suggests that many more could be exposed. Effects are expected to be similar to those outlined above.

An onshore pipeline spill in summer probably would affect only a few nests even considering all species. If the oil spread to streams or lakes, **long-tailed ducks**, **brant**, and **greater white-fronted geese** that gather on large lakes to molt could be adversely affected in larger numbers. Losses of oiled birds in this case could range up to a few hundred individuals, a minor effect for species whose populations are relatively abundant and stable or increasing (for example, **northern pintail**, **geese**, **glaucous gull**, most **shorebirds**, **songbirds**).

Reduction of prey populations from an oil or diesel fuel spill may reduce foraging success of **shorebirds** and **sea ducks** that depend on this local energy source for molt or migration. Substantial areas of at least superficially similar foraging habitat apparently is available onshore and offshore following the breeding period, although the amount of high quality foraging habitat in the Beaufort Sea area for particular species remains unknown, as are details of foraging habits for most species.

(2) Details on How a Large Oil Spill May Affect Marine and Coastal Birds

(a) General Effects from Developing the Liberty Prospect

1) Effects of Oil Contact

Direct oil contact usually is fatal, resulting in death from hypothermia, shock, and drowning when individuals are unable to maintain insulation and buoyancy normally provided by their water-repellent plumage. This was particularly evident in Elson Lagoon when 25,000 gallons (595 barrels) of oil was released from a naval vessel in 1944 causing birds to be blinded and suffocate on contact and that the oil did not disappear for 4 years (Thomas P. Brower, statement at public hearing in 1978, cited in U.S. Army Corps of Engineers, 1998). If birds ingest oil by preening it from their feathers or by eating oil-contaminated prey, they may die or have reduced endocrine gland and liver function, weight loss, production of fewer young, and their surviving nestlings may grow more slowly (USDOI, MMS, 1996a).

2) Effects from Decreased or Contaminated Prey Populations

If local prey populations, either terrestrial or aquatic, were reduced substantially by oil contact it could interfere with the ability of adults and young to accumulate energy for molt and/or migration. However, postbreeding female **eiders** and other **waterfowl**, **shorebirds**, and **seabirds** require high quality foraging habitat to replace energy reserves depleted during nesting and incubation and to accumulate additional nutrients, which will be used for migration. **Long-tailed ducks** require abundant food to offset increased demands of metabolism, temperature regulation and protein synthesis associated with molt. If prey populations decline, these birds will need to relocate in alternate similar foraging habitat. Terrestrial surveys (for example, Markon and Derksen, 1994; Walker, 1985; Walker and Acevedo, 1987), and petroleum industry marine bottom survey video records (LGL Environmental Research Ltd., 1998) suggest that alternate foraging habitat, at least superficially similar in appearance and with similar prey organisms evident, is readily available in the area, although the amount of high quality habitat for particular species available in the Beaufort Sea area remains unknown. Because limited snow-free areas or open water are available in spring, access to such areas is likely to be more restricted than in the postbreeding period. Contaminated prey may be rejected or, if eaten, produce some of the impacts noted above and in USDOI, MMS (1996a).

3) Oil-Spill Prevention and Response

General aspects of oil-spill prevention and response, an inventory of available equipment, and containment/cleanup methods for four seasonal scenarios are summarized in Section II.A.4. Most spill-response equipment is stored in Deadhorse (Alaska Clean Seas), but some is kept on Egg Island outside Gwydyr Bay. Oil-spill prevention and response strategies would be used to mitigate significant oil-spill impacts, but specific methods would not be used if it was determined they could cause additional harm to these species.

Aerial surveys for **waterfowl** and other birds in the central Beaufort Sea area recorded individuals from nearshore lagoon areas out to 35-65 kilometers offshore (Flint et al., 2000; Petersen et al., 1999; Stehn and Platte, 2000). Birds were most numerous in and offshore of Harrison Bay where, for this analysis, the Oil-Spill-Risk Assessment model estimates the chance of contact by a summer spill assumed to occur at Liberty Island or from the buried pipeline and enter offshore waters is less than 2% (Table A-12) in 30 days (Environmental Resource Areas 14-18, Map A-3), and Simpson Lagoon, where probability of contact is 8% (Environmental Resource Area 22). Although areas of greatest bird density have low probability of contact, an oil spill approaching these areas during the open-water season would require them to be surveyed for bird presence in order to plan a response strategy for a spill trajectory influenced by the prevailing weather patterns. If the spill is not contained before reaching this area, the most effective response may involve hazing. Although most waterfowl and loons remain offshore, molting **long-tailed ducks** and **surf scoters**, **glaucous gulls**, and **shorebirds** are found in nearshore areas and coastal habitats that could be contacted by oil that reaches the coast. Species foraging in such habitats could be displaced by coastal cleanup activities.

The area covered by a spill from the onshore portion of the pipeline (estimated 720-1,142 barrels) during the nesting season is likely to be small because of containment structures and procedures. If the spill entered aquatic habitats and spread more widely, a greater area would be affected. Numbers of nesting birds likely to be displaced and potentially lose their clutches or broods to predators as a result of disturbance by cleanup operations will vary, depending on the area affected and the magnitude of cleanup response required.

(b) Specific Spill Effects on Marine and Coastal Birds from BPXA's Proposed Liberty Development and Production Plan

1) Vulnerability of Birds to Oil Spills

For purposes of analysis, we assume a spill occurs at Liberty Island or from the buried pipeline and enters offshore waters. The Oil-Spill-Risk Assessment model predicts relatively high probabilities of a spill contacting these areas. **Waterfowl** and other aquatic birds are most vulnerable to a spill in the Liberty area when occupying shoreline habitats, lagoons, or other nearshore waters. Birds may have limited choices of where they can relocate, if oil enters preferred foraging areas in spring. Occurrence of many species on barrier and other islands in particular has been noted by Native residents. For example, Etta Ekolook recalled aaqhaaliq (**long-tailed duck**) molting in the Tigvariak Island area, although more so at other barrier islands with other **duck** species (Ekoolook, as cited in North Slope Borough, Commission on History and Culture, 1980). Further east, Mary Akootchook and Josephine Itta have seen many amauligruaq (**common eider**) and quinaluk (**king eider**) at Flaxman, Pole, and Belvedere Islands, niglingaq (**brant**) near Flaxman Island (Akootchook and Itta, as cited in North Slope Borough Commission on History and Culture, 1980). Thomas Napageak cites Pole Island as an important nesting area for **eiders** and other **waterfowl** (Napageak, as cited in U.S. Army Corps of Engineers, 1999). Fenton Rexford notes that many **waterfowl** go through the Kaktovik area (Rexford, as cited in U.S. Army Corps of Engineers, 1996), and Jennie Ahkivak recalls accompanying her father to Cross Island each spring to hunt **ducks** (Ahkivak, as cited in USDOI, BLM, 1974). Local residents have observed that large numbers of **waterfowl** pass through the Beaufort Sea area, and they are concerned that an oil spill could have a drastic effect on the populations (Rexford, as cited in U.S. Army Corps of Engineers, 1996). Seasonally, **gulls** and **ducks** have been observed by Andrew Oenga in the Pt. Brower area of the Sagavanirktok River Delta as early as late April (Oenga, as cited in North Slope Borough, Commission on History and Culture, 1980).

After nesting in tundra habitats is completed, many shorebirds and waterfowl move to coastal feeding areas from mid-June through September to rear their broods, molt, and put on fat reserves for migration (Connors, 1984; Connors, Meyers, and Pitelka, 1979; Johnson, 1991; Smith and Connors, 1993; Stickney and Ritchie, 1996). These individuals need to feed where prey are abundant to replace the energy reserves they have used during the breeding period. Considering the chance of oil-spill contact in specific areas during the Liberty Project activities, and typical bird distributions in summer, oiling of birds most likely would be in nearshore Foggy Island Bay (Land Segment 26, Environmental Resource Areas 34, 36) and the eastern Sagavanirktok River Delta (Land Segment 25 Map A-2). The Oil-Spill-Risk Assessment model estimates that chance of the spill assumed for this analysis to occur at Liberty Island or from the subsea pipeline and enter offshore waters contacting these areas within 30 days in the summer open-water season (Tables A-12, 13) is 17-26% (Foggy Island Bay shore and nearshore waters) to 12-22% (Sagavanirktok River Delta) These areas range from 3-10 kilometers offshore. Farther offshore, contact declines to 15% or less in Environmental Resource Areas 31, 58, 37, 60, 30, 39, 8, and 9 (Map A-2), which range from 13-53 kilometers offshore. Substantial numbers of **loons**, **waterfowl**, and **marine birds** can be found at any of these distances. Offshore near Liberty Island (Environmental Resource Areas 33 and 35), the model estimates that probability of spill contact is 34-60% (Table A-12). **Gulls**, **ravens**, **sea ducks**, and **phalaropes** would be vulnerable to a spill here if they are attracted to Liberty Island.

2) Potential Mortality from an Oil or Diesel Fuel Spill

In general, the long-term effect of spill-caused mortality on bird populations in the Liberty Project area is uncertain because of a lack of specific information required to estimate how long they might take to recover (for example, accurate values for population size, fecundity, productivity, age- and sex-specific survival and mortality). The effect of substantial oil-spill losses on populations that have undergone recent declines (**long-tailed ducks** in northwestern Canada and during late June censuses on the Arctic Coastal Plain, and **king** and **common eiders** in northern Alaska) may interfere with their recovery from oil spill-related losses. We expect spill effects to be minor for regional populations of species with stable or increasing populations, because natural recruitment will replace such losses fairly quickly. In most cases, losses probably would be difficult to separate from the natural variation in population numbers, as this has been found for other waterbird populations under similar circumstances (Eppley, 1992; see discussion in Section III.C.2(a)(2), Threatened and Endangered Species, Eiders, population effects). For most species, if the fraction of a population killed from an oil spill remains small, they are not expected to require lengthy recovery periods due to positive population growth rates and compensatory mechanisms. As the proportion killed increases, disruption of social behavior, loss of mates, and increase effect of predation may extend the time required for recovery. Declining populations or those with low growth capacity are at greater risk. This includes many of the species in the Beaufort Sea area such as loons, eiders and other sea ducks. All are declining in at least part of their range.

An oil spill that reaches shoreline habitats in Foggy Island Bay and areas to the west in July or August would contact some of the several hundred (about 950 may be present) broodrearing **brant**, **snow geese**, or **tundra swans**, and staging or molting birds (Johnson, 1991; Stickney and Ritchie, 1996). Staging shorebirds also are vulnerable in these habitats. For example, after the nesting period the numbers of **shorebirds** on the Sagavanirktok and Colville river deltas may range from 62-150 birds per kilometer of shoreline, with some favored habitats supporting more than 800 birds per square kilometer (Andres, 1994; Troy, 1982). If oil spreads along 21-30 kilometers of shoreline (Table A-7) during the fall migration period, it could be encountered by several thousand shorebirds. In fact, many more may be exposed to oil, because turnover of the migrating populations in a given area may occur every 7 days, continuously exposing new arrivals (Andres, 1994). Although we presume substantial numbers would not survive contact with oil, how many is unknown. **Shorebirds** also could be affected during this critical period of fattening for the migratory journey if their prey populations decline as a result of being oiled.

In lagoons and other nearshore waters, large numbers of **long-tailed ducks** and smaller flocks of **eiders** and other waterfowl and phalaropes are likely to be present in July or August. Densities of 40-275 **long-tailed ducks** per square kilometer (Map 6) have been observed in lagoons to the east and west of Liberty (Noel, Johnson, and Wainwright, 2000). Such values suggest a spill that enters a barrier island lagoon or bay during those months could kill in the range of 1,204-12,365 birds in the area traveled by a slick in 10 days (discontinuous area = 30-45 square kilometers, Table A-7). This represents a minor to significant loss (1-11%) from the estimated Arctic Coastal Plain population (14 year average estimated population from breeding pair surveys = 115,516; Mallek and King, 2000). Modeling efforts by Fish and Wildlife biologists (Stehn and Platte, 2000), using modeled trajectories for assumed spill sizes of 5,912 and 1,580 barrels and bird densities derived from Fish and Wildlife Service aerial survey counts in the central Beaufort Sea area in 1999 and 2000, yielded similar magnitudes of estimated exposure of birds to oil (assumed mortality). The authors state that the predictive value of their model was constrained by the incorporation of a number of important assumptions, and that there were other limitations of the bird density-oil-spill-trajectory overlay analysis. Factors contributing to the uncertainty of final model estimates of numbers of birds exposed to oil include errors inherent in estimating numbers of birds present in or passing through a prescribed area during aerial surveys performed at one point in time, turnover rates (duration of time a bird spends on the water at a specific site), and whether the sampled areas accurately represents all areas occupied by birds. Together, these have considerable potential to influence the number of deaths predicted to result from the oil spill scenarios analyzed. However, the relative magnitudes and patterns of exposure of birds to oil calculated by the model should have application for the management and protection of birds using this area. Using average estimated bird density and average to maximum spill-trajectory severity (area contacted), the model estimates that numbers of **long-tailed ducks** exposed to the larger spill would range from 1,443-6,498 in July, and 2,062-13,281 in August. Mortality of this magnitude would represent a significant effect on the regional population. **Long-tailed duck** numbers on the coastal plain appear generally to be stable, but declines in aerial survey counts in late June have been recorded recently and they are declining in northwestern Canada and elsewhere (Conant et al., 1997; Mallek and King, 2000; USDOI, Fish and Wildlife Service, 1999b). Little information is available on the relationship of the coastal plain population to the total continental population, or on certain aspects of their biology necessary to estimate how soon they would recover from such losses.

Counts of **king eiders** migrating past Point Barrow have declined by about 50% since 1976 (Suydam et al., 1997), and abundance during the breeding season has declined in the Point McIntyre area west of Prudhoe Bay (TERA, 1993b). Using Fish and Wildlife Service average estimated bird density and average to maximum spill-trajectory severity, the model estimates that numbers of **king eiders** exposed to the larger spill would range from 232-3,102 in July, and 8-152 in August, representing 1-16% and 0.1-2% of the population occurring from Harrison Bay to Brownlow Point during these months, respectively. A spill entering an offshore lead during the spring migration period potentially could contact many more individuals, if it were used as a resting area for large flocks of migrating **king eiders** as noted by Divoky (1984). Counts of **common eiders** also have declined 50% in the past 20 years. Comparable Fish and Wildlife Service estimates for **common eider** are 159-618 in July and 125-1,272 in August, representing 5-19% and 8-86% of the population surveyed in this area, respectively. Potentially, larger numbers of **common eiders** could be oiled if a spill entered nearshore leads during spring migration. Substantial losses of common eiders from an oil spill would result in a significant long-term population effect; mortality of king eiders of the magnitude predicted by the Fish and Wildlife Service model could result in a substantial population effect (Dickson, 1997; Stehn and Platte, 2000; U.S. Army Corps of Engineers, 1998). The maximum estimated numbers exposed to a spill represent a "worst case" scenario that could occur if no spill response was attempted. However, large numbers of birds nesting elsewhere on the coastal plain and Canada do traverse the central Beaufort Sea during spring and fall migration and thus potentially could be exposed to any oil spill, if they stop in this area. Both of these sea ducks are listed as "species at risk" by the Fish and Wildlife Service (Taylor, 2000a, pers. commun.).

Comparable average estimated mortality for **Pacific, red-throated,** and **yellow-billed loons, scoter** species, and **glaucous gull**, at average densities, are 23, 8, 3, 147, and 217 individuals exposed in July, and 9, 2, 0, 22, and 72 in August. These estimates of birds exposed to oil represent less than 5% of each of the respective populations occurring in the survey area except for July glaucous gulls (=8%). We do not have specific information for any of these species to forecast accurately how quickly they would recover from such losses.

Outside the barrier islands, where average **long-tailed duck** density equals 37 birds per square kilometer, mortality is not likely to exceed 1,665 birds, or 54 in offshore areas where the average density equals 1.2 birds per square kilometer (Johnson, 1990). Oil could contact flocks of **eiders** staging before migration in areas farther offshore. If an oil spill were to enter open water off a river delta (such as the Sagavanirktok) in spring, or is released into it from melting ice, spring migrants that use such open areas to stage before moving to nesting areas could contact the oil**. Loons, swans, brant, long-tailed ducks, eiders, gulls**, and **terns** are the most likely species to experience losses in this situation.

A 1,283-barrel diesel spill would dissipate relatively quickly and is not expected to persist beyond about 7 days. The number of birds affected is likely to be less than that affected by a crude oil spill of the same size because the area covered would be somewhat smaller (Table A-9).

3) Onshore Spill

A 720-1,142-barrel onshore pipeline spill in summer would contact only a small area, probably no more than a few acres, because of containment structures and procedures. Based on an estimated 72 nests per square kilometer (all species, including **waterfowl**, **shorebirds**, and **Lapland longspurs**) in a Kadleroshilik study area (TERA, 1995b), probably only one or two nest sites would be affected, although many individuals of various species traversing such an area over time could be affected. If the oil spreads to aquatic habitats (lakes, ponds, and streams), birds occupying these habitats could be affected, especially **long-tailed ducks**, **brant**, and **white-fronted geese** that gather on large lakes to molt. Such habitats also are used by substantial numbers of broodrearing waterfowl and shorebirds. Losses of oiled birds in this case (for example, **northern pintail, geese, glaucous gull**, most s**horebirds**, **songbirds**) could range up to a few hundred individuals, a minor effect for species whose populations are relatively abundant and stable or increasing.

d. Terrestrial Mammals

(1) Summary and Conclusion for Effects of an Oil Spill on Terrestrial Mammals

A large spill is most likely to contact some coastal areas from Prudhoe Bay, the Sagavanirktok River Delta east to Mikkelsen Bay, regardless of which spill scenario is assumed (Table A-13; Land Segments 25, 26, and 27). Caribou may use some of these areas for relief from insects. The main potential effect on terrestrial mammals that contact spilled oil could be the loss of fewer than 100 caribou (out of an estimated resident population of the Central Arctic Herd of 18,000 individuals) and a few muskoxen, grizzly bears, and arctic foxes. These losses are expected to be replaced by normal reproduction within about 1 year. A 1,500-barrel onshore pipeline spill could occur and oil less than 5 acres of vegetation along the pipeline landfall to the Badami tie in. Such a spill is not expected to directly affect caribou or other terrestrial mammals and would cause very minor ecological harm.

Secondary effects could come from disturbance associated with spill-cleanup activities and temporary local displacement of some caribou, muskoxen, grizzly bears, and foxes. These activities, however, would not affect the terrestrial mammals' movements or overall use of habitat.

(2) Details on How A Large Spill May Affect Terrestrial Mammals

(a) General Effects from Developing the Liberty Prospect

1) Effects of a Large Onshore Pipeline Spill

For this analysis, we assume that a 720-1,142-barrel onshore pipeline spill could occur and oil less than 5 acres of vegetation along the pipeline landfall to the Badami tie-in. Such a spill is not expected to directly affect caribou or other terrestrial mammals and would cause very minor ecological harm.

2) Effects of a Large Offshore Spill

Some grizzly bears use coastal beaches, mudflats, and river mouths in the Liberty area during the summer and fall for finding carrion. If an oil spill contaminates beaches and tidal flats along the Beaufort Sea coast, some grizzly bears and some arctic foxes are likely to eat contaminated food, such as oiled birds, seals, or other carrion. This could result in the loss of at least a few bears and a few foxes through kidney failure and other complications (Oritsland et al., 1981; Derocher and Stirling, 1991). Such losses should not be significant to the populations on the Arctic Slope. Bears could be scared away from the spill area by helicopters during cleanup; however, poor weather conditions may prevent helicopters from hazing bears and other wildlife away from the spill.

Caribou and muskoxen may become oiled or ingest contaminated vegetation. Caribou and muskoxen that become oiled are not likely to suffer from a loss of thermoinsulation during the summer, although they could absorb oil through the skin or inhale toxic hydrocarbons. Oil on young calves, however, significantly could reduce their thermoinsulation and lead to their death. Caribou would shed oiled hair if contact with the spill occurred during the summer before growing winter fur. However, if contact with oil occurred during the fall caribou wouldn't shed the oiled hair until the following summer. Toxicity studies of crude oil ingestion in cattle (Rowe, Dollahite, and Camp, 1973) showed the possibility of anorexia (significant weight loss) and aspiration pneumonia leading to death. Caribou that become oiled by contact with a spill in lakes, ponds, rivers, or coastal waters could die by inhaling toxic hydrocarbons or absorbing them through the skin.

3) Effects of Oil-Spill Response

If a large spill were to extensively oil coastal habitats containing herds or bands of caribou and muskoxen during the insect season, hundreds of people, many boats, and several aircraft operating to clean up the area probably would displace some caribou, muskoxen, grizzly bears, and foxes. These activities are not expected to affect the behavior and overall movements of these populations. Oil-spill-contingency measures that include the hazing of wildlife away from the oil spill could reduce the chances of caribou entering coastal waters with an oil slick. However, such hazing may have to be repeated to prevent caribou from entering the oiled water during the insect season. Poor weather conditions would prevent this contingency measure from being effective. The response plan discusses the importance of timely salvage of oiled carcasses and the required State and Federal permits (Alaska Clean Seas Tactics W-1 and -4 [Alaska Clean Seas, 1998]).

(b) Specific Effects of a Large Oil Spill from BPXA's Proposed Liberty Development and Production Plan

Unless otherwise specified, we determined probabilities for oil spill contact assuming activity levels under Alternative I (the Proposal) and associated spill rates (Appendix A). We focused on a large spill 720-1,142 barrels and crude-oil-spill contacts that occur within 180 days during the open-water season.

1) How an Onshore Oil Spill May Locally Affect Tundra Habitats

For this analysis, the onshore pipeline spill would occur and oil less than 5 acres of vegetation along the pipeline landfall to the Badami tie-in. Such an onshore spill would be expected to occur on the gravel pad near the tie-in location, and its effect on tundra is expected to be minimal. About 20-35% of past crude-oil spills have reached areas beyond pads (USDOI, BLM and MMS 1998). Because winter spans most of the year, about 60% of the time spills happen when workers can clean up oil on the snow cover before it reaches the vegetation (USDOI, BLM and MMS 1998). Most spills cover less than 500 square feet, or 0.01 acre, but may cover up to 4.8 acres if the spill is a windblown mist. Overall, past spills on Alaska's North Slope have caused minor ecological damage, and ecosystems have shown a good potential for recovery (Jorgenson, 1997). These habitat effects would be very local (greater than or equal to 5 acres) and are not expected to affect terrestrial mammal populations.

2) A Spill Could Affect Some Terrestrial Mammals at Particular Sites

Caribou, muskoxen, grizzly bears, and arctic foxes may frequent coastlines near the Liberty Project. The Oil-Spill Risk Assessment model estimates 11-26% chance of a spill starting at the Liberty location (L1) and contacting land along the coast of Foggy Island Bay-Mikkelsen Bay within 30 days during the summer open-water season (Tables A-13, Land Segments 25, 26, and 27). Overall, the Oil-Spill-Risk Assessment model estimates that there is an 87% chance that a spill starting at Liberty Island or along the buried pipeline contacts the shoreline (Table A12 , contact to Land within 30 days during the summer). The Liberty Project is unlikely to produce a spill that would contact coastal areas east of there, such as Flaxman Island. Some Central Arctic Herd caribou could contact oil in coastal habitats from the Sagavanirktok River (east of Endicott causeway) east to about Mikkelsen Bay. Caribou move into these areas to escape insects. Even in a severe situation, however, fewer than 100 animals from the Central Arctic Herd (out of a population of 18,000) are likely to get the oil on their coats and die by inhaling and absorbing toxic hydrocarbons. We base this number on summer surveys of the caribou seen in marine waters (Pollard and Ballard, 1993). Normal reproduction is likely to replace this loss within about 1 year. Caribou could be scared away from the spill area by helicopters during cleanup; however, poor weather conditions may prevent helicopters from hazing caribou away from the spill.

A 1,500-barrel diesel spill would dissipate quickly and likely would not persist beyond about 6 days. The number of caribou and other terrestrial mammals affected is likely to be lower than that affected by a crude oil spill of the same size. The terrestrial mammal populations are expected to recover within 1 year.

e. Lower Trophic-Level Organisms

(1) Summary and Conclusion for Effects of an Oil Spill to Lower Trophic-Level Organisms

A large oil spill would have only short-term effects on plankton, but long-term effects on the fouled coastlines. Up to 15% of the sound's coastline would be affected by a large spill. While the ice-gouged coastline is inhabited by mobile, seasonal invertebrate species that would recover within a year, fractions of the oil would persist in the sediments for about 5 years in most areas, and could persist up to 10 years in areas where water circulation is reduced. Liberty crude is highly viscous and particularly resistant to natural dispersion, so very little would be dispersed down in the water column and affect benthic communities such as the Boulder Patch kelp habitat. However, diesel oil, which would be used on the island for startup and emergency fuel, could be dispersed down to the seafloor. If 1,500 barrels of diesel were spilled from a fuel-delivery barge at the island during the open-water season, the concentration would be toxic within an area of about 18 square kilometers (7 square miles), as calculated in the water-quality section (III.C.2.l). Such toxicity would probably stunt the seasonal growth of kelp plants and reduce the population size of associated invertebrates for several years. Oil-spill responses in general would have both minor beneficial and adverse effects on these organisms.

(2) Details on How a Large Spill May Affect Lower Trophic-Level Organisms

Oil spills would have both general and specific effects on these organisms.

(a) General Effects Developing the Liberty Prospect

There would be general effects on plankton, on kelp and associated invertebrates in the Boulder Patch, and on coastal and other benthic invertebrates.

1) Effects on Plankton

Concerns about the effects of oil spills on plankton are widespread. The concerns were expressed during Northstar hearings by Fenton Rexford of Kaktovik, when he testified that "if there is an oil spill out there, it will kill off all those shrimp, the crab, [and the] phytoplankton; they will all be affected" (Rexton, as cited in U.S. Army Corps of Engineers, 1999: Secs. 6.2.1 and 6.2.6.2). Also, John Armstrong testified that "an oil spill would definitely break that [food chain] link and it will be irreparable" (Armstrong, as cited in Dames and Moore, 1988:2). Because of the widespread concerns, there have been several studies of effects on plankton during past oil spills. A national review of the studies showed large-scale adverse effects on plankton, such as those widely feared from an oil spill at Liberty Island or from the buried pipeline, have not been reported (National Research Council, 1985). For example, observation of phytokplanton biomass and primary productivity after the 1977 *Tsesis* spill in Sweden revealed no significant differences between clear and contaminated areas (Johanessen et al., 1980, as cited in National Research Council, 1985:442). Studies conducted after oil spills commonly show no significant effect on plankton populations. Even if it is assumed that an oil spill in the open ocean contacts many phytoplankters, the regeneration time of the organisms (9-12 hours) and the rapid replacement of organisms from nearby waters would keep the effects to a minimum (National Research Council, 1985). Field observations of zooplankton communities during oil spills and in chronically polluted areas have shown that the communities were affected, but that these effects appeared to be short-lived (Johanessen et al., 1980, as cited in National Research Council, 1985). Individuals in chronically polluted areas have experienced direct mortality, external contamination by oil, tissue contamination by aromatic constituents, inhibition of feeding, and altered metabolic rates. However, because of their wide distribution, large numbers, rapid rate of regeneration, and high fecundity, zooplankton communities exposed to oil spills or chronic discharges in open-water areas appear to recover quickly (National Research Council, 1985). In summary, we agree with the conclusion in the Northstar EIS that there would be only minor oil spill impacts to planktonic and epontic communities (U.S. Army Corps of Engineers, 1999: Section 8.7.2.1).

2) Effects on Boulder Patch Kelp Habitat

The kelp and associated invertebrates the Boulder Patch are described in Section VI.A.5. What is known about the effect of crude oil on kelp and marine plants has come largely from observations following oil spills. Both lethal and sublethal effects have been observed. Effects vary considerably, depending on plant species, type and concentration of oil, the timing and duration of exposure, and the method of cleanup, if any. Following the *Exxon Valdez* oil spill, the recolonization of heavily oiled intertidal rocky habitat began the first year after the spill (Duncan, Hooten, and Highsmith, 1993; van Tamelen and Stekoll, 1993), and complete recovery was expected in 5-6 years. Most areas that were oiled but not high-pressure washed recovered to prespill conditions by 1991. Further, all dominant flora and fauna (except barnacles) that were high-pressure washed suffered 60-100% mortality and, to date, have not recovered (Houghton et al., 1996). Hence, the high-pressure shoreline treatment associated with the *Exxon Valdez* oil spill appears to have had as large an effect on lower trophic-level populations as the oil itself. Observations like these have shown that while marine plants often are adversely affected by oil, they are not always affected in a substantial way. Further, in the areas that were substantially affected by oil, recovery to prespill conditions was likely to occur within 3 years (longer if high-pressure washed).

In the marine environment, hydrocarbons resulting from an oil spill are broken up by wave action into floating surface oil, dispersed and dissolved within the water column, and some oil is incorporated into bottom sediments. Marine plants are affected most by floating surface oil, and oil that is incorporated into shoreline bottom sediments through wave action. In marine environments that have distinct intertidal and subtidal floral and faunal communities, the most persistent effects often occur when intertidal and shallow subtidal benthic communities are contacted by oil, particularly in areas where water circulation is restricted (for example, bays, estuaries, mudflats, and rock armored shorelines). However, in the Beaufort Sea there is no intertidal zone in the traditional sense. This is due to the annual predominance of shorefast ice, which precludes marine plant life and most fauna along the shoreline, and the massive annual influx of freshwater into the nearshore marine environment during spring and summer. This influx transforms nearshore waters into a semifreshwater (brackish water) environment until fall, when marine waters again dominate due to reduced freshwater inflows. Nevertheless, marine plants do exist subtidally at a few locations in the Beaufort Sea, such as the Boulder Patch habitat in Stefansson Sound. The estimated effect of a large oil spill on marine plants in this area depends on the type and amount of oil reaching them. Liberty crude is a medium- to heavy-gravity crude with high viscosity (Appendix A, Sec. A.2 and Table A-4). A recent study of Liberty crude by S.L. Ross Environmental Research, Ltd. (2000) concluded that Liberty crude would be particularly resistant to natural dispersion in the water column. It would disperse very little and very slowly down into the Stefansson Sound water column. Additional details about the vertical mixing of this crude oil are summarized in Section III.C.2.l, including the specific concentrations at several depths and after several periods of time in Foggy Island Bay (Table III.C-5). For example, the table shows the concentration at the depth of the Boulder Patch (20 feet) after 10 days would only be 0.031 parts per million. In comparison, the concentration under the *Exxon Valdez* oil spill, which did not greatly affect subtidal eelgrass beds, was estimated to be more than an order of magnitude higher (0.8 parts per million at 33 feet) (Dean, Stekoll, and Smith,1996; Wolfe et al., 1994). For this reason, the amount and toxicity of Liberty crude oil reaching subtidal marine plants is expected to be so low that it would have no measurable effect on them, regardless of when a spill occurs.

3) Effects on Coastal and Other Benthic Invertebrates

Dominant marine invertebrates in the Beaufort Sea area include mollusks, annelids, echinoderms, and crustaceans. Crude oil can kill marine invertebrates from short-term exposure to high concentrations of hydrocarbons or long-term exposure to lower concentrations. Laboratory studies show that oil concentrations from 1-4 parts per million can kill adult and larval crab and shrimp after 96 hours of exposure (Starr, Kuwada, and Trasky, 1981). Large oil spills often have resulted in mortality of bivalves (Teal and Howarth, 1984), which are food for many species of marine birds, fishes, and mammals. Effects on bivalves can be almost immediate, but declines in numbers may continue for up to 6 years (Thomas, 1976). Marine invertebrates are most affected by floating surface oil and oil that is incorporated into the water column or shoreline bottom sediments through wave action.

Studies following the *Exxon Valdez* oil spill in 1989 revealed significant concentrations of hydrocarbons in shoreline sediments at heavily oiled sites, and a subsequent migration of oil into the shallow subtidal zone in 1991 (Wolfe et al., 1993). However, significant concentrations were not found in the subtidal zone. Gilfillan et al. (1993) showed that the toxicity of oiled intertidal sediments declined rapidly after the *Exxon Valdez* spill. Within 18 months, about 75% of the oiled shoreline had recovered. In fact, toxicological results indicate that the oiled shoreline was at toxic hydrocarbon levels for only a few months to 1 year. The remaining hydrocarbons were found to be generally nontoxic and are thought to serve as a food source for some biota (for example, bacteria).

The viscous Liberty crude would not mix down deep enough in the water column to affect the Boulder Patch kelp habitat or other benthic invertebrates. Therefore, even a large oil spill occurring from the Liberty offshore project and entering offshore waters during winter and spring (about 9 months) is not expected to have a measurable effect on marine invertebrates. All of the oil would remain trapped under the ice and little, if any, would contact marine invertebrates. If the spill were to occur during the summer, only a few land segments have a contact probability greater than 1%. The Oil-Spill-Risk Assessment model also estimates that these same land segments have a very low probability of one or more spills occurring and contacting them within 10 days, and that the probabilities are similar for all alternatives (Table A-14). The offshore area having the highest combined probability of contact (Environmental Resource Areas 30, 31, and 37) is the large area over the Boulder Patch. As explained above, the viscous Liberty crude would not mix down deep enough in the water column to affect the Boulder Patch or other benthos, unless dispersants were applied to the oil. However, the use of dispersants is not essential to the Liberty spill plan; their use would require further review and approval by the Coast Guard. Nevertheless, for purposes of assessment, we assume that a large oil spill does occur and that some of the coastline would be contacted by some portion of that spill.

Because the assumed summer oil spill is likely to occur within 6 miles of shore, it is not expected to take longer than 10 days to arrive there. During that time, some of the more toxic hydrocarbon fractions would have evaporated and are not expected to affect marine invertebrates in the nearshore area. Some of the oil arriving onshore is likely to be toxic and would have lethal or sublethal effects on some of the invertebrates that inhabit the nearshore area in summer.

Due to the predominance of shorefast ice in waters less than 6 feet deep, most of the Beaufort Sea nearshore area supports few resident fauna. Nevertheless, nearshore coastal lagoons do support many nonresident (seasonal) benthic invertebrates (for example, amphipods, mysids, copepods, clams, snails, crab, and shrimp), which are fed on by many vertebrate consumers during the summer. If contacted by surface oil, all of these nearshore benthic invertebrates are likely to be lethally or sublethally affected.

About three-quarters of a large Liberty oil spill may reach the shore, assuming strong onshore (south to southwest) winds. We assume that about half of this oil is still toxic when it arrives at the shoreline. Table A-7 in Appendix A indicates that the estimated length of oiled coastline for all alternatives would be less than 45 kilometers (approximately 15% of the Stefansson Sound coastline). Based on the above, the assumed large spill is estimated to have lethal and sublethal effects on about 15% of the nearshore benthic invertebrate population in the Stefansson Sound area.

The recovery of seasonal benthic invertebrates would be expected to occur within a season, after water quality in the nearshore/shoreline water column returns to prespill conditions, and other opportunistic marine invertebrates move into the area. The Northstar Final EIS also concluded that populations of mobile, marine invertebrates would recover within one season through immigration (U.S. Army Corps of Engineers, 1999:Sec. 8.7.2.1). However, oil incorporated into shoreline bottom sediments due to wave action is expected to remain there for several years. In the areas where shoreline bottom sediments are heavily oiled, some lethal and sublethal effects could occur each summer, when seasonal benthic invertebrates return to those areas. However, this is not expected to affect a measurable percentage of the seasonal benthic invertebrate population in Stefansson Sound. The recovery of resident benthic invertebrates within the affected shoreline areas would be expected to require about 5 years in most areas but could require up to 10 years in areas where water circulation is reduced. Oil incorporated into shoreline bottom sediments would have the greatest effect on resident species, because they are not seasonally restocked from deeper waters like seasonal benthic fauna. Subtidal marine organisms deeper than 2 meters (including those of the Boulder Patch area) are not likely to be affected, because they live below the zone where toxic concentrations of oil are expected. The Northstar EIS assessed the effects of oil spills on coastal invertebrates, concluding similarly that there could be long-term effects due to contamination of sediments (U.S. Army Corps of Engineers, 1999:Table 8-10).

The only other marine invertebrates likely to be contacted by surface oil or dispersed oil in the water column would be those closer to the surface. These include zooplankton (copepods, euphausiids, mysids, amphipods) and the larval stages of marine invertebrates such as annelids, mollusks, and crustaceans. Because of similarities in habitat use and distribution, the percentage of marine invertebrate larva contacted by floating or dispersed oil is likely to be similar to that expected for plankton (less than 2% of the Stefansson Sound population). Due to their wide distribution, large numbers, and a rapid rate of regeneration, the recovery of marine invertebrate larva is expected in less than a week. Recovery in bays, where water circulates more slowly, may take up to a year. The Northstar EIS also assessed the effects of oil spills on plankton, concluding similarly that there would be only relatively brief (few days) reductions in population numbers in the affected areas (U.S. Army Corps of Engineers, 1999:Table 8-10).

(b) Specific Effects of a Large Oil Spill from BPXA's Proposed Liberty Development and Production Plan

There would be no alternative-specific effects on plankton or coastal invertebrates, but there could be on the Boulder Patch kelp habitat.

Specific Effects on the Boulder Patch Kelp Habitat: The assessment of general effects on the Boulder Patch (Sec. III.C.2.e(2)(a)(2) concluded that the amount of Liberty crude oil reaching the seafloor community is expected to be so low there would be no measurable effect on it. However, the diesel fuel that would be stored on the island could have alternative-specific effects on the Boulder Patch, varying with the distance of the proposed island from the Boulder Patch. Storage of diesel fuel on the island would be necessary to provide power for initial drilling and thereafter for emergencies. Most small spills on the outer continental shelf were of stored oil, either stored crude or fuel oil (Anderson and LaBelle, 1994). Diesel spills from tanks on the island probably would not reach the ocean because of an 8-foot perimeter berm around the island (Sec. II.A.I.b(1), but diesel could be spilled during transportation and transfer to the island tanks. In the very unlikely case of a large spill near the island, the diesel fuel would mix deeper into the water column and drift slowly in alongshore currents to the east or west. If the plume drifted west toward the Boulder Patch, it probably would drift in the same direction as the offshore edge of the modeled sediment plume from island construction (Fig. III.C-1,-2, -3 and -4, and Ban et al., 1999). The water-quality analysis (Sec. III.C.2.l) concludes that a 1,500 barrel diesel spill during open water could create toxic conditions in an area of about 18 square kilometers (7 square miles). Because of the alternative-specific risk of diesel spills to the Boulder Patch, varying with the distance between the proposed island and Boulder Patch, the typical effects of diesel spills on kelp communities are reviewed next.

The effects of diesel-fuel spills on kelp communities have been studied in association with two spills and an experiment in polar regions. The studies showed that diesel spills probably would not kill kelp but would slow its growth; and that many of the invertebrates on the affected plants might be killed, recovering within a few years. This conclusion is based on the following three sets of studies in polar regions:

- Diesel effects on Norwegian coastal ecosystems were studied in a large, 2-year experiment (Ragan, Bird, and Bokn, 1987). The main aim was to mimic a small but continuous spill of diesel oil on benthic communities. The experiment showed that new tip growth of *Laminaria* plants was significantly shorter compared to tips of the control plants, but that the diesel treatments were not lethally toxic to the plants.
- Diesel effects on macrofaunal communities were studied after a small diesel fuel spill from the grounding of the *Nella Dan* on the sub-Antarctic island of Macquarie (Smith and Simpson, 1998). Kelp and other intertidal macrofaunal communities were studied 7 years after the spill. The studies concluded that there were no significant differences between the community structure in oiled and control locations in any of the three shore zones. However, they noted that some holdfast macrofaunal communities at oiled sites still showed evidence of impact.
- Arthur Harbor, Antarctica, was contaminated by fuel oil from the *Bahia Paraiso* (Kennicutt and Sweet, 1992). Two years after the spill, hydrocarbons were still detectable in limpet tissues, but little spill-related contamination could be detected in macroalgae. The investigators concluded that the overall effects were limited in time and space by the high-energy environment, the relatively small volume of material released, and the volatility of the released product.

Further, the kelp studies of the *Exxon Valdez* oil spill are informative, even though it was a spill of crude oil rather than diesel fuel. The subtidal macroalgal populations in Prince William Sound, including *Laminaria saccharina* populations, were studied 1 year after the *Exxon Valdez* spill (Dean, Stekoll, and Smith, 1996). The investigators found that within a year of the spill, there were no differences in the total density, biomass, or percentage cover of macroalgae between oiled and control sites, and they concluded that there were no apparent long-term impacts on subtidal macroalgae.

The four studies above indicate that a spill of diesel fuel that drifted over the Boulder Patch probably would not kill kelp but would slow the new, seasonal growth of plants in the affected area. The studies also indicate that the population size of invertebrates in the affected area probably would be reduced for several years, as discussed further below. In contrast, if a slick of Liberty crude oil floated over the Boulder Patch, the viscous oil probably would not be mixed down deep enough in the water column to affect the kelp community. The Liberty crude would be dispersed and mixed deeper only by the application of chemical dispersants or by very rough seas, such as those outside of the barrier islands.

(c) Effects of Oil-Spill Response

The Alaska Clean Seas technical manual identifies sensitive sections of the Beaufort Sea coastline on which oil might persist for a decade, including some within the project area (Alaska Clean Seas, 1998:Index Sheets 1 and 2). The most sensitive types of shoreline, such as river deltas and sheltered lagoons, are listed clearly in the manual as “areas of major concern” (for example, Tactic W-6). The manual also describes several tactics for protecting sensitive sections of the coastline. Intertidal and exclusion booms would be used along the shoreline in marshes and inlets (for example, Tactics C-13 and 14). Deflection booms would be used to divert oil to sections of the coastline that are less sensitive or more suitable for recovery; the oil would be collected by booms and pumped by skimmers to local storage tanks. The shorelines that might be contaminated, as a result of diversionary booming, would be flushed to remove oil from the shore zone.

Some coastal organisms probably would be adversely affected by these and other response tactics. Spill responses that would use mechanical tilling for aeration and remediation of shoreline sediments might effect the biota, as acknowledged for Tactic SH-8. Spill responses that use chemicals on oiled shorelines would affect biota, as acknowledged by Tactic SH-11. Spill responses that involve in-situ burning would affect shoreline biota, especially on relatively dry shorelines, as acknowledged by Tactics SH-10 and 11. The tactics for chemical treatments include warnings to avoid chemical use on cobble shorelines where there could be deep penetration, which would help to mitigate impacts. Further, all of the shoreline tactics note that approval by the Unified Command would be required for any shoreline cleanup, which would avoid unnecessary effects. Use of dispersants on a spill near the Boulder Patch would mix the oil farther down into the water column and could affect the kelp community. However, the use of dispersants is not essential to the Liberty Development and Production Plan and spill plan; their use would require further approval by the Coast Guard.

f. Fishes and Essential Fish Habitat

(1) Fishes

(a) Summary and Conclusion for Effects of an Oil Spill on Fishes

The likely effects on arctic fishes (including incidental anadromous species) from a large oil or diesel fuel spill assumed to occur at Liberty Island or from the buried pipeline and enter offshore waters would depend primarily on the season and location of the spill, the lifestage of the fishes (adult, juvenile, larval, or egg), and the duration of the oil contact. Due to their very low numbers in the spill area, no measurable effects are expected on fishes in winter.

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Effects would be more likely to occur from an offshore oil spill moving into nearshore waters during summer, where fishes concentrate to feed and migrate. The probability of an offshore oil spill contacting nearshore waters in summer ranges from less than 1-26%. If an offshore spill did occur and contact the nearshore area, some marine and migratory fish may be harmed or killed. However, it would not be expected to have a measurable effect on fish populations and recovery would be expected within 5 years. In general, the effects of fuel spills on fish are expected to be less than those of crude-oil spills.

If a pipeline oil spill did occur onshore, and contacted a small waterbody supporting fish (for example, ninespine stickleback, arctic grayling, and Dolly Varden char) with restricted water exchange, it would be expected to kill or harm most of the fish within the affected area. Recovery would be expected in 5-7 years. However, because of the small amount of oil or diesel fuel likely to enter freshwater habitat, the low diversity and abundance of fish in most of the onshore area, and the unlikelihood of spills blocking fish migrations or occurring in overwintering areas or small waterbodies (containing many fish or fish eggs), an onshore spill of this kind is not expected to have a measurable effect on fish populations on the Arctic Coastal Plain.

(b) Details on How a Large Spill May Affect Fishes

1) General Effects from Developing the Liberty Prospect

Fishes inhabiting the arctic region are described in Section VI.A.6. Arctic fish differ substantially from their counterparts inhabiting warmer regions. In addition to their many differences, arctic fish also have developed unique life history, behavioral, physiological, and population characteristics that enable them to exist under extremely harsh and fluctuating environmental conditions of both daily and seasonal occurrence. Occasionally, these conditions cause high mortalities, especially to the more sensitive lifestages (eggs and juveniles). Because of this, arctic fish populations have adapted to withstand at least short-term perturbations and fluctuations in the environment This adaptive ability to withstand at least short-term perturbations and fluctuations in the environment applies equally to both human caused and naturally caused events.

The effects of oil spills on fish have been discussed in previous Beaufort Sea EIS's (including the Sale 144 Final EIS [USDOI, MMS, 1996a]), which are incorporated here by reference and summarized. Oil spills have been observed to have a range of effects on fish (see Rice, Korn, and Karinen, 1981; Starr, Kuwada, and Trasky, 1981; Hamilton, Starr, and Trasky, 1979; Malins, 1977, for more detailed discussions). The specific effect depends on the concentration of petroleum present, the time of exposure, and the stage of fish development involved (eggs, larva, and juveniles are most sensitive). If lethal concentrations are encountered, or sublethal concentrations are encountered over a long enough period, fish mortality is likely to occur. However, mortality caused by a petroleum-related spill is seldom observed outside of the laboratory environment. Sublethal effects are more likely and include changes in growth, feeding, fecundity, and temporary displacement.

Other possibilities include interference with movements to feeding, overwintering, or spawning areas; localized reduction in food resources; and consumption of contaminated prey. Most acute-toxicity values (96-hour lethal concentration for 50% of test organisms [LC_{50}]) for fish generally are on the order of 1-10 parts per million. Concentrations observed under the oil slick of former oil spills at sea have been less than the acute values for fish and plankton. For example, concentrations observed 0.5-.0 meters beneath a slick from the *Tsesis* spill (Kineman, Elmgren, and Hansson, 1980) ranged from 50-60 parts per billion. Extensive sampling following the *Exxon Valdez* oil spill (about 260,000 barrels in size) also revealed that hydrocarbon levels were well below those known to be toxic or to cause sublethal effects in plankton (Neff, 1991). The low concentration of hydrocarbons in the water column following even a large oil spill appears to be the primary reason for the lack of lethal effects on fish and plankton. Studies following the *Exxon Valdez* oil spill (for example, Michael et al., 1998; Pearson, et al., 1999; Marty et al., 1999) concerning the effects of that spill on fish populations in Prince William Sound have been inconclusive. While adverse effects on some eggs and larva (pink salmon and herring) were likely to have occurred, natural perturbations cause extreme variation in these populations every year, and preclude any definitive conclusion.

2) Specific Effects of a Large oil Spill from BPXA's Proposed Liberty Development and Production Plan

a) An Offshore Spill May Affect Some Marine and Migratory Fishes Between May and September

From October through April, nearshore waters 6 feet or less in depth are frozen to the bottom, and marine fishes are widely dispersed seaward of the shorefast ice. Because of the barrier formed by this shorefast ice, and the fact that any oil trapped under floating ice would not disperse into the water, a winter offshore spill is not expected to have a measurable effect on marine fishes, or on migratory fishes overwintering in the Sagavanirktok River Delta area. During the open-water period, the nearshore area of the Beaufort Sea is used for feeding and migratory purposes by marine and migratory fishes, including the areas of greatest species diversity such as the Sagavanirktok River Delta. Hence, the occurrence of an offshore oil spill during the summer likely would have its greatest potential effect in the nearshore area. Based on the Oil-Spill-Risk Assessment model (Table A-13), the probability of an offshore oil spill occurring at Liberty Island or from the buried pipeline and contacting nearshore waters in summer ranges from less than 1-26% for all land segments. Only Land Segments 25-27 would have a greater than 10% chance of contact occurring within a year.

Nevertheless, if an offshore oil spill did occur and contact the nearshore area, some marine and migratory fish may be harmed or killed. However, lethal effects on fish from oil spills are seldom observed outside of the laboratory environment. For this reason, a relatively small oil spill, such as the large spill being considered for Liberty is expected to have mostly sublethal effects on the marine and migratory fish affected by it. Juvenile fish (for example, arctic cod), which are common in the nearshore area during summer, or nearshore spawners (for example, capelin) are among those most likely to be adversely affected. Some fish in the immediate area of a spill may be killed; however, it is not expected to have a measurable effect on marine and migratory fish populations. Recovery would be expected within 5 years. Oil-spill-cleanup activities are not expected to adversely affect fish populations. Small operational oil or fuel spills on Liberty Island are not likely to contact fish habitat and are not expected to affect fish.

b) An Onshore Pipeline Oil Spill May Affect Some Freshwater and Migratory Fishes

Onshore bodies of freshwater are much smaller than the marine environment, where the effects of former oil spills have been observed. However, the amount of oil spilled onshore (estimated at up to 720 barrels, Table A-1) is likely to be much less than what might occur from an offshore spill. Additionally, an onshore pipeline spill would not affect fishes unless it entered freshwater habitat supporting fishes. If an onshore oil spill did contact fish habitat, the likelihood of lethal effects is expected to be generally similar to that observed for oil spills at sea (i.e., very low). Sublethal effects are more likely to occur and would be similar to those discussed above. Some fish and food resources in the immediate area of an onshore oil spill may be harmed or killed, particularly if the spill occurred where and when fish were migrating, in overwintering areas during winter, or in small waterbodies having restricted water exchange.

Ninespine stickleback, arctic grayling, and Dolly Varden char have been found in the summer in the East Sagavanirktok Creek (Hemming, 1996). Ninespine stickleback move downstream and out of the creek in late summer as water temperatures drop. Dolly Varden char and arctic grayling may use it for summer rearing habitat (Hemming, 1996). Small runs of pink and chum salmon (anadromous species) sometimes occur in the Colville River, and in some of the drainages west of the Colville River; however, neither species has established populations anywhere on the North Slope (Bendock and Burr, 1984). A pipeline oil spill in winter is not likely to affect fishes. However, if a summer spill of sufficient size occurred in a small waterbody containing fish with restricted water exchange, the fish and food resources in that waterbody are likely to be harmed or killed. Recovery would be expected in 5-7 years. However, because of the small amount of oil likely to enter freshwater habitat, the low diversity and abundance of fish in most of the onshore area, and the unlikelihood of spills blocking fish migrations or occurring in overwintering areas or small waterbodies (containing many fish or fish eggs) with restricted water exchange, an onshore pipeline oil spill associated with Liberty is not expected to have a measurable effect on fish populations. Oil-spill-cleanup activities are not expected to adversely affect fish populations.

c) An Offshore Diesel Fuel Spill form Liberty Island May Affect Fishes Between May and September

Standard North Slope diesel fuel, from either the Kuparuk or Hay River, Northwest Territories, will be temporarily stored on Liberty Island. Based on the Oil-Spill-Risk Assessment model, the probability of an offshore oil spill contacting nearshore waters in summer ranges from less than 1-26% (Table A-13) Table A-9 describes the fate of the Liberty diesel spill in summer and winter broken-ice or meltout periods. The spill's short lifetime is due to large dispersion and evaporation rates (USDOI, MMS, 1998). During winter, about 80% of the diesel is estimated to evaporate and be dispersed by wave action within 30 days. During summer, all of the diesel is estimated to evaporate and be dispersed by wave action in only 7 days and is not expected to reach shore.

In general, the effects of fuel spills on fish are expected to be similar to those of crude-oil spills, although much reduced in duration due to evaporation and dispersion. Hence, the likelihood of lethal effects is expected to be even less than that observed for oil spills at sea. For this reason, a relatively small fuel spill, such as the hypothetical 1,500-barrel spill being analyzed for Liberty, is expected to have mostly sublethal effects on the marine and migratory fishes affected by it. Some fish in the immediate area of a spill may be harmed or killed; however, it is not expected to have a measurable effect on fish populations. The recovery of the number of fish harmed or killed would be expected within 5 years.

d) Effects of Oil-Spill Cleanup

Due to the low density of fish in the Beaufort Sea, and the low probability that they would be harmed by cleanup equipment, oil-spill-cleanup activities in open water or in broken ice are not expected to adversely affect fish populations. Reducing the amount of oil in the marine environment is expected to have a beneficial effect by reducing the possibility of hydrocarbons contacting fish and fish food resources. The extent of that benefit would depend on the actual reduction in the amount of oil contacting fish and fish-food resources, as compared to that of not reducing the amount of contact.

(2) Essential Fish Habitat

All of the effects to essential fish habitat are general and the following effects apply to all resources.

In the event of a large, offshore oil spill, the most likely potential threat to individual salmon would occur if spilled oil came in contact with spawning areas or migratory pathways. However, salmon are not believed to spawn in the intertidal areas or the mouths of streams or rivers of the Beaufort Sea. Therefore, contact between spilled oil and spawning areas is very unlikely. If spilled oil concentrated along the coastline at the mouths of streams or rivers, the potential movements of a small number of salmon could be disrupted during migrations. See Section III.C.2.f(1) for general discussions about the effects of spilled oil on the behavior and health of individual fish.

Zooplankton and fish form most of the potential diet for salmon in the Beaufort Sea (North Pacific Fisheries Management Council, 1997). Zooplankton populations could be subjected to short-term, localized, negative effects from oil spilled as a result of Liberty development (see Sec. III.C.2.e). Nearshore coastal lagoons support seasonal concentrations of zooplankton, which are potential prey for juvenile and adult salmon during summer. If contacted by surface oil, these zooplankton likely would be killed or otherwise affected. Crude or diesel oil spilled between May and September could cause the death of limited numbers of fish of a variety of species that are potential prey for salmon in the Beaufort Sea. Mortality rates would be expected to be low, with the most likely effects on fish being sublethal, including changes in growth, feeding, fecundity and temporary displacement (see Sec. III.C.2.f(1)). Although measurable effects on prey populations would not be expected, any mortality of fish potentially would have an adverse effect on essential fish habitat.

The extent to which marine plants are a component of salmon essential fish habitat, by providing habitat for potential prey, is discussed in the section on lower-trophic-level organisms (Sec. III.C.2.e). Juvenile lifestages of salmon inhabit fresh or estuarine waters and generally feed on insects (North Pacific Fisheries Management Council, 1999). Oil spilled in wetland habitat could kill vegetation and associated insect species and, thus, have an adverse effect on essential fish habitat lasting from less than 10 years to several decades. Because of the predominance of shorefast ice in the Liberty area, there is no resident marine flora in waters less than 6 feet deep. Therefore, no effects are expected on marine plants in those waters. Crude oil that reached benthic marine plants, such as macroalgae inhabiting the Boulder Patch, likely would be weathered and dispersed due to wave action and, thus, have little toxicity. Therefore, little effect would be expected on the exposure of marine life associated with benthic vegetation. On the other hand, spilled diesel fuel would mix deeper into the water column and drift slowly in the same direction as the modeled sediment plume from island construction (Sec. III.C.3.l and Ban et al., 1999). Although spilled diesel would be unlikely to kill plants in the Boulder Patch, seasonal growth could be slowed. Moreover, animal life associated with the Boulder Patch plant community likely would be reduced (Sec. III.C.2.e(2)).

Salmon and their prey require relatively clean water in which to live and perform their basic life functions. Essential fish habitat would be adversely affected to the extent that water quality would be degraded. As discussed extensively in Section III.C.2.l, water quality would be significantly degraded over a fairly large area for a period of from days to months, if a large spill of crude or diesel oil occurred. The relative effect of an oil spill on water quality during times of open water would be relatively long lived and widespread, as compared to times of broken or complete ice cover. The effects of a diesel spill generally would be more acute and widespread than the effects of a crude oil spill under similar environmental conditions.

g. Vegetation-Wetland Habitats

(1) Summary and Conclusion for Effects of an Oil Spill on Vegetation-Wetland Habitats

The main potential effects of a large offshore spill on vegetation and wetland include oil-fouling, smothering, asphyxiation, and poisoning of plants and associated insects and other small animals. In this case, complete recovery of moderately oiled wetlands of the Sagavanirktok River east to Mikkelsen Bay would take perhaps 10 years or longer. A second main effect is the disturbance of wetlands from cleanup activities. Complete recovery of heavily oiled coastal wetlands from these disturbances and oil could take several decades.

A large onshore spill would oil no more than 5 acres of vegetation along the pipeline landfall to the Badami tie-in would cause some ecological harm. Oiled vegetation should recover within a few years but may take more than 10 years to fully recover.

(2) Details on How a Large Oil Spill May Affect Vegetation-Wetlands

(a) General Effects Developing the Liberty Prospect

1) Effects of a Large Onshore Pipeline Spill

A 720-1,142-barrel onshore pipeline spill that would oil no more than 5 acres of vegetation along the pipeline landfall to the Badami tie-in would cause very minor ecological harm. Oiled vegetation should recover within a few years but may take more than 10 years to fully recover.

2) Effects of a Large Offshore Spill

Heavy oiling of saltmarsh vegetation and insects and other small animals in the marshes would kill some plants through fouling, smothering, and asphyxiation and poisoning from direct contact with the oil (Zieman et al., 1984). Oil contamination stunts the growth of saltmarsh vegetation growth, mainly because it stays on the shoots; the effect depends on the amount of oiling and contamination (Scholten, Leendertse, and Blaauw, 1987). On the other hand, sea grasses have been shown to grow well under chronic, low-level exposure to hydrocarbons (McRoy and Williams, 1977). Diesel fuel is more toxic than crude oil and could kill more vegetation, but diesel fuel would evaporate more quickly and not persist in the saltmarsh. Effects on coastal vegetation-wetland habitat would occur only if the offshore spill occurred during summer during open water or meltout during the spring. In winter, bottomfast ice covers the lagoon and coastal shorelines, and snow buffers the oil from the tundra.

3) Effects of Oil-Spill Response

If a large spill were to oil wetland saltmarsh habitats along the coast of Foggy Island during the summer season, hundreds of people operating cleanup equipment in the area would remove some of the oil from the shoreline, particularly on gravel shorelines such as the Endicott causeway, where adsorption booms could be effective in oil recovery. However, the cleanup of contaminated-oiled saltmarshes would be difficult. Oil removal by mechanical means would alter or destroy vegetation, and flushing techniques could drive some of the oil into marsh sediments-soils.

The Alaska Clean Seas tactics (Alaska Clean Seas, 1998) that rely on the use of mechanical equipment on marshes might cause significant adverse impacts, as acknowledged for Tactic SH-6. Spill responses that use mechanical tilling for aeration and remediation of shoreline sediments might lead to erosion/accretion and effects on biota, as acknowledged for Tactic SH-8. Spill responses that use chemicals on oiled shorelines would affect biota, as acknowledged by Tactic SH-11. Spill responses that involve in situ burning would affect shoreline biota, especially relatively dry shoreline biota, as acknowledged by Tactics SH-10 and 11.

The use of fertilizers or other additives to oiled marshes may enhance biodegradation of the oil, but cold temperatures in the Arctic would lessen the effectiveness of these techniques. Oil contamination of saltmarshes is likely to persist for several years after cleanup activities have ended.

(b) Specific Effects of a Large Oil Spill from BPXA's Proposed Liberty Development and Production Plan

1) Effects of a Large Onshore Spill

We assume that if a large onshore pipeline spill occurred, it would oil less than 5 acres of vegetation along the pipeline landfall to the Badami tie in. Such an onshore spill likely would occur on the gravel pad near the tie-in location and should have only a minimal effect on vegetation. About 20-35% of past crude oil spills reached areas beyond the pads (USDOI, BLM and MMS 1998). Because winter spans most of the year, spills happen about 60% of the time when workers can clean up oil on the snow cover before it reaches the vegetation (USDOI, BLM and MMS 1998). Most spills cover less than 500 square feet, or 0.01 acres, but may cover up to 4.8 acres if the spill is a windblown mist. Overall, past spills on Alaska's North Slope have caused minor ecological damage, and the ecosystem has shown a good potential for recovery (Jorgenson, 1997).

Rehabilitation of an oiled site on the Kuparuk oil field has resulted in the robust growth of grasses-sedges within 2 years, but recovery of shrubs has been slow—up to 7 years after the spill (Cater, Rossow, and Jorgenson, 1999).

2) Effects of a Large Offshore Spill

The spill assumed to occur at Liberty Island or from the buried pipeline and enter offshore waters would contact coastal areas within 30 days from the Sagavanirktok River Delta and Endicott causeway east to Mikkelsen Bay, regardless of which spill scenario is assumed (Table A-1). These areas include wetlands and other vegetation cover (estimated 21-45 kilometers of coastline oiled from a crude oil spill Table A-7). We focus on effects expected should a spill contact vegetation and wetlands within 30 days during summer.

The conditional probability of an oil spill starting at Liberty Island or along the pipeline and contacting vegetation within 30 days during the summer-open-water season are highest with wetlands in the Foggy Island Bay area west to the Sagavanirktok River Delta. The Oil-Spill-Risk Assessment model estimates an 11-26% chance of a spill starting at Liberty Island or subsea pipeline and entering offshore waters contacting land segments 27, 26, or 25 (Tables A-13 and A-19). Overall, the model estimates that there is an 87% conditional probability that a spill starting at Liberty Island (L1) or along the pipeline (P1 or P2) would contact land somewhere along the coast within 30 days during the summer (Table A-12 Land, all land segments, Map A-1). The spill could oil an estimated 21-30 kilometers of shoreline (Table A-7) and extend inshore a few feet to several yards, depending on tides and storm surges. A 1,500-barrel diesel spill would dissipate quickly and would not be expected to persist beyond about 6 days. The amount of wetlands contacted by diesel fuel is expected to be less than that contacted by crude oil. Coastal areas to the east, such as the Camden Bay shoreline, are unlikely to see oil spilled from the project area (1-2% conditional probability that a spill starting at Liberty Island (L1) or along the pipeline (P1 or P2) and contacting Land Segments 31-33, Tables A-13 and A-19, Map A-1). The shoreline of the Liberty Project area contains habitats with fairly high values (1 being the lowest and 10 being the highest) for oil-spill retention (lagoonal beaches have a value of 5 and peat shores have a value of 6) along the eastern Sagavanirktok River Delta and near the mouth of the Kadleroshilik River (Nummedal, 1980). Stranded oil on sheltered intertidal areas, especially along peat shorelines, is likely to persist for many years (Nummedal, 1980; Owens et al., 1983). Complete recovery of moderately oiled wetland in the Sagavanirktok River, Foggy Island Bay, and Mikkelsen Bay shorelines would take up to perhaps 10 years for crude oil and probably less than 5 years for diesel fuel.

h. Subsistence-Harvest Patterns

(1) Summary and Conclusion for Effects of an Oil Spill on Subsistence-Harvest Patterns

The chance of an oil spill greater than or equal to 500 barrels occurring from the offshore production island and the buried pipeline and entering the offshore waters is estimated to be low (Sec. III.C.1.d). Based on the assumption that a spill has occurred, the chance of an oil spill during summer from either Liberty Island or the pipeline contacting important traditional bowhead whale and seal harvest areas of Cross and McClure Islands over a 360-day period would be 16% or less. A spill also could affect other subsistence resources and harvest areas used by the communities of Nuiqsut and Kaktovik. For crude oil or diesel fuel spills, conditional probabilities have been used to determine the likelihood of oil contact with subsistence-resources areas (see a detailed discussion under How Oil Spill Contact May Affect Subsistence-Harvest Patterns, below).

Overall, oil spills could affect subsistence *resources* periodically in the communities of Nuiqsut and Kaktovik. If an oil spill occurred and affected any part of the bowhead whale's migration route, it could taint this culturally important resource. In fact, even if whales were available for the spring and fall seasons, traditional cultural concerns of tainting could make bowheads less desirable and alter or stop the subsistence harvest. Tainting concerns also would apply to polar bears and seals. Additionally, a large oil spill could cause potential short-term but serious adverse effects to oldsquaw and king and common eider populations. A potential loss of one or two polar bears could reduce their availability locally to subsistence users, although they are seldom hunted by Nuiqsut hunters except opportunistically while in pursuit of more preferred subsistence resources.

No harvest areas would become unavailable for use and all resources, except possibly bowhead whales, would remain available for use. Some resource populations could suffer losses and, as a result of tainting, bowhead whales could be rendered culturally unavailable for use. Tainting concerns in communities nearest a spill event could seriously curtail traditional practices for harvesting, sharing, and processing bowhead whales and threaten a pivotal underpinning of Inupiat culture. Whaling communities unaffected by potential spill effects are likely to share bowhead whale products with impacted villages. Harvesting, sharing, and processing of other subsistence resources should continue.

(2) Details on How a Large Oil Spill May Affect Subsistence-Harvest Patterns

(a) General Effects from Developing the Liberty Prospect

1) Effects from Oil Spills

Three potential spill scenarios are analyzed:

- a crude oil pipeline spill ranging from 715-2,956 barrels,
- a 925-barrel crude oil spill on the Liberty gravel island, and
- a 1,500-barrel diesel fuel spill on the Liberty gravel island.

The pipeline crude oil spill is analyzed in four ways:

- a complete cut of the pipeline, causing a 1,580-barrel spill;
- a chronic leak in the pipeline, causing a spill ranging from 715 barrels in open water/broken ice over a 7-day period to a 2,956-barrel spill under ice for a 30-day period (leak detection not working);
- a 125-barrel spill from a pipeline leak (leak detection working and spill detected in 24 hours), and
- a no-leak/no-spill scenario (with no breaches in the pipe-in-pipe systems and the leak detection working).

General effects from oil development could be expected from potential oil spills and tainting and cleanup disturbance that could occur after such a spill event. An oil spill affecting any part of the migration route of the bowhead whale could taint a resource that is culturally pivotal to the Inupiat. Even if whales were available for the spring and fall hunts, tainting concerns of could leave bowheads less desirable and alter or stop the subsistence hunt. Communities unaffected by a potential spill would share bowhead whale products with impacted villages, and the harvesting, sharing, and processing of other resources should continue. Concerns about tainting would apply also to polar bears and seals, and a large oil spill could cause potential short-term but serious adverse effects to some bird populations. A potential loss of a small number of polar bears would reduce their local availability to subsistence users. Oil-spill cleanup activities could produce additional effects on subsistence activities, potentially causing displacement of subsistence resources and subsistence hunters.

2) Effects on Subsistence Resources

a) Bowhead Whales

The potential for bowhead whales to be affected by spilled oil from the Liberty Project is relatively small, based on the estimated size of a spill and the relatively low chance of spilled oil reaching the main bowhead fall migration route outside the barrier islands (14% or less). However, if a spill occurred and contacted bowhead habitat during the fall whale migration, it is likely that some whales would be contacted by oil. It is likely that some of these whales would experience temporary, nonlethal effects (see Sec. III.C.2.a(1)). Traditional practices for harvesting, sharing, and processing subsistence resources could be seriously curtailed in the short term, if there are concerns over the tainting of bowhead whales or their feeding areas from an oil spill.

Barrow elder Thomas Brower, Sr., observed an oil spill from a U.S. Navy vessel in the Plover Islands east of Barrow in 1944 where about 25,000 gallons was spilled. According to Brower: "for four (4) years after that oil spill, the whales made a wide detour out to sea from these islands. Those native families could no longer hunt whales during these years at that location" (Brower, as cited in North Slope Borough, Commission on History and Culture, 1980). Although this event represents a seriously long interruption to normal bowhead whaling in the area, it does also reveal that species can experience recovery from an oil spill in the arctic after 4 years.

b) Seals and Polar Bears

Assuming a summer pipeline spill of 715-1,580 barrels, a pipeline spill of 715-2,956 barrels in broken ice or meltout, a 925-barrel platform crude oil spill, or a 1,500-barrel diesel fuel spill occurs at Liberty Island, seals and polar bears most likely would contact the spill offshore in the Prudhoe Bay, Foggy Island Bay, and Mikkelsen Bay areas. The main potential effect to seals and polar bears that contact crude oil or diesel fuel would be the loss of a range of about 9-300 ringed seals (out of a resident population of 40,000), fewer than 100 bearded seals (based on their sparse distribution in the project area out of a population of several thousand), and polar bears (probably no more than 10-15 out of a population of 1,300-2,500). The estimated 10-15 polar bears lost from a spill represents a severe event. The more likely loss from Liberty development would be no more than one or two bears, assuming a bear density of one bear per 30-50 square miles. If a smaller spill occurs, fewer seals and polar bears are expected to be affected. The seal populations are expected to recover individuals killed by the spill within 1 year and have no effect on the population.

If a larger spill (2,956 barrels) occurs during fall freezeup or melts out of the ice during spring breakup, significant effects to polar bears could occur. Polar bears are most likely to be oiled or eat oiled prey, such as a whale carcass on Cross Island or a concentration of seals in Foggy Island Bay. Perhaps an estimated 10-15 bears may be harmed. However, the probability of this occurrence is low. Therefore, the effect on the polar bear population is expected to be negligible (see Sec. III.C.2.b).

In the same oil-spill narrative mentioned above, Thomas Brower, Sr., stated that:

> In the cold, Arctic water, the oil formed a mass several inches thick on top of the water. Both sides of the barrier islands in that area—the Plover Islands—became covered with oil. That first year, I saw a solid mass of oil six (6) to ten (10) inches thick surrounding the islands. On the seaward side of the islands, a mass of thick oil extended out sixty (60) feet from the islands, and the oil slick went much further offshore than that. I observed how seals and birds who swam in the water would be blinded and suffocated by contact with the oil. It took approximately four (4) years for the oil to finally disappear (Brower as cited in North Slope Borough, Commission on History and Culture, 1980).

Again, it should be noted that some species' recovery was seen after 4 years.

c) Caribou

Spilled crude oil or diesel fuel is most likely to contact some coastal areas from Prudhoe Bay and the Sagavanirktok River Delta east to Mikkelsen Bay, regardless of which spill scenario is assumed. Caribou may use some of these areas for relief from insects. The main potential effect on terrestrial mammals that contact spilled oil could be the loss of fewer than 100 caribou and a few muskoxen, grizzly bears, and arctic foxes. These losses are expected to be replaced by normal reproduction within about 1 year. An onshore pipeline spill could occur and oil less than 5 acres of vegetation along the pipeline landfall to the Badami tie-in. Such a spill is not expected to directly affect caribou or other terrestrial mammals and would cause very minor ecological harm (see Sec. III.C.2.d).

d) Fishes

Likely effects on arctic fishes from a large oil or diesel fuel spill assumed to occur at Liberty Island or from the buried pipeline would depend primarily on the season and location of the spill, the lifestage of the fishes (adult, juvenile, larval, or egg), and the duration of the oil contact. Due to their very low numbers in the spill area, no measurable effects are expected on fishes in winter. Effects would be more likely to occur from an offshore oil spill moving into nearshore waters during summer, where fishes concentrate to feed and migrate. The probability of an offshore oil spill contacting nearshore waters in summer ranges from less than 1-26%. If an offshore spill did occur and contact the nearshore area, some marine and migratory fish may be harmed or killed. However, it would not be expected to have a measurable effect on fish populations and recovery would be expected within 5 years. In general, the effects of fuel spills on fish are expected to be less than those of crude-oil spills (see Sec. III.C.2.f).

e) Birds

An oil or diesel fuel spill would have the highest probability of contacting nearshore and offshore areas of Foggy Island Bay and the eastern Sagavanirktok River Delta, where waterfowl and other aquatic birds may be staging before migration. Mortality from a spill contacting oldsquaw in lagoons or other protected nearshore areas, where the entire regional population molts, is expected to exceed 3,000 individuals and could range much higher (3% to more than 20% of the average coastal plain population), if oil were to contact areas of high bird density. This potentially could result in at least a short-term (a few years) significant adverse effect on population numbers and productivity, especially if many of those molting in this area come from declining subpopulations in northwestern Canada. Oldsquaw mortality from spill contact outside barrier islands is likely to be a few thousand or less. Flocks of staging eiders could contact oil in areas farther offshore. King and common eider populations have declined 50% in the past 20 years, and substantial oil-spill mortality would aggravate this effect. For most species other than oldsquaw, the relatively small losses likely to result from a spill may be difficult to separate from the natural variation in population numbers, but they are not expected to require lengthy recovery periods. Species that are declining in numbers, such as king and common eiders, are expected to recover from oil spill mortality more slowly than if their numbers were stable.

A spill that enters open water off river deltas in spring could contact migrant loons and eiders. Some of the several hundred broodrearing, molting, or staging brant and snow geese could contact oil in coastal habitats. Also, several thousand shorebirds could encounter oil in shoreline habitats, and the rapid turnover of migrants during the migration period suggests that many more could be exposed. Effects are expected to be similar to those outlined above. An onshore pipeline spill in summer probably would affect only a few nests even considering all species. If the oil spread to streams or lakes, oldsquaw, brant, and greater white-fronted geese that gather on large lakes to molt could be adversely affected in larger numbers. Losses of oiled birds in this case could range up to a few hundred individuals, a minor effect for species whose populations are relatively abundant and stable or increasing. Reduction of prey populations from an oil or diesel fuel spill may reduce foraging success of shorebirds and sea ducks that depend on this local energy source for molt or migration, but alternate habitat is available during the open-water season following breeding period (see Sec. III.C.2.c).

3) Effects of Cleanup Activities on Subsistence Resources and Harvests

Disturbance to bowhead whales, seals, polar bears, caribou, fish, and birds potentially could increase from oil-spill cleanup activities. Offshore, skimmers, workboats, barges, aircraft overflights, and in situ burning during cleanup temporarily could cause whales to alter their swimming direction. Such displacement could cause some animals, including seals in ice-covered or broken-ice conditions, to avoid areas where they normally are harvested or to become more wary and difficult to harvest. People and boats offshore; and people, support vehicles, and heavy equipment onshore, as well as the intentional hazing and capture of animals could disturb coastal resource habitat, displace subsistence species, alter or reduce subsistence-hunter access to these species, and alter or extend the normal subsistence hunt. BPXA's Oil Discharge Prevention and Contingency Plan (BPXA, 2000b) includes a series of four scenarios for cleaning up oil in open water, solid ice, and broken ice. These scenarios identify logistics, equipment, and tactics for the various cleanup responses. Spill cleanup would reduce the amount of spilled oil in the environment and tend to mitigate spill-contamination effects. In the case of a winter spill, when few important subsistence resources are present, cleanup is likely to be fairly effective in dealing with a spill before migrating whales and other species return to the area during breakup and the open-water season. Far from providing mitigation, oil-spill cleanup activities should more likely be viewed as an additional impact, potentially causing displacement of subsistence resources and subsistence hunters (see Impact Assessment, Inc., 1998)

4) How Stipulations or Mitigating Measures Help Reduce Oil-Spill Effects

Mitigating measures from Beaufort Sea Sale 144 are in place for Liberty development, and this assumption is reflected in discussions about effects. Mitigation that would apply to subsistence-harvest patterns includes the stipulation on the Orientation Program (see Sec.I.H.6(b), Mitigation Analyzed in this EIS).

The Orientation Program stipulation requires the lessee to educate people working on exploration, development, and production about the environmental, social, and cultural concerns that relate to the area and its communities. The program should increase workers' sensitivity to, and understanding of, values, customs, and lifestyles of local Native communities and help prevent any conflicts with subsistence activities. BPXA's standard North Slope Environmental and Cultural Awareness training in the form of BPXA's "Achieving Environmental Excellence" program will form the foundation for environmental orientation for all personnel and contractors involved in Liberty offshore development. This program will be expanded to address specific issues of concern related to wildlife interaction, protection of marine mammals, best management practices to minimize the potential for spills, awareness of local sociocultural issues and concerns, and awareness of subsistence resources and activities. BPXA currently is developing a video to be used in the training; development of this video will be coordinated with the MMS. The overall training program will be submitted to the Regional Supervisor, Field Operations for review and approval. Personnel will receive appropriate training on at least an annual basis, and full training records will be maintained for at least 5 years.

(b) Specific Effects of a Large Oil Spill from BPXA's Proposed Liberty Development and Production Plan

How Oil Spill Contact May Affect Subsistence-Harvest Patterns: Crude oil spill sizes vary by season with a platform or pipeline spill of 715-1,580 barrels analyzed for the open-water/broken-ice season, and a platform or pipeline spill of 125-2,956 barrels analyzed for the solid-ice season.

Oil-spill contact in winter could affect polar bear hunting and sealing. During the open-water season, a spill could affect bird hunting, sealing, and whaling, as well as netting of fish in the ocean. During the summer, the chance of a crude oil spill of 715-1,580 barrels from the Liberty Island offshore portion of the pipeline contacting important Nuiqsut Environmental Resource Areas 56 (Cross Island and No Name Islands), 29 (Cross Island Whaling Area), 30 (Cross Island Whaling Area), 31(Cross Island Whaling Area), 58 (McClure Islands), 62 (Flaxman Island, an important polar bear denning area), and 55 (Midway Islands) ranges from a 3-12% chance of contact over a 30-day period and from a 4-13% chance over a 360-day period. Winter contact percentages are less for a 30-day period, ranging from 1-4% but are slightly higher over a 360-day period ranging from 5-19% (see Map 9 and Table A-1).

The chance of a summer spill (920-barrel crude oil spill or a 1,500-barrel diesel fuel spill with no diesel remaining after 7 days) originating from the Liberty gravel Island contacting important Nuiqsut environmental resource areas ranges from a 4-15% chance of contact over a 30-day period and from a 5-15% chance over a 360-day period. Percentages for winter contact are less for a 30-day period, ranging from 1-4% over a 30-day period but are slightly higher over a 360-day period, ranging from 7-21% (see Map 9 and Table A-1).

The potential for bowhead whales to be affected by spilled oil from the Liberty Project is relatively small, based on the estimated size of a spill and the relatively low chance of spilled oil reaching the main bowhead subsistence-harvest areas in summer or fall (15% or less).

Land Segments 18 through 28 (from the Colville River Delta to Bullen Point) and Environmental Resource Area 59 (Tigvariak Island) include areas historically used by Nuiqsut subsistence hunters to harvest caribou, waterfowl, marine fish, polar bears, and small furbearers. Percentages of contact from a pipeline spill for summer range from 0-33% over both 30- and 360-day periods, with the highest percent contact occurring in Land Segment 26, the segment directly onshore of the Liberty Island. This is not an area of high subsistence use at the present time. More recently, hunting appears to take place nearer to the community, and onshore areas of primary importance on the Colville River Delta (Land Segments 18 and 19) have percentages of contact ranging from 0-1% for both the 30- and 360-day periods. Winter percentages for these land segments and Environmental Resource Area 59 are less, ranging from 0-5% over a 30-day period and 1-30% over a 360-day period (see Map 9 and Table A-1).

Percentages of contact from summer offshore platform spills range from 1-26% over both 30- and 360-day periods, with the highest percent of contact occurring in Land Segment 26, the segment directly onshore of the Liberty Island. The onshore areas of primary importance on the Colville River Delta (Land Segments 18 and 19) have percentages of contact ranging from 0-1% for the 30-day period and 0-2% for the 360-day period. Winter percentages for Land Segments 18-28 and Environmental Resource Area 59 are less, ranging from 0-5% over a 30-day period and 1-27% over a 360-day period. The potential risk of oil spill contact to onshore subsistence harvest areas and their resources is very low (see Map 9 and Table A-1).

Important environmental resource areas for Kaktovik are Environmental Resource Areas 47 (Kaktovik Whaling Area) and 44 (Camden Bay), and Land Segments 32 through 37, which contain Kaktovik harvest areas for caribou, waterfowl, fish, and seals. Percentages of contact for offshore pipeline spills for summer range from 0-2% over a 30-day period and 0-3% over a 360-day period. For winter, spill contact is zero for the 30-day period and ranges from 0-3% for the 360-day period (see Map 9 and Table A-1).

Percentages of contact from summer offshore platform spills originating from the Liberty gravel Island and contacting important Kaktovik Environmental Resource Areas 47 (Kaktovik Whaling Area) and 44 (Camden Bay), and Land Segments 32 through 37 range from 0-3% chance of contact over the 30-and 360-day periods. Winter percentages are much less, with a near 0% chance of contact over a 30-day period and a 0-2% chance of contact over a 360-day period. The potential for bowhead whales to be affected by spilled oil from the Liberty Project is relatively small, based on the estimated size of a spill and the relatively low chance of spilled oil reaching Kaktovik's main bowhead subsistence-harvest areas (3% or less). The potential risk of oil-spill contact to onshore subsistence harvest areas and their resources is very low (see Map 9 and Table A-1).

Additionally, the chance of spills originating from the nearshore portion of the pipeline and contacting the environmental resource areas and land segments referenced above for Nuiqsut and Kaktovik is the same or slightly less than from the offshore portion of the Liberty pipeline and, therefore, is not analyzed here.

(c) Native Views on Oil Spills

1) Nuiqsut's Views on Oil Spills

Ruth Nukapigak from Nuiqsut spoke in 1983 about the effects she had seen from drilling nearby. She had discovered that fish are afraid of suds or foam and had seen oil in the water. She had heard that when there is an oil spill, it's cleaned up with suds or foam. For those living in Nuiqsut, she believes their food is really going to change

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from what the oil companies are going to be doing (Nukapigak, 1983, as cited in USDOI, MMS, 1983a). Maggie Kovalsky, also from Nuiqsut, expressed the same fear about effects on Nuiqsut's subsistence foods. She explained that if a spill ever happened, she thinks it would harm a lot of the food they depend on, such as fish and bowhead whale and duck (Kovalsky, 1984). Nuiqsut elder Sarah Kunaknana was worried that an oil spill could occur and damage the habitat of the bowhead whales and other sea mammals (Kunaknana, 1990, as cited in USDOI, MMS, 1990d).

In a Statewide survey conducted from 1992-1994 by the Alaska Department of Fish and Game, Division of Subsistence, 80% of the respondents in Nuiqsut believed that industry could not contain and clean up a large oil spill. A similar question about containing and cleaning up a small oil spill got negative responses from 60% of the people in Nuiqsut (State of Alaska, Dept. of Fish and Game, 1995a). Ice forces can be unpredictable, and Frank Long, Jr., a whaler from Nuiqsut, expressed local concern that an oil spill could be caused by ice scraping a pipeline or drill pipe, and the resulting spill would damage the entire food chain (Long, 1995, as cited in USDOI, MMS, 1995a). In 1996, people in Nuiqsut reiterated their belief that technology does not exist to clean up an oil spill under the ice; they believe it is a matter of when a spill will occur, not if it will occur. They want assurance against disaster and impact funds set aside for them in case this happens (Dames and Moore, 1996b).

Issues about using local expertise and people are prevalent in Nuiqsut. Leonard Lampe, Nuiqsut's current mayor, reported:

> As a member of the village oil spill-response team, we were not allowed to go out onto the ice even for drills under certain very dangerous conditions. So what if a spill occurs under those conditions? There will be no way to clean it up (Lampe, 1995, as cited in USDOI, MMS, 1995a).

2) Kaktovik's Views on Oil Spills

Over many years, Kaktovik has voiced its concerns over ice hazards to oil rigs and possible oil spills. In 1979, Philip Tiklul from Kaktovik observed that the ice movements are strong enough to damage an oil rig and cause a spill (Tiklul, 1979, as cited in USDOI, MMS, 1979b). Kaktovik subsistence hunter Jonas Ningeok explained that the weather is very unpredictable. Sudden snowstorms can be dangerous. Pressure ridges may form in the ice, damage the oil rig, and cause a spill (USDOI, MMS, 1990b). At the same hearing in 1990, Nolan Soloman expressed a similar concern when he stated that oil rigs may fail under the strain of the ice (Soloman, 1990, as cited in USDOI, MMS, 1990b). Recently, Fenton Rexford, President of Kaktovik Inupiat Corporation and subsistence hunter, declared that the:

> Inupiat…here in Kaktovik are adamantly against offshore production until there is proven technology of a cleanup of an oil spill under ice-infested waters. It wasn't quite proven yet on onshore even… (Rexford, 1996, as cited in Dames and Moore, 1996d).

Kaktovik residents have often spoken about the threat from oil spills to subsistence food resources. Herman Rexford voiced concern in 1982 that an oil spill would damage the food the whales live on (Rexford, 1982, as cited in USDOI, MMS, 1982a). During public hearings in 1995, whaling captain Isaac Akootchook worried that an oil spill could occur under the ice and go unnoticed, causing significant damage to subsistence resources (Akootchook, 1995, as cited in USDOI, MMS, 1995c). At hearings for the Northstar project, Fenton Rexford said:

> We know there are a lot of waterfowl that come from all over the world that go through this area…so that is one of…the issues I would like to see in here [the EIS]. They come from all over the world for only a 3-month period, and if there is a spill, that would have a drastic effect (Rexford, 1996, as cited in Dames and Moore, 1996d).

3) Barrow's Views on Oil Spills

Barrow is very concerned about oil spills, particularly oil-spill response. In 1983, Percy Nusunginya from Barrow related:

> This summer there was supposed to be a demonstration on oil spill response but the weather did not cooperate in the Arctic, so we will expect the industry to have an oil spill on a calm day" (Nusunginya, 1983, as cited in USDOI, MMS, 1983b).

Don Long from Barrow stated in 1990:

> Any disruption, whether it be oil spill or noise, would only disturb the normal migration [of bowhead whales], and a frightened or a tense whale is next to impossible to hunt" (Long, 1990, as cited in USDOI, MMS, 1990c).

Eugene Brower from Barrow expressed the general concern that spill-cleanup procedures under ice do not exist (Brower, 1990, as cited in USDOI, MMS, 1990c) and, similarly, in the 1995 hearings in Barrow, Edward Hopson asserted that technology is not in place to deal with spills in the Arctic Ocean (Hopson, 1995, as cited in USDOI, MMS, 1995a). Marie Adams, also from Barrow, observed that an oil spill in the "fragile ecosystem" of the Arctic could devastate the bowhead whale because these animals migrate through "narrow open-lead systems," which could be the preferred path of an oil spill (Adams, 1990, as cited in USDOI, MMS, 1990c).

Having been a whaler since 1916, Thomas P. Brower, Sr., from Barrow, in a 1978 interview, gave an extraordinary account of this oil spill in the Arctic and its effects:

> I have also seen how sensitive the whales are to water pollution. The commercial whaling ships would always avoid pumping their bilge tanks in the whaling areas. I observed that if some bilge water had to go over the side, it would always be first strained and cleaned before dumping. In 1944, I saw the effects of an oil spill on Arctic wildlife, including the bowhead. I had been asked to be on the flagship [the *U.S.S. Spica*] of a Navy convoy moving along the Beaufort Sea coast. While I was on the flagship, I saw twenty (20) other ships including several Navy oil tankers. In August 1944 one of the cargo ("Liberty") ships [the *S.S. Jonathan Harrington*] ran aground on a sandbar off Doctor Island in Elson Lagoon, southeast of Utqiagvik [Barrow]. They needed to lighten the ship to get free. To my disgust, instead of bringing up a tanker to transfer the cargo, they simply dumped the oil into the sea. About 25,000 gallons of oil were deliberately spilled into the Beaufort Sea in this operation. In the cold, Arctic water, the oil formed a mass several inches thick on top of the water. Both sides of the barrier islands in that area--the Plover Islands--became covered with oil. That first year, I saw a solid mass of oil six (6) to ten (10) inches thick surrounding the islands. On the seaward side of the islands, a mass of thick oil extended out sixty (60) feet from the islands, and the oil slick went much further offshore than that. I observed how seals and birds who swam in the water would be blinded and suffocated by contact with the oil. It took approximately four (4) years for the oil to finally disappear. I have observed that the bowhead whale normally migrates close to these islands in the fall migration. Native families living in the area of Utqiagvik and Elson Lagoon were accustomed to catching small whales in the fall for the winter food supply. But I observed that for four (4) years after that oil spill, the whales made a wide detour out to sea from these islands. Those native families could no longer hunt whales during these years at that location...If there were a major blowout, all the Inupiat could be faced with the end of their marine hunting, just as those families near Elson lagoon suffered in 1944 through 1948. (North Slope Borough, Commission on History and Culture, 1980).

(d) Factors Affecting Subsistence-Harvest Patterns in Nuiqsut and Kaktovik

There is a heavy reliance on caribou in the annual average harvest for Nuiqsut (30-37% of the total subsistence harvest) and Kaktovik (11-16% of the total subsistence harvest) (see Table VI.B-4; Stoker, 1983, as cited by Alaska Consultants, Inc, (ACI)/Braund, 1984; S.R. Braund 1989; State of Alaska, Dept. of Fish and Game 1995b; S.R. Braund and Assocs. and the Institute for Social and Economic Research, 1993; Pedersen, 1995a, 1995b; S.R. Braund and Assocs., 1996).

There is a heavy reliance on bowhead whales in the annual average harvest for Nuiqsut (4-38% of the total subsistence harvest) and Kaktovik (27-63% of the total subsistence harvest). Percentages have continued to rise, because International Whaling Commission quotas have almost doubled in recent years (see Table VI.B-4; Stoker, 1983, as cited by ACI and S.R. Braund and Assocs., 1984; S.R. Braund and Assocs. 1989; State of Alaska, Dept. of Fish and Game, 1995b; North Slope Borough Planning Dept., 1993; Kaleak, 1996).

There is a reliance on fish in the annual average harvest for Nuiqsut (33-44% of the total subsistence harvest) and Kaktovik (13-21% of the total subsistence harvest) (see Table VI.B-4; S.R. Braund and Assocs. 1989; State of Alaska, Dept. of Fish and Game 1995b).

The values of hunting and fishing are central to the Inupiat way of life and culture.

Nuiqsut and Kaktovik are small North Slope Inupiat villages chiefly depending on subsistence resources. In 1990, Nuiqsut's population was 354 and Kaktovik's was 224. In 1997, the State of Alaska, Department of Labor's population estimates for Nuiqsut was 410 and Kaktovik's was 222 (State of Alaska, Dept. of Fish and Game, 1995b; State of Alaska, Dept. of Labor, 1998).

Map 9 shows subsistence-resource areas for Nuiqsut. It reflects important harvest areas for marine mammals that would be vulnerable if an oil spill occurred and contacted these areas. For a more detailed description of oil-spill effects on subsistence resources, see Section IV.B.9 of the Beaufort Sea Sale 170 Final EIS (USDOI, MMS, 1998). As in the preceding discussion, we have included indigenous Inupiat knowledge on potential effects to harvests and resources in the following discussion.

(e) The Cultural Importance of Subsistence

Eugene Brower testified in Barrow at the public teleconference for our draft EIS on the 1997-2002 5-Year Oil and Gas Leasing Program for the OCS. He asserted the importance of the subsistence harvest to Inupiat lifeways in the Chukchi and Beaufort Seas:

> These two oceans produce the main food supply for the Inupiat people living off the two oceans. And these two oceans are our garden. They may not produce oranges or apples or sauerkraut or cauliflower, cattle, or chicken, but they produce the food that keeps us alive. You may not like how we eat it, but the good Lord put these animals in this region so that we, The Inupiat, can live off these

> animals (Brower, 1996, as cited in USDOI, MMS, 1996b).

Frank Long, Jr., President of the Nuiqsut Whaling Captains Association, expressed the importance of the bowhead whale hunt to the Inupiat way of life at an Arctic Synthesis Meeting we convened in Anchorage, Alaska, in 1995:

> We know that whaling is dangerous, but it is our livelihood. We have to supply our community's nutritional needs for the winter. The captain doesn't get the whole whale; after it is harvested, it belongs to the whole community. We share it… (Long, 1996).

In 1994, Glenn Roy Edwards, whaler and Arctic Slope Regional Corporation official, related:

> Without whaling, there would be no purpose to Barrow. I depend on my job; I like my job. But if it came down to a choice, I'd leave it to come out here and go whaling. I am first a whaler (Balzar, 1994).

i. Sociocultural Systems

(1) Summary and Conclusion for Effects of an Oil Spill on Sociocultural Systems

Effects on the sociocultural systems of communities of Nuiqsut and Kaktovik could come from disturbance from small changes in population and employment and periodic interference with subsistence-harvest patterns from oil spills and oil-spill cleanup. Effects from these sources are not expected to displace ongoing sociocultural systems, but community activities, and traditional practices for harvesting, sharing, and processing subsistence resources could be seriously curtailed in the short term, if there are concerns over the tainting of bowhead whales from an oil spill.

(2) Details on How a Large Oil Spill May Affect Sociocultural Systems

(a) General Effects from Developing the Liberty Prospect

Effects on sociocultural systems of local communities could come from disturbance from small changes in population and employment, periodic interference with subsistence-harvest patterns from oil spills and oil-spill cleanup, and stress due to fears of a potential spill and the disruptions it would cause. Traditional practices for harvesting, sharing, and processing subsistence resources could be seriously curtailed in the short term if there are concerns over the tainting of bowhead whales from an oil spill, but overall effects from these sources are not expected to displace ongoing sociocultural systems. Oil-spill employment (response and cleanup) could disrupt subsistence-harvest activities for at least an entire season and disrupt some sociocultural systems, but most likely, it would not displace these systems. The sudden employment increase could have sudden and significant effects, including inflation and displacement of Native residents from their normal subsistence-harvest activities by employing them as spill workers. Cleanup employment of local Inupiat could also alter normal subsistence practices and put stresses on local village infrastructures by drawing local workers away from village service jobs.

(b) Specific Effects of a Large Oil Spill from BPXA's Proposed Liberty Development and Production Plan

1) Effects of an Oil Spill on Sociocultural Systems

Effects on the sociocultural systems of communities of Nuiqsut and Kaktovik could come from disturbance from small changes in population and employment and periodic interference with subsistence-harvest patterns from oil spills and oil-spill cleanup. Effects from these sources are not expected to displace ongoing sociocultural systems, but community activities, and traditional practices for harvesting, sharing, and processing subsistence resources could be seriously curtailed in the short term, if there are concerns over the tainting of bowhead whales from an oil spill.

Because Liberty development is enclave based, stresses to the local village infrastructure, health care, and emergency response systems are expected to be minimal. Demands on local village infrastructures from construction, operation, maintenance, and abandonment from the Liberty Project would not be expected, because all these activities would be staged out of Prudhoe Bay or the Liberty production island itself.

Stress created by the fear of an oil spill also is a distinct predevelopment impact-producing agent within the human environment. Stress from this general fear can be broken down to the particular fears of:

- being inundated during cleanup with outsiders who could disrupt local cultural continuity;
- the damage that spills would do to the present and future natural environment;
- drawn out oil-spill litigation;
- contamination of subsistence foods;
- lack of local resources to mobilize for advocacy and activism with regional, State, and Federal Agencies;
- lack of personal and professional time to interact with regional, State, and Federal agencies;
- retracing the steps (and the frustrations involved) taken to oppose offshore development;
- responding repeatedly to questions and information requests posed by researchers and regional, State, and Federal outreach staff; and
- needing to employ and work with lawyers to draft litigation to attempt to stop proposed development.

A State of Alaska Department of Fish and Game social-effects survey administered by the Division of Subsistence Management in 1994 in Nuiqsut included questions on effects from outer continental shelf development. Sixty-percent of the respondents did not believe a small oil spill could be contained or cleaned up, and 80% did not believe a large oil spill could be contained or cleaned up. The overall study on 21 Alaskan communities concluded that impacts persist from the *Exxon Valdez* oil spill on subsistence use and the social and cultural system that subsistence activities support (Fall and Utermohle, 1995; Impact Assessment, Inc., 1998; Field et al., 1999).

A study by Picou et al. (1992) showed that 18 months following the *Exxon Valdez* spill, residents of Cordova had experienced long-term negative social effects—disruption to work roles and increased personal stress. Additionally, they observed that:

> work disruption was correlated with intrusive stress…and fishermen experienced more work disruption than…other occupations. It may be possible that other natural resource community activities such as participation in subsistence harvests…may identify subpopulations more vulnerable to long-term negative social impacts (Picou et al., 1992).

Another good source of information on spill effects is the Social Indicators Study of Alaskan Coastal Villages, Volume VI: Analysis of the *Exxon Valdez* Spill Area, 1988-1992 (Human Relations Area Files, Inc., 1994). The summary of findings section affirmed that, immediately after the spill and continuing into early 1990, Native people decreased their harvests of wild resources and relied on preserved foods harvested before the spill. By the winter of 1991, the Natives' normal harvesting activities had begun to resume, but the proportions of wild foods in their diets remained below those of 1989. The study also demonstrated in its analysis that non-Natives and Natives "define the environment and resources within the environment very differently. Commodity valuation takes precedence" for non-Natives and "instrumental use and cultural and spiritual valuation take precedence" for Native people (Human Relations Area Files, Inc., 1994).

2) Effects of Cleanup Activities on Sociocultural Systems

The likelihood of an oil spill from Liberty development is low. However, if one occurred, oil-spill employment (response and cleanup) could disrupt subsistence-harvest activities for at least an entire season and disrupt some sociocultural systems. Most likely, it would not displace these systems. If a large spill contacted and extensively oiled coastal habitats, the presence of hundreds of humans, boats, and aircraft would displace subsistence species and alter or reduce access to these species by subsistence hunters (see Sec. III.C.2.h, Effects of Cleanup Activities on Subsistence Resources and Harvests). Employment generated to clean up an oil spill of 125-2,956 barrels could call for 30-125 cleanup workers (see Economy, Sec. III.C.2.k). The sudden employment increase could have sudden and significant effects, including inflation and displacement of Native residents from their normal subsistence-harvest activities by employing them as spill workers. Cleanup is unlikely to add population to the communities, because administrators and workers would live in separate enclaves; cleanup employment of local Inupiat could alter normal subsistence practices and put stresses on local village infrastructures by drawing local workers away from village service jobs.

BPXA's Oil Discharge Prevention and Contingency Plan (BPXA, 2000b) includes a series of four scenarios for cleaning up oil in open water, solid ice, and broken ice. These scenarios identify logistics, equipment, and tactics for the various cleanup responses. Spill cleanup would reduce the amount of spilled oil in the environment and tend to mitigate spill effects. A decline in the certainty about the safety of subsistence foods, potential displacement of subsistence resources and hunters, and changes in sharing and visiting could lead to a loss of community solidarity. Far from providing mitigation, oil-spill cleanup activities more likely should be viewed as an additional impact, causing displacement and employment disruptions (see Impact Assessment, Inc., 1998).

3) How Stipulations or Mitigating Measures Help Reduce Oil-Spill Effects

We assume mitigating measures from Beaufort Sea Sale 144 are in place for Liberty development, and this assumption is reflected in discussions about effects. See, for example, the discussion in Sections III.C.2.h and III.C.3.h, Subsistence-Harvest Patterns.

At a town meeting for the Northstar Project, Nuiqsut residents reiterated that they do not believe the technology exists to clean up an oil spill under the ice; they believe it is a matter of when a spill would occur, not if it would occur. They want assurance against disaster and impact funds set aside for them if a spill occurs (Dames and Moore, 1996b). Earlier village comments expressed the same attitude.

In 1979, Gordon Rankin from Kaktovik suggested that a compensation fund be set aside for villages in case there is a devastating oil spill (Rankin, 1979, as cited in USDOI, MMS, 1979b).

Barrow resident Charles Okakok said that subsistence users should be compensated by the oil industry in case of an oil spill (Okakok, 1995, as cited in USDOI, MMS, 1995b). Natives living on the North Slope often have repeated this sentiment.

Nuiqsut residents clearly want to be active in any spill response and cleanup. At a community meeting for the Northstar Project, the people of Nuiqsut said they wanted to be part of a newly structured and formed village oil-spill-response team, so that they could positively contribute in an emergency situation (Dames and Moore, 1996e). Their involvement in the past has not always gone smoothly. At the same community meeting, two Nuiqsut men felt their skills and knowledge were not respected when asked to participate in an oil-spill-response drill on a rig near the Northstar Project in February 1991. They believed their skills and knowledge could have been better used by the command structure of that team (Dames and Moore, 1996e).

(3) Environmental Justice

See Section III.C.3.i.(6), Effects of Disturbance, for a detailed discussion of Environmental Justice.

j. Archaeological Resources

(1) Summary and Conclusion for Effects of an Oil Spill on Archaeological Resources

The geography, prehistory and history of the Liberty Project area is very different from that of Prince William Sound, where the effects of the *Exxon Valdez* oil spill were concentrated; therefore, direct analogies cannot be drawn regarding the numbers and types of sites that may be affected should such a spill occur in the Liberty Project area. However, general findings and conclusions regarding the types and severity of impacts to archaeological sites present within the *Exxon Valdez* oil spill area are applicable to the Liberty Project area. The most important understanding that came from the *Exxon Valdez* oil spill was that the greatest effects to archaeological sites were not from the oil itself, but from the cleanup activities (Bittner, 1993, Dekin, 1993). The effects from cleanup activities were due both to physical disturbance of sites from cleanup equipment and due to vandalism by cleanup workers. Regardless, researchers concluded that less than 3% of the archaeological resources within the spill area suffered any significant effects (Mobley, et al, 1990; Wooley and Haggarty, 1993) and that level of effect would be expected in the unlikely event that an oil spill would occur from the Liberty development.

(2) Details on How a Large Spill May Affect Archaeological Resources

Following the *Exxon Valdez* spill, the greatest effects came from vandalism, because more people knew about the locations of the resources and were present at the sites. Known and previously undiscovered archaeological sites in the Liberty Project area would also be vulnerable to vandalism during cleanup activities. This type of damage increases with added population and activities during cleanup. To address this problem, the Exxon Valdez Cultural Resources Program instituted an intensive education program aimed at cleanup workers. This program not only instructed cleanup workers how to recognize an archaeological site and what to do if they found a site, but also reminded them of the penalties for vandalizing a site (Mobley et al., 1990). Surveillance was instituted at some sites deemed to be particularly vulnerable to vandalism. Similar measures would be instituted should a large oil spill occur within the Liberty Project area.

Archaeological sites can also be physically disturbed or destroyed by general cleanup operations. Physical disturbance of a site can destroy artifacts and alter the relationships between artifacts, site features, and the environmental and cultural contexts present within the site. Such disturbance can result in the loss of significant archaeological information. During the *Exxon Valdez* cleanup operations, archaeological surveys were conducted prior to initiating cleanup operations. Avoidance of archaeological sites identified during these surveys by beach cleanup activities was the preferred mitigation. If avoidance was not possible, site mapping, scientifically recording and collecting artifacts, and onsite monitoring by an archaeologist during cleanup activities was instituted. Similar measures would be instituted should a large oil spill occur within the Liberty Project area.

Contrary to expectation, the physical contact of spilled crude oil with archaeological sites does not seem to cause a significant impact. The infrared absorption spectrophotometer and radiocarbon analysis conducted on archaeological sites from the *Exxon Valdez* spill area found that most of the sites were contaminated with hydrocarbons such as gasoline and kerosene from sources not related to the *Exxon Valdez* oil spill. Only 2 of 26 samples were identified as possibly being contaminated by crude oil from the *Exxon Valdez.* All samples were split for radiocarbon dating, with half of each sample being pretreated with solvents to remove the hydrocarbon contamination, and the other half being left untreated. The results of the subsequent radiocarbon dating indicated no systematic age difference between the pretreated and untreated halves of each sample (Dekin, 1993).

Two studies of the numbers of archaeological sites damaged by the *Exxon Valdez* spill had similar findings. In the first study by Mobley et al. (1990), of 1,000 archaeological sites in the area affected by the *Exxon Valdez* oil spill, about 24 sites (2.4%) were damaged. In the second study by Wooley and Haggarty (1993), of 609 sites studied, 14 sites (2.3%) suffered major effects. Although no direct analogies can be drawn regarding the numbers and types of sites that may be affected should such a spill occur in the Liberty Project area, the general findings and conclusions regarding the types and severity of impacts to archaeological sites present within the oil spill area are applicable to the Liberty Project area.

The significance of an archaeological site is more important than the numbers of sites disturbed. Disturbing 20 archaeological sites that do not contain significant or unique information may not be as harmful as disturbing one very significant site. However, after the *Exxon Valdez* spill, because there was insufficient time to thoroughly evaluate the significance of each site, the Advisory Council on Historic Preservation declared all archaeological sites were to be treated as if they were significant and eligible for the *National Register of Historic Places* (Mobley et al., 1990).

k. Economy

(1) Summary and Conclusion for Effects of an Oil Spill on the Economy

Employment generated to clean up possible large oil spills of 715-2,956-barrel oil spills is estimated to be 30-125 cleanup workers for 6 months in the first year, declining to zero by the third year following the spill.

(2) Details on How a Large Spill May Affect the Economy

All of the potential effects noted below from oil spills to the economy are general effects that would result from developing the Liberty Prospect. No specific effects to the BPXA proposal are identified in the following analysis.

General Effects: The 30-125 workers make up about 0.3-1.2% of the workers who cleaned up the *Exxon Valdez* oil spill. This percentage is derived from the ratio of workers per barrel of spilled oil during the cleanup of the *Exxon Valdez* oil spill and applied to the volumes of potential spills from the Liberty Prospect. The most relevant historical experience of a spill in Alaskan waters was in 1989, when the *Exxon Valdez* spilled 240,000 barrels of oil in Prince William Sound. This spill generated enormous employment, which grew to 10,000 workers cleaning up in relatively remote locations for about 6 months in 1989. Smaller numbers of cleanup workers returned in the warmer months of each year following the spill until 1992. Many local residents quit their jobs to work on the cleanup, often at much higher wages. This generated a sudden and significant inflation in the local economy (Cohen, 1993). Similar effects in the North Slope Borough would be lesser, because administrators and workers probably would live in existing enclaves.

The number of workers actually used to clean up a 715-2,956-barrel oil spill would depend largely on procedures in the oil-spill-contingency plan, quality of equipment and training, efficiency of the cleanup, and quality of the coordination among many organizations and groups.

The publication *Liberty Development Project* (Northern Economics, Inc., 1998) also assesses the economic effects of oil spills.

l. Water Quality

(1) Summary and Conclusion for Effects of an Oil Spill on Water Quality

During open water, hydrocarbons dispersed in the water column from a large (greater than or equal to 500 barrels) crude oil spill could exceed the 0.015-parts per million chronic criterion for 10-30 days in an area that ranges from 30-45 square kilometers (11.6-17.4 square miles) to 51-186 square kilometers (19.7-71.8 square miles). Hydrocarbons in the water could exceed the 1.5-parts per million acute (toxic) criterion during the first day in the immediate vicinity of the spill. A large crude oil spill in broken sea ice or when the sea ice melts could exceed the chronic criterion for several days in an area of about 7.6 square kilometers (2.9 square miles). Hydrocarbons from a 1,283-barrel diesel oil spill during open water could exceed the acute (toxic) criterion for about 7 days in an area of about 18 square kilometers (7 square miles). During broken sea ice or melting ice conditions, a 1,283-barrel diesel spill could exceed the acute (toxic) criterion for about 1 day in an area of about 1 square kilometers (0.4 square miles) and the chronic criterion for more than 30 days in an area of about 103 square kilometers (39.8 square miles). The effects from a spill occurring under the ice would be similar to those described for broken ice or melting conditions; the oil would be trapped and essentially remain unchanged until breakup occurred and the ice began to melt.

A large crude or refined oil spill (greater than or equal to 500 barrels) would significantly affect water quality by increasing the concentration of hydrocarbons in the water column to levels that greatly exceed background concentrations; however, the chance of a large spill occurring and oil entering the offshore waters is estimated to be about 1%. Also, regional (more than 1,000 square kilometers [386 square miles]), long-term (more than 1 year) degradation of water quality to levels above State and Federal criteria because of hydrocarbon contamination is very unlikely.

(2) Details on How a Large Oil Spill May Affect Water Quality

(a) General Effects from Developing the Liberty Prospect

Inupiat testifying at public hearings related to proposed oil and gas activities in the Beaufort Sea expect oil spills to pollute the marine environment and threatened their subsistence lifestyle by tainting, harming or killing the marine mammals, fishes and birds that are important food sources (Sec III.C.2.h, effects of large oil spills on Subsistence Resources).

Accidental discharges of crude or refined oil that reach the marine environment will effect water quality by adding chemical pollutants to the water. One way of evaluating the effects of an oil spill on water quality is to compare the

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estimates of hydrocarbon concentrations with State or Federal standards or criteria.

Applicable ambient-water-quality standards for marine waters of the State of Alaska state:

- Total aqueous hydrocarbons in the water column may not exceed 15 micrograms per liter (0.015 parts per million).
- Total aromatic hydrocarbons in the water column may not exceed 10 micrograms per liter (0.010 parts per million).
- Surface waters and adjoining shorelines must be virtually free from floating oil, film, sheen, or discoloration (State of Alaska, Dept. of Environmental Conservation, 1995).

The State of Alaska criterion of a maximum of 0.015 parts per million of total aqueous hydrocarbons in marine waters provides the readiest comparison and is used in this discussion of water quality. This analysis considers 0.015 parts per million to be a chronic criterion and 1.5 parts per million—a hundredfold higher level—to be an acute (toxic) criterion. Following spills, water-column concentrations of hydrocarbons are difficult to compare to Federal water-quality standards because of ambiguity in the standards. Federal standards are set at 0.01 of the applicable LC_{50}: no absolute Federal concentration standard exists for hydrocarbons (Environmental Protection Agency, 1986). The LC_{50} is the continuous-flow, 96-hour lethal concentration at which half the organisms die. “Applicable” in this case refers to lifestages of species identified as the most sensitive, biologically important species in a particular location.

Aromatic compounds are the most toxic constituents of crude oil partly because they are the most soluble constituents. The highest rates of dissolution of aromatics from a slick and, consequently, accumulation in underlying water occur in the first few hours after a spill (Payne, 1987). At sea, water depth and shoreline do not restrict the movement of slick or water, and the slick and underlying water generally move at different angles to the wind. The rate of horizontal dispersion or mixing in the ocean is orders of magnitude greater than the rate of vertical dispersion. By the time dissolved oil worked down 10 meters (33 feet) in the water column, it would have spread horizontally and been diluted over a distance of perhaps 10,000 meters (33,000 feet). The slick itself would become patchy, with the total area containing the widely separated patches of oil being orders of magnitude larger than the actual amount of surface area covered by oil. Thus, at sea, the water under the slick changes continuously; and aromatics do not continue to accumulate in the same water.

The more volatile compounds in an oil slick, particularly aromatic volatiles, usually are the most toxic components of the slick and, therefore, are of more concern. In situ, cold-water measurements by Humphrey et al. (1987), Kirstein and Redding (1987), Payne (1981, 1982, and 1987), Payne and McNabb (1984), and Payne et al. (1984a) demonstrate for individual dissolved compounds or bulk dispersed oil from a slick that significant decreases in water concentrations take from hours to tens of days. However, the bulk of these volatile compounds are lost in less than 3 days.

As noted in Section VI.C.2.b(5), the background concentrations of hydrocarbons in the Beaufort Sea generally are less than or equal to 1 part per billion (0.001 parts per million). The chronic criterion used in this analysis (0.015 parts per million) is about 15 times greater than the background concentrations of hydrocarbons.

Major spills generally result in peak dissolved-hydrocarbon concentrations that are only locally and marginally at toxic levels—parts per million or more. After the *Exxon Valdez* oil spill (0.258 million barrels), concentrations of hydrocarbons in the water were not measured in the first 6 days of the spill. However, Wolfe et al. (1994) used an earlier version of the MMS weathering model (Payne et al., 1984a) to estimate water concentrations after passage of the storm on the third day of the spill, arriving at an average value of 0.8 parts per million within the top 10 meters (33 feet) of the water, within the “effective” or discontinuous spill area. Wolfe et al. also summarize the actual measurements made in Prince William Sound. Seven to 11 days after the spill, residual concentrations ranged from 0.067-0.335 parts per million petroleum hydrocarbons, 0.0015 parts per million volatile organic analytes (mostly mononuclear aromatics), and 0.001-0.005 parts per million polynuclear aromatic hydrocarbons. Concentrations in Prince William Sound decreased to levels below the chronic criteria levels of concern, to between 0.001 and 0.006 parts per million petroleum hydrocarbons and 0.0001 parts per million polynuclear aromatic hydrocarbons after 21-41 days. The concentration decreases within these timeframes were attributable to advection and dilution, not decomposition.

The concentrations of oil in the water column are relatively low, because oil is only slightly soluble in water and vertical, and especially horizontal, dispersion and consequent dilution would rapidly decrease hydrocarbon concentrations for all but the largest spills in several hours. For spills of the magnitude of the *Exxon Valdez* spill, hydrocarbon concentrations could remain elevated above chronic criteria for as long as 10-20 days.

(b) Specific Effects of a Large Oil Spill from BPXA’s Proposed Liberty Development and Production Plan

Accidental crude oil spills may occur from operations associated with the Liberty development and production facility or from a pipeline leak or rupture (Sec. II.A.1.b(3)(d)). Estimates of the amount of oil that might be spilled from the facility or the pipeline are shown in Table III.C-4. The volumes associated with a pipeline spills are based on the characteristics of the Liberty Pipeline leak-detection systems. These systems are the Leak Detection and Location System (LEOS), which has a detection rate of 0.3 barrels per day and the pressure-point analysis and mass balance line pack compensation systems, which have a detection rate of 0.15% of the daily flow rate; during peak production the flow rate through the pipeline is estimated to be 65,000 barrels per day, and 0.15% of this rate is 97.5 barrels per day. These systems are described in Section II.A.1.b(3)(b).

The analysis considers the effects a large (greater than or equal to 500 barrels) spill from the offshore segment of the Liberty pipeline could have on water quality. The spill scenarios include an environmental component that considers the effects of water and/or ice on the fate and behavior of the oil. The spills are assumed to occur during (1) open water (July through September); (2) winter broken ice or spring meltout (October through June), when the oil would be present on the surface of the water and/or ice; and (3) winter, when the oil would be trapped under the ice (Table III.C-4). The Liberty pipeline offshore leaks that are analyzed for these environmental conditions are:

- a 715-barrel leak over 7 days that is detected by visual inspection of the pipeline. and assumes that LEOS fails and the oil leaks from the pipeline at a rate below the detection level of the pressure-point analysis and mass-balance line-pack compensation systems (Sec II.A.1.b(3)(b)1); and
- a 1,580-barrel leak caused by a pipeline rupture that is detected by either the LEOS or the pressure-point analysis and mass-balance line-pack compensation systems (Sec II.A.1.b(3)(b)).

In addition, a pipeline spill under the ice could leak an estimated 2,956 barrels over 30 days. The scenario leading to this type of spill assumes the LEOS system fails, and the leak rate is below the detection level of the pressure-point analysis and mass-balance line-pack compensation systems. The leak is detected by visual inspection of the pipeline. This oil would be trapped under the ice until spring meltout. Because little if any of this oil would be weathered while trapped, the effects of this spill are analyzed as part of the meltout scenario.

Tables A-7 and A-8 in Appendix A give the weathering characteristics of the spilled oil in open water and during broken-ice/meltout conditions. Based on estimates of the amount of oil dispersed in the water column and the discontinuous area (Tables A-7 and A-8), the concentrations of oil dispersed in the water column from pipeline spills of 125, 715, and 1,580 barrels (open-water conditions) and spills of 125, 715, and 2,956 barrels (broken-ice/meltout conditions) are shown in Table III.C-5. The 715-barrel oil spill is assumed to take place during a 7-day period, and the daily spill rates are the same. The concentration of dispersed oil in the water after the first day would be about the same as the concentration estimated for the 125-barrel spill, which is the result of a small leak over a 24-hour period. The concentration of dispersed oil in the water after 3 and 10 days is assumed to range between the concentration for the 125-barrel spill and the concentration for a 715-barrel spill in which the entire 715 barrels leaked into the water in less than 1 day. After 30 days, the concentration of dispersed oil from the 715-barrel spill is assumed to uniformly distributed in the water.

The facility spill is assumed to be 925 barrels, and all the oil from this spill reaches the marine environment. As with the pipeline spills, the environmental conditions at the time of the spill affects the fate and behavior of the oil. The weathering characteristics of the 925-barrel spill are shown in Appendix A Table A-6c. The analysis includes the effects on water quality for a spill in open-water or broken-ice/meltout conditions. The concentration of hydrocarbons in the water from the 925-barrels spill in open-water and broken-ice/meltout conditions are shown in Table III.C-5. An accidental diesel oil spill also may occur from diesel stored on the island to run the electric generators when natural gas is not available; the size of such a spill is assumed to be 1,283 barrels. Table A-9 in Appendix A gives the characteristics of this size spill in the open-water and under broken-ice/meltout conditions. Based on estimates of the amount of oil dispersed in the water column and the discontinuous area, the estimated concentrations of oil dispersed in the water column for these spills are shown in Table III.C-6.

The analysis of the effects of these spills on water quality does not consider the effects that spill cleanup could have in reducing the volume of oil released into the water column. See Section II.A.4.a for a discussion of oil-spill-cleanup measures.

Oil spilled under landfast ice in winter most likely would remain trapped under the ice in an unweathered condition until melting begins in spring. The hydrocarbon concentrations during melting would be similar to those described for broken-ice or ice meltout conditions.

Within Foggy Island Bay, the concentration of dispersed oil in the water column after the first day of a pipeline or facility spill in open water could range from 0.153-0.510 parts per million (Table III.C-5); the amount depends of the size of the spill and the rate oil enters the water. The 715-barrel pipeline spill is assumed to occur over a 7-day period and the concentration of oil in the water, 0.510 parts per million, is based on 125 barrels leaking into the environment during the first day of the spill. The 1,580-barrel spill is the result of a pipeline rupture in which the oil flows into the environment in a relatively short time; the concentration of dispersed oi from this size spill is estimated to be 0.194 parts per million. The concentration of oil dispersed in the water from the 925-barrel facility spill is estimated to be 0.153 parts per million. The concentrations after the first day for a 715-, 925-, or 1,580-barrel spill are greater than the 0.015 parts per million that was assumed to be the total hydrocarbon chronic criterion (Sec. III.C.2.l(2)(a)). Hydrocarbon concentrations may be greater than the acute (toxic) criteria, 1.50 parts per million, near the spill site and for less than a day. After the first day, the concentrations of hydrocarbons dispersed in the water from a potential large spill would be less than the acute (toxic) criteria. In general dispersion continues to reduce the concentration of the oil in the water. However, even after 10 days, the concentrations from the spills might be greater than the chronic criterion (Table III.C-5). The time required for the dispersed hydrocarbons to decrease to concentrations below the chronic criterion could range from 10-30 days or more (Table III.C-5). For the 1,580-barrel spill, the concentration at 1.931 parts per million is greater than the 1.50 parts per million that was assumed to be the total hydrocarbon acute (toxic) criterion; after 3 days of dispersion, the concentration is reduced to 0.450 parts per million.

One of the factors limiting dispersion, and lowering of the concentration of oil dispersed in the water column, in Foggy Island Bay is water depth. In the bay water depths generally are less than 20 feet. Outside the bay beyond the barrier islands, water depths increase from 20-40 feet within several miles of the islands.

Circulation on the nearshore waters primarily is wind driven. Wind direction and frequency of wind shifts influence the direction of the surface currents, the time watermasses remain in an area and the amount of horizontal and vertical mixing between watermasses. The change in the flow direction of nearshore surface water responds within several hours to changes in the wind direction (Segar, 1989 as cited in USDOI, MMS, 1990a). The residence time of water in the nearshore environments largely depends on frequency and direction of the easterly and westerly winds (Envirosphere, 1988a, as cited in USDOI, MMS, 1990a). During the years dominated by persistent easterly winds, the residence time is relatively short, because the coastal watermasses are transported offshore. However, in the years when westerly winds predominate the residence time is relatively long, because the watermasses are kept onshore. Other phenomenon that force the movement of watermasses include freshwater runoff and tides.

The wind-generated surface currents have velocities that are about 3% of the wind velocity (Sec. III.C.3.l(2)). Current velocity decreases with depth and, at a depth of 3 meters (10 feet), the current velocity is about 0.9% of the wind speed. The currents help to disperse substances in the water horizontally and the waves help to disperse vertically. The fate and behavior of oil spilled during open water was estimated by using a 12-knot wind speed and 0.4-meter wave height (Tables A-7 and A-8).

In July through September, Beaufort Sea winds with velocities less than 7 knots blow about 20-30% of the time; 7-11 knot winds about 20-30%, 11-17 knot winds about 25-30%, and greater than 17 knot winds about 15-25% (Brower et al., 1988). Winds with a velocity of 11 knots could generate a surface current of about 0.3 knots and a subsurface current of about 0.1 knots at a depth of about 10 feet.

Distances from Liberty Island to the larger openings (channels) between the barrier island ranges from about 9.5-17 nautical miles; these distances are shown in Table III.C-7.

The travel times shown in Table III.C-7 indicate a watermass containing spilled oil could begin leaving Foggy Island Bay a day or two after a spill. The timing mainly depends on the wind velocity, persistence, and direction. Seaward of the barrier island, water depths increase with distance from the islands, and water depth becomes less of a factor in limiting dispersion than it was in Foggy Island Bay.

The effect that water depth has on dispersion of hydrocarbons is shown in Table III.C-5. For example, the concentration of hydrocarbons from the 1,580-barrel spill dispersed to a depth of 10 feet in Foggy Island Bay 3 days after the spill is estimated to be 0.063 parts per million. In waters 33 feet deep in the Beaufort Sea, the concentration is estimated to be 0.019 parts per million. After 10 days in Foggy Island Bay in waters 20 feet deep, the concentration of dispersed hydrocarbons from a 1,580-barrel spill is estimated to be 0.024 parts per million; in the Beaufort Sea, in waters 33 and 49 feet deep the concentrations are estimated to be 0.0125 and 0.010 parts per million, respectively. The effects of dispersion time and water depth on the concentrations of hydrocarbons from a 715- or 925-barrels spill is shown in Table III.C-5.

As the watermass containing the spilled oil passes through the barrier islands and into the Beaufort Sea, the rate of dispersion probably would increase because of greater water depths and effect the wind has on the water due to the greater fetch, the distance over which the wind blows. The time for the concentration of dispersed oil to go below the chronic criterion, 0.015 parts per million, would be less in the Beaufort Sea than in Foggy Island Bay. The effect of increasing water depth on reducing hydrocarbon concentrations already has been discussed for the 3- and 10-day periods.

The amount of diesel oil dispersed in the water column one day after a 1,283-barrel spill is estimated to be 43.557 parts per million (Table III.C-6); this is about 29 times greater than the acute (toxic) criterion. One of the reasons the concentration of dispersed diesel oil is greater than that of the crude oil spill is that the diesel contains a greater percent of the lighter, more soluble, hydrocarbons than the crude oil. Continued dispersion reduces the concentration and, at the end of 7 days, the concentration of hydrocarbons in the water from the diesel oil spill would be reduced to an estimated 1.219 parts per million; a concentration slightly less than the acute (toxic) criterion, 1.5 parts per million. Movement of the water through Foggy Island Bay and into the Beaufort Sea in response to the winds would continue to reduce the concentration of hydrocarbons in the water in much the same manner as previously described for the crude oil spills.

Estimates also are shown in Tables A-7, A-8, and A-9 for crude and diesel oil spills in winter broken-ice or meltout conditions. Under these conditions, rates of weathering, evaporation, and dispersion are slower than they are for the open-water spill. For the same time intervals, the amount of oil dispersed in the water is less than for the open-water spill. The concentrations of hydrocarbons in the water for 1-, 3-, 10-, and 30-day intervals are shown in Table III.C-5 for the crude oil spills and Table III.C-6 for diesel oil spills. For the same time intervals, the hydrocarbons concentrations are less than for broken-ice/meltout spills than open-water spills.

For spills occurring under broken-ice or meltout conditions, more oil remains in the water compared to the same time intervals for the open-water spills (Tables A-7, A-8, and A-9). Under these conditions, the effects of the spills would last longer than for the open-water spills. If the spill occurred in broken-ice conditions as the winter season is beginning or developing, oil from the spills would be frozen into the ice. When melting begins, the unweathered oil would enter the water column. The effects on the amount of oil dispersed in the water column would be reduced in proportion to the amount of oil that evaporated and dispersed before freezeup.

A meltout spill occurs during the transition period from frozen to open-water conditions. During the initial part of this transition period, evaporation and dispersion rates are estimated to be similar to those shown in Tables A-7, A-8, and A-9. As the ice melts, water temperatures increase and the winds play an increasing role in generating currents and waves because of more open water. With these changes, oil evaporation and dispersion rates would approach those of the open-water conditions. As this happens, the concentration of hydrocarbons dispersed in the water may be relatively constant, or might increase, before decreasing. For a given volume of oil spilled, the concentration of hydrocarbons dispersed in the water is expected to decrease with time, and this is the scenario shown for conditions that remain constant over some period of time as depicted in Tables A-7, A-8, and A-9.

If a spill occurs under the ice, we assume the oil would become frozen into the ice and not weather until meltout begins. The processes affecting oil and the concentrations of hydrocarbons dispersed in the water would be the same as those described for a meltout spill.

(3) Effects of Oil-Spill-Cleanup Activities on Water Quality

Oil-spill-cleanup activities are not expected to affect water quality by adding any new or additional substances to the water. Removing oil from the environment would help reduce the amount of oil that gets dispersed into the water. However, the amount of oil removed depends on environmental conditions during cleanup operations. As the oil is removed, the amount contributing oil to dispersion decreases and, as the oil is dispersed, the concentration decreases. The effect of removing oil would be to reduce the concentration in the water relative to the amounts estimated in the previous analysis for a given time interval or given area.

m. Air Quality

(1) Summary and Conclusion for Effects of an Oil Spill on Air Quality

Oil spills from the offshore gravel island and the buried pipeline could cause a small, local increase in the concentrations of gaseous hydrocarbons (volatile organic compounds) due to evaporation from the spill. The concentrations of volatile organic compounds would be very low and normally be limited to only 1 or 2 square kilometers (0.4-0.8 square miles). During open-water conditions, spreading of the spilled oil and action by winds, waves, and currents would disperse the volatile organic compounds so that they would be at extremely low levels (although over a relatively larger area). During broken-ice or melting ice conditions, because of limited dispersion of the oil, there would be some increase in volatile organic compounds for several hours, possibly up to 1 day. The effects from a spill occurring under the ice would be similar to but less than those described for broken ice or melting conditions; the oil would be trapped and essentially remain unchanged until the ice began to melt and breakup occurred. Some of the volatile organic compounds, however, would be released from the oil and dispersed, even under the ice. In any of these situations, moderate or greater winds would further reduce the concentrations of volatile organic compounds in the air. Concentrations of criteria pollutants would remain well below Federal air-quality standards. The overall effects on air quality would be minimal.

(2) Details on How an Oil Spill May Affect Air Quality

All of the potential effects noted below from oil spills to air quality are general effects that would result from developing the Liberty Prospect. No specific effects to the BPXA proposal are identified in the following analysis.

Sources of air pollutants related to outer continental shelf operations are accidental emissions resulting from gas or oil blowouts, evaporation of spilled oil, and burning of spilled oil. The number of blowouts on the U.S. outer continental shelf, almost entirely gas and/or water, averaged 4.1 per 1,000 wells drilled from 1971 through 1991 (Danenberger, 1993). Typical emissions from such accidents consist of hydrocarbons (volatile organic compounds); only fires associated with blowouts or oil spills produce other pollutants, such as nitrogen oxides, carbon monoxide, sulfur

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dioxide, and particulate matter. We expect accidental emissions to have little effect on onshore air quality.

A gas blowout could release 20 tons per day of gaseous hydrocarbons, of which about 2 tons per day would be nonmethane volatile organic compounds. Based on modeling work by Hanna and Drivas (1993), we would expect that for oil spills from the offshore gravel island or the buried pipeline, the lighter volatile organic compounds—those with the lowest vapor pressure—would evaporate almost completely within a few hours after the spill occurred. Hanna and Drivas (1993) discusses the rate or evaporation and ambient concentrations of 15 different volatile organic compounds. A number of these compounds, such as benzene, ethylbenzene, toluene, and n-xylenes, are classified by the Environmental Protection Agency as hazardous air pollutants. The study results showed that these compounds evaporate almost completely within a few hours after the spill occurs. Ambient concentrations peak within the first several hours after the spill starts and are reduced by two orders of magnitude after about 12 hours. The heavier compounds take longer to evaporate and may not peak until about 24 hours after a spill occurs. Total ambient concentrations of volatile organic compounds are significant in the immediate vicinity of an oil spill, but concentrations are much reduced after the first day.

Diesel oil could be spilled either while being transported or from accidents involving vehicles, vessels, or equipment. A diesel spill would evaporate faster than an oil spill. Ambient hydrocarbon concentrations would be higher than with a crude oil spill but also would persist for only a shorter time. Because any such spill probably would be smaller than some potential crude oil spills, we would expect that any air-quality effects from a diesel spill would be even lower than for other oil spills.

Oil or gas blowouts may catch fire. In addition, in situ burning is a preferred technique for cleaning up and disposing of spilled oil (see the following subsection). Burning could affect air quality in two important ways. (1) For a gas blowout, burning would reduce emissions of gaseous hydrocarbons by 99.98% and very slightly increase emissions of other pollutants. If an oil spill were ignited immediately after spillage, the burn could combust 33-67% of crude oil or higher amounts of fuel oil (diesel) that otherwise would evaporate. (2) Incomplete combustion of oil would inject about 10% of the burned crude oil as oily soot, plus minor quantities or other pollutants, into the air. In situ burning would be less effective in areas of broken ice than in open water, but it would still reduce the effects of volatile organic compounds to the ambient-air quality.

(3) Effects of Oil-Spill Cleanup Activities on Air Quality

In situ burning as part of cleaning up of spilled crude or diesel oil temporarily would adversely affect air quality, but the effects would be low. (For a much more detailed discussion, see Fingas et al. [1995]). Extensive ambient measurements were performed during two experiments involving the in situ burning of approximately 300 barrels of crude oil at sea. During the burn, carbon monoxide, sulfur dioxide, and nitrogen dioxide were measured only at background levels and were frequently below detection levels. Ambient levels of volatile organic compounds were high within about 100 meters of the fire, but were significantly lower than those associated with a non-burning spill. Measured concentrations of polyaromatic hydrocarbons were found to be low, as it appeared that a major portion of these compounds were consumed in the burn. Effects of in situ burning for spilled diesel oil would be similar to those associated with a crude oil spill.

Additional work by McGrattan et al. (1995) reported that smoke-plume models have shown that the surface concentrations of particulate matter does not exceed the health criterion of 150 micrograms per cubic meter beyond about 5 kilometers downwind of an in situ burn. This is quite conservative, as this health standard is based on a 24-hour average concentration rather than a 1-hour average concentration. This appears to be supported by field experiments conducted off of Newfoundland and in Alaska.

Other air quality effects from cleanup activities would include emissions from vessels, vehicles, and equipment used in the cleanup effort; these should be very low.

n. Effectiveness of Oil-Spill-Related Mitigating Measure on Seasonal Drilling Restriction

This mitigating measure was proposed by members of the Interagency Team as a way to reduce the risk to marine resources during periods of broken ice, when oil-spill cleanup is more difficult (See Sec. I.7). This mitigation provides protection to resources for potential oil spills by eliminating the potential for a blowout during periods of broken ice during the development phase of the project. The proposed measure would restrict the drilling of any well below a specified threshold depth, which would prevent penetration of the oil-bearing strata during the restricted period. The restricted periods would be before and during broken-ice periods for breakup and freezeup. This type of stipulation was applied to exploratory drilling activity in early outer continental shelf lease sales in the Beaufort Sea and similar restrictions were required by mitigating measures for the Northstar Project.

(1) Effectiveness of this Mitigating Measure

This mitigating measure would be effective in reducing the risk of an oil spill from a blowout spill during broken ice to marine mammals, including the bowhead whale; and eiders and marine birds. The added protection to these subsistence resources could lower the effects to subsistence harvest patterns and sociocultural systems. This mitigating measure also would provide some protection to water and air quality. This mitigating measure would reduce or eliminate the chance of a blowout spill occurring before and during broken-ice periods when oil-spill cleanup is more difficult and less effective. Very large oil spills are evaluated in Section IX.

(2) Evaluation of Need for Mitigating Measure

The probability of an oil spill from a blowout already is very low. More than 24,000 wells have been drilled on the outer continental shelf and no oil spills of consequence from a blowout from an exploratory or development well has occurred since 1971. Only one 100-barrel spill was associated with an exploratory well blowout in 1992. The probability of a blowout from development drilling is significantly less than from exploratory drilling. This is attributed to increased knowledge of geologic conditions from one or more exploratory wells, acquisition of additional 3-dimensional geophysical data, better correlation between well and geophysical data and correlation with analogous reservoirs and continuity with each subsequent development well.

The threat of a blowout is greatest when drilling in unexplored formations and encountering unexpected pressures. The drilling schedule BPXA proposes would start in January of Year 3. Approximately four wells would be completed before drilling is restricted for breakup in Year 3 in accordance with this proposed mitigating measure. Other mitigating measures are noted in Section I.H.6.a and b. BPXA's drilling plan require all drilling activities to stop from July 15 to November 15 in Year 3, which is when the second sealift of production facilities would arrive. By breakup in Year 3, BPXA would have about half (11 of 23) of the wells completed. With the drilling history for 12 wells, the chance of encountering a blowout drilling the other 12 wells would be very small.

This restriction would delay the drilling schedule for up to eight wells and extend the time it takes to complete the drilling of all 23 wells. The wells still could be drilled to a specified level above threshold depths and then the wells could be completed after freeze up. This potential mitigating measure would likely would delay completion of drilling by 2 or more months.

3. Disturbances

The Liberty Project involves constructing a gravel island about 6 miles offshore, using gravel hauled by truck over ice roads to a prepared subsea pad, and construction of a pipeline from the island to an existing onshore pipeline. The island and pipelines would be constructed mainly in winter, so most potential disturbance from construction would occur in that season. Construction of the subsea pipeline trench and onshore pipeline permanently would disturb habitats where they are located. The following are examples of disturbances:

- sediment and turbidity from the dumping of gravel during construction of the proposed island and from the pipeline trenching and backfilling activities;
- noise from construction and drilling activities; and
- noise from the transportation of people and materials to and from the gravel island.

No additional seismic activity is proposed for the Liberty Project. Ground transportation and helicopters would handle most winter transportation. Helicopters, supply boats, and some barges would cover transport over water. Long-term disturbances would include noise from various kinds of transportation and any other drilling that may occur over the operational life of the field.

Releases of particulate matter and attendant turbidity in the water may come from the following sources: remnant fill from the pipeline trench, particulate leaching from the island, and final island preparation (reshaping). When refilling pipeline trenches, the excess fill that could not be deposited back into the trench would be placed on the ice parallel to the pipeline and would filter into the Beaufort Sea as breakup progresses. Particulate matter would leach from the island, especially during the first season after construction. After initial construction and before the placement of filter fabrics and cement blocks, some island reshaping may be necessary. This would be of a short-term duration.

The project description in Section II.A.1 and Table II.A-1 more thoroughly discusses Liberty development and its sources of noise and habitat disturbance.

a. Threatened and Endangered Species

(1) Bowhead Whales

(a) Summary and Conclusion for Effects of Disturbances on Bowhead Whales

Noise sources that may affect bowhead whales are drilling and other noise associated with production operations, vessel traffic, aircraft traffic, construction, and oil-spill cleanup. Underwater industrial noise, including drilling noise measured from artificial gravel islands, has not been audible in the water more than a few kilometers away. Because the main bowhead whale's migration corridor is 10 kilometers or more seaward of the barrier islands, drilling and production noise from Liberty Island is not likely to reach many migrating whales. Noise also is unlikely to affect the few whales that may be in lagoon entrances or inside the barrier islands due to the rapid attenuation of industrial sounds in a shallow-water environment. Subsistence whalers have stated that noise from some drilling activities displaces whales farther offshore away from their traditional hunting areas.

Marine-vessel traffic outside the barrier islands probably would include only seagoing barges transporting modules and other equipment and supplies from Southcentral Alaska to the Liberty location, most likely between mid-August and mid- to late September in Year 2 and Year 3. Barge traffic continuing into September could disturb some bowheads. Whales may avoid being within 1-4 kilometers of barges. Fleeing behavior usually stops within minutes after a vessel has passed but may last longer. Vessels and aircraft inside the barrier islands should not affect bowhead whales.

Because island and pipeline construction would occur during the winter and be well inside the barrier islands, it is not likely to affect bowhead whales. Reshaping of the island and placement of slope-protection material should be completed by mid-August, before the bowhead whales start their migration. Whales should not be affected by these activities, even during the migration, because the island is well shoreward of the barrier islands, and whales infrequently go there. Bowhead whales are not likely to be affected by sediment or turbidity from placing fill for island construction, island reshaping before placing slope-protection material, or pipeline trenching or backfilling.

(b) Details on How Disturbances May Affect Bowhead Whales

1) General Effects from Developing the Liberty Prospect

The scoping process revealed concern that manmade noise affects bowheads by raising background noise levels. Increased noise levels could interfere with communication among bowheads, mask important natural sounds, cause physiological damage, or alter normal behavior, such as displacing the migration route farther from shore. Sound is transmitted efficiently through water. Hydrophones often detect underwater sounds created by ships and other human activities many kilometers away, far beyond the distances at which the sounds can be detected by senses other than hearing. Sound transmission from noise sources is affected by a variety of things, including water depth, salinity, temperature, sound frequencies, ice cover, bottom type, and bottom contour. Generally, sound travels farther in deep water than in shallow water. Sound transmission in shallow water varies, because it is strongly influenced by the acoustic properties of the bottom material, bottom roughness, surface conditions, and ice cover. Sound may travel better under smooth annual ice cover than in open water of the same depth. However, as ice cracks and roughness increases, sound transmission generally becomes poorer. At this point, the roughness of the under-ice surface influences sound-transmission loss more strongly than bottom properties do (Richardson and Malme, 1993).

Marine mammals use calls to communicate and probably listen to natural sounds to obtain information important for detection of open water, navigation, and predator avoidance. Hearing in baleen whales has not been studied directly. No specific data exist on sensitivity, frequency or intensity discrimination, or localization (Richardson et al., 1995). For each species, the frequency range of reasonably acute hearing in baleen whales likely includes the frequency range of their calls. Most baleen whale sounds are concentrated at frequencies below 1 kilohertz, but sounds up to 8 kilohertz are not uncommon (Richardson et al., 1995). Most calls emitted by bowheads are in the frequency range of 50-400 Hertz, with a few extending to 1,200 Hertz. The frequency range in bowhead songs can approach 4000 Hertz (Richardson et al., 1995). Based on indirect evidence, at least some baleen whales are quite sensitive to frequencies below 1 kilohertz but can hear sounds up to a considerably higher but unknown frequency. Most of the manmade sounds that elicited reactions by baleen whales were at frequencies below 1 kilohertz (Richardson et al., 1995). Some or all baleen whales may hear sounds at frequencies well below those detectable by humans. Even if the range of sensitive hearing does not extend below 20-50 Hertz, whales may hear strong infrasounds at considerably lower frequencies. Based on work with other marine mammals, if hearing sensitivity is good at 50 Hertz, strong infrasounds at 5 Hertz might be detected (Richardson et al., 1995).

At least one author speculates that under some conditions, extremely loud noise may temporarily, or even permanently, impair a bowhead's hearing (Kryter, 1985, as reported in Richardson and Malme, 1993). According to Richardson and Malme (1993), we have no evidence that noise from routine human activities (aside from explosions) would cause permanent negative effects to a marine mammal's ability to hear calls and other natural sounds. Given their mobility and avoidance reactions, whales would not likely remain close to a noise source for long. Also, baleen whales themselves often emit calls with source levels near 170-180 decibels re 1 microPascal (dB re 1µPa), which is comparable to those from many industrial operations. We do not know whether noise pulses from nonexplosive seismic sources, which can be much higher than 170-180 decibels, are physically injurious at any distance. The avoidance reactions of bowheads to approaching seismic vessels normally would prevent exposure to potentially injurious noise pulses.

There is little information regarding visual or olfactory effects to bowhead whales. Richardson, et al. (1995) stated that Inupiat whalers hunting from the ice-edge find that bowhead whales are alarmed by the sight or sound of humans or human activities (Carroll and Smithhisler, 1980, as reported in Richardson, et al., 1995). He also commented that gray whales probably would react to visual cues as well as sound when very close to an actual industrial site, indicating that bowheads may react similarly. We believe it is unlikely that bowheads' olfactory or visual senses would be affected by the Liberty Project, considering that the location of the Liberty Project is shoreward of the barrier islands, well removed from the bowhead migration route, and the fall migration route is through a relatively open Beaufort Sea compared to a fairly confined lead system during the spring migration.

The zone of audibility is the area within which a marine mammal can hear the noise. The ability of a mammal to hear the sound, such as from seismic operations, depends upon its hearing threshold in the relevant frequency band and the level of ambient noise in that band. The radius of the zone of audibility also depends upon the effective source level of the seismic pulse for horizontal propagation and on the propagation loss between the source and the potential receiver. The zone of responsiveness around a noise source is the area within which the animal would react to the noise. This zone generally is much smaller than the zone of audibility. The distance at which reactions to a particular noise become evident varies widely, even for a given species. A small percentage of the animals may react at a long distance, the majority may not react unless the noise source is closer, and a small percentage may not react until the noise source is even closer still. The activity of a whale seems to affect how a whale will react. In baleen whales, single whales that were resting quietly seemed more likely to be disturbed by human activities than were groups of whales engaged in active feeding, social interactions, or mating (Richardson et al., 1995). Habitat or physical environment of the animal also can be important. Bowhead whales whose movements are partly restricted by shallow water or a shoreline sometimes seem more responsive to noise (Richardson et al., 1995).

a) Effects from Drilling Activities

Stationary sources of offshore noise (such as drilling units) appear less disruptive to bowhead whales than moving sound sources (such as vessels). Some bowheads nearby may be expected to respond to noise from drilling units by slightly changing their migration speed and swimming direction to avoid closely approaching them. Miles, Malme, and Richardson (1987) predicted the bowhead whale's zone of responsiveness to continuous noise from drilling at an artificial island. The predicted zone of responsiveness for drilling from an artificial island at the Sandpiper Island site was a radius of 0.2 kilometers (0.12 miles), compared to a radius of 3-4 kilometers (1.8-2.5 miles) for drilling from an operating drillship at that same site when the signal-to-noise ratio is 30 decibels. (The signal-to-noise ratio is the ratio of industrial noise-to-ambient noise. In this example, the industrial noise is caused by drilling from an artificial island

and from a drillship). Roughly half of the bowheads are expected to respond when the signal-to-noise ratio is 30 decibels. A smaller proportion would react when the ratio is about 20 decibels (farther from the source), and a few may react at an even lower ratio or a greater distance from the source.

Bowhead whales have behaved normally while on their summer-feeding grounds within a few kilometers of operating drillships, well within the zone where drillship noise is clearly detectable (Richardson, Wells, and Wursig, 1985; Richardson and Malme, 1993). In general, bowheads appear more likely to avoid a structure if support vessels are around it. Although underwater sounds from drilling on some artificial islands and caissons have been measured, we have little information about reactions of bowheads to drilling from these structures. Underwater sound levels at various distances from a caisson-retained island (with support vessels nearby) in Canada’s Beaufort Sea were similar to those from a drillship. Underwater noise levels from drilling operations on natural barrier islands or artificial islands are low and are not audible beyond a few kilometers (Richardson et al., 1995). Noise is transmitted very poorly from the drill rig machinery through land into the water. Even under open-water conditions, drilling sounds are not detectable very far from the structure. Drilling noise from caisson-retained islands is much stronger. At least during open-water conditions, noise is conducted more directly into the water than from island drill sites. Noise associated with drilling activities at both sites varies considerably with ongoing operations. The highest documented levels were transient pulses from hammering to install conductor pipe.

Studies Looking at the Effects of Noise from Drilling Operations on Gravel Islands

Seal Island (Northstar area): Noise measurements were made during the open water season near Seal Island, a man-made gravel island off Prudhoe Bay in water 12 meters deep (Map 1). Davis, Greene, and McLaren (1985) measured underwater noise from Seal Island during the open-water season while well logging was occurring but not drilling operations. Underwater sound levels recorded from bottom hydrophones 1.65-2.4 kilometers from Seal Island were strongly affected by wind speed and active barge or tug traffic at the island. The strongest tone was 486 Hertz from turbochargers on generators used for well-logging operations. This tone was measured by a hydrophone on a boat at distances of up to 5 kilometers from the island. The hydrophones readily detected noise from moving barges or tugs at the island at 2.4 kilometers from the island even during high winds. Noise levels in the 20-1,000 Hertz band from barge traffic were about 118 dB re 1 µPa at 1.6 kilometers and had decreased to 108-110 dB re 1 µPa at 2.4 kilometers. At that rate of sound attenuation, the noise level from barges was estimated to be about 92 dB re 1 µPa at 6 kilometers. However, they could not detect underwater sounds at 2.3 kilometers, while people were on the island and power generators were operating but without logging or drilling.

Aerial surveys for bowhead whales near Seal Island in 1982 (during island construction) and 1984 found most whales in waters more than 18 meters deep, which is consistent with data from previous studies (Davis, Greene, and McLaren, 1985). In 1982, one whale was sighted in 12 meters of water about 11 kilometers northwest of Seal Island. In 1984, two sightings of single whales were made in 12-15 meters of water. Whales migrating in water more than 18 meters deep would have been too far away to detect noise from Seal Island, because industrial noise was not audible in the water more than a few kilometers away. Bowhead calls recorded on hydrophones were thought to be from whales that were in waters at least 18 meters deep. Acoustic data suggest some bowheads were closer to Seal Island in 1984 than in 1982. Localizations made by the hydrophone array indicated whales were present between 2.5 and 6 kilometers from Seal Island. No evidence exists to suggest that bowheads avoided Seal Island in 1984 compared to 1982.

Sandpiper Island: Johnson et al. (1986) measured underwater noise at a fixed location 0.5 kilometers from Sandpiper Island, a manmade gravel island off Prudhoe Bay in water 15 meters deep (Map 3b). Sound was measured using a bottom hydrophone system at 0.5 kilometer from the island and sonobuoys at greater distances from the island. The median sound levels observed at a fixed location 0.5 kilometer from Sandpiper Island were relatively low. Median noise levels in the 20-1,000-Hertz band were 93 and 95 dB re 1 µPa during two periods without drilling and 100 dB re 1 µPa during a period with drilling. In the absence of shipping or other industrial sounds, the expected level of noise in the 20-1,000-Hertz band is about 100 dB re 1 µPa for Beaufort Sea State 2 conditions (wind speeds at 7-10 knots and wave heights up to 0.5 meters). The most obvious tones were at 20 and 40 Hertz from power generators on the island.

The low-frequency industrial sounds from Sandpiper Island attenuated rapidly with distance, at least partly because the water was shallow. The low-frequency sounds were evident when ambient-noise levels were low but were largely masked during periods when ambient noise was above average. Sound levels at a sonobuoy 3.7 kilometers from Sandpiper Island (76 dB re 1 µPa in the 20- and 40-Hertz bands) were 24-30 decibels less than the levels at the bottom hydrophone 0.5 kilometer from the island. The bottom hydrophone measured drilling sounds of 100 dB re 1 µPa in the 20-Hertz frequency band at 0.5 kilometer from Sandpiper Island. The sounds were severely attenuated at 3.7 kilometers and not detectable at 9.3 kilometers. The effective source level of the 40-Hertz tone was estimated at 145 dB re 1 µPa at 1 meter.

Impulsive hammering sounds associated with installation of a conductor pipe were as high as 131-135 dB re 1 µPa at 1 kilometer when pipe depth was about 20 meters below the island. In contrast, broadband drilling noise at this distance was about 100-106 decibels. During hammering, the transient signals had the strongest components at 30-40 Hertz and about 100 Hertz. Moore et al. (1984, as reported in Richardson et al., 1995) reported that received levels for transient piledriving sounds recorded at 1 kilometer from an artificial island near Prudhoe Bay were 25-35 decibels above ambient levels in the 50-200-Hertz band. They estimated that the sounds might be received underwater as far as 10-15 kilometers from the source, farther than drilling sounds.

Aerial surveys for bowhead whales in 1985 saw no bowheads closer than 30 kilometers from Sandpiper Island (Johnson et al., 1986). Almost all bowheads traveled in water more than 18 meters deep, as was found in the surveys for Seal Island. Sandpiper and Northstar islands are both about 6 kilometers south of the 18-meter contour. No drilling occurred at Sandpiper Island between September 4 and October 12, 1985, although drilling did resume a few days before the migration ended. With the exception of impact-piledriving sounds, industrial noise from Sandpiper Island was not audible in the water more than a few kilometers away. Because the migration route of almost all bowheads is more than 18 meters deep, few whales moved into the zone where industrial noise potentially was detectable.

The authors concluded that the number of whales that passed along the southern edge of the migration route and approached the artificial islands, both Seal and Sandpiper, must have been a very low fraction of the total population, given the absence of sightings close to the islands.

Richardson et al. (1995) summarized that noise from drilling activities varies considerably with operations. The highest documented levels were transient pulses from hammering to install conductor pipe. Underwater noise associated with drilling from natural barrier or artificial islands is usually weak, and is inaudible beyond a few kilometers. Richardson et al. (1995) estimated that drilling noise generally would be confined to low frequencies and would be audible at a range of 10 kilometers only during unusually quiet periods, while the audible range under more typical conditions would be approximately 2 kilometers.

Inupiat whalers believe that noise from some drilling activities displaces whales farther offshore away from their traditional hunting areas. They express these concerns mainly for drilling activities from drillships with icebreaker support that were operating offshore in the main migration corridor. They also are concerned about noise from the SSDC, the drilling platform used to drill two wells on the Cabot Prospect east of Barrow in 1990 and 1991. The two wells drilled for the Cabot Prospect were spudded on October 19, 1990, and November 1, 1991, respectively. Mr. Jacob Adams, Mr. Burton Rexford, Mr. Fred Kanayurak, and Mr. Van Edwardson, with the Barrow Whaling Captain's Association, stated in written testimony at the Arctic Seismic Synthesis and Mitigating Measures Workshop on March 5-6, 1997, in Barrow, Alaska (USDOI, MMS, 1997a): "We are firmly convinced that noise from the Cabot drilling platform displaced whales from our traditional hunting area. This resulted in us having to go farther offshore to find whales." Additional traditional knowledge on the effects of noise on subsistence activities can be found in Section III.C.3.h.

Richardson and Malme (1993) point out that data, although limited, suggest that bowheads react less dramatically to stationary industrial activities producing continuous noise, such as stationary drillships, than to moving sources, particularly ships. Most observations of bowheads tolerating noise from stationary operations are based on opportunistic sightings of whales near ongoing oil-industry operations, and we do not know whether more whales would have been present without those operations.

Because other cetaceans seem to habituate to continuous or repeated noise that is not harmful, it suggests bowheads may also habituate to certain nonthreatening noises. In Canada, however, bowheads did not use habitat as much after the first few years of intensive offshore oil exploration that began in 1976 (Richardson et al., 1985). Cumulative effects from repeated disturbance may have caused the whales to leave the area, but we do not have enough data on the bowhead's summer distribution to determine whether changes in distribution in the early 1980's were greater than natural annual variations, such as responding to changes in the location of food sources. Ward and Pessah (1988) concluded that the available information from 1976-1985 and the historical whaling information do not support the suggestion of a trend of decreasing use of the industrial zone by bowheads as a result of oil and gas exploration. They concluded that the exclusion hypothesis is likely invalid.

The whale's activity seems to affect the whale's reaction. In baleen whales, single whales that were resting quietly seemed more likely to be disturbed by human activities than groups of whales engaged in active feeding, social interactions, or mating (Richardson et al. 1995). Migrating bowhead whales in the fall may be slightly more responsive to noise from drilling operations than summering bowheads. This may be due in part to greater variability of noise from the drill site in the fall, including variable activities of icebreakers and other support vessels. Habitat or physical environment of the animal also can be important. Bowhead whales whose movements are partly restricted by shallow water or a shoreline sometimes seem more responsive to noise (Richardson et al., 1995).

b) Effects from Vessel Traffic

Vessel traffic could affect bowheads. According to Richardson and Malme (1993), most bowheads begin to swim rapidly away when vessels approach quickly and directly. Avoidance usually begins when a fast-approaching vessel is 1-4 kilometers (0.62-2.5 miles) away. In one

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instance, seven interaction incidents between bowhead whales and vessels were observed from a circling aircraft. The vessels ranged from a 13-meter diesel-powered fishing boat to small ships. A few whales may react at distances from 5-7 kilometers (3-4 miles), and a few whales may react only when the vessel is less than 1 kilometer (0.62 mile) away (Richardson and Malme, 1993). Received noise levels as low as 84 dB re 1µPa (6 decibels above ambient noise) may cause strong avoidance of an approaching vessel at 4 kilometers (2.5 miles).

In the Canadian Beaufort Sea, bowheads observed in vessel-disturbance experiments began to orient away from an oncoming vessel at 2-4 kilometers (1.2-2.5 miles) and to move quickly away when approached closer than 2 kilometers (1.2 miles) (Richardson and Malme, 1993). Vessel disturbance during these experiments temporarily disrupted activities and sometimes disrupted social groups when groups of whales scattered as a vessel approached. Reactions to slow-moving vessels, especially if they do not approach directly, are much less dramatic. Bowheads are often more tolerant of vessels moving slowly or in directions other than toward the whales. Fleeing from a vessel usually stopped within minutes after the vessel passed, but whales may remain scattered for a longer period. Observations made in the central Beaufort Sea during the fall were similar. Koski and Johnson (1987) reported that bowheads 1-2 kilometers to the side of the track of an approaching oil-industry supply vessel swam rapidly away to a distance of 4-6 kilometers from the vessel's track. After some disturbance incidents, at least some bowheads return to their original locations (Richardson and Malme, 1993). Koski and Johnson (1987) reported some individually recognizable bowheads returned to feeding locations within 1 day after being displaced by boats. Whether they would return after repeated disturbances is not known. Some whales may exhibit subtle changes in their surfacing and blow cycles, while others appear to be unaffected. Bowheads actively engaged in social interactions or mating may be less responsive to vessels. Bowheads that are actively migrating may react differently than bowheads that are engaged in feeding or socializing.

c) Effects from Aircraft Traffic

Most offshore aircraft traffic supporting the oil industry involves turbine helicopters flying along straight lines, and underwater sounds from them are transient. According to Richardson et al. (1995), the angle at which a line from the aircraft to the receiver intersects the water's surface is important. At angles greater than 13 degrees from the vertical, much of the incident sound reflects, rather than penetrates, the water. Therefore, strong underwater sounds are detectable while the aircraft is within a 26-degree cone above the receiver. Usually, a receiver could hear an aircraft in the air well before and after briefly hearing it underwater during its short pass overhead.

Observations show that most bowheads do not react much to occasional, single passes by low-flying helicopters ferrying people and equipment to offshore operations at altitudes above 150 meters (500 feet) (Richardson and Malme, 1993, as cited in USDOI, MMS, 1996a). Below 150 meters (500 feet), some whales probably would respond to the aircraft noise by diving quickly (Richardson and Malme, 1993). Bowhead reactions to a single helicopter flying overhead probably are temporary (Richardson et al., 1995). Noise from aircraft generally is audible for only a brief time (tens of seconds) if the aircraft remains on a direct course, and the whales should resume their normal activities within minutes. Patenaude et al. (1997) found that most reactions by bowheads to a Bell 212 helicopter occurred when the helicopter was at altitudes of 150 meters or less and lateral distances of 250 meters or less. A total of 64 bowhead groups were observed near an operating helicopter. Most (47 groups) were observed during a single helicopter overflight or within 2 minutes after landing or during takeoff (9 groups). Immediate dives occurred during 5 of 46 overflights, when the helicopter approached altitudes 150 meters or less. In one case at 150 meters or less, a bowhead breached three times, possibly in response to the helicopter, commencing 30 seconds after the helicopter passed at an altitude of 180 meters and a lateral distance of 1600 meters. Based on 52 bowhead observations at known lateral distances, reactions did not occur significantly more often when the helicopter was operating at a lateral distance of 250 meters or less. The most common reactions were abrupt dives and shortened surface time and most, if not all, reactions seemed brief. However, the majority of bowheads showed no obvious reaction to single passes, even at those distances. The helicopter sounds measured underwater at depths of 3 meters and 18 meters showed that sound consisted mainly of main rotor tones ahead of the aircraft and tail rotor sounds behind the aircraft; more sound pressure was received at 3 meters than at 18 meters; and peak sound levels received underwater diminished with increasing aircraft altitude.

d) Effects from Construction Activities

Island and pipeline construction activities, including placement of fill material, installation of sheetpile, concrete slabs, or gravel bags for slope protection, trenching for the pipeline, and pipelaying, would cause noise that could disturb bowhead whales. However, for the following reasons, this noise is not expected to affect bowhead whales. Fill material for island construction and construction of offshore pipelines are generally done during the winter, when bowhead whales are not present. Placement of slope protection materials would generally be completed by mid-August, before the whales migrate. Placement of sheetpile would generate noise during the open-water period for one construction season but also should be completed in early to mid-August, before the whales migrate. Noise is not likely to propagate far due to the shallow waters and the presence of barrier islands that may lie between the location and the migration corridor used by bowhead whales. Even during the migration, noise from these activities would be minor and would not affect bowhead whales.

e) Effects from Oil-Spill-Cleanup Activities

Disturbance effects to bowhead whales from oil-spill-cleanup activities are discussed in Section III.C.2.a.

2) Specific Effects of Disturbances from BPXA's Proposed Liberty Development and Production Plan

Noise sources associated with the Liberty Project that may affect bowhead whales are drilling, vessel traffic, aircraft traffic, construction, and oil-spill cleanup. Although subsistence whalers have long been concerned that noise from seismic surveys displaces the bowhead whale migration farther seaward, seismic operations are not part of the Liberty Project and are not discussed here. Information on the effects of seismic surveys on bowhead whales, including the results of recent studies, can be found in Section V.C.1.a. in the section on cumulative effects.

a) Effects from Drilling Activities

Drilling activities from the proposed Liberty Project will be done from an artificial gravel island in Foggy Island Bay in 22 feet of water located 1.5 miles west of the abandoned Tern Island. The gravel island would be constructed during the winter in the first part of Year 2. The drilling program would start in Year 3 and continue into Year 4. BPXA proposes to drill an estimated 23 development and service wells. They may drill additional wells later.

Studies Looking at the Effects of Noise from Drilling Operations on Gravel Islands

Tern Island (Liberty Area): Greene (1997) measured underwater sounds under the ice at Liberty from drilling operations at Tern Island in Foggy Island Bay (approximately 2.4 kilometers east of the proposed location of Liberty Island) in February 1997. Sounds from the drill rig generally were masked by ambient noise at distances near 2 kilometers. The strongest tones were at frequencies below 170 Hertz, but the received levels dropped rapidly with increasing distance, falling below the ambient noise level about 2 kilometers away. Greene detected no drilling sounds at frequencies above 400 Hertz, even at 200 meters from the drill rig.

Greene noted that if production proceeds at Liberty, the types and frequency characteristics of some of the resulting sounds would be similar to those from the drilling equipment in this study. Electric-power generators, pumps, and auxiliary machinery again would be involved, as would a drill rig during the early stages of production. However, the production island would have additional processing and pumping equipment. If this equipment requires much more electric power, generators may produce sounds that are detectable farther away. Still, these sounds would decrease quickly with distance because of high spreading losses (35 decibels per tenfold change in range) plus attenuation rates of 2-9 decibels per kilometer (0.002-0.009 decibels per meter). Sound transmission within the lagoon for activities at Liberty would be similar to the sound transmission measured for activities at Tern Island, but the barrier islands to the north and the lagoon's very shallow water near those islands should make underwater sound transmission very poor beyond the islands and into the Beaufort Sea.

Greene (1998) measured ambient noise and acoustic transmission loss underwater at Liberty Island in Foggy Island Bay during the open-water season of 1997 to complement transmission loss and ambient noise measurements made under the ice at Liberty in February 1997. For wind speeds of 0, 10, 20, and 30 knots, typical overall ambient-noise levels in the 20-5,000-Hertz band were 85, 94, 104, and 114 dB re 1 µPa, respectively. For the data from both recorders taken together, the median 20-5,000-Hertz-band level for the 44 days was 97 dB re 1 µPa, or 9 decibels above the corresponding level for Knudsen's standard for Sea State zero. The levels were consistent with other ambient-noise measurements made in similar locations at similar times of the year. The measured ambient-noise levels in winter generally were lower than those measured in summer, which means that industrial sounds would be expected to be detectable at greater distances during the winter. Bowheads are not present in the winter.

Acoustic transmission loss was measured using a four-element sleeve-gun array and a minisparker as sources. The sleeve-gun array is a relatively low-frequency source (63-800 Hertz) as compared to the minisparker (315-3150 Hertz). Received sounds were recorded quantitatively at distances up to 8.1 kilometers southeast and 10.1 kilometers north of Liberty. At greater distances (up to 10 kilometers), the sounds from the sleeve-gun array diminished generally according to -25 log(R), while the minisparker sound diminished at approximately -10 log(R), corresponding to cylindrical spreading. This difference is attributed to the sleeve-gun array being a low-frequency source as compared to the minisparker. Propagation loss rates varied with frequency. The minisparker had a higher linear loss rate, which corresponds to higher absorption and scattering losses at higher frequencies.

Because the bowhead whale's main migration corridor is 10 kilometers or more seaward of the barrier islands, drilling and production noise from Liberty is not expected to reach most of the migrating whales (BPXA, 1998a). In the general Prudhoe Bay area, the southern edge of the main migration route is about 20 kilometers offshore for bowheads (Moore and Reeves, 1993; Miller et al., 1997; BPXA, 2000a). Some whales do migrate closer to the barrier islands, and a few move into lagoon entrances and inside the barrier islands. Whales have not been sighted closer than 10 kilometers from Liberty Island, the distance that noise is likely to be audible (Davis, Greene, and Mclaren, 1985; Johnson et al.,1986; Greene, 1997, 1998) and few whales, if any, are expected to be present near

Liberty Island because of its location and the water depth. The few whales that move into lagoon entrances and inside the barrier islands also should not be bothered by this noise, because these areas generally are beyond the distance that drilling noise is likely to be audible. Because of the location, water depth, and distance of Liberty from the bowhead whale fall migration route, the effects of noise on bowheads are expected to be less than that determined for the Northstar development project, which was concluded to be minor (U.S. Army Corps of Engineers, 1998).

b) Effects from Vessel Traffic

This project likely would have minimal vessel traffic outside the barrier islands. The process modules and permanent living quarters would be transported to the site on seagoing barges during the open-water season, after the island is constructed. Two sealifts are planned. Infrastructure would be sealifted to the island in Year 2 and process modules in Year 3. This barge traffic is likely to be part of a sealift and probably would be the only vessel traffic on the project that occurs outside the barrier islands east of Prudhoe Bay. Barge traffic around Point Barrow is likely to be limited to a short period from mid-August through mid- to late September. Barges likely would remain shoreward of the barrier islands between Prudhoe Bay and Liberty Island and probably would not affect bowhead whales. Unless it encounters severe ice conditions, barge traffic should be completed before the bowhead whale migration reaches this area. If the barge traffic continues during the whale migration, it may disturb some bowheads as described above. Any disturbance is likely to be temporary. Nonemergency vessel traffic outside the barrier islands would be scheduled to avoid interference with subsistence whaling.

Each year, marine vessels would transport supplies between Prudhoe Bay or Endicott and Liberty during the open-water season from July through September. The construction phase would require as many as 150 round trips. Resupply during drilling and production could require four or five barge trips. Again, because these barges would travel inside the barrier islands between Prudhoe Bay or Endicott and Liberty Island, they are unlikely to affect bowhead whales.

c) Effects from Aircraft Traffic

Noise from helicopter traffic associated with this project should not affect bowhead whales. Aircraft would fly only between Prudhoe Bay and Liberty Island, well south of the migration corridor and inside the barrier islands. Aircraft would stay at an altitude of at least 1,500 feet, except during takeoffs, landings, and bad weather conditions. Helicopters would fly an average of 10-20 times per day during the summer for completion of construction activities and 2-3 times per week during production.

The only fixed-wing aircraft proposed for this project would be for pipeline surveillance. Fixed-wing aircraft flying at low altitude (300 meters [1,000 feet]) often cause hasty dives. Reactions to circling aircraft sometimes are conspicuous if the aircraft is below an altitude of 300 meters (1,000 feet), uncommon at 460 meters (1,500 feet), and usually undetectable at 600 meters (2,000 feet). Repeated low-altitude overflights at 150 meters (500 feet) during aerial photogrammetry studies of feeding bowheads sometimes caused abrupt turns and hasty dives (Richardson and Malme, 1993). Aircraft on a direct course usually produce audible noise for only tens of seconds, and the whales should resume their normal activities within minutes (Richardson and Malme, 1993). Patenaude et al. (1997) found that few bowheads (2.2 %) were observed to react to Twin Otter overflights at altitudes of 60-460 meters. During the four spring seasons, 11 bowhead whale groups were observed to react overtly to a Twin Otter. Reactions consisted of two immediate dives, one unusual turn, and eight brief surfacings, representing 2.2 % of the bowhead groups (507 groups) sighted from the aircraft. Most observed reactions by bowheads occurred when the Twin Otter was at altitudes of 182 meters or less and lateral distances of 250 meters or less. Eight groups out of 218 groups reacted to the Twin Otter at altitudes of 182 meters or less. There was little, if any, reaction by bowheads when the aircraft circled at an altitude of 460 meters and a radius of 1 kilometer. The effects from disturbance by aircraft are brief, and the whales should resume their normal activities within minutes.

d) Effects from Construction Activities

Island and pipeline construction activities, including placement of fill material, installation of sheetpile, trenching for the pipeline, and pipelaying, would cause noise that could disturb bowhead whales. However, for the following reasons, this noise is not expected to affect bowhead whales. Workers would place fill material for island construction and construct the offshore pipeline during the winter, when bowhead whales are not present. Any minor adjustments to side-slope protection would be completed by mid-August, before the whales migrate. Placement of sheetpile would generate noise during the open-water period for one construction season but should be completed in early to mid-August, before the whales migrate. Noise is not likely to propagate far due to the shallow waters and the barrier islands that lie between Liberty and the migration corridor used by bowhead whales (BPXA, 1998a). Even during the migration, noise from these activities would be minor and would not affect bowhead whales.

Bowhead whales are not likely to be affected by sediment or turbidity from placing fill for island construction, island reshaping before placing slope-protection material, or pipeline trenching or backfilling. BPXA would construct the island and pipeline during the winter, when bowhead whales are not present. The island would be reshaped and slope-protection material placed by mid-August, before the whales migrate. Whales should not be affected by these activities, even during the migration, because the island is well shoreward of the barrier islands and whales infrequently go there.

(2) Eiders

(a) Summary and Conclusion for Effects of Disturbances on Spectacled and Steller's Eiders

Helicopter flights to Liberty Island during pack-ice breakup may disturb some spectacled eiders feeding in open water off the Sagavanirktok River Delta. If they relocate to other areas, competition for food available during this period following migration may result in decreased breeding success in some individuals. Likewise, summer flights to the island may displace some eiders from preferred marine foraging areas or juveniles from coastal habitats occupied after they fledge. The extra energy and time used in responding to such disturbance and finding alternate habitat may result in decreased survival of some juvenile eiders. Using boats instead of helicopters to supply Liberty Island during the open-water season would minimize airborne disturbance but would increase the possible disturbance from boats.

Onshore, frequent flights over nesting or broodrearing eiders may cause them to relocate in less favorable habitat; eiders that abandon a nest probably will not renest. Females temporarily displaced from a nest by occasional onshore pipeline inspection flights may expose eggs to predation. Either situation may result in fewer young produced. Most onshore activities in the Liberty area are likely to affect at most only a few individuals, and careful selection of aircraft routes could eliminate most disturbance of nesting eiders. Displacement of eiders from the vicinity of disturbing activities would eliminate them from only a small proportion of available similar habitat, although the amount of high quality habitat in the Beaufort Sea area remains unknown, as are details of eider foraging habits. This likely would be a minor effect.. Development of the Liberty Prospect is expected to result in only a small amount of habitat loss involving displacement of few eiders to alternate sites. Spill-cleanup activities may disturb nesting, broodrearing, or staging eiders or juveniles occupying coastal habitats, resulting in decreased survival. Spectacled eider mortality from collisions with Liberty Island structures is estimated to be 2 or less per year. Collisions with the onshore pipeline are considered unlikely.

The small losses and displacements likely to result from the above activities may cause population effects that would be difficult to separate from natural variation in population numbers. However, any decline in productivity or survival resulting from the Liberty Project would be additive to natural mortality and could interfere with the recovery from any decline the coastal plain spectacled eider population may experience. Disturbance of spectacled eiders by Liberty Project activities could result in a take under the Endangered Species Act. Steller's eiders are not expected to be found in the Liberty Project area.

(b) Details on How Disturbances and Related Factors May Affect Spectacled and Steller's Eiders

1) General Effects from Developing the Liberty Prospect

a) Effects from Collisions with Structures on Liberty Island or Onshore

Because eiders typically fly at a relatively low altitude over water (Johnson and Richardson, 1982), the potential exists for these sea ducks to collide with offshore structures that protrude above the surface. This would be true especially under conditions of poor visibility (for example, fog). Information currently available on spectacled eider migration routes and other movements in the Liberty Island area, behavior, and vulnerability to obstructions during migration makes it difficult to estimate potential mortality. However, although collision of an entire flock with Liberty Island could result in substantial mortality, the island actually will be a small obstruction in the Beaufort Sea and most eiders are likely to see and avoid it. Thus, spectacled eider mortality from collisions with the island are estimated to be 2 or less per year as they were for Seal Island, the site of the Northstar Project (USDOI, Fish and Wildlife Service, 1999a). Eiders colliding with the elevated onshore portion of the pipeline is considered unlikely, because it is only 1.5 miles long and would project only about 6 feet above the surface. Eiders are likely to be at very low density near the pipeline, and most of their activities would involve walking or swimming rather than flight. Mortality from pipeline collisions is expected to be negligible.

b) Increase in Predator Populations

We assume that BPXA would comply with all applicable regulations governing waste management and feeding of wildlife and, therefore, they would not be responsible for any increase in predator populations that could lead to the mortality of spectacled eiders.

2) Specific Effects of Disturbances and Related Factors from BPXA's Proposed Liberty Development and Production Plan

a) Effects from Aircraft Operations

Impacts from aircraft flights supplying offshore oil development would depend on the type of aircraft, flight frequency, altitude, routes used (distance from aircraft to habitats likely to be used by eiders), and season.

During breakup (May/June), helicopters could fly 10-20 times per day (Table V-8) over open-water areas off the Sagavanirktok Delta, where migrant eiders may forage until the nesting areas are free of snow. If birds are disturbed by this activity, they may relocate to other foraging areas. This could increase competition for the food available during this energetically stressful period following spring migration and could result in decreased. Because limited open water is available in spring, access to such areas is likely to be more restricted than in the post-breeding period. During the summer, nonbreeding individuals, failed breeders, and males may be feeding in nearshore or offshore areas. Helicopters flying over these areas 10-20 times per day could cause birds to move away from routinely used routes, which could increase the stress of preparing for migration. Movement of eiders from near these routes would cause them to avoid only a small proportion of available foraging habitat. Bottom survey video records indicate that alternate foraging habitat, similar in appearance and with similar prey organisms evident, is widely distributed in the region. This likely would be a minor effect.

Frequent helicopter flights over nesting or broodrearing eiders on tundra and the Sagavanirktok River Delta, or other coastal habitats occupied by juveniles after they fledge, may cause them to relocate in less favorable habitat. Eiders that abandon a nest probably would not renest because of the short season and their limited reserves of stored energy. Precautions planned to protect snow geese on Howe Island, (discussed in Sec. II.A.1.b(5)(a)) also would lessen effects from helicopter disturbance on any eiders in that area. These precautions specify that helicopters will fly at 1,500 feet and avoid Howe Island by 1 mile during the nesting and broodrearing periods. Because helicopters would fly to Liberty Island only 2-3 times per week during the production phase, they are not as likely to disturb eiders.

Helicopters flying at low altitudes during the weekly inspections of the 1.5 mile onshore pipeline could displace nesting eiders away from areas near the pipeline for up to several hours. Temporary displacement of adults from nests may expose eggs or recently hatched nestlings to predators, resulting in fewer young produced. Most onshore activities in the Liberty area are likely to affect at most only a few individuals.

b) Effects from Construction and Vehicle Traffic

Most construction activity would occur in winter, when eiders are absent. Constructing a gravel island, trenching to bury the pipeline in the seabottom, and storing excess material at sea are not expected to disturb the spectacled eider population. If open water occurs on the lee side of the production island, spring migratory eiders may use it as staging and foraging habitat.

c) Effects from Vessel Traffic

Routine trips by supply vessels, including an estimated 150 trips per summer (estimate 1-2/day) within the barrier island/Foggy Island Bay area, would displace most birds temporarily from near the route. This traffic is likely to disrupt feeding in the area, but probably would increase the birds' energy use only slightly. Some birds may habituate to this disturbance, and others may abandon the area near any routinely used route. The annual sealift arrival of several vessels is expected to cause only temporary disturbance. Using vessels instead of helicopters during periods of open water would lessen airborne disturbance while increasing disturbance directly at the water surface, probably along a limited corridor. Because there is only sparse information currently available on routes that spectacled eiders use during migration and other movements through the area and their vulnerability to disturbance by vessels, it is difficult to estimate potential effects of vessel traffic on individuals or populations.

d) Effects from Habitat Alteration

Construction of a gravel island, digging a trench for burying the pipeline, storage of dredged material from the trench, or smothering of bottom organisms by sediment settling would bury about 81+ acres of bottom where eiders could forage. This represents an insignificantly small proportion of the habitat available within eider diving capability in the Beaufort Sea and is expected to have a minimal effect on food intake and fat storage by eiders. Construction of small gravel pads where the pipeline comes ashore and connects to the Badami pipeline would bury less than 1 acre of tundra habitat. Gravel mining is likely to displace only a few eiders, at most, from the mine-site vicinity. These losses are likely to represent an insignificant reduction of available habitat, which is unlikely to cause the displacement of more than a few eiders to alternate nesting or broodrearing sites, or reduced eider productivity.

e) Disturbance Effects from Spill Cleanup

Spill cleanup in coastal areas may disturb broodrearing or staging eiders or juveniles occupying coastal habitats often during the initial period of cleanup and less frequently in the following years. Predators may take some eggs or young while adults are displaced off their nests if located near a site of operations, and birds disturbed often during this activity may have lowered reproductive success. An estimated 300 cleanup workers, plus many boats and aircraft, would be present for 6 months during the first year after a spill. This level of activity is likely to displace eiders from habitats where they obtain food needed for growth, molting, and migration. Complete cleanup may take 4 years; but after the first year, effort could focus on periods when few eiders are present. Onshore cleanup of a pipeline spill could displace any eiders (probably few within this short distance) from habitats in this 1.5-mile long corridor.

Eiders colliding with the elevated onshore portion of the pipeline is considered unlikely, because it is only 1.5 miles long and would project only about 6 feet above the surface. However, males and unsuccessful females, successful females accompanied by their fledged young, or overland migrants arriving in spring, flying locally or to the marine environment for staging or migration, potentially could strike the pipeline. The Northstar Development Project Biological Opinion (USDOI, Fish and Wildlife Service, 1999a), stated that the presence of a comparable onshore pipeline was not likely to cause mortality of spectacled eiders.

b. Seals and Polar Bears

(1) Summary and Conclusions for Disturbance Effects on Seals and Polar Bears

Construction activity would displace some ringed seals within perhaps 1 kilometer of the island and along the pipeline route in Foggy Island Bay. Seals and polar bears would be exposed to noise and disturbance from pipeline dredging and burial activities in Foggy Island Bay. This disturbance of seals and polar bears would be local, within about 1 mile along the pipeline route, and would persist for one season.

Food smells coming from the camp on the island may attract a few bears to the production-island. This attraction could require deliberate hazing of these polar bears, but this effect would not be significant to bear abundance or distribution.

Low-flying helicopters or boats would cause some ringed and bearded seals to dive into the water, and a few females may be temporarily separated from their pups. This displacement is expected to be brief (a few minutes to less than 1 hour). Low flying helicopters moving to and from the Liberty Project area could briefly disturb a few polar bears. These disturbances would not affect overall seal or bear abundance and distribution in Foggy Island Bay.

Vehicle traffic on the ice roads from the Endicott causeway directly to the production island and along the coast to Foggy Island Bay/Kadleroshilik River could disturb and displace a few denning polar bears and a small number of denning ringed seals (see Map 2B). The number of bears and seals potentially displaced is expected to be low and would not affect the populations of ringed seals and polar bears.

(2) Details on How Disturbances May Affect Seals and Polar Bears

(a) General Effects from Developing the Liberty Prospect

1) Traditional Knowledge on Disturbance of Seals and Polar Bears

Natives of the North Slope are concerned that noise heard miles away from drilling platforms may drive ringed and bearded seals away from subsistence-hunting areas (Philip Tikluk from the village of Kaktovik, as cited in Kruse et al., 1983). This may happen during construction when high levels of industrial activity occur. Thus, construction could displace some ringed and bearded seals for 2 years within perhaps 1 kilometer of the Liberty Island in Foggy Island Bay. However, the presence of a production island in the sea could result in the formation of leads and cracks in the ice on the leeward side of the island. Such local changes in the ice habitat after island construction is completed could attract seals that, in turn, could attract polar bears to the drilling platforms, as was reported in association with exploration gravel islands in the Canadian Beaufort Sea (Stirling, 1988).

Constructing gravel islands in the seals' ice habitats and breathing-hole ice habitats is a concern (Akootchook, 1986, pers. commun.).

2) Attraction of Polar Bears to Development Facilities

Polar bears would be attracted to facilities by food smells and because they are curious animals. For their own protection, oil workers may have to haze a few polar bears attracted to the gravel island. In an extreme situation, workers may have to kill a bear. Under the Marine Mammal Protection Act, oil companies must have permits to take or harass polar bears. Based on consultation with the Fish and Wildlife Service, companies typically would not kill a bear unless absolutely necessary. Even in a worst-case situation, we would expect no more one or two bears to be lost to such encounters over the 15-year life of the project. This effect would not be significant to the polar bear population. Advising oil workers and the contractors to consult the MMS *Guidelines for Oil and Gas Operations on Polar Bear Habitats* (LGL Ecological Research Assocs., 1993) and BPXA's Polar Bear Interaction Plan for Liberty should help to lessen encounters with polar bears.

(b) Specific Effects of Disturbance from BPXA's Proposed Liberty Development and Production Plan

1) Assumptions about Development Activities that could Disturb Seals and Polar Bears

We assume the oil industry and its contractors would follow the Information to Lessees on Bird and Marine Mammal Protection and Letters of Authorization issued by the Fish and Wildlife Service recommending a 1-mile buffer around occupied polar bear dens. If so, they would avoid flying below 545 meters (1,500 feet) or within 1.6 kilometers (1 mile) of seal haulout sites and other known areas of concentration for marine mammals, whenever weather conditions permitted, and avoid disturbing denning polar bears. General locations of where seals and polar bears (including past bear-den locations) have been recorded and are presented in the Liberty Environmental Report (BPXA, 1998a). Compliance should prevent excessive or frequent disturbance of seals and polar bears. However, we do expect some unavoidable temporary disturbance of hauled out and feeding seals and a few polar bears in the following instances:

- Weather conditions keep helicopters from flying at least 545 meters (1,500 feet) above or 1.6 kilometers (1 mile) from concentrations.
- Aircraft fly low over concentrations of seals and polar bears during takeoffs and landings.

- Boats disturb some seals or polar bears near icefloes and leads.

Possible disturbance of seals and polar bears would result from the following:
- Construction of one production island, 6.1 miles of offshore pipeline, and 1.5 miles of onshore pipeline.
- Helicopter flights to and from Prudhoe Bay and the production island (10-20 flights/day during construction and 3 flights/week to 1 flight/day during operations).
- Vessel traffic, including 150 barge trips moving within the barrier islands from West Dock or Endicott to and from Liberty Island.
- Ice-road traffic, 400 supply trips/day during the winter construction season to and from Endicott to Liberty, traffic from the construction of ice roads, the production island, offshore and onshore pipelines, and onshore gravel pads and gravel mining.

No seismic activities are expected to be associated with development of the Liberty Project.

The specific effects of these activities are as follows.

2) Effects from Air and Vessel Traffic

Some of the 10-20 helicopter round-trip flights per day to and from Liberty Island during ice breakup in the spring could briefly disturb some ringed and bearded seals hauled out on icefloes or in the water near the island. Boat traffic, including 150 barge trips and sealift barge convoys (the latter would occur during two open-water construction seasons), could disturb some seals. These disturbances are more likely to occur when the helicopters are required to fly low (less than 1,500 feet) on approach to the island or when the weather is poor, and when barge and boat traffic pass near seals hauled out on ice or in the water. These disturbances would be brief (a few minutes to less than 1 hour) and would not significantly affect the seal population. Helicopter, boat, and barge traffic may briefly disturb a few polar bears near the island and along the coast of Foggy Island Bay. These disturbances are not expected to affect the overall bear abundance and distribution. To lessen potential disturbance of marine mammals and reduce conflicts with subsistence hunters, BPXA would direct its contractors to route all marine vessels transiting between Prudhoe Bay or Endicott to and from the Liberty Project area to travel shoreward of the barrier islands. During the open-water season, few ringed and bearded seals are likely to be present shoreward of the barrier islands, where the vessel traffic associated with Liberty would occur (see Map 2B).

3) Effects from Onshore Construction

BPXA would construct a pipe-valve gravel pad (135 x 97 feet) about 100-150 feet inland at Foggy Island Bay, where the pipeline elevates to its onshore run. Workers constructing the pad and installing the pipeline could temporarily disturb a few (1-3) polar bears within a mile of these activities. Contractors must follow the Fish and Wildlife Service Letter of Authorization to reduce encounters with bears and avoid disturbing dens that could be near the pad or along the pipeline.

4) Effects from Ice Roads

A few adult ringed seals and pups would be displaced by ice roads where the roads pass over floating fast ice to the Liberty Island and from the island to the Kadleroshilik River gravel mine site and from Endicott-Duck Island to the Liberty Island (see Map 2B). Ice roads that are routed over grounded fast ice near the shore would not pass over ringed seal pupping habitat. The number of seals displaced is expected to be very low, perhaps 1-2 seals per kilometer of ice road (about 20 miles of ice road would pass over floating fast ice; see Map 2B). This seasonal effect is expected to occur over the 15-year life of Liberty along the route between Liberty and the Endicott causeway, when this ice road is constructed and used. This displacement is not expected to affect the seal population or greatly affect their distribution in Foggy Island Bay. Construction of ice roads for the Northstar Project affected the behavior of a few seals within 0.64 kilometer of the ice roads but had no effect on ringed seal distribution and abundance (Richardson and Williams, 1999).

Ice roads for winter development may disturb a few polar bear maternity dens during the 2 years of construction activities (Blix and Lentfer, 1991; Amstrup, 1993; USDOI, Fish and Wildlife Service, 1995b). However, denning polar bears have tolerated high levels of seismic activity and ice-road traffic (the latter only 400 meters from the den) (Amstrup, 1993). The proposed ice road and noise from vehicle traffic on the road from the Endicott causeway along the coast of Foggy Island Bay and near the Kadleroshilik River could disturb and displace a few denning polar bears. However, the number of bears potentially displaced is likely to be low and would not affect the population (see Map 2B). As recommended by the Fish and Wildlife Service, BPXA plans to obtain a Letter of Authorization for unintentional take of polar bear, especially during winter months, in accordance with existing regulations. We expect the monitoring program and mitigation required under the authorization to prevent significant disturbance of denning polar bears.

5) Effects from Constructing Liberty Island

Construction could displace some ringed and bearded seals for 2 years within perhaps 1 kilometer of the Liberty Island in Foggy Island Bay. The island would remove a small amount (about 5-6 acres) of ringed seal pupping habitat at the island location over the 15-20 year life of the project. The amount of displacement and change in habitat use (within 1 mile of the island) is likely to be very small compared to natural variations in seasonal habitat use and in the ringed seals' distribution in Foggy Island Bay due to annual variation in ice coverage (Brower et al., 1988). This

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local loss of habitat would not affect the population or overall distribution of seals in Foggy Island Bay. A few polar bears may be attracted to the island from food odors and because they are curious. Workers may have to haze (scare away) these bear, but this would not affect bear abundance or distribution.

Drilling and operation noises from the Liberty Island usually would not be detectable above background noises beyond 2,000 meters (Greene, 1997). Low-frequency noises from drilling on the Liberty Island may cause some secondary disturbance. During construction of an island in winter 1981-1982, monitoring showed a slight change in ringed seal distribution near the island and density increasing with distance from the island (Frost et al., 1988).

6) Effects of Pipeline Burial

Pipeline burial would alter benthic habitat along the pipeline installation route. Seals and polar bears would be exposed to noise and disturbance from pipeline dredging and burial activities in Foggy Island Bay. This disturbance of seals and polar bears would be local, within about 1 mile along the pipeline route, and would persist for one season. Pipeline construction involves trenching, hydraulic dredging, backfilling material into the trench, and storing excess trenching material on the ice. These activities are likely to temporarily displace some seal prey organisms from the immediate area of the activities, and a few individual prey organisms could be harmed or killed. However, these effects are not expected to continue after construction is completed or to have a measurable effect on prey populations.

c. Marine and Coastal Birds

(1) Summary and Conclusion for Effects of Disturbances on Marine and Coastal Birds

Helicopter flights to Liberty Island during the pack-ice breakup may disturb some loons and king or common eiders feeding in open water off the Sagavanirktok River Delta. If they relocate to other areas, competition for food available during this period following migration may result in lowered survival. During the summer, flights to the island may displace some long-tailed ducks and eiders from preferred marine foraging areas and snow goose and brant family groups from coastal broodrearing areas. These flights are not likely to directly cause bird mortality, but extra energy and time used in response to disturbance and to find alternate areas may result in decreased fitness and, potentially, survival to breeding age in some individuals. Substantial areas of at least superficially similar foraging habitat apparently are available onshore and offshore following the breeding period, although the amount of high quality foraging habitat in the Beaufort Sea area for particular species remains unknown, as are details of foraging habits for most species. Using vessels instead of helicopters would minimize airborne disturbance while increasing surface disturbance. The latter generally would result in negligible effects to bird populations.

Frequent flights over nesting or broodrearing waterfowl and shorebirds on the mainland may cause birds to relocate in less favorable habitat. Birds that abandon a nest may not renest, or may be delayed to a less favorable period. Adults temporarily displaced from nests by occasional onshore pipeline inspection flights may expose eggs or nestlings to predation. Any of these situations may result in fewer young produced.

Most onshore activities in the Liberty area are likely to disturb relatively few birds. Construction and vehicle traffic in winter may displace a few ptarmigan from near the activity. Spill-cleanup activities may displace some nesting, broodrearing, juvenile, or staging waterfowl and shorebirds from preferred habitats, resulting in lower survival. Development of the Liberty Prospect is expected to result in a small amount of habitat loss involving displacement of a few birds to alternate sites. This is likely to be a minor effect, unless it results in decreased survival either by itself or in combination with other factors. Mortality from collisions with onshore structures is expected to be negligible.

The small losses and displacements likely to result from the above activities are expected to cause minor changes in numbers that may be difficult to separate from natural variation in population numbers for any species (Eppley, 1992). Such changes are not expected to require lengthy recovery periods. However, any mortality resulting from development of the Liberty Prospect would be additive to natural mortality, requiring some time for recovery from such losses, and may interfere with the recovery of Arctic Slope populations should declines in these species (for example, king and common eiders) take place.

(2) Details on How Disturbances and Related Factors May Affect Marine and Coastal Birds

(a) General Effects from Developing the Liberty Prospect

1) Effects from Collisions with Structures on Liberty Island

Because several loon, waterfowl, shorebird, and seabird species fly at a relatively low altitude over water, the potential exists for these birds to collide with offshore structures that protrude above the surface. This would be true especially under conditions of poor visibility (for example, fog). Information currently available on bird migration routes and other movements in the Liberty Island area, behavior, and vulnerability to obstructions during migration makes it difficult to estimate potential mortality. However, because Liberty Island would be a small obstruction in the Beaufort Sea and most individuals encountering the island during migration or other movements are likely to see and avoid it, bird mortality from collisions with the island likely would be low. Birds colliding with the elevated onshore portion of the pipeline is considered unlikely, because it is only 1.5 miles long and would project only about 6 feet above the surface. However, some loons, waterfowl, shorebirds, raptors, or passerines flying locally or to the marine environment for feeding, staging or migration, potentially could strike the pipeline. Mortality from pipeline collisions is expected to be negligible.

2) Increase in Predator Populations

We assume that BPXA would comply with all applicable regulations governing waste management and feeding of wildlife and, therefore, they would not be responsible for any increase in predator populations that could lead to mortality of marine and coastal birds.

(b) Specific Effects of Disturbances and Related Factors on Eiders from BPXA's Proposed Liberty Development and Production Plan

1) Effects from Aircraft Operations

Impacts from aircraft flights supplying offshore oil development would depend on the type of aircraft, flight frequency, altitude, routes used (lateral distance to wildlife), and season. Because displacement would eliminate a relatively small proportion of available foraging habitat, effects are likely to be minor.

During breakup (May/June), helicopters could fly 10-20 times per day (Table V.B-8) over open-water areas off the Sagavanirktok Delta where migrant waterfowl, particularly loons and eiders, forage until the nesting areas are free of snow. If birds are disturbed by this activity, they may relocate to other foraging areas, which would increase competition for the food available during this energetically stressful period following spring migration and may result in decreased survival. Because limited open water is available in spring, access to such areas is likely to be more restricted than in the postbreeding period. Substantial areas of at least superficially similar foraging habitat apparently are available offshore, although the amount of high quality foraging habitat in the Beaufort Sea area for particular species remains unknown. In general, bottom survey video records from a variety of sites (LGL Ecological Research Assocs., 1998) show habitat similar in appearance and with similar prey organisms evident, suggesting that it is readily available in the region, so access from the surface determined by ice cover may be the principal limiting factor.

During the summer, many nonbreeding individuals, failed breeders, and males not involved with raising young, such as long-tailed ducks and eiders, may be feeding in nearshore areas or lagoons. Helicopters flying over these flocks 10-20 times per day could displace them from the vicinity of routinely used routes causing increased stress.

Frequent helicopter flights over nesting, broodrearing, or juvenile waterfowl and shorebirds on tundra and the Sagavanirktok River Delta or other coastal habitats may cause them to relocate in less favorable habitat. Birds that abandon a nest probably would not renest because of the short season available and limited energy reserves, or may be delayed to a less favorable period when young are less likely to survive. Snow geese at the Howe Island colony and brant on the delta are particularly sensitive to disturbance by aircraft, but planned precautions (discussed in Sec. II.A.1.b(5)(a)) should lessen the effects on these and other species occurring in the same areas. These state that helicopters will fly at 1,500 feet and avoid Howe Island by 1 mile during the nesting and broodrearing seasons. Because helicopters would fly to Liberty Island only 2-3 times/week during production, they are not as likely to fly over flocks of waterfowl or other species.

Helicopters that fly at low altitudes during weekly inspections of the 1.5-mile onshore pipeline could displace nesting shorebirds, passerines, and waterfowl from areas near the pipeline for up to several hours. For example, this could involve 2.4 Pacific loon, 3.1, long-tailed duck, 29.0 pectoral sandpiper, and 60.4 Lapland longspur nests if a 0.5 kilometer zone of disturbance on either side of the pipeline is assumed (calculated from TERA, 1995b). Temporary displacement of adults from nests may expose eggs or nestlings to predators, resulting in fewer young produced. Sensitive species, especially if disturbed early in the nesting season, may abandon the nesting attempt and the year's productivity, or experience a delay as a result of displacement and renesting that reduces productivity. Any of these results may cause local declines in the number of young produced. However, most onshore activities in the Liberty area are likely to affect relatively few individuals given the small area and low nesting density likely to be involved.

2) Effects from Construction and Vehicle Traffic

Most construction activity would occur in winter, when only the four resident species may be present. None would be common along a traffic route between Deadhorse and the Liberty Project area. Construction of two small pads and pipeline and vehicle traffic mainly would displace a few ptarmigan from the immediate work area or route of ice roads. We expect this effect to be negligible compared to seasonal changes in distribution. Constructing a gravel island, trenching to bury pipeline in the seabottom, and storing excess material are not expected to disturb bird populations.

3) Effects from Vessel Traffic

Supply vessels would make an estimated 150 trips per summer (estimated 1-2/day) during the 2-year construction phase. This level of activity within the barrier island/Foggy Island Bay area probably would disturb most birds near any routinely used route, at least when vessels are present. This would disrupt feeding in the area but probably increase the birds' energy use only slightly, because alternate foraging areas are available. Some birds may habituate to this disturbance and others may abandon the area. During the summer seasons of the 2-year drilling and production phases, vessels would make 4-5 trips/month and 4-5 trips per summer, respectively. These and the annual sealift arrival of several vessels are expected to cause only temporary disturbance, increasing the birds' energy use only slightly, if at all. Using vessels instead of helicopters during periods of open water would lessen airborne disturbance while increasing surface disturbance. Brant and canvasbacks are easily disturbed to flight (Korschgen, George, and Green, 1985; Ward and Stehn, 1989), which is assumed to increase energy needs, while long-tailed ducks were not seriously affected by systematic boat disturbance in Simpson Lagoon (Johnson and Richardson, 1981). Because the information currently available on routes most species use during migration and other movements, behavioral response to vessels, and vulnerability to disturbance by vessels, it is difficult to estimate potential effects on individuals or populations.

4) Effects from Spill Cleanup

Spill cleanup in coastal areas or on barrier islands may cause significant disturbance if it occurs while waterfowl or shorebirds are nesting, broodrearing, molting, or staging for migration, or juveniles are occupying coastal habitats, especially during the initial period of cleanup. Predators may take some eggs or young while adults are displaced off their nests, and birds disturbed often during this activity may have lowered reproductive success or survival. An estimated 300 cleanup workers, along with many boats and aircraft, would be present for 6 months during the first year after a spill (see Secs. III.C.2.k and II.A.4). This level of activity is likely to displace large numbers of shorebirds and waterfowl from habitats where they obtain food needed for growth, molting, and migration. Complete cleanup may take 4 years; however, after the first year, effort could focus on periods when fewer birds are present. Onshore cleanup of a pipeline spill could displace birds from habitats in this 1.5-mile long corridor.

5) Effects from Disturbance of Habitats

Construction of a gravel island, digging a trench for burying the pipeline, and storage of dredged material from the trench would bury about 81 acres of bottom where sea ducks could forage. This represents a very small proportion of the area where such habitat is available (bottom survey video records indicate that alternate foraging habitat, similar in appearance and with similar prey organisms evident, is widely distributed in the region) and is expected to have a minimal effect on food intake and fat storage by birds. Construction of small gravel pads where the pipeline comes ashore on a low coastal bluff and where the pipeline connects to the Badami pipeline would bury less than 1 acre of tundra habitat. Likely vegetation in this area is moist sedge or dwarf shrub. Such habitat is widespread in the area, so the few shorebirds and/or songbirds potentially displaced (all species combined = 0.28 nests per square kilometer; TERA, 1995b) would have ready access to comparable nesting sites. Although birds may elect not to nest beneath or adjacent to the pipeline, it is not expected to represent a significant disturbance factor because of its short length and abundant similar habitat is available locally. Gravel mining is likely to displace only a few individuals from the mine-site vicinity (see Sec. III.D.2.c for details). These losses are likely to represent a negligible reduction of available habitat.

d. Terrestrial Mammals

(1) Summary and Conclusion for Disturbance Effects on Terrestrial Mammals

Helicopter and ice-road traffic, encounters with people, and mining and construction operations could disturb individual or small groups of these mammals for a few minutes to a few days or no more than about 6 months within about 1 mile of these activities. These disturbances would not affect populations. This traffic could briefly disturb some caribou, muskoxen, and grizzly bears, when the aircraft pass overhead or nearby, but would not affect terrestrial mammal populations.

Traffic for constructing the ice roads, production island, pipeline, and gravel pads and to haul gravel and supplies could disturb some caribou and muskoxen along the ice roads during the 2 years of development and during other winters, when further work on the project is needed. This traffic would occur during December though early May, with more ice-road construction and traffic occurring during the 2 years of development. Some continued ice-road activity would occur during the 15 years of production to support project operations. These disturbances would have short-term effects on individual animals and would not affect populations.

Encounters between grizzly bears and oil workers or with facilities could lead to the removal of problem bears. However, the amount of onshore activity associated with Liberty (1.4 miles of onshore pipeline with no onshore camp facilities) is not likely to result in the loss of any bears. Arctic fox numbers could increase in the project area because of the possible availability of food and shelter on the production island. However, the amount of onshore activity associated with Liberty (1.4 miles of onshore pipeline with no onshore camp facilities) would not result in a significant increase in fox abundance. BPXA's wildlife interaction plan and treatment of galley wastes should help to reduce the availability of food to foxes.

(2) Details on How Disturbances May Affect Terrestrial Mammals

(a) General Effects from Developing the Liberty Prospect

1) Effects of Disturbance on Grizzly Bears

Some grizzly bears have been be attracted to oil fields, especially to galleys and garbage containers, and people have had to kill some bears to protect themselves and property (Schallenberger, 1980). Some industrial activities and people could disturb sleeping grizzly bears. Bears that are abruptly awakened can pose a threat to workers, causing injury and the possible death of people and the bear. Once bears are used to human sources of food, improved garbage handling and other measures to reduce these sources are not always effective. The bears will work harder to get to artificial food sources they are used to having. Alaska Department of Fish and Game bear biologists may have to capture and physically transport problem bears from the oil fields. If the problem bear returns and poses a continued threat to people and property, it may be destroyed. The proper handling and storage of food and garbage should avoid attracting bears to Liberty construction and facility sites. Such measures are described in the Liberty Development and Production Plan (BPXA, 2000a). The plan states that waste and garbage would be incinerated on Liberty Island or transported to existing North Slope facilities for processing or disposal.

Grizzly bears in the Liberty area are not likely to encounter construction workers and most onshore development activities, because those activities would occur during winter when the bears are denning and because the camps would be located on the production island offshore. Advising oil workers to consult MMS *Guidelines for Oil and Gas Operations on Polar Bear Habitats* to lessen interactions with polar bears also would be applicable to encounters with grizzly bears. Implementing these guidelines would reduce the chances of adverse grizzly bear-human interactions that may lead to the injury or loss of people and bears.

2) How Habitat Disturbance-Alteration May Benefit Arctic Foxes

Arctic foxes could benefit from Liberty development, because they could find shelter under buildings and potential food (temporary refuse storage) that would be on the production island. Camps and oil field facilities in the Prudhoe Bay area provide food sources for foxes at dumpster sites near galleys and dining halls and at dump sites (Eberhardt et al., 1982; Rodrigues, Pollard, and Skoog, 1994). Crawlspaces under housing, culverts, and pipes provide foxes with shelter for resting and, in some cases, artificial dens (Eberhardt et al., 1982; Burgess and Banyas, 1993). Oil development has not harmed the fox population (Eberhardt et al., 1982). On the contrary, arctic fox numbers and productivity are higher in the Prudhoe Bay area as compared to adjacent undeveloped areas (Burgess et al., 1993). BPXA's wildlife interaction plan and treatment of galley wastes and other garbage should help to reduce the availability of this food to foxes.

(b) Specific Effects of Disturbance from BPXA's Proposed Liberty Development and Production Plan

1) Effects from Air Traffic

Helicopter flights would average 10-20 flights per day during the 2-3 years of development. This traffic could briefly disturb some caribou, muskoxen, and grizzly bears, when the aircraft pass overhead or nearby, but would not affect terrestrial mammal populations.

2) Effects from Ice Roads

BPXA would not build permanent access roads along the Badami pipeline or next to the onshore pipeline that ties into it. Most of the length of ice roads would be located offshore and routed from the Endicott causeway to the production island. The short ice roads would connect the island with the gravel mine on the Kadleroshilik River (see Map 2A). Traffic for constructing the ice roads, production island, pipeline, and gravel pads and to haul gravel and supplies could disturb some caribou and muskoxen along the ice roads during the 2 years of development and during other winters, when further work on the project is needed. This traffic would occur during December though early May, with more ice-road construction and traffic occurring during the 2 years of development. Some continued ice-road activity would occur during the 15 years of production to support project operations. These disturbances would have short-term effects on individual animals and would not affect populations.

3) Effects from Gravel Mining

Gravel mining would alter a small area of river habitat along the Kadleroshilik River (about 38 acres of sparsely vegetated river barrens land cover and about 7 acres of reserve area at the gravel mining site, for a total disturbed area of about 45.1 acres). This alteration would not disturb many terrestrial mammals. Most caribou migrate south to the Brooks Range during the winter months when gravel will be mined, but small bands may be present.

Muskoxen have been sighted recently along the Kadleroshilik River, but few were sighted during the winter (LGL Alaska Research Assocs., Inc.; Woodward-Clyde Consultants; and Applied Sociocultural Research, 1998). There are no known grizzly bear dens near the preferred gravel mining site on the Kadleroshilik River (see Map 2A). Grizzly bears would be denning during the winter and would not encounter mining and ice-road activities.

4) Traditional Knowledge on Disturbance of Caribou

In 1979, Nuiqsut resident Nannie Woods talked about caribou being less abundant at the Sagavanirktok River since the development at Prudhoe Bay. She said that fewer caribou are there now than there used to be in the summer (Woods, 1979, as cited in USDOI, MMS, 1979a).

Mayor Leonard Lampe, at an MMS Liberty Project Information Update Meeting in November 1999, said that they do not see as many calving caribou as they did before. The Tarn well has changed their south/north migration, and Alpine may affect their east/west migration. Caribou have to cross three pipelines now. There is some concern with the Liberty pipeline, especially toward shore, because it comes ashore in an insect-relief area; for this reason, he would like to see the onshore portion buried. At the same meeting, Elder Ruth Nukapigak stated she believed contamination is happening to the caribou from air pollution. They smell the smoke from Alpine and scatter (See Appendix E-2).

e. Lower Trophic-Level Organisms

(1) Summary and Conclusion for Effects of Disturbances on Lower Trophic-Level Organisms

Island construction for Alternative 1 would bury about 23 acres of typical benthic organisms. Pipeline trenching would disturb additional benthos, burying up to 14 acres with very low (1%) coverage of kelp, boulders, and suitable substrate. Sediment plumes from pipeline and island construction would reduce Boulder Patch kelp production by up to 6% during 1 year. The buried 14 acres would equal less than 0.1% of the Boulder Patch kelp habitat. The density of the kelp, boulders and suitable substrate in the pipeline corridor is very low, averaging about 1% coverage; therefore, the lost kelp biomass and production probably would be less than .01% of the Boulder Patch totals, but the effect (kelp substrate burial) would last forever.

Some of the suspended sediment from pipeline trenching and island construction would drift over other parts of the Boulder Patch, reducing light penetration and kelp production during 1 year. This reduction is estimated to be less than 6%, about one-third of which would be due to the proximity between the Boulder Patch to the Zone 1 disposal area for excess sediments. However, in relation to the large range of natural variability, these suspended sediment effects would be barely detectable.

The island's concrete slopes from 6 feet deep to the seafloor would be colonized by kelp and other organisms that grow on hard substrates. This portion of the concrete slope would become a home for colonies of species similar to those of the Boulder Patch area. Upon abandonment, the concrete mats probably would become buried naturally or would be removed, cutting back on the new kelp habitat. BPXA could also mitigate some trenching effects, if excess quarry boulders were placed on the backfill in the outer portion of the trench. The quarry boulders probably would reduce the longevity of trenching effects from permanent ones to decade-long ones, because a Boulder Patch study showed that bare rocks were colonized by kelp within a decade.

(2) Details on How Disturbances May Affect Lower Trophic-Level Organisms

The following detailed assessment is based on data in several reports, including the Environmental Report for the Liberty Development Project (BPXA, 1998a); the Proceedings of the MMS Arctic Kelp Workshop during May 1998 (USDOI, MMS, Alaska OCS Region, 1998a); and a brief report prepared for BPXA on the effects of sediment plumes on light attenuation and kelp production (Gallaway, Martin and Dunton, 1999). The assessment is divided into two subsections, presenting separately the details of disturbance from island construction to the Boulder Patch in subsection 2 and then from pipeline construction in subsection 3. The main reason for the division is that pipeline construction would create a plume of natural seabed sediments, whereas the island construction with mined gravel would create a relatively small, coarse-grained plume. Further, each subsection is further divided into assessments of general and specific effects.

(a) General Effects of Developing the Liberty Prospect

There would be a general benefit from the addition of a slope-protection system to any island: the system would provide a new, temporary habitat for Boulder Patch organisms. The island for Alternative 1 would be in 22 feet of water and would have gradually sloping sides to the seafloor (Fig. II.A-3). The slope of the island would have an overlay of filter fabric and a cover of concrete mats (Figs. II.A-5 and 6). From the waterline to about 6 feet deep, winter ice would abrade the island's slope each year, so this part of the slope would not support sessile, permanently attached organisms such as kelp. However, from 6 feet deep to the seafloor, kelp would probably grow on the mats, just as it grew on the mats around the old Northstar Island (Coastal Frontiers Corp., 2000). Even though the kelp and possibly the associated organisms, such as sponges, soft coral, and sea anemones, would be colonizing a new habitat, they probably would not be viewed as undesirable invaders, just as they were not on the old Northstar Island. A re-colonizing study estimated that bare rock may need 10 years to develop the plant and animal communities common to the Boulder Patch (Martin and Gallaway, 1994). Thus, we expect the Liberty Island slope may need up to 10 years to develop similar communities, although many species likely would become well established before that time. However, the new kelp community would probably perish upon island abandonment. One reason is that the concrete mats might be removed, as they were at Tern. Another reason is based

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on the results of the recent inspection of the abandoned old Northstar Island (Coastal Frontiers Corp., 2000). Some of the Northstar mats on which kelp was growing were left on the lower slopes during abandonment in 1994. The 1999 inspection revealed that the remaining mats are covered with gravel that eroded from the upper part of the island berm, and that there is very little kelp; therefore, the benefits of slope-protection systems for kelp would probably be temporary with any alternative island design or location.

(b) Specific Effects of Disturbances from BPXA's Proposed Liberty Development and Production Plan

There would be specific effects from both island and pipeline construction.

1) Specific Effects from Island Construction

Construction of Liberty Island would alter the seafloor habitat permanently and would kill the benthic animals living there. Underwater surveys show the seafloor at the Alternative 1 site is silty mud and contains less than 10% rock cover, similar to most of the Beaufort Sea's floor (Fig. III.C-1). Placing gravel to construct Liberty Island would kill the benthic invertebrates occupying about 23 acres of this habitat. Similar amounts of benthos were buried during construction of several exploration islands in Stefansson Sound during the past 2 decades, including Tern, Duck, Endeavor, BF-37, Niakuk, Goose, and Sag islands. The 23 acres would be relatively small compared to the area that was affected by the Endicott causeway and Northstar pipeline, which were constructed within this same region and depth range. Liberty's effects would be similar to the concluding statements in the Northstar EIS about the project effect on benthic infaunal and epifaunal invertebrates aside from those in the Boulder Patch kelp community:

> The trenching for the pipeline will impact both infauna and epifauna through direct physical disturbance, burial with sediment, or from increased turbidity in the surrounding water. Trenching the shallow waters of the lagoon would have a negligible effect on benthic invertebrates. Impact to marine invertebrates in deeper waters would be considered minor because of the rapid recolonization and geographic range of these species (U.S. Army Corps of Engineers, 1999:6-29).

Island construction also would increase the amount of under-ice suspended sediment in the water column. Because of the prevailing under-ice currents in this area, a sediment plume from island construction would drift east or west in line with the isobaths. If the plume drifted west, it would drift over the kelp in the Boulder Patch (Fig. III.C-2), depositing a thin blanket of sediment over the kelp and reducing the amount of available light for growth. An under-ice plume from construction that drifted west toward the Boulder Patch probably would affect up to 105 acres (BPXA, 1998a:5-8). Because the more productive rocky areas are widely scattered, the plume is likely to affect less than 105 acres of productive Boulder Patch habitat. The heavier sediments should settle out within one-half mile of the island and are not expected to reach the Boulder Patch. Sediments larger than clay-sized particles are likely to settle out within 3-7 miles of the construction area (USDOI, MMS, Alaska OCS Region, 1998a:8). Sediments that reach the Boulder Patch are likely to reduce the amount of light for marine kelp living in rocky bottom areas. This was the primary concern regarding the health and growth of Boulder Patch kelp communities during winter (USDOI, MMS, Alaska OCS Region, 1998a).

Storms and river discharges place a lot of sediment into the waters of the Boulder Patch area. These discharges, plus variations in snow cover, annually make up to two-thirds of the winter ice in this area uninhabitable for ice algae (there is not enough light). This results in naturally fluctuating growth rates for Boulder Patch kelp communities. The plume from construction could reduce kelp growth in some rocky bottom areas where clear-ice conditions exist. This possibility was considered in a recent analysis by Gallaway, Martin, and Dunton (1999:16-18), which is based partly on field observations during construction of the BF-37 gravel island. They concluded that under worst-case conditions:

- Island construction may reduce kelp production in the Boulder Patch by 2%.
- No changes are expected in the health or distribution of Boulder Patch communities.
- The effects of island construction would be limited to 1 year and would constitute short-term impacts.

We believe that the above conclusions are conservative, and that they were based on the appropriate modeling methods, calculations, and assumptions. Hence, any effects due to island construction are expected to fall within the range of natural variation for Boulder Patch kelp communities. Any reduction in the amount of light due to island construction is expected to be very small and is not expected to have a measurable effect on kelp communities in the Boulder Patch. Any sediment accumulating on kelp from construction is likely to wash away in currents and wave action, as typically happens with natural sediment accumulations.

2) Specific Effects of Pipeline Construction

Pipeline construction would involve about 6 miles of trenching and backfilling in marine waters along the pipeline corridor. Alternative-specific effects would result from both suspended sediments and trenching.

a) Suspended Sediments

Pipeline construction also would increase the amount of suspended sediment in the water column during winter trenching and backfilling (Fig. III.C-3) and during the natural dispersal at breakup of any excess sediment that is stored on the ice (Fig. III.C-4 and 5). The dense part of the plume is predicted to move less than 1,000 feet alongshore to the west or east, as indicated partly by BPXA measurements during preparation of the Northstar test trench. The plume from pipeline construction could reduce kelp growth in some rocky bottom areas where clear-ice conditions exist. This possibility also was considered by Gallaway, Martin, and Dunton (1999) and Ban et al. (1999). They concluded that under worst-case conditions:

- Suspended sediments from pipeline trenching may reduce kelp production in the Boulder Patch by 4% (Fig. III.C-1), and the excess-sediment stockpiled on the ice cover (Fig. III.C-5) may reduce it by another 2%. In other words, about one-third of the effect would be due to the proximity between the Boulder Patch and disposal zone.
- No changes are expected in the health or distribution of Boulder Patch communities.
- The effects from construction would be limited to 1 year and would constitute short-term impacts.
- The effects of pipeline repair, if necessary, probably would be site specific and less than the construction effects.

The effects probably would be less than these worst-case predictions, as indicated by some recent field measurements during construction of Northstar pipeline in late April 2000 (Trefry, 2000, pers. commun.). The measurements were made at six sites in the Northstar area, two of which were within a couple hundred meters east and west of the pipeline corridor while the trench was being backfilled. The measurements included three water samples and a turbidity profile at each site. In spite of the backfilling, the sampled water appeared to be low with less than 0.5 milligrams per liter of sediment (Trefry, 2000, pers. commun.).

One reason that the measurements were lower than the predictions is that some of the dredged sediment probably froze before it was used as backfill over the pipeline. Hence, any effects due to suspended sediments from pipeline construction are expected to fall within the range of natural variation for Boulder Patch kelp communities.

b) Trenching

Some benthic plants and animals would be disturbed by pipeline trenching (see Sec. II.A.1.b(3)(a)4)). Most of the seafloor in the project area is covered with sandy/silty sediments that are disrupted naturally by the ice cover and strudel scour (BPXA, 1998a:Sec. 4.6). The resident organisms in the silty/sandy sediments generally are small and short-lived. The Liberty effects would be similar to the conclusion in the Northstar Final EIS that: "natural re-population of the trench area by infaunal invertebrates is expected within a few years" (U.S. Army Corps of Engineers, 1999:6-26).

The BPXA Environmental Report also describes the Boulder Patch and the diverse community of organisms associated with the kelp and solid substrate. The report notes that there is diffuse kelp and solid substrate in the outer section of the pipeline corridor (BPXA, 1998a:Secs. 4.6.3 and 5.2.5). The kelp and solid substrate occurs in a 4,700-foot section that is diagramed in Figures III.C-1 and 5, Surveys for Boulders and Kelp. A similar map was prepared for a BPXA report on construction effects on Boulder Patch kelp production (Ban et al., 1999); the map clarifies the location and distribution of dense kelp near the Alternative 1 island site. The band's location and distribution indicate that the light kelp that is illustrated in Figure III.C-1 probably is the shoreward, marginal end of the dense band that is illustrated in the report by Ban et al. (1999). The map that was prepared by Ban et al. is redrawn as Figures III.C-2 through 4 and is used as the base map for our assessment of alternatives.

After the Environmental Report was prepared (BPXA, 1998a), additional side-scan and video surveys were conducted along the 4,700-foot section. The preliminary results of the surveys were summarized by the investigators during the MMS Arctic Kelp Workshop in May 1998 (USDOI, MMS, Alaska OCS Region, 1998a), and the final results were summarized in a July 1998 report to BPXA (Coastal Frontiers Corp., 1998). The report explains that the video detected scattered bivalve shells, pebbles, and rocks, some of which were found to have small pieces of kelp attached; and that the "concentrations of these objects appeared to represent less than 1% of the sea bottom in most instances, and in no case greater than 2%" (Coastal Frontiers Corp., 1998:16). Figure III-C.2 shows that the distance to a portion of the Boulder Patch with a concentration over 10% is at least 1,600 feet (500 meters). Therefore, the average density of kelp and solid substrate in the 4,700-foot long section was assumed to be 1% for the following assessment of trenching effects.

The width of the area that would be disturbed by trenching would be related mainly to the amount of slumping on the sides of the trench. The Development and Production Plan explains that the slump or slope angle would be 3:1 typically (extending three times the trench depth to each side), but that the excavation limits could be up to 5:1 in unconsolidated sediments (Fig. II.A-12 and BPXA, 2000a:Fig. 8-4 and p. 71). The 5:1 ratio means that the overall disturbed area could be up to 10 times the trench depth plus the bottom width of the trench. Thus, the bottom of the proposed trench for Alternative 1 would be up to 12 feet deep and 12 feet wide (Fig. II.A-12 and Table II.A-1), and the overall width at the top would be up to 132 feet.

The boulders with kelp near the center of the Boulder Patch lie at the sediment surface in a layer that is very thin, "no more than one boulder thick" (Dunton, Reimnitz, and Schonberg, 1982). We assume that the solid substrate with kelp that lies in the pipeline corridor is no different, that it also lies at the sediment surface in a layer that is very thin. After trenching, if the solid substrate could be returned to the sediment surface, it probably would be recolonized by kelp in a decade (Martin and Gallaway, 1994). However, the operation probably could not return the kelp and solid substrate to the sediment surface, and the only natural process that might return it to the surface would be gradual erosion over geological time scales.

In summary, trenching would bury up to 611,000 square feet or 14 acres of kelp and solid substrate at very light densities. The 14 acres can be compared with the total area of the adjacent Boulder Patch. The area in which kelp and solid substrate exceed 10% coverage recently was estimated as 64 square kilometers, or 15,871 acres (Ban et al., 1999). Therefore, the buried 14 acres would equal less than 0.1% of the Boulder Patch area. Furthermore, the concentration of kelp in the Boulder Patch is more than 10 times that in the pipeline corridor, so the lost kelp biomass and production probably would be less than 0.01% of the total.

The burial of kelp and solid substrate in the pipeline corridor would be mitigated partly by a countervailing effect—the creation of a new kelp habitat on the concrete blocks in the island's slope-protection system (Sections III.C.1.b (5) and III.D.3.e (2) (a)). The concrete blocks below the ice-scour depth (6 feet) would add about 3 acres of kelp habitat. However, this new kelp habitat might be temporary because the slope-protection materials might be removed during the abandonment phase in 15-20 years, as noted in Section III.D.6.e(2)(b) of this EIS and Section 15 of the Plan (BPXA, 2000a). BPXA could also mitigate some trenching effects if excess quarry boulders were placed on the backfill in the outer portion of the trench. The quarry boulders would probably reduce the longevity of trenching effects from permanent ones to decade-long ones because a Boulder Patch study showed that bare rocks were colonized by kelp within a decade. Future unanticipated effects on kelp could be mitigated by Lease Sale Stipulation No. 1, Protection of Biological Resources. The stipulation explains that MMS may require additional biological surveys and, based on the surveys, may require the lessee to "modify operations to ensure that significant biological populations or habitats deserving protection are not adversely affected."

f. Fishes and Essential Fish Habitat

(1) Fishes

(a) Summary and Conclusion For Effects of Disturbances on Fishes

Noise and discharges from dredging, gravel mining, island construction, island reshaping, and pipeline trenching associated with Liberty are expected to have no measurable effect on fish populations (including incidental anadromous species). While a few fish could be harmed or killed, most in the immediate area would avoid these activities and would be otherwise unaffected. Effects on most overwintering fish are expected to be short term and sublethal, with no measurable effect on overwintering fish populations. Placement of the concrete mat would create additional food resources for fishes and, thereby, would have a beneficial effect on nearshore fish populations in the Beaufort Sea.

(b) Details on How Disturbances May Affect Fishes

General Effects: All of the potential effects noted below from disturbances to fish and essential fish habitat are general effects that would result from developing the Liberty Prospect. No specific effects to the BPXA proposal are identified in the following analysis.

1) Disturbance from Pipeline Construction May Affect Some Fishes

Pipeline construction involves trenching, hydraulic dredging, backfilling material into the trench, and storing excess trenching material on the ice. These activities are likely to temporarily displace fish from the immediate area of the activities, and a few fish could be harmed or killed. However, these effects are not expected to continue after construction is completed or to have a measurable effect on fish populations.

2) Discharges from Gravel Mining, Island Construction, and Reshaping May Affect Fishes in the Immediate Area

During construction, a few fishes in the immediate area of a discharge could be harmed or killed. However, most are expected to avoid these areas, and no measurable effects would be expected at the population level.

3) Noise from Construction May Affect Some Fishes

Noise from island construction (winter), reshaping (summer), sheetwall piledriving (summer), and similar activities may affect fishes. Fishes sometimes avoid sudden noise but typically ignore the same noise, if it is continuous over a longer period of time. Fishes appear to respond to sound waves within the range of 5-1,000 Hertz (Bell, 1990). Because the proposed activities are expected to generate noise within this range, some fishes in the immediate area may be temporarily disturbed. Because marine fish are widely dispersed and are largely unrestricted in their movements, noises associated with these activities would not be expected to have a measurable effect on marine fish populations.

However, freshwater and migratory fishes overwinter in fresh- or brackish water, where depths are sufficient to provide ample space and oxygen below the winter ice. Hence, overwintering fishes essentially are captives in these areas until spring breakup. Because they depend on overwintering habitats and are unable to move away from noise, the noise generated by construction-related activities may stress some overwintering fishes in the immediate area of the proposed activities and, thereby, decrease the likelihood of survival for some. However, noise effects on most overwintering fishes are expected to be short term and sublethal. For this reason and because most activities are not likely to occur above overwintering habitat, these activities are not expected to have a measurable effect on overwintering freshwater and migratory fish populations.

(2) Essential Fish Habitat

None of the lifestages of salmon have been documented to use or inhabit the areas expected to be disturbed directly by Liberty construction and operations. Nonetheless, the waters surrounding the development have been included in the area designated Essential Fish Habitat for Alaskan salmon. Thus, Essential Fish Habitat would be adversely affected by disturbances to potential prey, to prey habitat, to potential substrate, and to marine and fresh waters. As a result of disturbances caused by Liberty Island construction and operation, fish and zooplankton might experience short-term, localized but unmeasurable effects. This would include potential adverse effects from noise during construction and operations and from increased turbidity and sedimentation as a result of dredging, gravel mining, island construction, and pipeline trenching (Secs. III.C.3.e and III.C.3.f(1). Marine plants could be subjected to short-term, localized, negative effects due to mechanical removals of individuals and from sedimentation resulting from pipeline trenching and island construction (Sec. III.C.3.e). Pipeline construction is expected to bury up to 14 acres of kelp and solid substrate, and sediment plumes are expected to reduce kelp production by 6% during 1 year (Sec. III.C.3.e). The effect of disturbance on water quality is discussed in Section III.C.3.l. Water quality would be primarily affected by increased turbidity that would result from gravel island and pipeline construction, Liberty Island abandonment, and gravel mine reclamation. Turbidity and salinity of seawater discharged from the Liberty Island production facility are expected to be slightly higher than water in surrounding Foggy Island Bay (Sec. III.C.3.l). All of these disturbances are expected to be fairly localized and short term.

g. Vegetation-Wetland Habitats

(1) Summary and Conclusion of Effects of Disturbances on Vegetation-Wetland Habitats

Disturbances mainly come from constructing gravel pads and ice roads and installing the onshore pipeline and tie-in with the Badami pipeline. Gravel pads, pipeline trench, and the 1.4-mile-long onshore pipeline would destroy only 0.8 acres of vegetation and affect a few acres of nearby vegetation and have only local effects on the tundra ecosystem. Ice roads would have local effects (compression of tundra under the ice roads) on vegetation, with recovery expected within a few years, and no vegetation would be killed. The construction and installation of the onshore pipeline and gravel pad on State land will be required to have a Section 404/10 permit and approval by the Corps of Engineers, as stated in the Liberty Development Project Development and Production Plan (BPXA, 2000a). The permit and approval process is expected to minimize adverse effects on wetlands.

(2) Details on How Disturbances May Affect Vegetation-Wetland Habitats

(a) General Effects from Developing the Liberty Prospect

1) Effects from Gravel Pads

We assume the gravel fill would cover 0.8 acres of tundra at the pads. The plant cover impacted at the pad sites is mainly cotton grass/sedge (*Eriophorum/Carex*) and dwarf shrubs (*Salix* and *Vaccinium*) (Noel, 1998). Some nearby tundra vegetation would be partially covered by dust that blows off the gravel pads and smothers some of the original plants, resulting in a shift to weedy species, and causes thermokarsting, which develops into high-centered polygons with deep moats (Jorgenson, 1997, as cited in U.S. Army Corps of Engineers, 1998). For this analysis, we assume the project would include an onshore valve and helicopter pad at the shore crossing and Badami pipeline tie-in, which may spread dust over a few acres. This local effect would not be significant to the tundra ecosystem in the project area.

A gravel pad could change the moisture in the nearby tundra, because the pad would cause snow to drift and accumulate around it and would block normal surface water flow in the summer. This blockage thickens the active layer (soil that thaws during summer), which increases production of grasses and mosses in wet habitats or decreases production of shrubs and lichen in moist or dry habitats within about 160 feet of the pad (USDOI, BLM and MMS, 1998). Thus, changes have occurred in water drainage and tundra moisture (wetness) near gravel pads. Soils at the pipeline landfall contain 8 centimeters of organic material, 7 centimeters of silt, and 21 centimeters of buried organic material; below 36 centimeters, there is permafrost (Noel, 1998)

From 1968-1983, flooding caused the greatest effect on vegetation. In the Prudhoe Bay oil field during the first 15 years of development (Walker et al., 1986, 1987), flooding resulted when roads and pads intercepted the natural flow of water and caused ponding. Thus, the Liberty Project would have to identify natural drainage patterns before construction and maintain them during and after construction. Even if such conditions were not required (under Corps of Engineers permits) or completely successful, flooding is not expected to affect more land than that affected by dust and snow drifting, as described above. Permits (State and Federal) require that natural drainage be maintained. A change in vegetation from flooding could result in more aquatic grasses and sedges versus dwarf shrubs.

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2) Effects from Onshore Pipeline:

The onshore pipeline route to the Badami tie-in avoids crossing wet herbaceous vegetation on the tundra just west of the Kadleroshilik River. Each beam would disturb about 2 inches of vegetation around it in addition to the vegetation it directly affects (Jorgenson, 1997, as cited by the U.S. Army Corps of Engineers, 1998). The disturbance zone would result from locally deposited excess trench material and possible thermokarsting; it could change the composition of plant species. Each vertical beam would disturb about 1.4 square feet of vegetation, 6% of which would be destroyed or replaced. This would result in 0.0032 acre being disturbed per pipeline mile, or 0.0035 acre.

Pipelines also could harm vegetation indirectly through snow drifting or shading. Any vegetation under a pipeline would receive less direct sunlight during the growing season, potentially leading to a more shallow active layer in the soil and reduced photosynthesis by the plants. If this effect did occur, it would take place only along the 1.4-mile long pipeline.

(b) Specific Effects of Disturbance from BPXA's Proposed Liberty Development and Production Plan

1) Liberty's Gravel Pads:

Liberty's gravel pads and pipeline trench development would cover only 0.8 acre, they are likely to have very little effect on nearby tundra, because permits (State and Federal) require that natural drainage be maintained.

2) Effects of Ice Roads

BPXA would not build permanent access roads along the Badami pipeline or next to the onshore pipeline that ties into it. Most of the length of ice roads would be located offshore and routed from the Endicott causeway to the production island. The short ice roads would connect the island with the gravel mine on the Kadleroshilik River, with two coastal lakes used as water sources for the ice roads (see Map 2A). Ice roads tend to compress and flatten the vegetation under them, and compressed vegetation would be common along onshore ice roads to the gravel mine and to the freshwater lakes. Ice roads probably would melt later in spring than nearby tundra and green up later because of the ice cover, resulting in "green trails" along the ice roads. Compression would not kill the vegetation, and we expect it to recover within a few years. We assume currently implemented stipulations on ice roads would be followed for the Liberty Project.

h. Subsistence-Harvest Patterns

(1) Summary and Conclusion for Effects of Disturbances on Subsistence-Harvest Patterns

For the communities of Nuiqsut and Kaktovik, disturbances periodically could affect subsistence resources, but no resource or harvest area would become unavailable and no resource population would experience an overall decrease. Disturbance and noise could affect subsistence species that include bowhead whales, seals, polar bears, caribou, fish, and birds. Oil-spill cleanup would increase these effects. Disturbances could displace subsistence species, alter or reduce subsistence hunter access to these species, and therefore alter or extend the normal subsistence hunt, but potential disruptions to subsistence resources should not displace traditional practices for harvesting, sharing, and processing those resources. Beluga whales rarely appear in the Liberty Project area. We do not expect them to be affected by noise or other project activities, nor do we expect changes in Kaktovik's subsistence harvest of beluga whales.

(2) Details on How Disturbances May Affect Subsistence Resources

Analytical descriptions of affected resources and species, as well as Inupiat knowledge concerning effects, are found in Sections III.C.2, III.C.3, and III.D for Subsistence-Harvest Patterns. Analysis and Inupiat knowledge are found in Section IV.B.9 of the Beaufort Sea Sale 170 Final EIS (USDOI, MMS, 1998).

(a) General Effects From Developing the Liberty Project

Disturbance from construction activities could cause some animals to avoid areas where they are normally harvested or to become more wary and difficult to harvest, as in the case of bowhead whales. Research shows bowheads do not seem to travel more than a few kilometers from their original swimming direction because of construction noise. For aircraft and vessel noise, these changes also appear to be temporary, lasting from a few minutes but can last up to 1 hour for seismic activity. Traditional Inupiat testimony, however, affirms effects at greater distances and changes in swimming directions for longer periods, and Inupiat are concerned that whales will go farther offshore, making the subsistence hunt more difficult. In some instances, as in the case of nesting birds, construction activities may decrease the biological productivity of an area. Restrictions may be placed on subsistence hunters using firearms around new oil-related installations (such as roads, the island, pipelines, and landfalls) to protect oil workers and equipment from harm. Finally, structures such as onshore pipelines may limit hunters' access to certain active hunting sites.

Onshore oil developments at Prudhoe Bay already disturbed the subsistence harvest, often as the indirect result of increased wage employment from projects and services funded by the North Slope Borough. Wage employment has upgraded hunting technology but constricted the time available for hunting. Also, development in Prudhoe Bay has restricted access to nearby traditional hunting areas. Household incomes, however, have seen a decrease, no longer bolstered by earnings from the Borough's Capital Improvement Program. Lower incomes encourage more subsistence activity and foster an increase in harvest levels for many subsistence resources.

(b) Specific Effects of Disturbances from Developing BPXA's Proposed Liberty Development and Production Plan

1) Bowhead Whales

Underwater industrial noise, including drilling noise, from artificial gravel islands is not audible in the water more than a few kilometers away. Because the bowhead whales' migration corridor is about 10 kilometers seaward of the barrier islands, drilling and production noise from Liberty Island is not likely to reach most migrating whales. This noise also is unlikely to harm the few whales that may be in lagoon entrances or inside the barrier islands. Vessel traffic outside the barrier islands probably would consist of seagoing barges carrying equipment and supplies from Southcentral Alaska to the Liberty location, most likely between mid-August and mid-to-late September. Barges operating in September could disturb some bowheads, which may try to avoid the barges at distances 1-4 kilometers away. Fleeing usually stops within minutes after a vessel has passed, but may last longer. We do not expect vessel and aircraft traffic inside the barrier islands to affect bowhead whales. BPXA would build the gravel island and pipeline during the winter and well inside the barrier islands, and construction should not affect bowhead whales. Native whalers have stated that bowhead whales also can react to odors and bright colors.

Nuiqsut whaling captain Frank Long, Jr., stated that oil-industry activity offshore has affected not only whales but also seals and birds (Long, as cited in USDOC, NOAA, NMFS, 1993). Expressing concern about aircraft disturbance, a Nuiqsut resident and whaling captain said in recent testimony for an offshore lease sale that seismic traffic and helicopter overflights "were the cause of whales migrating farther north out to the ocean, 20 miles farther north than their usual migration route" (USDOI, MMS, 1995a). Earlier, Patsy Tukle from Nuiqsut had expressed this same sentiment. He explained that ships and helicopters are interfering with whale hunting, even though they are not supposed to. He affirmed the need to enforce controls so whaling may go on unimpeded (Tukle, 1986, as cited in USDOI, MMS, 1986b). To show that aircraft disturb bowhead whales, Kaktovik resident Susie Akootchook related her observations while counting whales in Barrow:

> I worked with the whale census and worked with Chris Clark that time they did the whale census over at Barrow. And I was with the acoustic crew listening in with speaker phones and those microphones were like a 100, 75 to 50 feet under. And if you guys are planning on using your choppers, there is going to be a lot of noise. One time I was on a ship, and I had the headsets on and then heard an airplane. Mind you, from under the water, listening in, I can hear an airplane flying over. From that end of the mike to that end of the mike, I could hear it all the way clear. And when I went out there and checked, it was way up there. And that noise, whether you use choppers or airplanes, it's going to be disruptive…." (Akootchook, 1996, as cited in Dames and Moore, 1996d).

Thomas Napageak, President of the Native Village of Nuiqsut and Alaska Eskimo Whaling Commission Chairman, related in 1979 that he had not seen one whale while going to Cross Island every year and believes it is the result of seismic activity in the area (Napageak, 1979, as cited in USDOI, MMS, 1979a). Maggie Kovalsky from Nuiqsut, testifying in 1984 on Endicott development, explained that with all the noise and activities, bowhead whales that migrate not far from that area all the way to Canada probably will be hurt (Kovalsky, 1984). In a Statewide survey by the Alaska Department of Fish and Game, Division of Subsistence from 1992-1994, 86.7% of the respondents in Nuiqsut believed that there were fewer marine mammals as a result of development on the outer continental shelf (State of Alaska, Dept. of Fish and Game, 1995a). At a village meeting for the Northstar Project in 1996, Nuiqsut residents said they feared effects from the project, because it was in the migratory path of the bowhead whales. They made it clear that seismic and transportation noise are of primary concern to Beaufort Sea residents for impact to bowhead whales (Dames and Moore, 1996c).

In 1979, Kaktovik residents were concerned about disturbance of migrating whales from drilling noise. Whaling captain James Killbear expressed this concern (Killbear, 1979, as cited in USDOI, MMS, 1979b). Herman Aishanna, former mayor, vice mayor, and head of Kaktovik's Whaling Captains' Association, maintained that in 1985 the SSDC (single steel drilling caisson) did affect the whale subsistence hunt, even though it was idle. He reported: "We got no whales that year" (Aishanna, as cited in USDOC, NOAA, NMFS, 1993). Fenton Rexford, President of Kaktovik Inupiat Corporation (Kaktovik's village corporation), stated that, during exploratory drilling in Canadian offshore waters, "we were not successful or had a very hard time in catching our whale when there was activity with the SSDC, the drilling rig off Canada. And it diverted [bowhead whales] way offshore; made it very difficult for our whalers to get our quota" (Rexford, testimony on the MMS Draft EIS for the 5-Year OCS Oil and Gas Leasing Program 1997-2002, as cited in USDOI, MMS, 1996d). At the MMS Information Update Meeting held March 29, 2000, in Barrow, the Alaska Department of Fish and Game made a presentation on a draft study of subsistence economics and oil development in Nuiqsut and Kaktovik, which affirmed a strong connection to anthropogenic effects as the cause for Kaktovik's unsuccessful whaling season in 1985 (Pedersen et al., In prep.).

Speaking about the disappointing spring hunt in 1978, when only four whales were caught, Thomas Brower, Sr., from Barrow explained:

> The gravel island drilling at this time may make it impossible for the [whaling] captains to supply [the village] with needed winter food supplies. The gravel island drilling at this time may make it impossible for the captains to fill this need for adequate nutrition for the long Arctic winter" (North Slope Borough, Commission on History and Culture, 1980).

Charles Okakok from Barrow spoke out against drilling because he believed, as many Inupiat subsistence whalers believe and have observed, that the noise may be detrimental to the bowhead whale hunt (Okakok, 1990, as cited in USDOI, MMS, 1990c). Barrow resident Arthur Neakok maintained that ice presents an extreme hazard to ships and drilling (Neakok, 1990, as cited in USDOI, MMS, 1990c). At the same hearing, Eugene Brower expressed concern that multiyear ice would cause problems during drilling (Brower, 1990, as cited in USDOI, MMS, 1990c).

Herman Rexford from Kaktovik recounts that oil ships affect the migration of the whales. He would like to see no ships or exploration at Kaktovik during the fall whaling time. He knows that the ships are noisy and can affect whaling routes (Rexford, 1986, as cited in USDOI, MMS, 1986a). Herman Aishanna, Kaktovik vice mayor, recounted that "tugs make a lot of noise in the summertime" (Aishanna, 1996, as cited in Dames and Moore, 1996d). Thomas P. Brower, Sr., from Barrow, began whaling as a boy in 1917. He stated in a 1978 interview that:

> The whales are very sensitive to noise and water pollution. In the spring whale hunt, the whaling crews are very careful about noise. In my crew, and in other crews I observe, the actual spring whaling is done by rowing small boats, usually made from bearded seal skins…. We keep our snow machines well away from the edge of the ice so that the machine sound will not scare the whales…. In the fall, we have to go as much as 65 miles out to sea to look for whales. I have adapted my boat's motor to have the absolute minimum amount of noise, but I still observe that whales are panicked by the sound when I am as much as 3 miles away from them. I observe that in the fall migration the bowheads travel in pods of 60-120 whales. When they hear the sound of the motor, the whales scatter in groups of 8 -10 and they scatter in every direction. (North Slope Borough, Commission on History and Culture, 1980)

2) Seals and Polar Bears

Aircraft and vessels could cause some ringed and bearded seals to dive into the water and may separate some pups from their mothers. Even so, the displacement should last only a few minutes to less than 1 hour. Low-flying aircraft would briefly disturb or displace a few polar bears along traffic routes, but these local effects should not change bear or seal abundance and distribution in Foggy Island Bay. Ice roads and noise from vehicle traffic on the roads from the Endicott causeway along the coast to Foggy Island Bay-Kadleroshilik River and the Badami unit could disturb and displace a few denning polar bears and a small number of denning ringed seals (see cumulative-effects discussion for Subsistence-Harvest Patterns for a discussion of cumulative effects on polar bear denning; see Sec. V.C.2). These few displacements would not affect populations. Gravel-island and pipeline construction would displace some ringed seals within perhaps 1 kilometer of the island and along the pipeline route in Foggy Island Bay. Food smells from the island camp may attract a few bears. Workers may need to haze those bears or remove them from camp, but this hazing would not be significant to polar bear abundance or distribution. In the fall, pregnant females selecting den sites may avoid areas with disturbance. Offshore construction would have very local effects on seals and not change overall populations in the bay. During cleanup of oil spills, hundreds of humans, many boats, and several aircraft probably would displace some seals and polar bears from oiled areas and temporarily stress others. These activities would not greatly affect population movements or behavior. A lesser source of disturbance would be low frequency noises from drilling on the production island. During construction of a gravel island in winter 1981-1982, monitoring showed a slight change in the distribution of ringed seals near the island—density increased with distance from the island.

3) Caribou and Other Terrestrial Mammals

Helicopters, ice-road traffic, and gravel mining could locally disturb some caribou, muskoxen, grizzly bears, and arctic foxes for a few minutes to a few days within 1 mile of these activities. Helicopter traffic (10-20 trips/day during 2-3 years of development) could briefly disturb some caribou, muskoxen, and grizzly bears. These brief disturbances would not affect populations. Traffic for constructing the island, pipeline, and gravel pads; to mine gravel; and to supply operations (100 trips/year) could briefly disturb some caribou and muskoxen. Ice-road construction and use would occur during December though early May, with more ice-road construction and traffic during the 2 years of development and some continued ice-road activity during the 15 years of production. These short-term disturbances of individual animals would have little effect on populations. All of these activities could destroy a small amount of the caribou's local habitat but with little overall effect on feeding patterns or distribution.

If grizzly bears approach oil workers, the workers may have to remove problem bears to protect themselves. Arctic foxes could increase near the project, because more food and shelter would be available to them. These interactions would have very little effect on populations of bears and foxes. If a large oil spill were to extensively oil coastal habitats containing herds or bands of caribou and muskoxen during the insect season, hundreds of workers, many boats, and several aircraft operating to clean up the area probably would displace some of them. We do not expect these losses to significantly affect populations on the Arctic Slope.

In 1979, Nuiqsut resident Nannie Woods talked about fish and caribou being less abundant at the Sagavanirktok River since the development at Prudhoe Bay. She explained that the river's tributaries also do not have as many fish, and that fewer caribou are there now than there used to be in the summer (Woods, 1979, as cited in USDOI, MMS, 1979a).

At the MMS Information Update Meeting held March 29, 2000, in Barrow, the Alaska Department of Fish and Game made a presentation on a draft study of subsistence economics and oil development in Nuiqsut and Kaktovik, which affirmed a strong connection to anthropogenic effects as the cause for the displacement of subsistence hunters from traditional caribou hunting areas near Nuiqsut during the 1993 and 1994 harvest seasons (Pedersen et al., In prep.).

Mayor Leonard Lampe said at an MMS Liberty Project Information Update Meeting in November 1999 that they do not see as many calving caribou as they did before. The Tarn well has changed their south/north migration, and Alpine may affect their east/west migration. Caribou have to cross three pipelines now. There is some concern with the Liberty pipeline, especially toward shore, because it comes ashore in an insect-relief area; for this reason, he would like to see the onshore portion buried. At the same meeting, Elder Ruth Nukapigak stated she believed contamination is happening to the caribou from air pollution. They smell the smoke from Alpine and scatter (See Appendix E-2).

4) Fishes

Disturbances to fishes would be brief, local, and, for the most part, not lethal. Disturbances would come from the construction of the gravel island, island reshaping, trenching for the undersea pipeline, aircraft and vessel traffic, ice-road construction, and drilling. Fish temporarily may avoid areas near these activities during Liberty's development and production. Grounding of sea ice surrounding the pipeline trench and constructing and reshaping the gravel island may kill some fish.

Subsistence hunter Isaac Nukapigak, from Nuiqsut, observed that cisco are not spawning out near the Colville Delta anymore, explaining that oil activities in State waters there are having an effect (Nukapigak, 1995, as cited in USDOI, MMS, 1995d). Nuiqsut resident Joan Taleak maintained reservations about local traffic by industrial vessels during her 1983 testimony for a proposed outer continental shelf sand and gravel lease sale. She was concerned about the hauling of gravel barges conflicting with her way of life from fishing since her childhood. She recounted her worry that there would be no more whitefish if the sale activities occurred (Taleak, 1983, as cited in USDOI, MMS, 1983a).

Native concern about the effects of development on fish stocks has been evident since the Endicott Project. In 1984, Thomas Napageak, Nuiqsut whaling captain and Chairman of the Alaska Eskimo Whaling Commission, said: "The causeway sticking out into the ocean will change currents along the coast. Furthermore, it will change the migration route of the fish we depend on" (Napageak, as cited in U.S. Army Corps of Engineers, 1984a). Complaints about reduced fish size and harvest size persist in Nuiqsut. Fish resources accounted for 33% of the community's total subsistence harvest in 1993 (Pedersen, 1996) and 25% in 1995 (Brower and Opie, 1997). Nuiqsut fish harvesters have noted that Arctic cisco have decreased, coinciding with operation of Endicott's water-treatment plant (Dames and Moore, 1996b). Wilber Ahtuangaruak, from Nuiqsut, maintained almost 2 decades ago that there "aren't as many whitefish since the oil companies started drilling at Flaxman Island" (Ahtuangaruak, 1979, as cited in USDOI, MMS, 1979a); Joseph Akpik, from Nuiqsut, asserts that offshore exploration would affect the cisco population (Akpik, 1995, as cited in USDOI, MMS, 1995a).

At an MMS Liberty Project Information Update Meeting in November 1999 in Nuiqsut, Elders Lloyd Ipalook, Alice Ipalook, and Ruth Nukapigak said that fish stocks were very low. Alice Ipalook and Ruth Nukapigak both noted that they have seen a decrease in whitefish since the work at Kalubik, and that there used to be 100-200 fish caught per day versus 6-9 per day now (see Appendix E).

5) Birds

We expect no losses to marine and coastal birds detectable above natural changes in their populations, taking into account aircraft operations, construction and vehicle traffic, vessel traffic, and oil-spill cleanup.

Kaktovik resident Mike Edwards stated in public testimony that he thought noise would harm the waterfowl, an important springtime source of food (Edwards, 1979, as cited in USDOI, MMS, 1979b).

(3) Other Issues

(a) Access

Local residents have voiced concerns about access restrictions. Sarah Kunaknana, talking about local subsistence hunters, stated that others say they do not hunt near Prudhoe Bay anymore because of oil development (Kunaknana, as cited in Shapiro, Metzner, and Toovak, 1979). Billy Oyagak from Nuiqsut said supply ships, choppers, and drilling interfered with whale hunting, making it difficult to find any animals. That year, the hunt required 5 weeks to complete (Oyagak, 1986, as cited in USDOI, MMS, 1986b). Nelson Ahvakana, from Nuiqsut, was concerned that areas that are supposed to be left open for subsistence hunting effectively will be closed because of increased security at the new drill sites, and access to subsistence resources will be restricted (Ahvakana, 1990, as cited in USDOI, MMS, 1990d).

This concern takes on even more substance as the Northstar Project, the Liberty Project, development at the Alpine field, and leasing in the National Petroleum Reserve-Alaska become realities. During the 1996 meeting on the Northstar Project in Nuiqsut, two Nuiqsut men described being denied access to fishing and hunting areas around Prudhoe operations, even though they have traditional rights to be there. They do not want new projects to restrict or deny access (Dames and Moore, 1996c). Another whaler voiced concern that BPXA or the Federal Government will block the whalers from taking their traditional whaling route to Cross Island. They prefer to travel within the barrier islands, because they are more protected from the sea (Dames and Moore, 1996c).

Barrow resident Charles Brower stated in 1986 that an onshore pipeline could interfere with subsistence access—additional hunting restrictions would occur, requiring a permit (Brower, 1986, as cited in USDOI, MMS, 1986a).

(b) Construction

Native residents expressed concern at a Northstar public meeting about the possibility of steel and concrete fatigue over the 15-year project life of the Northstar Project (Dames and Moore, 1996b).

(c) Dredging

Speaking at public hearings in Nuiqsut, Edward Nukapigak, Sr., declared: "…If they want gravel, they should not get it from the paths of the animals that we eat" (Nukapigak, 1983, as cited in USDOI, MMS, 1983a). At village meetings in August 1996 for the Northstar Project, Natives stated that currents can change the bottom contours, potentially affecting the buried pipeline, particularly from river overflow (Dames and Moore, 1996b). Nuiqsut whaling captains believe that Seal Island, as planned for Northstar, needs more protection from natural elements to be considered safe by the community (Dames and Moore, 1996c).

> Testifying at public hearings for a proposed offshore sand and gravel lease, Othniel Oomittuk from Barrow explained that the "water from the dredge operation would also [dis]place the bowhead from their normal fall migration pattern. It drives the whales out, as whalers can't get to them with their small whaling boats" (Oomittuk, 1983, as cited in USDOI, MMS, 1983a).

(4) How Stipulations or Mitigating Measures Help Reduce Disturbance Effects

Mitigating measures from Beaufort Sea Sale 144 are in place for Liberty development, and this assumption is reflected in discussions about effects. Mitigation that would apply to subsistence-harvest patterns includes the stipulations on the Orientation Program and the Subsistence Whaling and Other Subsistence Activities (See Sec. I.H.6, Mitigation Analyzed in this EIS).

The Orientation Program stipulation requires the lessee to educate people working on exploration, development, and production about the environmental, social, and cultural concerns that relate to the area and its communities. The program should increase workers' sensitivity to, and understanding of, values, customs, and lifestyles of local Native communities and help prevent any conflicts with subsistence activities. BPXA's standard North Slope Environmental and Cultural Awareness training in the form of BPXA's "Achieving Environmental Excellence" program will form the foundation for environmental orientation for all personnel and contractors involved in Liberty offshore development. This program will be expanded to address specific issues of concern related to wildlife interaction, protection of marine mammals, best management practices to minimize the potential for spills, awareness of local sociocultural issues and concerns, and awareness of subsistence resources and activities. BPXA currently is developing a video to be used in the training; development of this video will be coordinated with the MMS. The overall training program will be submitted to the Regional Supervisor, Field Operations for review and approval. Personnel will receive appropriate training on at least an annual basis, and full training records will be maintained for at least 5 years.

The stipulation on Subsistence Whaling and Other Subsistence Activities requires industry to avoid unreasonable conflict with subsistence activities during operations, especially the bowhead whale hunt. Before submitting a plan, the lessee must consult with the subsistence communities of Barrow, Nuiqsut, and Kaktovik; the North Slope Borough; and the Alaska Eskimo Whaling Commission about the proposed operations. These consultations ensure that they coordinate siting and timing with subsistence whaling and other subsistence-harvest activities. MMS can restrict uses under the lease, if necessary, to prevent conflicts, but subsistence whalers and industry have been able to negotiate agreements that work for both parties. An example is the recent agreement coordinating the timing of seismic activity for the Northstar Project and the subsistence whale hunt. BPXA and the North Slope Borough, Alaska Eskimo Whaling Commission, and city of Nuiqsut worked out this agreement. BPXA has committed to a dialogue with Native whalers and is now working on a Conflict Avoidance Agreement that would cover Liberty production activities. This agreement would limit major construction activities to the winter season, and generally limit vessel transit to Liberty Island to routes inside the barrier islands. The Alaska Eskimo Whaling Commission prefers to negotiate a Conflict Resolution Agreement with industry on an annual basis using a regional rather than a project specific approach so as to address potential impacts from all ongoing development projects. The Alaska Eskimo Whaling Commission and BPXA currently are actively pursuing such an agreement. An ongoing consultation process with subsistence whalers will be used to identify any concerns not addressed by BPXA proposed mitigation as well as identifying additional mitigating measures to be considered, such as monitoring of bowhead whales for effects from development and operations noise (see Sec.I.H.6, Mitigation Analyzed in this EIS).

i. Sociocultural Systems

(1) Summary and Conclusion for Effects of Disturbances on Sociocultural Systems

Effects on the sociocultural systems of communities near the Liberty Project area could occur as a result of disturbance from industrial activities; changes in population and employment; and effects on subsistence-harvest patterns. These effects could affect the social organization, cultural values, and social health of the communities. Together, effects may periodically disrupt but not displace ongoing social systems, community activities, and traditional practices for harvesting, sharing, and processing subsistence resources.

(2) Details on How Disturbances May Affect Sociocultural Systems

(a) General Effects From Developing the Liberty Prospect

1) Factors Affecting Sociocultural Systems

The primary aspects of sociocultural systems analysis are social organization and cultural values, as described in Section VI.B.2. For the purpose of effects assessment, we assumed that effects on social organization and cultural values could be brought about at the community level, predominantly by industrial activities, increased population, increased employment, and effects on subsistence-harvest patterns associated with the Liberty Project. Potential effects are evaluated relative to the tendency of introduced social forces to support or disrupt existing systems of organization and relative to how rapidly they occur and their duration (see Langdon, 1996). A more in-depth discussion of effects on sociocultural systems can be found in Section IV.B.10 of the Beaufort Sea Sale 170 Final EIS (USDOI, MMS, 1998). Local Inupiat knowledge on potential effects to harvests and resources is included below.

An analysis of the social organization of a society involves examining how people are divided into social groups and networks. Social groups generally are based on kinship and marriage systems and on nonbiological alliance groups formed by such characteristics as age, sex, ethnicity, community, and trade. Kinship relations and nonbiological alliances serve to extend and ensure cooperation within the society. Social organization could be affected by an influx of new population that causes growth in the community and/or change in the organization of social groups and networks.

Disruption of the subsistence cycle also could change the way these groups are organized. Activities such as the sharing of subsistence foods are profoundly important to the maintenance of family ties, kinship networks, and a sense of community well-being. In rural Alaskan Native communities, task groups associated with subsistence harvests are important in defining social roles and kinship relations: the individuals one cooperates with help define kin ties, and the distribution of specific tasks reflects and reinforces the roles of husbands, wives, grandparents, children, friends, and others. Disruption of these task groups would damage the social bonds that hold the community together. Any serious disruption of sharing networks could appear as a threat to the way of life in that community and could trigger an array of negative emotions—fear, anger, and frustration—as well as a sense of loss and helplessness. Because of the psychological importance of subsistence in these sharing networks, perceived threats to subsistence activities are a major cause for anxieties about oil development.

An Alaska Department of Fish and Game social-effects survey administered by the Division of Subsistence Management in 1994 in Nuiqsut included questions on effects from outer continental shelf development. One question asked was: “How do you think the offshore development of oil and gas in this area would affect the following resources available for harvest? Would the resource decrease, not change, or increase?” Eighty-percent of Nuiqsut respondents answered that fish resources would decrease, 87% said marine mammals would decrease, 43% said land mammals would decrease, and 55% said that birds would decrease; 67% were not in favor of the search for oil, and 42% believed the search for oil would have an adverse impact on subsistence; 68% were not in favor of the

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development and production of oil, and 52% believed that oil development and production would have an adverse impact on subsistence (Fall and Utermohle, 1995).

Analysis of cultural values shows values shared by most members of a social group. Generally, these values reflect what is desirable. They are ideals accepted, explicitly or implicitly, by members of a social group. Forces powerful enough to change the basic values of an entire society would include a seriously disturbing change in the physical conditions of life—a fundamental cultural change imposed or induced by external forces. One example would be an incoming group that demands residents accept their culture. Another would be a basic series of technological inventions that change physical and social conditions. Such changes in cultural values can occur slowly and imperceptibly or suddenly and dramatically (Lantis, 1959). Disturbance from oil development may bring about dramatic change to cultural values on the North Slope, which include strong ties to Native foods, to the land and its wildlife, to the family, to the virtues of sharing the proceeds of the hunt, and to independence from institutional and political forces outside the North Slope (see Sec. III.C.3). A serious disruption of subsistence-harvest patterns could alter these cultural values.

For the system of sharing to operate properly, some households must be able to produce, rather consistently, a surplus of subsistence goods; it is obviously more difficult for a household to produce a surplus than to simply satisfy its own needs. For this reason, sharing, and the supply of subsistence foods in the sharing network, could be more sensitive to harvest disruptions than the actual harvest and consumption of these foods by active producers. Thus, when oil development disturbance occurs, it may disrupt a community's culture, even though it doesn't cause "biologically significant" harm to a subsistence species' overall population.

2) Population and Employment

Employment projections as a consequence of Liberty development are provided in Section III.D.5, Economic Effects.

There may be some degree of development-induced employment, but these changes, particularly as they translate into Native employment, historically have been and are expected to continue to be insignificant. Even though Native employment in oil-related jobs on the North Slope is low, Native leaders continue to push for programs and processes with industry that would encourage more Native hire. The North Slope Borough has attempted to facilitate Native employment in the oil industry at Prudhoe Bay and is concerned that the industry has not done enough to accommodate training of unskilled laborers or to accommodate their cultural needs in participating in subsistence hunting. The North Slope Borough also is concerned that industry recruits workers using methods common to Western industry practices and would like to see serious attempts by industry to hire North Slope Borough residents. Few village residents currently are employed by the oil industry, even though recruitment efforts are made and training programs are available (see Sec. III.D.5, Economic Effects).

BPXA has made a commitment to hire local workers on the North Slope and within Alaska. Many of the contractors hired by BPXA (design, construction, drilling, operations) are either North Slope Native Corporations (Arctic Slope Regional Corporation et al.) or subsidiaries of such corporations or otherwise affiliated with such corporations through joint ventures or other relationships. This relationship should provide significant local economic benefit (BPXA, 1998a). BPXA's Itqanaiyagvik program is a hiring and training program designed to put more Inupiat into the oil field workforce. It is a joint venture with the Arctic Slope Regional Corporation and its oil field subsidiaries and is being coordinated with the North Slope Borough and the North Slope Borough School District. Another part of this initiative is an adult "job shadowing" program and Alliances of Learning and Vision for Under Represented Americans, a program developed with the University of Alaska to prepare candidates for degree programs in technical and engineering professions. Most graduates of the adult job shadowing program already are working in oil field jobs (BPXA, 1998d).

(b) Specific Effects of Disturbances From Developing BPXA's Proposed Liberty Development and Production Plan

Because staging would be from Deadhorse, social systems in the communities of Nuiqsut and Kaktovik would experience little direct disturbance from the staging of people and air freight expected from the development and production of Liberty oil. These activities would have little effect on sociocultural systems. Oil workers from the Liberty Project likely would not interact with Nuiqsut or Kaktovik residents, and there would be no expected displacement of social systems. As well, changes in population and employment are not likely to disrupt sociocultural systems.

Stress would occur if a village were not successful in the bowhead whale harvest, with possible disruption of the sharing networks and task groups. This stress also could disrupt the community's social organization but likely would not displace the social processes of whaling and sharing. Other more successful villages will share with a village having an unsuccessful whaling season and recently, there have been no unsuccessful whaling seasons by Nuiqsut since 1994 and Kaktovik since 1991 (Braund, Marquette, and Bockstoce, 1988; Alaska Eskimo Whaling Commission, 1987-1995). Recently, negotiated conflict resolution agreements between the Alaska Eskimo Whaling Commission, subsistence whaling communities, and the oil industry have successfully served as a means to coordinate whaling activities and potential disturbance to whaling from industry activities.

Any effects on social health would have ramifications in the social organization, but North Slope Borough Native communities have, in fact, proven quite resilient to such effects with the Borough's continued support of Inupiat cultural values and its strong commitment to health, social service, and other assistance programs. Health and social-service programs have attempted to meet the needs of alcohol and drug-related problems with treatment programs and shelters for wives and families of abusive spouses and with greater emphasis on recreational programs and services. However, in comments before the Department of the Interior's Outer Continental Shelf Policy Committee's May 2000 meeting, North Slope Borough Mayor George Ahmaogak stated resident are extremely concerned that a lack of adequate financing for individual North Slope Borough city governments has hampered the development of these programs, and declining revenues from the State of Alaska have seriously impaired the overall function of North Slope Borough city governments. Partnering together, Tribal governments, city governments, and the North Slope Borough government may be able to provide programs, services, and benefits to residents. For several years, all communities in the Borough have banned the sale of alcohol, although alcohol possession is not banned in Barrow, and many communities are continually under pressure to bring the issue up for a local referendum vote (North Slope Borough, 1998).

Effects on social health in Nuiqsut could have direct consequences on the sociocultural system but would not have a tendency toward the displacement of existing systems above the displacement that has already occurred with the current level of development. Effects in Kaktovik would be periodic and would not displace existing sociocultural systems.

(3) Native Views on Disturbance

At hearings in 1982, Mark Ahmakak from Nuiqsut stated that there should be economic benefits to Nuiqsut, such as cheaper diesel (Ahmakak, 1982, as cited in USDOI, MMS, 1982b). The consensus is that some benefit should come to the community from nearby oil activities. Nuiqsut resident Joseph Ericklook expressed the community's wish to see employment opportunities for local people result from development (Ericklook, 1990, as cited in USDOI, MMS, 1990d). In a 1996 public meeting for the Northstar Project, a Nuiqsut elder stated that she wanted potential human-health issues that could result from the project looked into beforehand. These issues could be found in information from other projects. She specifically expressed concern about cancers, health problems related to air pollution, and shortened lifespans (Dames and Moore, 1996e). As early as 1983, Nuiqsut residents asked to be part of industry activities in the region. Mark Ahmakak stated: "I think that if you are going to go ahead with this sale that you should utilize Natives in…the areas affected by this lease sale; then utilize some of these Natives as monitors on some of your projects" (Ahmakak, 1983, as cited in USDOI, MMS, 1983a). There are concerns about protecting traditional sites from development. Nannie Woods expressed her opposition to leasing in the Colville River Delta because of her concern that her husband's burial site might be disturbed by development (Woods, 1982, as cited in USDOI, MMS, 1982b). Recently, a Nuiqsut elder had her "home place" at Prudhoe Bay desecrated by an oil company. Her house was looted and built over. She emphasized that graves of family members are in the area and that she has been denied access there (Dames and Moore, 1996e). At a November 1999 MMS Liberty Project Information Update Meeting in Nuiqsut, Elders told MMS to be aware of gravesites on the shoreline of Foggy Island Bay (see Appendix E).

Mayor Lon Sonsalla from Kaktovik believes that to keep up with development activities, they need an impact office there to review EIS documents and monitor offshore activities (Sonsalla, 1996, as cited in USDOI, MMS, 1996d). During MMS scoping meetings for Sale 170, in November 1006, Susie Akootchook, Village Coordinator for Kaktovik, commented that traditional fishing and hunting sites need protection, and that a contingency plan needs to be developed to protect them (Burwell, 1996, pers. commun.).

Rex Okakok from Barrow expressed the problem when he said: "Our land and sea are still considered and thought by outsiders to be the source of wealth, a military arena, a scientific laboratory, or a source of wilderness to be preserved, rather than as a homeland of our Inupiat" (Okakok, 1987, as cited in USDOI, MMS, 1987). Considering such use of Inupiat territory, Robert Edwardson from Barrow said that he would like to see revenues paid to the Inupiat for mineral rights (Edwardson, 1995, as cited in USDOI, MMS, 1995b). All three communities believe that some form of impact assistance should be forthcoming to compensate them for absorbing oil development that has occurred and that is yet to come.

(4) Native Allotments

Native allotments are considered Indian trust resources (lands). These allotments are small land parcels (up to 160 acres) given to families for private use per the Alaska Native Allotment Act (1906). The use or lease of these allotments requires consensus of all family heirs and the approval of the Bureau of Indian Affairs. Native allotments in the project vicinity are shown in Map 1. Although the onshore portion of the proposed pipeline is near one of the allotments, it would not be impacted by the project either during construction or operation. Allotment holders have been identified and will be notified about local public hearings on the project and be sent copies of the Draft EIS for review and comment.

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(5) How Stipulations or Mitigation Measures Help Reduce Disturbance Effects

See preceding Section III.C.3.h, Summary of Disturbance Effects on Subsistence-Harvest Patterns, for a discussion of mitigation measure that would help reduce disturbance effects.

(6) Environmental Justice

Alaska Inupiat Natives, a recognized minority population, are the predominant residents of the North Slope Borough, the area potentially most affected by Liberty development. Inupiat Natives may be disproportionately affected because of their reliance on subsistence foods, and Liberty development may affect subsistence resources and harvest practices. Disproportionately adverse effects on Alaskan Natives could result from Liberty development under the Proposal. Effects will focus on the Inupiat community of Nuiqsut, and possibly of Kaktovik, within the North Slope Borough.

Environmental justice is an initiative that culminated with President Clinton's February 11, 1994, Executive Order 12898, "Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations," and an accompanying Presidential memorandum. The Executive Order requires each Federal Agency to make the consideration of environmental justice part of its mission. Its intent is to promote fair treatment of people of all races, so no person or group of people shoulders a disproportionate share of the negative environmental effects from this country's domestic and foreign programs. It focuses on minority and low-income people, but the Environmental Protection Agency defines environmental justice as the "equal treatment of all individuals, groups or communities regardless of race, ethnicity, or economic status from environmental hazards" (U.S. Department of Energy, 1997; Envirosense, 1997).

Executive Order 13084, "Consultation and Coordination with Indian Tribal Governments," requires MMS to be in consultation with Inupiat tribal governments on the North Slope on "Federal matters that significantly or uniquely affect their communities…" so an effective process is established that "permits elected officials and other representatives of Indian tribal governments to provide meaningful and timely input…." We have met with local tribal governments to discuss subsistence issues and the Liberty Project during scoping meetings in the community of Nuiqsut on March 18, 1998, in the community of Barrow on March 19, 1998, in the community of Kaktovik on March 31, 1998, and have held meetings in Anchorage on March 25 and April 8 and in Fairbanks on April 1, 1998. We have established a dialogue on environmental justice with these communities, and followup meetings to address environmental justice issues were held on November 1, 1999, in Barrow; November 2, 1999, in Nuiqsut; and on November 5, 1999, in Kaktovik. Major concerns expressed at the meetings included

- the need for continued participation by the North Slope Borough in the Liberty planning process;
- better communication between the Borough and Federal agencies;
- more concrete guidelines for the consultation process, increased use of traditional knowledge;
- a request for assistance with the bowhead whale census, the need for oil-spill response training in the villages;
- the need for establishing a subsistence advisory panel;
- a better assessment of cumulative impacts and continued fears about ice gouging damaging the Liberty pipeline;
- oil-spill cleanup in broken ice;
- noise effects on bowhead whales;
- the use of gravel bags in Liberty island construction; and
- air pollution for development at Prudhoe Bay (see Appendix E).

Mitigation in place for the Liberty Project was developed through negotiations with local, borough, and agency representatives, and Inupiat Traditional Knowledge had a large part in mitigation development and in the timing of project activities. Local Inupiat government representatives are members of our Outer Continental Shelf Lease Sale Advisory Committee that meets to discuss and resolve issues that arise from recent offshore lease sales. Conflict avoidance agreements between the oil industry and Inupiat whalers are an important mechanism for overcoming conflicts. BPXA has committed to a dialogue with Native whalers and is now working on a Conflict Avoidance Agreement that would cover Liberty production activities. The Alaska Eskimo Whaling Commission prefers to negotiate a Conflict Resolution Agreement with industry on an annual basis using a regional rather than a project-specific approach to address potential impacts from all ongoing development projects.

(a) Demographics

1) Race

In 1993, the North Slope Borough conducted the North Slope Borough Census of Population and Economy. It found that of the 6,538 Borough residents, 4,941 identified themselves as Native and 1,597 identified themselves as non-Native. Of the Native population, 97.71% or 4,828 were Inupiat Eskimo, 93 were identified as "other Alaskan Natives," and 20 were American Indians. For the North Slope Borough as a whole, the population is 73.9% Inupiat and 26.1% non-Inupiat. Of the Inupiat population, 49.2% lived in Barrow and 50.8% lived in the other seven villages that comprise the North Slope Borough. Sixty-nine percent of the North Slope Borough population resides in the three communities of Barrow, Nuiqsut, and Kaktovik (North Slope Borough, 1995).

2) Income

According to the U.S. Department of Commerce, the average household income in 1993 for the State of Alaska was $64,652, and the average State per capita income was $23,000. Based on Department of Commerce data, the Alaska Department of Labor has portrayed the North Slope Borough as having one of the highest per capita incomes in the State; but data collected by the North Slope Borough 1993 Census of Population and Economy take exception to these figures based primarily on different methods used in data collection. Federal data use a sampling procedure, but the Borough conducts house-to-house household surveys. Also, Federal figures include “transfer payments” such as unemployment, welfare, Social Security, and Medicare/Medicaid payments. The North Slope Borough survey includes all income reported to the Internal Revenue Service, including Alaska Permanent Fund and Alaska Native Claims Settlement Act corporation dividends. The North Slope Borough figures determined an average household income of $54,645 and a per capita income of $15,218 in 1993. When figured for ethnicity, the average Inupiat household income was $44,551 and for non-Inupiat it was $74,448. The average Inupiat per capita income was $10,765 and the non-Inupiat per capita income was $29,525. Of all the households in the North Slope Borough surveyed, 23% qualified as very low-income households, and another 10% qualified as low-to-moderate-income households. As 66% of the total households surveyed were Inupiat, it would appear that a large part of the households falling in the very low- to low-income range are Inupiat. Poverty-level families in the North Slope Borough numbered 88, or 6% of all households (North Slope Borough, 1994).

(b) Subsistence Consumption of Fish and Game

As defined by the North Slope Borough Municipal Code, subsistence is “an activity performed in support of the basic beliefs and nutritional need of the residents of the borough and includes hunting, whaling, fishing, trapping, camping, food gathering, and other traditional and cultural activities” (State of Alaska, Dept. of Natural Resources, 1997). This definition gives only a glimpse of the importance of the practice of the subsistence lifeway in Inupiat culture, but it does underscore that it is a primary cultural and nutritional activity on which Native residents of the North Slope depend. For a more complete discussion of subsistence and its cultural and nutritional importance, see Section VI.B.1, Subsistence-Harvest Patterns.

Disproportionately adverse effects on Alaskan Natives could result from Liberty development under the Proposal. Effects will focus on the Inupiat community of Nuiqsut, and possibly of Kaktovik, within the North Slope Borough. The sociocultural and subsistence activities of these Native communities could be affected by routine development and accidental oil spills. Possible oil-spill contamination of subsistence foods is the main concern regarding potential effects on Native health. Interestingly, after the *Exxon Valdez* spill, testing of subsistence foods for hydrocarbon contamination from 1989-1994 revealed very low concentrations of petroleum hydrocarbons in most subsistence foods. In fact, the U.S. Food and Drug Administration concluded that eating food with such low levels of hydrocarbons posed no significant risk to human health (Hom et al., 1999). They recommended avoiding shellfish, which accumulates hydrocarbons. Of course, human health could be threatened in areas affected by oil spills but we can reduce these risks through timely warnings about spills, forecasts about which areas may be affected, and even evacuating people and avoiding marine and terrestrial foods that may be affected. Federal and State agencies with health-care responsibilities would have to sample the food sources and test for possible contamination.

Whether subsistence users will use such tested foods is another question that involves cultural “confidence” in the purity of these foods. Based on surveys and findings in studies of the *Exxon Valdez* spill, Natives in affected communities largely avoided subsistence foods as long as the oil remained in the environment. Perceptions of food tainting and avoiding use remained (and remain today) in Native communities after the *Exxon Valdez* spill, even when agency testing maintained consumption posed no risk to human health (State of Alaska, Dept. of Fish and Game, 1995a; Hom et al., 1999; Burwell, 1999).

The ability to assess and communicate the safety of subsistence resources following an oil spill is a continuing challenge to health and natural resource managers. After the *Exxon Valdez* spill, analytical testing and rigorous reporting procedures to get results out to local subsistence users were never completely convincing to all subsistence users about the safety of their food, because scientific conclusions often were not consistent with Native perceptions about environmental health. According to Peacock and Field (1999), a discussion of subsistence-food issues must be cross-disciplinary, reflecting a spectrum of disciplines from toxicology, to marine biology, to cultural anthropology, to cross-cultural communication, to finally understanding disparate cultural definitions of risk perception itself. Any effective discussion of subsistence-resource contamination must understand the conflicting scientific paradigms of Western and Native science, the vocabulary of the social sciences, and include local knowledge and observations throughout the collection, evaluation, and reporting process. True restoration of environmental damage, according to Picou and Gill (1996), “must include the reestablishment of a social equilibrium between the biophysical environment and the human community” (Field et al., 1999; Nighswander and Peacock, 1999; Fall et al., 1999). Since 1995, subsistence restoration resulting from the *Exxon Valdez* oil spill has taken a more comprehensive approach by partnering with local communities and by linking scientific methodologies with traditional knowledge (Fall et al., 1999; Fall and Utermohle, 1999).

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(c) Mitigation

Alaska Inupiat Natives, a recognized minority population, are the predominant residents of the North Slope Borough, the area potentially most affected by Liberty development. Inupiat Natives may be disproportionately affected because of their reliance on subsistence foods, and Liberty development may affect subsistence resources and harvest practices. Sale 144 lease stipulations (applicable here) and mitigating measures that would protect subsistence resources and harvest practices are Stipulations 1, Protection of Biological Resources; 2, Orientation Program; and 5, Subsistence Whaling and other Subsistence Activities. For a discussion of the Orientation Stipulation see Section III.C.3.h, How Stipulations or Mitigation Measures Help Reduce Effects.

The Orientation Program stipulation requires the lessee to educate people working on exploration, development, and production about the environmental, social, and cultural concerns that relate to the area and its communities. The program should increase workers' sensitivity to, and understanding of, values, customs, and lifestyles of local Native communities and help prevent any conflicts with subsistence activities. BPXA's standard North Slope Environmental and Cultural Awareness training in the form of BPXA's "Achieving Environmental Excellence" program will form the foundation for environmental orientation for all personnel and contractors involved in Liberty offshore development. This program will be expanded to address specific issues of concern related to wildlife interaction, protection of marine mammals, best management practices to minimize the potential for spills, awareness of local sociocultural issues and concerns, and awareness of subsistence resources and activities. BPXA is currently developing a video to be used in the training; development of this video will be coordinated with MMS. The overall training program will be submitted to the Regional Supervisor, Field Operations for review and approval. Personnel will receive appropriate training on at least an annual basis, and full training records will be maintained for at least 5 years.

BPXA is proposing to incorporate several measures into the design, construction, and operations to reduce any potential conflicts with subsistence users. These measures include: ongoing community liaison, involving quarterly meetings in local communities; a program to incorporate Inupiat traditional knowledge into project planning; and plans to involve community residents in required monitoring, through the Alaska Eskimo Whaling Commission, in oil-spill prevention and response through the industry North Slope spill cooperative Alaska Clean Seas and in developing and implementing a training program in cultural and environmental awareness.

The stipulation on Subsistence Whaling and Other Subsistence Activities requires industry to avoid unreasonable conflict with subsistence activities during operations, especially the bowhead whale hunt. Before submitting a plan, the lessee must consult with the subsistence communities of Barrow, Nuiqsut, and Kaktovik; the North Slope Borough; and the Alaska Eskimo Whaling Commission about the proposed operations. These consultations ensure that they coordinate siting and timing with subsistence whaling and other subsistence-harvest activities. We restrict uses under the lease, if necessary, to prevent conflicts. However, subsistence whalers and industry have been able to negotiate agreements that work for both parties. An example is the recent agreement coordinating the timing of seismic activity for the Northstar Project and the subsistence whale hunt. BPXA and the North Slope Borough, Alaska Eskimo Whaling Commission, and the city of Nuiqsut worked out this agreement. BPXA has committed to a dialogue with Native whalers and is now working on a Conflict Avoidance Agreement that would cover Liberty production activities. This agreement would limit major construction activities to the winter season, and generally limit vessel transit to the Liberty Island to routes inside the barrier islands. The Alaska Eskimo Whaling Commission prefers to negotiate a Conflict Resolution Agreement with industry on an annual basis using a regional rather than a project specific approach so as to address potential impacts from all ongoing development projects. The Commission and BPXA are actively pursuing such an agreement at the present time. An ongoing consultation process with subsistence whalers will be used to identify any concerns not addressed by BPXA proposed mitigation, as well as identifying additional mitigating measures to be considered, such as monitoring of bowhead whales for effects from development and operations noise (see Sec. I.H.6, Mitigation Analyzed in this EIS). Industry also is required to consult with subsistence communities when activities may affect the availability of polar bears for subsistence use and to develop a Plan of Cooperation as part of the Incidental Take Program.

Collectively, these stipulations would aid substantively in preventing interference with the bowhead whale migration by reducing potential disturbance, would prevent conflicts to the bowhead whale hunt by assuring hunter access, and would mitigate against disturbance and contamination to onshore habitats and other subsistence resources such as caribou and polar bear. Effects to subsistence resources and subsistence harvests are expected to be mitigated substantially though not eliminated.

j. Archaeological Resources

(1) Summary and Conclusion For Effects of Disturbances on Archaeological Resources

Any bottom- or surface-disturbing activity, such as pipeline construction, island installation, anchoring of vessels, or oil-spill-cleanup activities could damage previously unidentified archaeological sites. Physical disturbance of sites could cause destruction of artifacts, disturbance or complete loss of site context, and resulting loss of data. Archaeological sites are a nonrenewable resource and could not be replaced.

At the MMS Information Update Meeting held March 29, 2000, in Barrow, the Alaska Department of Fish and Game made a presentation on a draft study of subsistence economics and oil development in Nuiqsut and Kaktovik, which affirmed a strong connection to anthropogenic effects as the cause for Kaktovik's unsuccessful whaling season in 1985 (Pedersen et al., In prep.).

Archaeological surveys are required both onshore and offshore in areas where there is the potential for archaeological resources to occur. Therefore, potential impacts to archaeological resources from physical disturbance would be mitigated. If a previously unknown archaeological site is discovered during construction, MMS and the State Historic Preservation Officer will be immediately contacted.

(2) Details on How Disturbances May Affect Archaeological Resources

All of the potential effects noted below from disturbances to archaeological resources are general effects that would result from developing the Liberty Prospect. No specific effects to the BPXA proposal are identified in the following analysis. The greatest effects on archaeological sites would result from any bottom- or surface-disturbing activity, such as pipeline construction, island installation, anchoring of vessels, or oil-spill-cleanup activities.

(a) Prehistoric Sites

1) Onshore

No prehistoric sites have been found within the proposed Liberty Project area (Lobdell, 1998a:12).

2) Offshore

The Prehistoric Resource Analysis included in Section VI.B.3 concludes that there is potential for preserved prehistoric archaeological sites to exist within the project area. As a result of this analysis, we have requested that an archaeological report based on geophysical data be prepared by BPXA in accordance with 30 CFR 250.26. If the archaeologist's report identifies any areas that might have the potential for preserved prehistoric sites, we would require that these areas either be investigated further to determine conclusively whether a site exists at the location or be avoided by all bottom-disturbing activities. This report was received by MMS in January, 1999. It stated that "Suitable situations for the preservation of archaeological remains of terrestrial origin cannot be identified in the present data…."

(b) Historic Sites

1) Onshore

Lobdell & Associates surveyed the proposed project area in August 1997 (Lobdell, 1998a) and recorded two Historic Period sites: Foggy Island Bay Site #2 (49-XBP-024) and Foggy Island Bay Site #3 (49-XBP-026). Both are ruins of historic sod houses. Foggy Island Bay Site #2 is 0.2 mile northwest of the proposed onshore pipeline route (Alternative I) and undergoes active thermokarst erosion (Lobdell, 1998a:8). Foggy Island Bay Site #3 is 1 mile southeast from the proposed onshore pipeline for the Eastern Pipeline Route in Alternative III.A. In addition to ruins of sod houses, this site also contains a grave located 70 meters from the house ruins. Thermokarst erosion has not affected the site, because a substantial fronting strand flat protects it from geological processes (Lobdell, 1998a:11).

A copy of the survey report was sent to the State of Alaska, Office of History and Archaeology. The State Historic Preservation Office issued a letter, dated May 2, 1998, which indicated that no onshore archaeological properties would be impacted by the proposed Liberty Project (Smith, 1998, pers. commun.).

2) Offshore

The two known shipwrecks within the project area were derived from literature sources and have not yet been ground-truthed (USDOI, MMS, 1998:III-C-26). They are the *Reindeer* and the *Duchess of Bedford* (see Sec. V.B.3). While we do not expect a shipwreck to be present in the project area, the information on these wrecks is insufficient to pinpoint their location. The Cultural Resource Assessment received from BPXA in January, 1999 stated that: "…there is no evidence, archival or physical, to indicate the presence of a shipwreck within the project area."

k. Economy

General Effects of Disturbance on the Economy: We do not expect disturbances to affect the cash economy. The economic effects on the Alaska economy caused by construction activities in general are described in Section III.D.5. For effects of disturbances to the subsistence aspects of the economy, see Section III.C.3.h, Subsistence-Harvest Patterns. If there were any effects from disturbances to the economy, they would be general effects that would result from developing the Liberty Prospect and would apply to all alternatives in this EIS, except for the no action alternative.

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I. Water Quality

(1) Summary and Conclusions for Effects of Disturbances on Water Quality

The greatest effect on water quality from gravel island and pipeline construction would be additional turbidity caused by increases in suspended particles in the water column. Increases in turbidity generally are expected to be considerably less than the 7,500 parts per million suspended solids used in the analysis as an acute (toxic) criterion for water quality (Sec. III.C.3.l(2)); exceptions may occur within the immediate vicinity of the construction activity. Turbidity increases from construction activities generally are temporary and expected to occur during the winter and end within a few days after construction stops. Material excavated from the pipeline trench but not used for backfill most likely would be left in an area where active erosion of sediment particles could occur during breakup and open water. This material would be similar in composition to seafloor sediments in the trenching and disposal areas, and its contribution to future turbidity from waves and currents is expected to be about the same as the sediments existing at the seafloor surface before pipeline construction. Construction activities are not expected to introduce or add any chemical pollutants.

(2) Details on How Disturbances May Affect Water Quality

(a) General Effects from Developing the Liberty Prospect

Activities likely to affect water quality include construction activities such as dumping mined or excavated material into the marine environment and/or dredging seafloor sediments. These activities introduce additional fine-grained particles into the water. Some of these particles could remain suspended in the water, add to the natural turbidity and be transported away from the activity site. The size, duration, and amount of turbidity depend on the grain-size composition of the material being dumped or dredged, the rate and duration of the activity, the turbulence in the water column, the current regime and, where applicable, the degree of ice bonding between particles being discharged. As noted in Section VI.C.2.b(1) (river discharge), coastal erosion, and resuspension of fined-grained particles deposited on the seafloor add particles to the natural turbidity of the nearshore Beaufort Sea waters. Suspended-sediment concentrations in the nearshore waters may range from 30 to more than 300 micrograms per liter (30-300 parts per million) (Sec. VI.C.2.b(1)). In the winter, suspended-sediment concentrations may range from about 2-70 micrograms per liter (2-70 parts per million) (Sec. VI.C.2.b(1)).

Suspended sediments have very low direct toxicity for sensitive species, with expected toxicity somewhere between that of a clay such as bentonite (LC_{50} [=concentration at which half the test organisms die within 3 days] more than 7,500 parts per million for the eastern oyster) and that of calcium carbonate (LC_{50} more than 100,000 parts per million for the sailfin molly) (National Research Council, 1983). These are very low toxicities, falling into the ranges generally described as slightly toxic to nontoxic. Direct toxicity from suspended sediments, therefore, has not been considered a regulatory issue, and toxic or acute marine standards have not been formulated by either the State of Alaska or the Environmental Protection Agency.

For purposes of analysis, we use 7,500-parts per million suspended solids as an unofficial, acute (toxic) criterion for water quality. This value is the lowest (most toxic) LC_{50} for a clay or calcium carbonate reported in the National Research Council (1983) assessment of drilling fluids in the marine environment.

The State of Alaska standards and Federal criterion for marine waters that do exist are considered chronic standards and a chronic criterion in this analysis. Both State standards and the Federal criterion are directed toward protecting biota from chronic stresses rather than from acute toxicity, but the limits are very different in formulation. One State standard is 25 nephelometric-turbidity units, and the Federal criterion and a second State standard are no more than a 10% decrease in the seasonally averaged compensation depth for photosynthetic activity. A third State standard is no more than a 10% reduction in maximum secchi disk depth.

Experiences with actual dredging or dumping operations in other areas show a decrease in the concentration of suspended sediments within a short time (2-3 hours) and distance downcurrent (1-3 kilometers [0.6-2 statute miles]) from the discharge. Similarly, in the dredging operations associated with the construction of artificial islands and harbor improvement in mostly sandy sediments of the Canadian Beaufort Sea, the turbidity plumes also tended to disappear shortly after operations ceased; they generally extended a few hundred meters to a few kilometers (1 kilometer = 0.62 statute miles) (Pessah, 1982).

The amount of suspended sediment associated with the summer construction of Endeavor Island in 3.7 meters (12 feet) of water in the Beaufort Sea decreased in concentration downstream from the island (Nortec, 1981, as reported in BPXA, 1998a). The suspended-sediment concentration was 70 micrograms per liter (70 parts per million) at a distance of 30 meters (100 feet) from the island; 30 micrograms per liter (30 parts per million) at 180 meters (600 feet); and 10 micrograms per liter (10 parts per million) at 1,830 meters (6,000 feet).

Turbidity formed by construction activities likely would be smaller in the winter than in the summer during open water. Ice bonding between particles would reduce the quantity of fine-grained particles that could be suspended in the water during island construction.

Also, the extent of a plume depends on the capability of moving water to transport suspended particles. This capability is directly related to current speed and, in general, the under-ice currents are not as strong as open-water currents (Table VI.C-8). Water samples collected during the excavation of a test trench for the Northstar Development showed a decrease in suspended-sediment concentrations with distance from the trench. The trench was excavated with a backhoe along the proposed Northstar pipeline route in 1996 (Montgomery and Watson, 1996, as reported in Ban et al., 1999). A water sample collected at the seafloor during trenching had a suspended-sediment concentration of 885 milligrams per liter. The suspended-sediment concentration in waters collected within 150 meters of the trench had concentrations ranging from 20-121 milligrams per liter. Suspended-sediment concentrations ranged from 19-35 milligrams per liter in water samples collected more than 150 meters from the trench.

During construction of the Northstar pipeline, sediments excavated in the bottomfast-ice zone in water less than 6.5 feet deep typically were not suspended into the surrounding water (URS Corporation, 2000).

Wind generated waves and currents could resuspend fine-grained particles that settle on the seafloor. Wave height and period are functions of the velocity of the wind, the fetch or distance over which the wind blows, and the duration or time the wind blows. Generally, increases in wind speed or duration and fetch increases wave height. In shallow waters, such as Foggy Island Bay, wave height and period increase with the square root of the water depth. Wind-generated surface currents have velocities that are about 3% of the wind velocity (measured at a height of 10 meters [33 feet] above the surface) (Bowden, 1983). Some observations have shown surface currents deviate to the right (in the Northern Hemisphere), but the direction seldom exceeds 10 degrees in coastal waters (Bowden, 1983). The current velocity decreases with depth; at 3 meters (10 feet) the current velocity is estimated to be about 0.9% of the wind speed (Bowden, 1983). Moving water has the potential to resuspend particles on the seafloor and transport them in a horizontal direction.

The variables affecting resuspension of particles also include grain size, shape, distribution, and density; cohesion of particles; water depths; current velocities; turbulence; and water densities. The threshold mean velocity, measured 1 meter (3.28 feet) above the seafloor, to erode a particle 0.5 millimeter in diameter is estimated to be about 20 centimeters per second (0.4 knot) (Shepard, 1963). Particles larger and smaller than 0.5 millimeter require more energy, greater current velocities, to erode them from the seafloor. The increase in threshold velocity with decreasing grain size results from the cohesion of particles that must be overcome; cohesion between particles increases with decreasing particles size. Silt-size particles range in size from 0.062-0.004 millimeter in diameter. The mean threshold velocity to erode these particles ranges from about 20-40 centimeters per second (0.4-0.8 knot) for the larger particles to about 70-200 centimeters per second (1.4-4 knots) for the smaller particles; these ranges show there is considerable uncertainty in estimating current velocities that will erode particles from the seafloor. Resuspension of clay-size particles, less than 0.004 millimeter in diameter, would require currents greater than 70-200 centimeters per second (1.4-4 knots).

Less energy—current speed—is required to keep a particle suspended than is required for suspension. Currents with velocities of about 4 centimeters per second (0.1 knot) are capable of keeping a medium sand-size particle (0.5 millimeter in diameter) suspended; erosion of this size particle needs currents of about 20 centimeters per second (0.4 knot). Silt- and clay-size particles (greater than 0.062 millimeters in diameter) can remain suspended with currents less than 4 centimeters per second (0.1 knot). Based on observations at Oliktok Point and Barter Island, winds from an easterly direction (northeast, east, and southeast) blow about 50-60% of the time along the Beaufort Sea coast in July, August, and September (Brower et al., 1988). Easterly winds force the nearshore waters to move in a westerly direction along the coast parallel to the bathymetry. Winds with velocities of 11-16 knots blow about 10-20% of the time and with velocities greater than 17 knots about 5% of the time. Easterly winds generated waves with heights of 0-1 meter (0-3 feet) about 30-35% of the time and heights of 1-2 meters (3-6 feet) about 5-10% of the time.

Winds from a westerly direction (northwest, west, and southwest) blow about 25-35% of the time in July, August, and September (Brower et al., 1988). Westerly winds force the nearshore waters to move in a easterly direction along the coast parallel to the bathymetry. Winds with velocities of 11-16 knots blow about 5-6% of the time and with velocities greater than 17 knots about 2% of the time. Westerly winds generated waves with heights of 0-1 meter (0-3 feet) about 15-20% of the time and heights of 1-2 meters (3-6 feet) about 5-10% of the time.

Erosion of seafloor sediments also occurs during strudel scouring. Strudel scour occurs in the spring (late May to early June), prior to breakup, when rivers flood the sea ice in the nearshore areas. The waters can drain through openings in the ice with a force large enough to erode seafloor sediments and create scour depressions (Appendix D-5). Suspended particles would add to the natural turbidity and carried away from the scour site by nearshore currents.

Trace metals and hydrocarbons could be added to the marine environment when excavated material is dumped into the water or sediments are dredged from the seafloor.

The nearshore Beaufort Sea sediments come from the river and coastal erosion. Boehm et al. (1990) noted the concentrations of a number of specific trace metals in the sediments were comparable with the average concentrations in the continental crust—the primary source material for marine sediments. The specific trace metals were barium, chromium, lead, zinc, and vanadium. Barium, chromium, lead, and zinc frequently are present in drilling fluids at concentrations significantly greater than in sediments. Vanadium frequently is present in crude oils in concentrations greater than in sediments. Concentrations of these metals that are above background levels could indicate contamination from drilling muds or oil spills.

As part of the MMS's Beaufort Sea Monitoring Program, the trace metals in nearshore sediments were analyzed to determine if there were any changes in their concentrations between samples collected in 1984-1986 and samples collected in 1989 and could any changes be related to oil and gas development; the results of these studies were reported by Boehm et al. (1987, 1990). Boehm et al. (1990) noted the regional means of trace metal concentrations for the 1989 data were in close agreement with the 1984-1986 data. Along the Beaufort Sea coast, there are regional differences in the trace metal concentrations in the fine fraction (silt-and clay-size particles) of the sediments, but these differences are related to differences in the depositional processes. The mean concentration of barium, 840 micrograms per liter, in west Harrison Bay was higher than in other regions where the mean ranged from 620-710 micrograms per liter. The mean concentration of chromium in west and east Harrison Bay was 140 and 106 micrograms per liter, respectively, while mean concentrations in other regions ranged from 82-94 micrograms per liter. Also, the mean concentrations of copper (28 micrograms per liter) and vanadium (192 micrograms per liter) in east Harrison Bay were higher than in other regions where mean concentrations of copper ranged from 20-24 micrograms per liter) and vanadium from 150 to 160 micrograms per liter. The hydrocarbons in the nearshore Beaufort Sea sediments come mainly from biogenic (terrestrial plants) and petrogenic (fossils fuels) sources (Boehm et al., 1990). Some of the hydrocarbons also come from pyrolytic sources; pyrolytic hydrocarbons are found in the atmosphere as products of incomplete combustion. The biogenic and petrogenic hydrocarbons reach the nearshore as suspended particulate matter in the rivers or are eroded from coastal deposits sediments that include peat. The rivers flow through a variety of terrains that include tundra, coal, and shale outcrops and natural petroleum seeps. Rivers are the main major source of petrogenic (polycyclic aromatic hydrocarbons [PAH]) and biogenic (saturated [alkanes] hydrocarbons). Coastal peat contributes significantly to the accumulated alkanes and less to the PAH's in the marine sediments. There are regional differences in the PAH concentrations in the sediments, but these differences are related to differences in the depositional processes rather than local pollution.

The PAH's phenanthrene, 2-methylnaphthalene (plus 1-methylnaphthalene), benzo(a)pyrene also were reported in surface samples from the nearshore, lagoons, and bays along the Beaufort Sea coast (Boehm et al., 1990); their concentrations in the sediments ranged from 0-190 nanograms per gram (0.190 milligram per kilogram), 0-1,100 nanograms per gram (1.100 milligrams per kilogram), and 0-7.7 nanograms per gram (0.0077 milligram per kilogram), respectively.

The potential sources for these types of PAH's are noted in Table III.C-11. Neff (1985) notes PAH's may be formed by:

- high-temperature pyrolysis of organic material,
- low- to moderate- temperature diagenesis of sedimentary organic material to form fossil fuels, and
- direct biosynthesis by microbes and plants.

The ERL's and ERM's for hydrocarbons also are used to assess possible adverse biological effects from PAH's in sediments. The ERL's and ERM's (defined in Table VI.C-3) for three of the PAH's found in the surface sediments are shown below (Long and Morgan, 1990):

	ERL	**ERM**
Phenanthrene	225	1,380. parts per billion
2-Methylnaphthalene	65	670
Benzo(a)pyrene	400	2,500

As part of the MMS's Beaufort Sea Monitoring Program, the hydrocarbons in nearshore sediments were analyzed to determine if there were any changes in the hydrocarbon composition between samples collected in 1984-1986 and samples collected in 1989 and could any changes be related to oil and gas development; the results of these studies were reported by Boehm et al. (1987, 1990). Boehm et al. (1990) reported excellent agreement between saturated hydrocarbon composition in the sediments between the two periods, which indicated no petroleum hydrocarbons attributable to recent drilling or petroleum production activities were detected at any location. Also, the concentrations of PAH's in the sediments sampled in the 1989 period did not differ significantly from those sampled in the 1984-1986 period. The samples from both periods showed there were significant amounts of petrogenic PAH's in all sediments. The analysis of the constituents indicates the petrogenic PAH's come from fossil (coal and oil) sources; most of the particles eroded from these sources were carried to the marine environment by rivers but some may have come from the coastal erosion.

Studies of hydrocarbons in Beaufort Sea sediments by Shaw et al. (1979), Shaw (1981), Kaplan and Venkatesan (1981), and Venkatesan and Kaplan (1982) are summarized in Boehm et al. (1987). The characteristics of the saturated hydrocarbons in the nearshore sediments indicated the most prevalent source was terrigenous plant material; most of this material would have been carried to the marine environment as suspended matter in the rivers. The presence of certain indicator hydrocarbons; cadalene, retene, and simonellite; in many of the samples indicated early diagensis of plant material, possibly including peat, contributed to the PAH's in the sediments. The sediments also contained PAH's of petrogenic origin, but these hydrocarbons were not identified as coming from known sources such as the oil seep in the Cape Simpson area, Prudhoe Bay crude oil, or Mead River coal. In the offshore sediments, the saturated hydrocarbons mostly came from higher plants and the PAH's were of pyrogenic origin. The characteristics of the pyrogenic aromatic compounds indicated long-range transportation of combustion products rather than local sources.

(b) Specific Effects of Disturbances from BPXA's Proposed Liberty Development and Production Plan

Activities likely to affect water quality in Foggy Island Bay are constructing a solid-fill gravel island and digging and backfilling a trench for a crude-oil pipeline. Island and pipeline construction would be done in winter over a 2-year period. Island construction would occur during the first winter season and pipeline construction during the second winter season. Dumping material for the gravel island is estimated to require about 45-60 days, and pipeline trenching is estimated to take about 49 days (Table IV.C-2). The gravel island would be used to support production and associated facilities of the Liberty Project. The pipeline would transport crude oil from the island to existing onshore facilities. Both the gravel island and pipeline construction would be done from artificially thickened ice in the landfast ice zone. Ice roads would be used to transport equipment and materials to the island and pipeline construction sites.

1) Effects of Constructing the Production Island

The production island would be constructed in water about 21 feet deep. The island is located seaward of the area where the water is frozen from the surface to the seafloor in the winter, the bottomfast-ice zone; this area extends from the shoreline out to depths of about 6 or 7 feet.

An estimated 773,000 cubic yards of gravel would be used to construct the production island (Sec. II.A.1.b). This gravel would be mined from a permitted site on the Kadleroshilik River floodplain. (The volume of gravel to be mined is estimated to be 797,600 cubic yards; 773,000 cubic yards for the gravel island, 17,000 cubic yards to fill the slope protection bags and 7,600 cubic yards to manufacture the concrete slope-protection blocks.) The mine site is located on a mostly unvegetated island in the river's floodplain (BPXA, 1998a). The gravel would be trucked to the Liberty site over ice roads and dumped into the water through openings cut into the ice. The amount of fine-grained particles in the gravel fill material is estimated to range from 2-12%; these are the amounts of fine-grained material estimated for the gravel used in Prudhoe Bay construction projects (Woodward-Clyde Consultants, 1982; Dames and Moore, 1988; and Nortec, 1981, as reported in BPXA, 1998a). The amount of fine-grain particles that separates from the dumped mass and becomes suspended is estimated to be about 10% (Dames and Moore, 1988, as cited in Ban et al., 1999) or 12% (Ban et al., 1999). The gravel will be mined in the winter and there will be some ice-bonding of particles. Thus, the amount of fine-grained particles that actually separates from the dumped masses will most likely be less than the 10-12% estimated.

Dumping river gravel would affect water quality by increasing the amount of suspended particulate matter in the water column in the area below the floating fast ice in several ways, including (1) suspension of sediments by currents generated from the gravel hitting the seafloor and (2) separation of fine-grained particles from the material falling through the water.

The effects of seafloor sediments suspended in the water column from dumping gravel and pipeline construction are assumed to be similar. The effects of suspending the seafloor sediments during pipeline construction are analyzed in Section III.C.3.l(2)(b)2. Seafloor sediments in Foggy Island Bay consist mainly of fine sand-, silt-, and clay-size particles (Sec. VI.C.1.c(2)). The concentration of suspended sediments associated with trench excavation and backfilling are estimated to range from 500-1,000 milligrams per liter near the seafloor and 50-100 milligrams per liter near the surface (URS Corporation, 2000). Concentrations of suspended particles generally decrease as the distance from the disturbance increases. The larger and/or denser particles settle closer to the source, while the smaller and/or less dense particles are carried farther. Suspended sediment concentrations at 1 and 10 kilometers are expected to be less than 20 and 10 milligrams per liter, respectively. See Section III.C.3.l(2)(b)2 for a more complete analysis of the effects of suspending the seafloor sediments in Foggy Island Bay during pipeline construction.

When the dumped gravel forms the base of Liberty Island and covers the seafloor and as height of the build up increases, the effects of gravel dumping on suspending seafloor sediments will decrease.

As the dumped gravel falls through the water column, some of the fine-grained particles would separate from the mass and remain suspended; factors effecting suspension and transport of particles are discussed in Section III.C.2.1(2)(a). If the amount of gravel dumped into the water is 20,000 cubic yards per day (the assumed maximum dumping rate), the suspended sediment concentration in the immediate vicinity of the dumping activity is estimated to be 250 milligrams per liter (Ban et al., 1999). The concentration of particles suspended in the water decreases with distance from the source. The larger and/or denser particles in the plume would settle closer to the island than the smaller and/or less dense particles farther away. If the current speed is 2 centimeters per second (0.04 knot), the concentration of suspended particles would be reduced to 50 milligrams per liter at a distance of 0.5 kilometer (0.3 miles from the construction site, 20 milligrams per liter at 1.25 kilometers (0.78 mile) distance and 10 milligrams per liter at 1.5 kilometers (0.93 mile) downcurrent (Ban et al., 1999). The suspended-sediment plume width at the 10-milligram-per-liter concentration interval is estimated to be 400 meters. The suspended-sediment plume is a temporary feature and would disappear within a few days after island construction is complete. The thickness of the depositional layer decreases with distance from the island construction site.

As noted in Section III.C.2.l(2)(a), silt- and clay-size particles can remain suspended with currents less than 4 centimeters per second (0.1 knot). The mean under-ice currents range from 0.7 to less than 2 centimeters per second (0.01-0.04 knot). Under-ice currents have the capability of keeping some of the smaller constituents of the fine-grained fraction in suspension.

The extent of the turbidity plume can be estimated by considering the area that might be affected by the deposition of particles from the plume. During construction, if the under-ice currents transport the suspended particles to the northwest, the size of the area affected by particle deposition is shown in Figure III.C-2. The larger particles in the plume would settle close to the island and the thickest part of depositional layer also would be closer to the island. The turbidity plume also would contain particles that are smaller than those in the depositional area shown in Figure III.C-2. These smaller particles would be carried farther in suspension and extend the size of the plume over an area that is greater than that indicated by the particles deposited on the seafloor. The suspended sediment plume is a temporary feature and would disappear within a few days after island construction is complete.

The gravel used to construct Liberty Island would be mined from a State of Alaska permitted site and the gravel is not expected to contain any contaminated material.

Summer construction activities such as grading and shaping the island's surface and subsurface slope and placement of the slope-protection systems would result in some additional suspension of fine-grained sediments. Maintenance of the slope-protection systems during the life of the island also might result in suspension of fine-grained sediments. The increase in turbidity as a result of these activities is expected to be about the same as the increases in turbidity caused by waves in shallow waters; the effects would be short term, lasting only as long as the activity, and greatest in the vicinity of the island.

2) Effects of Constructing the Pipeline

The pipeline trench, about 6.1 miles long, would be dug in the winter from the sea ice covering Foggy Island Bay. The ice from the shore out to depths of about 6 or 7 feet extends from the surface to the seafloor. In waters deeper than about 6-7 feet, the ice in Foggy Island Bay floats on the water with little or no horizontal movement; the stability in the winter allows construction activities to be conducted from the ice surface. The trench would be deep enough to allow for a 12-inch pipeline to be covered with at least 7 feet of material. An estimated 724,000 cubic yards of sediments would be excavated from the trench, and most of it would be used as backfill (Table II.A-1). However, as shown in URS Corporation (2000:Fig. 4), about one-third of the pipeline trench lies in waters less than 6.5 feet deep in the area where the sea ice is frozen to the seafloor; sediments excavated from this part of the pipeline trench are not expected to be resuspended in the water. Excavated material not used as backfill would be left on the ice to return to the seafloor by natural processes during spring breakup. Pipeline construction would affect water quality by increasing suspended-particulate matter in the water column mainly in the area below the floating fast ice in the winter and in the vicinity of the area where excess trench material lies during the open-water period. Trenching would disturb and resuspend the seafloor sediments in those areas beneath the ice where the sea water has not frozen to the seafloor. Dumping excavated material into the water column to fill the trench also would cause some of the fine-grained particles to separate from the descending sediment mass and remain in suspension; however, exposure to subfreezing temperatures likely would freeze the particles together and reduce some particle separation. The capability of the under-ice currents to carry fine-grained particles is described in Sections III.C.3.l(2)(a) and III.C.3.l(2)(b)1). The extent of the turbidity plume formed by these resuspended sediments likely would be less during open water (Sec. III.C.3.l(2)(a)). The effects of currents on the extent of a turbidity plume are noted previously in the section on Effects of Constructing the Production Island (Sec. III.C.3.l(2)(b)1)).

The Liberty pipeline trench will be mainly excavated with backhoes; a cutterhead suction dredge will be used to groom the trench to its final shape and depth. The material excavated from the pipeline trench would consist of a variety of sediment types that include stiff clayey silt, silt, sandy silt/silty sand, sandy gravel, silty gravel, and peat (URS Greiner Woodward Clyde, 1998a). As the buckets are lifted, water flowing over the top would wash out some of the fine-grained material from the exposed surface. The movement of these sediments in or through the water column could separate some of the smaller size particles from the mass being moved. Clays in the excavated material tend to be cohesive and form large clumps when disturbed (Miller, as reported in BPXA, 1998a); the cohesiveness of the clays would help to decrease the amount of fine-grained material available for suspension during both digging and backfilling.

Both trenching and backfilling operations are likely to be performed at the same time along the pipeline route (Sec II.A.1.b(3)(a)). In the floating fast-ice zone, suspended sediments generated from these operations could form a turbidity plume in the presence of currents in the water column between the bottom of the floating ice and the seafloor surface. The currents under the ice generally are lower than during the open water period (Sec. III.C.3.l(2)(a)). Thus, for a given distance from the activity, the turbidity plume likely would have lower concentrations and consist of finer particles.

During Liberty pipeline construction, suspended-sediment concentrations in the water column greater than 100 milligrams per liter are estimated to occur within 0.75 kilometer (0.46 mile) of the trench, based on excavating 724,000 cubic yards (Ban et al., 1999); fine-grained particles comprise an estimated 40% of the excavated sediments. The amount of suspended particles in the water column would decrease with distance from the construction area. Concentrations of 20 and 10 milligrams per liter are estimated to be reached at distances of about 1 kilometer (0.62 mile) and 10 kilometers (6.2 miles), respectively, from the trench. These estimates are based on an initial suspended-sediment concentration of l,000 milligrams per liter throughout the water column and a current velocity of 0.02 meters per second (0.04 knot) that carries the sediment to the northwest.

In another study, URS Corporation (2000) estimates initial suspended sediment concentrations from pipeline construction could range from 500-1,000 milligrams per liter near the seafloor and 50-100 milligrams per liter at the surface. This study was done to improve the capability to predict the effects of Liberty development construction on the Boulder Patch Community. The previous analysis assumed an initial suspended sediment concentration of 1,000 milligrams per liter was uniform throughout the water column.) If the initial concentrations are less than 1,000 milligrams per liter, suspended sediment concentrations at 1 and 10 kilometers could be less that the 20 and 10 milligrams, respectively, estimated previously. Fine-grained particles (silt- and clay-size particles) are estimated to comprise about 65% of the material excavated from the trench.

Excavated trench material will be stored in two areas (URS Greiner Woodward Clyde, 1998a) (Fig. II.A-18). One of these areas consists of a 230-acre site in waters 5-10 feet deep about 4 miles southwest of the Liberty site (Zone 1, Fig. II.A-18). The other site is along the proposed pipeline route (Zone 2, Fig. II.A-18). Trench sediments would be stockpiled in different parts of Zone 1 and graded to an average thickness of about 1 foot. Stockpile separation and grading would minimize the potential for mounding on the seafloor (URS Greiner Woodward Clyde, 1998b).

After the pipeline has been buried, the amount of material stored on the ice is estimated to be about 110,000 cubic yards (Ban et al., 1999). About 100,000 cubic yards would be in Zone 1 and 10,000 cubic yards along the northern part of Zone 2. The stockpiles of in Zone 1 will cover about 62 acres. Excavated material stored along the southern part of the proposed pipeline route would be scraped from the ice. The stored material will consist of a variety of particle sizes; sediments along the proposed Liberty pipeline route are composed of a heterogeneous mixture of clay-, silt-, sand- and gravel-size particles (URS Greiner Woodward Clyde, 1998a).

These sediments could return to the water column in any number of ways that might include:

- sinking to the seafloor directly beneath the ice pad as the ice melts in place;
- dumping into the water when the melting ice becomes unstable and overturns;
- eroding of particles by waves in open-water areas;
- melting and transporting of particles by meltwater in the frozen material; or
- melting, eroding, and transporting of particles during river flooding of the fast ice.

Depending on weather, ice conditions and breakup, and river flood stage, natural removal of the stockpiled sediments could take up to several weeks.

When the material stockpiled on the ice returns to the seafloor, some of the fine-grained material would be suspended in the water column. Ban et al. (1999) estimated the effects on water column turbidity. They assumed all stockpiled material would fall from the ice in 24 hours during the broken-ice period, 10% of the material would be suspended in the water column, and a current of 0.05 meter per second (0.1 knot) would transport the water in a northerly direction. Based on these assumptions, the suspended-sediment concentration below Zone 1 is estimated to be 1,168 milligrams per liter, and below the storage area adjacent to the northern part of Zone 2 is estimated to be 14 milligrams per liter. The suspended-sediment concentrations decrease with distance from the storage sites. Concentrations of 200, 20, and 10 milligrams per liter are estimated to occur at about 0.5 kilometer (0.3 mile), 2.75 kilometers (1.70 miles) and 7 kilometers (4.3 miles), respectively, from Zone 1. These estimates probably represent maximum suspended-sediment concentrations over 1 or 2 days. If the return of the stockpiled material takes more than a day, suspended-sediment concentrations could be reduced and/or last for a longer period. Also exposure to subfreezing temperatures would freeze the particles together and reduce some particle separation when the stockpiled material returns to the seafloor. The suspended concentration estimates are based on no ice bonding of particles and, thus, estimate possible maximum concentrations.

Breakup and melting of the ice used to store unused trench material likely would take several weeks. The extent of the turbidity plume associated with the return to the water column of the trench sediments stockpiled on the fast ice can be estimated from the seafloor area covered by deposition of the particles. The stored material will consist of a variety of particle sizes; sediments along the proposed Liberty pipeline route are composed of heterogeneous mixture of clay-, silt-, sand- and gravel-size particles (URS Greiner Woodward Clyde, 1998a). As noted in the section on Effects of Constructing the Production Island (Sec. III.C.3.l.2(b)1)), the extent of the turbidity plume can be estimated by considering the area that might be affected by the deposition of particles from the plume. The turbidity plume also would contain particles that are smaller than those that might be shown in a depositional area. These smaller particles would be carried farther in suspension and extend the size of the plume over an area that is greater than that indicated by the particles deposited on the seafloor.

During broken-ice conditions or open water, winds from the east force the nearshore waters to move in a westerly direction parallel to the bathymetry; the characteristics of Beaufort Sea coastal winds are summarized in Section III.C.2.l(2)(a). Under these conditions, particles in the turbidity plume from the Zone 1 spoils area would be deposited in an area that extends in a northerly direction from the spoils site (Fig. III.C-5). Westerly winds force the nearshore waters to move in an easterly direction parallel to the bathymetry.

The thickness of the layer formed by excess trench material falling to the seafloor would be greatest in the vicinity of the storage area and would decrease with distance. The areal extent and thickness of this layer were calculated from a sediment deposition model (URS Greiner Woodward Clyde, 1998a). Within 400-530 meters of Zone 1, the layer formed by excess trench material falling to the seafloor would decrease to a thickness of 10 millimeters. The layer would have a thickness of 1 millimeter within 10-13 kilometers (6.2-8.1 miles) under easterly winds and within about 6.1 kilometers (3.8 miles) under westerly winds. Within 170-180 meters of Zone 2, the layer formed by excess trench material falling to the seafloor would decrease to a thickness of 1 millimeter.

The areal extent of the turbidity plume formed by the falling excess trench material could be approximated by considering where some of the smallest particles might be deposited. Particles 0.005 millimeter in diameter would be deposited at distances of about 13-18 kilometers (8-11 miles) from Zone 1; the thickness of the deposits at these distances is calculated to be about 0.02 millimeter under easterly winds and 0.01 millimeter under westerly winds. Particles 0.005 millimeter in diameter would be deposited at distances of about 18-56.5 kilometers (11-35 miles) from the Zone 2 site; the thickness of the deposits at these distances is calculated to be about 0.001-0.002 millimeter under easterly winds and 0.001 millimeter under westerly winds.

If all or most of the excess trench material returns to the seafloor in the vicinity of the storage site, a layer, or scattered layers, or variable thickness could form. The layer(s) would consist of a heterogeneous mixture of clay-, silt-, sand-, and gravel-size particles. These sediments are similar to the grains-size composition of present-day surface sediments in Foggy Island Bay. The layer(s) probably would cover an area greater than 62 acres, assuming some spreading occurs when the material reaches the seafloor. Most of the material would be in water 5-10 feet deep.

Depending on wind and wave conditions, the fine-grained particles in the excess trench material on the seafloor could be suspended. In Simpson Lagoon, time-series plots between wind speed and suspended-particle concentrations suggest the threshold wind velocity to induce wave-current resuspension of bottom sediment in waters 3 meters (10 feet) deep is about 8 meters per second (15.5 knots) (Naidu et al., 1984). Multiyear satellite images suggest the turbidity in coastal waters in mid- and late summer are, for the most part, associated with wave-induced resuspension of cohesionless muddy sediments from shallow-water regions (Naidu et al., 1984). The resuspended fine particles generally are carried westward.

Foggy Island Bay is a dynamic environment where a number of phenomena interact to produce changes in the seafloor. These phenomena include winds and storms, sea ice, and river flooding of the nearshore ice. As shown in Figure VI.C-2, the shorelines in the bay also are eroding at rates of 2-3 meters (about 6-10 feet per year). The barrier islands northeast of the Liberty Project area, the McClure Islands and Narwhal Island, are migrating toward the southwest. The movement between 1975 and 1990 is shown in Figure VI.C-3; the distances range from less than 0.1 mile to about 0.4 mile. As will be described in the following, ice gouges and scour depressions fill rates range from 1-8 feet per year.

The location of Liberty Island in Foggy Island Bay generally limits the fetch. The fetch for winds from westerly, southwesterly, south, or southeasterly directions (Point Brower to Tigvariak Island) is about 5-6 miles. The McClure Islands lie about 5-6 miles northeast of Liberty Island, and the fetch for winds from the northeast would be limited to these distances. Winds from the north and east have fetches greater than about 10 miles, taking into account the distances to the islands and channels between the island groups.

Table III.C-8 shows predicted wave height and period-based wind speeds of 20, 30, and 40 miles per hour; fetches of 5, 10, and 15 miles; and water depths of 5 and 10 feet; the characteristics of Beaufort Sea coastal winds are summarized in Section III.C.2.l(2). The wave heights shown in the table are within the range of observed wave heights along the Beaufort Sea coast for easterly and westerly winds.

The above information suggests winds in Foggy Island Bay are capable of generating currents and waves with enough force and turbulence to suspended loose particles in the excess trench material. As noted above, the threshold mean velocity to erode medium sand-size particles (0.5 millimeter in diameter) is about 0.4 knot, and the velocity of a wind-generated current at a depth of 10 feet is estimated to be about 0.9% of the wind speed. With a 5-knot wind, the current at a depth of 10 feet is estimated to be about 0.4 knots. The mean threshold velocity to erode silt-size particles (0.062-0.004 millimeter in diameter) ranges from about 0.4-4.0 knots. Winds with velocities of 11-16 knots blow about 15-25% of the time, and wind with velocities greater than 17 knots blow about 5-7% of the time. At a depth of 10 feet, 11- and 17- knot winds could produce currents of about 1 and 1.5 knots, respectively. As previously noted, wave-current induced resuspension of bottom sediments in water 10 feet deep was suggested to occur with 15.5 knot winds.

Most of the excess trench material will be dumped into waters less than 10 feet deep, where resuspension of existing sediments is likely to occur during the summer. Some of the trench material will be stockpiled along the pipeline route in waters deeper than 10 feet; if weather and/or ice conditions do not allow the area to be cleared, some of the spoils will be dumped in waters deeper than 10 feet. The contribution of the trench material to the background suspended-sediment concentration likely would be about the same as that of the area into which the sediments were dumped.

Depending on the cohesiveness of the sediments in the excess layer of trench material and the occurrence of events that could disrupt this cohesiveness, removing the fine-grained material from the layer could be a long-term process—perhaps up to several or more open-water seasons. Disruptive events include storms, strudel scour, and the movement of ice in the bottomfast zone during the spring breakup.

The increased current velocities and wave turbulence associated with the passage of storms significantly could reduce the amount of material in the excess trench material layers, depending on the intensity of the storms. Annual maximum sustained winds for 2-, 5-, 25,- and 100-year return periods are shown in Table III.C-9.

Current velocities at a depth of 10 feet are estimated to be about 3.5 and 4.7 knots for wind with velocities of 39 and 52 knots, respectively.

In the spring when the nearshore ice begins to melt and lift off the seafloor, winds and currents will begin to move ice grounded on or near the mounds. Movement against the mounds could erode particles from the surfaces. Loose particles would be more susceptible to suspension by waves and currents during the open-water period.

Waters from the Sagavanirktok, Kadleroshilik, and Shaviovik rivers contribute to the spring over-ice flooding in Foggy Island Bay. In the vicinity of the Liberty pipeline, the flooding can extend from about 1.2-3.3 miles offshore; the distance varies from year to year (Blanchet et al., 2000). The 230-acre storage site lies between the Sagavanirktok and Kadleroshilik rivers about 1.2-2.2 miles offshore in water 5-10 feet deep. The deepest scours occur in water 5-8 feet deep (Blanchet et al., 2000).

Surveys in Foggy Island Bay in 1997 and 1998 indicated the maximum scour widths in waters 5-10 feet deep ranged from 20-130 feet and depths from 1-8.5 feet (Blanchet et al., 2000). Scour densities in 1997 and 1998 were 7.5 and 4.3 scours per square mile, respectively. If we assume the layer of trench material lies within an area equal in size to the ice storage area (230 acres), the number of scours that might effect this area in a year could range from one to three (230 acres is slightly more than one-third of a square mile). Observations by Reimnitz and Kempema (1983, as reported in Blanchet et al., 2000), indicated that when the flow of floodwaters from the ice stops, the particles suspended by the flow will settle into the crater.

Floodwaters flowing from the ice into the water column with enough force to scour the seafloor sediments also might be capable of eroding particles from the mounds of excess trench material.

Natural fill of the scours also indicates the dynamic nature of the waters in Foggy Island Bay. The rate at which the scours and ice gouges were filled in Foggy Island Bay and on the Sag Delta ranges from less than 1 to about 8 feet per year (Blanchet et al., 2000). The scours and gouges were filled with particles that moved along the seafloor in response to bottom currents and/or particles carried in suspension. Rates of fill are shown in Table III.C-10.

The average concentrations of several trace metals in samples from cores taken along the proposed pipeline route and in Foggy Island Bay are shown in Table VI.C-3. The concentrations of chromium, lead, and barium in the core samples are below or within the range of concentrations found in Beaufort Sea nearshore, lagoon, and bay sediments (Table VI.C-3). Arsenic and mercury concentrations are less than or within the range of concentrations found in Beaufort Sea shelf, slope, and abyssal sediments (Table VI.C.3). Table VI.C-3 also shows that the concentrations of arsenic, chromium, mercury, and lead in the sediment cores from Foggy Island Bay are less than the sediment quality criteria, ERL and ERM, used to assess possible adverse biological effects from metals in sediments (see Table VI.C-3 for definitions of ERL and ERM).

Thus, it appears that the trace metals observed in the cores came from natural sources. Dispersion likely would reduce the concentration of any metals introduced into the water column by construction activities.

Samples from cores collected in Foggy Island Bay in 1997 and 1998 also were analyzed for semivolatile and volatile PAH's (Montgomery Watson, 1997, 1998). The core sites were located along proposed pipeline routes. Two routes, one to the southwest and the other to the southeast, went from Liberty Island to the shoreline in the southern part of the bay; the third route went in a northwesterly direction to Endicott. No PAH's were detected in the 11 cores obtained in 1997; samples from these cores were taken at depths of 1 and 8 feet. However, five semivolatile PAH's were detected in the 4 cores obtained in 1998; the cores were sampled at depths of 1, 3, and 9 feet (PAH's were detected in only 13 of the 70 core samples analyzed). (The detection limits for the 1998 samples were several tens of times more sensitive than for the 1997 samples.) The PAH's and their concentration ranges are shown below:

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Phenanthrene: not detected to 0.033 milligram per kilograms (33 parts per billion)
2-Methylnaphthalene: not detected to 0.025 milligram per kilogram (25 parts per billion)
Benzo(a)pyrene: not detected to 0.092 milligram per kilogram (92 parts per billion)
Phenol: not detected to 0.038 milligram per kilogram
4 Methylphenol (p-Cresol): not detected to 280 milligrams per kilogram

For phenanthrene and 2-methylnaphthalene in the core samples, the concentrations were within the range observed in the surface sediments (Sec. III.C.2.l(2)(a); for benzo(a)pyrene the concentrations observed in the cores were greater than in the surface sediments. The concentrations of phenanthrene, 2-methylnaphthalene, and benzo(a)pyrene in the cores are less that the ERL for each PAH (Sec. III.C.2.l(2)(a)). Thus, it appears that the PAH's observed in the cores came from natural sources. Dispersion likely would reduce the concentration of any PAH's introduced into the water column by pipeline trenching and backfilling operations or disposal of unused material excavated from the trench. Neff (1985) notes the relative PAH concentrations in sediments almost always are greater by a factor of 1,000 or more than those in the water column.

Disposal of the unused material dredged from the trench will have to comply with a dredge material permit issued by the Corps of Engineers in accordance with Section 103 of the Marine Protection, Research and Sanctuaries Act (Woodward-Clyde Consultants, 1998). The disposal must be independently evaluated by the Corps of Engineers and the Environmental Protection Agency.

3) Effects of Repairing the Pipeline

Damage to the pipeline would require repairs, which would mean excavating the trench to expose the pipeline. Repair work most likely would be done in the winter when the ice is stable enough so that it can be thickened to support the repair equipment or during the open-water period (Table II.C-6). The pipeline repair techniques are described in Section II.A.1.b(3)(b)3) and summarized in Table II.C-7. The types of effects associated with excavating and backfilling would be the same as those analyzed for pipeline construction. These activities would affect water quality by increasing suspended-particulate matter in the water column in the area of the activity. In the winter, if the repair work takes place in the bottomfast-ice zone, there would be very little, if any, effects in the water column. If the repair work takes place in the floating fast-ice zone, the effects would be in the water column mainly in the area below the floating ice.

Depending on the type of repair, the amount of sediment excavated could range from 1,150-6,490 cubic yards (Table II.C-7). The rate at which the trench backfill material would be removed is likely to be less than the rate at which sediment was excavated to form the trench. An estimated 10-15 days would be required to excavate 6,490 cubic yards (Table II.C-7). Repair excavation would take place in a small area, and the size of the associated turbidity plume is expected to be smaller than the one formed during the initial trench excavation. In the winter, the excavated material would be stored on the ice and used as backfill when the pipeline repair is finished. During the open-water period, the excavated material would be placed on the seafloor alongside the trench and used as backfill when the pipeline repair is completed. Backfilling would cause some of the fine-grained particles to separate from the excavated material when it is moved. The effects of excavating and backfilling would be similar to those previously analyzed for pipeline construction. However the amount of material moved for pipeline repair is about 1% or less of the volume handled during construction.

The greatest effect on water quality from dredging would be related to turbidity. Pipeline excavation and backfilling are not expected to introduce or mobilize any chemical pollutants.

m. Air Quality

No effects from disturbances to air quality are expected. Impacts to air quality would result from discharges (air emissions). These impacts are presented in Section III.D.1.m.

D. OTHER ISSUES CONCERNING THE LIBERTY PROJECT

During the scoping process, other issues about potential effects to resources also were identified. This section addresses these other potential effects by providing a detailed analysis, including references, of the possible impact to the relevant resource(s). All of the effects in this section are considered “general” unless otherwise identified as “specific.” By “general,” we mean common to all alternatives. By “specific,” we mean effects of the BPXA’s Proposed Liberty Development and Production Plan.

1. Discharges (Water Discharges and Air Emissions)

The majority of wastes generated during construction and developmental drilling would consist of drill cuttings and spent muds. Some waste also would be generated during operations from well-workover rigs. Drilling fluids would be disposed of through onsite injection into a permitted disposal well or would be transported offsite to permitted disposal locations.

In addition, domestic wastewater, solid waste, and produced waters would be generated during the project. Solid wastes, including scrap metal, would be hauled offsite for disposal at an approved facility. Produced waters would be reinjected.

An approved treatment unit would treat sanitary and domestic wastewater. Effluent from the unit would be chlorinated, and the treated effluent would be either discharged to sea or disposed of in an approved injection well. As a contingency, BPXA has applied for a National Pollution Discharge Elimination System permit authorizing marine discharge of sanitary and domestic wastewater. The permit application also would include discharges from a seawater-treatment plant, desalination-unit filter backwash, construction dewatering, and fire-control test water.

Chronic discharges of contaminants would occur every breakup from fluids entrained in the ice roads. Entrained contaminants from vehicle exhaust, grease, antifreeze, oil, and other vehicle-related fluids would pass into the Beaufort Sea system at each breakup. These discharges are not expected to be major; however, they would exist over the life of the field.

Sources of potential air emissions would be oil- or gas-turbine electric generators; heavy construction equipment; tugboats and support vessels; and drill-rig-support equipment, including boilers and heaters. The use of best available control technology and compliance with the Environmental Protection Agency emission standards would be required.

a. Threatened and Endangered Species

(1) Bowhead Whales

General Effects: Most discharges would be reinjected into the waste-disposal well and not into the marine environment. We do not expect discharges to affect bowhead whales.

At the Barrow Scoping Meeting on March 19, 1998, concern was expressed that leaching from cement blocks used for slope protection may cause a sheen on the water and/or introduce scents into the water. These may be detected by bowheads, causing them to divert from their normal migration route. Our analysis indicates that the concrete would contain no chemicals that could leach out and cause a sheen or scent in the water. Bowhead whales should not be affected by the use of concrete blocks as slope protection.

(2) Eiders

General Effects: No effects on eiders from discharges are expected.

b. Seals and Polar Bears

General Effects: Most discharges would be reinjected into the waste-disposal well and not into the marine environment. Thus, these discharges are not likely to affect seals and polar bears.

c. Marine and Coastal Birds

General Effects: No effects from discharges are expected to birds.

d. Terrestrial Mammals

General Effects: Most discharges would be reinjected into the waste-disposal well. These discharges are not likely to affect terrestrial mammals in the project area.

e. Lower Trophic-Level Organisms

Most fluid discharges would be reinjected into the waste-disposal well and not into the marine environment.

Our experience with gravel bags on several exploration islands (BF-37, Mukluk, Sandpiper, Tern, etc.) has shown that fabric is sometimes discharged accidentally during abandonment operations. During the long period of time that the islands were used and actively maintained, essentially no fabric was discharged from them. However, when Sandpiper Island was about to be abandoned, bags were discharged accidentally due to severe ice and wave damage to the island. Hundreds of bags drifted to shore, where most were recovered by company-funded shoreline monitors. A few floating bags entangled the outboards of subsistence whale boats.

This experience indicates that fabric would not be discharged from Liberty during active maintenance, and that the agency would probably require the careful removal of gravel bags during abandonment. However, if some buried fabric was accidentally left, some might drift away from the island. The fabric that would be used on Liberty differs from that used on Sandpiper Island—the former would sink upon release, and the small amount would probably not affect the benthos.

Any gravel that would be released from the bags and/or the islands would be relatively coarse, compared to natural sediment trenched from the seafloor and stored on the ice during construction. Any gravel from the bags and/or islands probably would slump down the island slopes rather than drift away in sediment plumes.

In summary, there would be no discharge effects to lower trophic-level organisms.

f. Fishes and Essential Fish Habitat

(1) Fishes

Treated seawater would be the primary discharge from Liberty. Seawater used on Liberty Island could contain chlorine, sanitary and domestic wastewater, and brine (see Sec. III.D.1.l for additional details). These would be mixed with seawater before being discharged into the sea, thereby reducing their concentration. The discharged water would be treated with sodium metabisulfite to reduce the water's total residual chlorine. Upon discharge, the treated seawater would be diluted by 50:1 within approximately a 20-foot radius of the discharge pipe. Because the mixing zone is so small and the dilution factor so large, seawater discharges are not expected to harm fish. Any fish in or near the discharge area likely would move away or avoid it, and no other effects would be expected.

(2) Essential Fish Habitat

None of the lifestages of Pacific salmon have been documented to use or inhabit the areas expected to be affected by the discharge of waste from Liberty Island construction and operations and, thus, salmon are not likely to be killed or otherwise affected. The quality of marine waters would be affected by associated discharges in the vicinity of Liberty over the life of the development. The temperature, turbidity, and salinity of seawater discharged from the Liberty Island production facility are expected to be slightly higher than waters in surrounding Foggy Island Bay (Sec. III.D.1.l). Chronic discharges of contaminants entrained in ice roads, including contaminants from vehicle exhaust, grease, antifreeze, oil, and other vehicle-related fluids, would pass into the Beaufort Sea system at each breakup. These discharges are not expected to be major, but they would exist over the life of the field (Sec. III.D.1.l). Although water quality and, therefore, essential fish habitat, would be minimally affected, no measurable effects from discharges are expected for fish, zooplankton, or plants living in the vicinity of the Liberty development (Sec. III.D.1).

g. Vegetation-Wetland Habitats

General Effects: Permitted discharges from Liberty likely would not measurably affect vegetation or wetlands, because they would be released offshore away from coastal wetland areas.

h. Subsistence-Harvest Patterns

(1) Summary and Conclusion for Effects of Discharges on Subsistence-Harvest Patterns

For the Liberty Project, most discharges would be reinjected into the waste-disposal well and not into the marine environment. Thus, we do not expect discharges to affect subsistence resources and uses. Liberty development would not affect subsistence resources; thus, it also would not disrupt traditional practices for harvesting, sharing, and processing those resources.

BPXA's Plan states that there would be no significant adverse impacts from combustion emissions during construction. Combustion emissions during pipeline laying would be transitory, and they would have no significant impact on air quality in the region because of frequent winds (see Sec. III.D.1.m). Short-term increases in dust levels at the mine and construction sites are not expected to have negative impacts on the environment. No impacts on subsistence resources are expected, but concerns remain in nearby Nuiqsut that some effects have occurred and continue to occur from air emissions.

(2) Details on How Discharges May Affect Subsistence Resources

General Effects: Discharges are not expected to affect bowhead whales, seals, polar bears, terrestrial mammals, and fish. Discharges should not affect birds significantly through direct contact or by affect their prey.

(3) How Stipulations or Mitigating Measures Help Reduce Discharge Effects

Mitigating measures from Beaufort Sea Sale 144 are in place for Liberty development, and this is reflected in discussions about effects. See Section III.C.3.i, Summary of Disturbance Effects on Sociocultural Systems, for a detailed discussion of stipulations and mitigating measures.

(4) Nuiqsut's Views on Discharges

Nuiqsut residents voiced concerns about dumping drilling muds from Seal Island into the ocean and the effects on fish and wildlife (Dames and Moore, 1996b).

Regarding air discharges, Elder Bessie Ericklook from Nuiqsut maintained that because the oil fields have been established [at Prudhoe Bay], the foxes have been dirty and discolored in the area of Oliktok Point (Ericklook, 1979, as cited in USDOI, MMS, 1979a). Leonard Lampe, current Mayor of Nuiqsut, recently expressed further air-pollution problems and habitat concerns, asserting that Nuiqsut has been experiencing such effects for some time: "A lot of air pollution, asthma, bronchitis—a lot with young children. We see smog pollution that goes from Prudhoe Bay out to the ocean and sometimes to Barrow when the wind is blowing that way…." (Lavrakas, 1996:1, 5).

(5) Kaktovik's Views on Discharges

In August 1979, Kaktovik elder Flossie Hobson expressed a concern about the bioaccumulation of carcinogenic compounds from oil and gas development (Hobson, as cited in USDOI, MMS, 1979b).

(6) Barrow's Views on Discharges

Eugene Brower from Barrow, testifying at hearings for the Beaufort Sea Oil and Gas Lease Sale 124, expressed concern that disposal of drilling muds could cause contamination (Brower, as cited in USDOI, MMS, 1990c). A Barrow whaling captain stated during the Northstar Project's hearings that he wanted to see strict monitoring of what goes into the ocean, such as waste disposal, leaks, and reinjection materials (Dames and Moore, 1996a).

i. Sociocultural Systems

General Effects: No disruptions to traditional practices for harvesting, sharing, and processing those resources are expected, and no discernable disruption to sociocultural systems should occur, although fear and stress concerning offshore development already exist in the local population and should be considered predevelopment impacts based on Picou and Gill's (1993) work on social impacts from the *Exxon Valdez* oil spill.

Effects to the sociocultural systems of communities near the Liberty Project could occur because of disturbance from industrial activities, including discharges; changes in population and employment; and effects on subsistence-harvest patterns. Discharge effects associated with Liberty development to the subsistence-harvest patterns in the communities of Nuiqsut and Kaktovik would not impact subsistence resources.

j. Archaeological Resources

No effects on archaeological resources from surface discharges are expected, because there would be no surface disturbance.

k. Economy

General Effects: No effects from discharges are expected on the economy.

l. Water Quality

(1) Summary and Conclusion for Effects of Discharges on Water Quality

Treated seawater would be the primary discharge from the Liberty Island production facility. The discharged waters would be a few degrees warmer and contain higher concentrations of suspended sediments and dissolved salts when compared to the water in Foggy Island Bay. Increases in turbidity generally are expected to be considerably less than the 7,500 parts per million suspended solids used in the analysis as an acute (toxic) criterion for water quality. The water also would contain some chemicals that have been added to prevent biofouling, scaling, and corrosion. Mixing in the receiving waters of the bay is estimated to dilute the effluent waters by a 50:1 ratio within about 6 meters (20 feet) of the island. Additional mixing would continue, as waters are carried away from the island by the currents.

(2) Details on How Discharges May Affect Water Quality

General Effects: The discharged waters would be a few degrees warmer and contain higher concentrations of suspended sediments and dissolved salts when compared to the water in Foggy Island Bay. The water also would contain some chemicals that have been added to prevent biofouling, scaling, and corrosion.

(a) Permitted Discharges

The pollutant content of the permitted discharges will be regulated through a National Pollution Discharge Elimination System permit issued by the Environmental Protection Agency and evaluated in the Ocean Discharge Criteria Evaluation in Support of the Liberty Development Project National Pollutant Discharge Elimination System Permit Application (URS Greiner Woodward Clyde, 1998a). Discharges into Foggy Island Bay from activities associated with production operations on Liberty Island are estimated to average 93,110 gallons per day; the maximum discharge is estimated to be 112,118 gallons per day Application (URS Greiner Woodward Clyde, 1998a).

The discharges would be discharged through an outfall located on the south side of the island in waters 15 feet deep (Fig. II.A-4). The discharges that will flow though this outfall are from the continuous-flush system, potable-water desalination-system brine blowdown, sanitary and domestic wastewater, and seawater-treatment-plant backwash. The characteristics of these and other discharges are described in the following subsections.

1) Continuous-Flush System (average flow 21,600 gallons per day/maximum flow 21,600 gallons per day)

The discharge from the continuous flush system consists of the seawater that would be continuously pumped through the process-water system to prevent ice formation and blockage. The transfer of heat from the pumps and piping is expected to raise the temperature of the seawater in the system about 1 degree Celsius. As noted in Section VI.C.5.d, summer water temperatures range from 0-9 degrees Celsius and winter from 2-0 degrees Celsius. Chlorine, in the form of calcium hypochlorite, will be added to the water to reduce biofouling. Before discharge, water from the continuous-flush system would be mixed with other discharges. After mixing sodium metabisulfate will be added to the effluent to reduce total residual chlorine concentration to comply with limits of the National Pollution Discharge Elimination System Permit (Appendix I-2). The effluent pH will vary slightly from the intake seawater because of the chlorination/dechlorination processes, but this variation is not expected to be more than 0.1 pH units. As noted in Section VI.C.2.b(3), the pH in the central part of the Beaufort Sea ranges from 7.5-8.2 during open water and 6.8-8.0 under the ice.

2) Potable-Water Desalination-System Brine Blowdown (average flow 40,320 gallons per day/maximum flow 57,600 gallons per day)

Seawater is used to generate potable water. The dissolved salts become more concentrated in the excess feed water (60-65‰) that does not evaporate (brine) than they are in the intake seawater (15-30‰). The temperature of the brine is estimated to be 5-7 degrees Celsius (11-15 degrees Fahrenheit) above ambient conditions. Periodically, sulfuric or sulfamic acids would be injected to remove mineral buildup in the desalination facility. The brine would pass through a dechlorination process prior to discharge. Before discharge, the brine would be mixed with other discharges.

3) Sanitary and Domestic Wastewater (average flow 9,072 gallons per day/maximum flow 10,080 gallons per day)

Sanitary wastes mean human-body waste discharged from toilets and urinals; domestic wastes include wastes from showers, sinks, galleys, and laundries (Environmental Protection Agency, 1986). Any facility using a marine-sanitation device that complies with pollution-control standards and regulations under Section 312 of the Federal Water Pollution Control Act, as amended, shall be deemed to be in compliance with the discharge limitations of the National Pollution Discharge Elimination System permit (Environmental Protection Agency, 1986).

Typically, the sanitary and domestic wastewaters would be injected into the permitted disposal well. However, during construction and periods when the well is not available, the wastewaters would be mixed with other discharges. A disinfectant system using ultraviolet light will be placed in the wastewater stream between secondary treatment and final disposal. Sludge from the secondary treatment would be injected into the disposal well or, if the well is not available, at an approved facility in the Prudhoe Bay area.

4) Seawater-Treatment-Plant Backwash (average flow 22,118 gallons per day/maximum flow 22,118 gallons per day)

Treated seawater would be injected into the producing rock formations to enhance oil recovery. Particles suspended in the seawater are removed as the water passes through a strainer and hydrocyclone. Backwash from the strainer and hydrocyclone will contain concentrations of suspended particles that are greater than the intake seawater. In summer, the suspended-sediment concentrations in the backwash are expected to have a daily average of 4,600 milligrams per liter (4,600 parts per million); the maximum concentration is expected to be 28,000 milligrams per liter (28,000 parts per million). In winter, backwash suspended-sediment concentrations are expected to average 780 milligrams per liter (780 parts per million), with maximum levels of 1,600 milligrams per liter (1,600 parts per million). Ambient seawater suspended-sediment concentrations in summer generally are greater in summer than winter. The seawater-treatment plant backwash is mixed with other discharges prior to discharge into Foggy Island Bay.

5) Fire-Control Test Water (typically no flow/maximum flow 2,500 gallons per minute)

The Liberty production facility includes a water-distribution system to provide emergency seawater to suppress and extinguish fires. Weekly tests of the fire-control pumps would circulate untreated seawater throughout the system and directly back to the seawater intake sump. The weekly tests are not expected to change the temperature of other physical properties of the seawater.

6) Construction Dewatering (average flow 1,000,000 gallons per day/maximum. flow 1,000,000 gallons per day)

Seawater that has seeped through the gravel fill and collected in the excavations and casings would be discharged into the water adjacent to the island. This discharge will contain some of the particles suspended in the seawater and may contain some of the fine-grained particles that were part of the gravel-fill material used to construct the island.

(b) Effluent Dispersion

Discharge from the continuous-flush system, brine from the potable-water-desalination system backwash from the seawater-treatment plant and, on occasion, sanitary and domestic wastewater are mixed before they are released into Foggy Island Bay. These discharges are treated with sodium metabisulfite to reduce the total residual chlorine in the water. The discharges during production operations are expected to contain detectable levels of chlorine and have increased suspended solids, salinity, and temperature compared to the surrounding waters. Mixing of these discharges reduces the concentration of suspended sediments and the salinity, added substances, and temperature of water released into the bay. The average suspended-sediment concentration in the combined effluent was computed to be 1,281 milligrams per liter (1,281 parts per million). The mixed discharges will be released into the bay from an outfall located on the south side of Liberty Island at a depth of 5 meters (15 feet); the outflow is horizontal and directed to the south.

Modeling of the outflow indicated that dilution of 50:1 occurs within 6 meters (20 feet) horizontally and 1.5 meters (5 feet) vertically of the outfall. This dilution indicates the concentration of suspended sediments released into the water column would be reduced from 1,281 milligrams per liter (1,281 parts per million) to about 26 milligrams per liter (26 parts per million). Alaska Water Quality Standards (18 ACC 70.20) require that a permitted discharge in State waters must not cause the turbidity to exceed 25 National Turbidity Units outside an approved mixing zone. For similar installations (for example, Endicott Development) the criterion of 25 National Turbidity Units has been interpreted as being approximately equal to 30 milligrams per liter (30 parts per million) total suspended solids. Although Liberty Island is located in Federal waters, the 3-mile Federal/State boundary is located just over a statute mile west of Liberty. As noted in Section VI.C.2, the waters in Foggy Island bay are well mixed, not stratified, for most of the year. Thus, mixing would continue as currents transport the mixed receiving and outfall waters away from the island.

Initial and the continued mixing of the effluent in the waters surrounding Liberty Island and implementation of the Best Management Practices Plan, as required by the National Pollution Discharge Elimination System Permit, to minimize the number and quantity of pollutants and the toxicity of the effluent will ensure the water quality of Foggy Island Bay is not degraded except in an area adjacent to the effluent outlet.

Production operations at Liberty Island would require an average daily intake of an estimated 3,535,200 gallons of seawater; maximum seawater intake is estimate to be 3,555,000 gallons per day. Enhanced oil recovery will require the use of about 95% of the intake that passes through the seawater-treatment plant. The other systems, such as the continuous-flush and potable-water desalination, use the rest of the water.

Other discharges that are part of production operations would be disposed in an onsite injection well permitted by the MMS as an industrial disposal well for fluids that are exempt from the Resource Conservation and Recovery Act nonhazardous and Resource Conservation and Recover Act; these discharges include drilling muds and cuttings and produced waters.

(c) Deck-Drainage Discharge

Deck drainage means all waste resulting from platform washing, deck washing; spillage; rainwater; and runoff from curbs, gutters, and drains, including drip pans and wash areas. In addition to rainwater, deck drainage would include water from snow and ice melt, storm waves, and sea spray. A deck-drainage and grading system will be installed to capture spills and any precipitation or seawater that falls or washes onto the island. Deck drainage containing fluids that are nonhazardous and exempt from the Resource Conservation and Recovery Act will be disposed in the onsite injection well. Fluids classified as hazardous waste by the Resource Conservation and Recovery Act will be managed at a designated storage area pending shipment to an approved hazardous-waste-disposal facility.

m. Air Quality

(1) Summary and Conclusion for Effects of Discharges on Air Quality

The Liberty Proposal would cause a small, local increase in the concentrations of criteria pollutants. Concentrations would be within the Prevention of Significant Deterioration Class II limits and National Ambient Air Quality Standards. Therefore, the effects would be low. (See supporting materials and discussions in Sec. VI.C.3.). The air-quality analysis is based on the specific emission controls and emission limitations that BPXA would apply to meet the appropriate Environmental Protection Agency regulations. This will include the requirement to use dry, low nitrogen oxide technology for the turbines to reduce emissions further. These controls become part of the proposed project and are written into the permit and, thus, are binding. The use of best available control technology and compliance with the Environmental Protection Agency emission standards is the primary factor in reducing emissions of criteria pollutants (such as nitrogen oxides and sulfur dioxide). BPXA also plans voluntary reduction of greenhouse gases (notably carbon dioxide); this also would result in a slight additional reduction in emissions of other pollutants. These voluntary measures, however, will not be

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part of the permit and, therefore, are not enforceable. BPXA's Development and Production Plan (BPXA, 2000a), especially Sections 12.3 (p.104) and 6.2.1 (pp. 45-47) have some additional information; their *Part 55 Permit Application for the BP Exploration (Alaska) Inc. Liberty Development Project*, includes a thorough discussion of control measures.

(2) Details on How Emissions from the Liberty Project May Affect Air Quality

The Liberty Project's activities would produce the following air pollutants: nitrogen oxides, carbon monoxide, sulfur dioxide, particulate matter, and volatile organic compounds. See Section IV.B.12 of the Sale 144 Final EIS (USDOI, MMS, 1996a) for a discussion of the formation and effects of these materials; we incorporate that discussion here by reference. The Sale 144 final EIS also discusses the types and amounts of air pollutants.

The type and relative amounts of air pollutants from this project would vary with its remaining phases—development (construction and commissioning), and production. For more detail on the emission sources in each phase, please refer to *Air Quality Impact of Proposed OCS Lease Sale No. 95* (Jacobs Engineering Group, Inc., 1989). Although this report has never been published, it is available for reference from MMS. We summarize the significant emission sources below.

For development, including temporary construction operations and drilling, the main sources of emission offshore would be the following:
- gas turbines used to provide power for drilling;
- reciprocating engines for electrical power, including rig generator (during construction phase only; standby only during commissioning);
- heavy construction equipment used to install facility and pipelines (including gravel-hauling dump trucks);
- construction and commissioning support equipment, including cranes, pumps, generators, compressors, pile drivers, welders, heaters, and flare;
- tugboats (needed to move equipment and supply barges) and support vessels; and
- drill-rig-support equipment, including boilers and heaters.

For all these operations, the best available control technology would be applied under the Environmental Protection Agency's air-quality regulations. The main emissions would be nitrogen oxides, with lesser amounts of sulfur dioxide, carbon monoxide, and particulate matter. Once in the atmosphere, nitric oxide gradually converts to nitrogen dioxide.

For production, the main source of offshore emissions would be the turbines for power generation and gas compression. The emissions would consist mainly of nitrogen oxides, with smaller amounts of carbon monoxide and particulate matter. Another source of emissions would be evaporative losses from pump and compressor seals and valve packing; using seal systems designed to reduce emissions would minimize these sources. The produced water and slop-oil tanks are equipped with a vapor-recovery system, which recovers emissions of volatile organic compounds from these tanks and returns them to the process. BPXA plans to have a flare available 24 hours a day, 365 days a year. If there were venting (unexpected), it would emit volatile organic compounds. However, flaring largely would burn up any emissions of volatile organic compounds, and they should not create a pollution problem. Flaring however, would, produce some nitrogen oxides, sulfur dioxide, particulate matter, and carbon monoxide. Venting or flaring would produce only a very small amount of sulfur dioxide, because sulfur in the produced gas should be very low (but never completely absent). BPXA lists the total potential emissions, after conclusion of the temporary construction operations and commissioning, as follows (tons per year):
- Carbon Monoxide, 156.4
- Nitrogen Oxides, 868.1
- Particulate Matter Less Than 10 Micrograms in Diameter, 30.9
- Sulfur Dioxide, 23.9
- Volatile Organic Compounds, 56.2

Other sources of pollutants related to outer continental shelf operations are accidents such as blowouts and oil spills. Typical emissions from such accidents consist of hydrocarbons (volatile organic compounds); only fires associated with blowouts or oil spills produce other pollutants.

(a) Air-Quality Regulation and Standards

Federal and State statutes and regulations define air-quality standards in terms of maximum allowable concentrations of specific pollutants for various averaging periods (see Table VI.C-4). These maxima are designed to protect human health and welfare. However, one exceedance per year is allowed, except for standards based on an annual averaging period. The regulations also include Prevention of Significant Deterioration provisions for nitrogen dioxide, sulfur dioxide, and PM_{10} to limit deterioration of the existing air quality that is better than that otherwise allowed by the standards (an attainment area). Maximum allowable increases in concentrations above a baseline level are specified for each Prevention of Significant Deterioration pollutant. There are three classes (I, II, and III) of Prevention of Significant Deterioration areas. Class I allows the least degradation and also restricts degradation of visibility. The areas adjacent to the Liberty Proposal area are Class II, which allows for a moderate incremental decrease in the air quality of the area. Baseline Prevention of Significant Deterioration pollutant concentrations and the portion of the Prevention of Significant Deterioration increments already consumed are established for each location by the Environmental Protection Agency and the State of Alaska before issuance of air-quality permits. Air-quality standards do not directly address all other potential effects, such as acidification of precipitation and bodies of freshwater or effects on nonagronomic plant species.

With the enactment of the Clean Air Act Amendments of 1990, the Environmental Protection Agency has jurisdiction for air quality over this project area. The lease operator must comply with that agency's requirements for outer continental shelf sources, including the provisions of Title I, Part C, of the Clean Air Act (Prevention of Significant Deterioration of Air Quality). Section 328 states that for a source located within 25 miles of the seaward boundary of a State (this includes Liberty), requirements would be the same as those that would apply if the source were located in the corresponding onshore area.

(b) Air-Quality Impact Analysis

The Liberty development scenario states that peak-year production would be 65,000 barrels. BPXA performed a site-specific air-quality-modeling analysis for the Liberty Proposal. We include their data (from their *Part 55 Permit Application for the BP Exploration (Alaska) Inc. Liberty Development Project)* as Tables III.D-1 and III.D-2.

To characterize ambient air quality concentrations resulting from air emissions associated with the project, the Environmental Protection Agency-approved Industrial Source Complex Short-Term Model (ISCST3 version 96113) and the Offshore and Coastal Dispersion Model (version 5, 97363) were used to calculate surface concentrations at all land and ice/water receptors. The recommended regulatory default options listed in the *Guideline* (Environmental Protection Agency, 1995) were used.

BPXA applied the models to simulate concentrations of pollutants generated by the proposed facility. The models used 5 years of meteorological data collected at Prudhoe Bay Pad A. Effects from any other industrial facilities located about 50 kilometers from the proposed facility also were modeled.

Table III.D-1 shows that the maximum concentrations of nitrogen dioxide, sulfur dioxide, and particulate matter less than 10 micrograms in diameter were within the maximum allowable limits for a Class II area. These maximum concentrations occur within about 200 meters of the facility boundary. Concentrations decrease rapidly with distance beyond the point of highest concentration. Table III.D-2 also compares the maximum concentrations with the national ambient air-quality standards for both the initial drilling/commissioning period and long-term operations. It shows that impacts are greatest in the initial drilling/commissioning period. Impacts during long-term operations are considerably lower than those during initial drilling and commissioning. In all phases, pollutant concentrations are within the ambient standards.

(3) Other Effects on Air Quality

Other effects of air pollution from outer continental shelf activities and other sources on the environment not specifically addressed by air-quality standards include the possibility of damage to vegetation, acidification of coastal areas, and atmospheric visibility impacts. Effects may be short term (hours, days, or weeks), long term (seasons or years), regional (Arctic Slope), or local (nearshore only). Visibility may be defined in terms of visual range and contrast between plume and background (which determines perceptibility of the plume). BPXA ran the VISCREEN model and found noticeable effects on only a very limited number of days, ones that had the most restrictive meteorological conditions. No effects at all were simulated during average conditions.

A significant increase in ozone concentrations onshore is not likely to result from the development or production scenario associated with the Proposal. Photochemical pollutants such as ozone are not emitted directly; they form in the air from the interaction of other pollutants in the presence of sunshine and heat. Although sunshine is present in the Liberty Project area most of each day during the summer, temperatures remain relatively low (Brower et al., 1988). Also, activities occurring as a result of the field development are offshore and separated from each other, diminishing the combined effects from these activities and greatly increasing atmospheric dispersion of pollutants before they reach shore. At a number of air-monitoring sites in the Prudhoe Bay and Kuparuk areas, ozone measurements show that the highest 1-hour maximum ozone concentrations generally are in the range of 0.05-0.07 parts per million, which is well within the existing maximum 1-hour average ozone standard of 0.12 parts per million. The highest 8-hour average ozone concentration is always somewhat lower than the maximum 1-hour average. Therefore, ozone levels are expected to be within the revised 8-hour average ozone standard of 0.08 parts per million. (**Note:** The 8-hour Federal ozone standard currently is under litigation. The Environmental Protection Agency cannot enforce the standard until the legal issues are resolved.) Because the projected ozone precursor emissions from the proposed Liberty project are considerably lower than the existing emissions from the Prudhoe Bay and Kuparuk oil fields, the proposed project would not cause any ozone concentrations to exceed the 8-hour Federal standard.

Olson (1982) reviewed susceptibility of fruticose lichen, an important component of the coastal tundra ecosystem, to sulfurous pollutants. There is evidence that sulfur dioxide concentrations as low as 12.0 micrograms per cubic meter for short periods of time can depress photosynthesis in several lichen species, with damage occurring at 60 micrograms per cubic meter. Also, the sensitivity of lichen to sulfates is increased in the presence of humidity or moisture, conditions that are common on coastal tundra. However, because of the small size and number of sources

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of sulfur dioxide emissions, we may assume the ambient concentrations at most locations to be near the lower limits of detectability. Because of the distance of the proposed activities from shore, attendant atmospheric dispersion, and low existing levels of onshore pollutant concentrations, the effect on vegetation resulting from the Liberty Proposal is expected to be minimal. Maximum modeled pollutant concentrations are well below levels that can damage lichens, according to laboratory studies. Research at Prudhoe Bay from 1989 through 1994 showed no effects of pollutants there on vascular plants or lichens (Kohut et al., 1994). That research was conducted in areas typical of the closest onshore area to Liberty. Monitoring the vascular and lichen plant communities over the 6 years has not revealed any changes in species composition that could be related to differences in exposures to pollutants.

Cement Dust: A scoping comment expressed concern about potential cement dust in the air and cement residue washing from the concrete blocks creating a sheen on the water, causing whales to avoid the area. We believe that any effects will be negligible because:

- all fabrication of the proposed concrete blocks (which include cement) would occur in existing, approved, and permitted facilities (where emissions are closely regulated) in the Prudhoe Bay area or in Anchorage; and
- nothing would be added to the concrete blocks (such as an applied coating) that could wash off and cause a potential problem.

(4) Effects of Accidental Emissions

Sources of air pollutants related to outer continental shelf operations are accidental emissions resulting from gas or oil blowouts, evaporation of spilled oil, and burning of spilled oil. The number of blowouts on the U.S. outer continental shelf, almost entirely gas and/or water, averaged 3.3 per 1,000 wells drilled from 1956 through 1982 (Fleury, 1983). Danenberger (1993) determined a frequency of 4.1 blowouts per 1,000 wells drilled from 1971 through 1991. Typical emissions from such accidents consist of hydrocarbons (volatile organic compounds); only fires associated with blowouts or oil spills produce other pollutants, such as nitrogen oxides, carbon monoxide, sulfur dioxide, and particulate matter. A discussion of the effects of a gas blowout or oil fire associated with an accidental spill is contained in Section IV.B.12.(3) of the Final EIS for Sale 144 (USDOI, MMS, 1996a), which we incorporate here by reference. Soot is the major contributor to pollution from a fire. This soot, which would cling to plants near the fire, would tend to slump and wash off vegetation in subsequent rains, limiting any health effects. We expect accidental emissions to have little effect on onshore air quality.

(5) Nuiqsut's Views on Air Emissions

Elder Bessie Ericklook from Nuiqsut maintained that since the oil fields have been established at Prudhoe Bay, the foxes have been dirty and discolored in the area of Oliktok Point (Ericklook, 1979, as cited in USDOI, MMS, 1979a). Leonard Lampe, current Mayor of Nuiqsut, recently expressed further air-pollution problems and habitat concerns, asserting that Nuiqsut has been experiencing such effects for some time: "A lot of air pollution, asthma, bronchitis—a lot with young children. We see smog pollution that goes from Prudhoe Bay out to the ocean and sometimes to Barrow when the wind is blowing that way..." (Lavrakas, 1996:1, 5). Because of the distance from the Liberty Project to Nuiqsut (approximately 90 miles or 145 kilometers) and the relatively small size of this project in comparison with the Prudhoe Bay complex, we believe that the Liberty Project would have essentially no effect with respect to these observations.

2. Gravel Mining

BPXA would need about 990,000 cubic yards of gravel for the following elements of the Liberty Project:

- islands for the main production and for potential relief well islands,
- pads for pipeline landfall,
- backfill for parts of the pipeline trench, and
- pad for the tie-in with the Badami pipeline.

The BPXA planning standard and permit application for the mine site would be for mining up to 2 million cubic yards of gravel.

BPXA has proposed mining a new site, approximately 45 acres, on an island in the Kadleroshilik River flood plain, located about 1.4 miles upstream from the Beaufort Sea. BPXA plans on extracting the gravel by blasting, ripping, and removing it in two 20-foot lifts (BPXA, 2000a:Sec. 9.22). The first phase of mining would start in January or February in Year 2 with the extraction of gravel from 19 acres. The second phase would start the next winter, with the extraction of gravel from 12 acres. The total disturbed area would be about 31 acres. About 24 acres of the disturbed area would be wetland habitat and would be destroyed in the development of the mine site(See Tab. III.D-6). Another 22 acres are planned for reserve, in case an emergency relief well is needed. About 17 acres of the reserve area is considered wetland habitat. The total mine site including the reserve area would cover about 53 acres, with about 41 acres being considered as wetland habitat.

Table 2 of BPXA's environmental report (BPXA, 1998a:5-16) provides detailed information about the vegetation at the proposed mine site for Phases 1 and 2:

- 40% well-drained vegetated river bars with dry dwarf shrubs and lichen tundra.
- 20% partially vegetated river bars above the active river channel with dry barren shrubs and grass.

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- 10% partially vegetated gravel river bars in the active river channel, which regularly flood during spring breakup.
- 30% completely barren river gravel.

BPXA would stockpile the unusable material in a designated reserve area. After the gravel is mined, the stored material would be used to contour the side or bottom faces of the mine site and to improve future habitat potential. After the first year of mining, BPXA would rehabilitate the area mined during the first phase and connect it to the active channel of the Kadleroshilik River. During spring breakup, the mine site would flood with freshwater, and subsequent coastal storm-surge flooding would create brackish conditions. Overwintering habitat in this river system is very limited, and the State of Alaska, Department of Fish and Game believes that these rehabilitated areas can be very important areas for fish rehabilitation. The rehabilitated mine site could provide potential overwintering habitat for fish. The second phase of gravel mining would follow the same steps as for Phase 1 and be rehabilitated in the same manner the following year. The second phase would not be connected directly to the Kadleroshilik River, but it would be connected to the Phase 1 area. About 24 acres of wetland habitat would be lost from the development of this mine site (See Tab IV.D-6).

The State of Alaska, Department of Fish and Game has published guidelines for the development of gravel pits on the North Slope (McClean, 1993). Other studies have been conducted on the North Slope, but many of those are out of print or currently unavailable. Other than the Alaska Department of Fish and Game reports, very little has been documented about the effects of gravel mining in North Slope rivers in the permafrost zone, especially in terms of the physical processes that shape rivers and the instream habitat used by native fishes. In this particular case, a 31-acre gravel pit (with a 22-acre reserve area) would be dug in the active floodplain of the river and eventually connected to the river channel. There is little information on how a gravel mine on the North Slope of Alaska would affect natural processes and functions of a braided river system, for example, sediment transport and stream-channel meandering, groundwater-surface water interactions, and nutrient cycling.

In contrast, there is a great deal of information on the effects of gravel mining in stream systems in other states. The Oregon Water Resources Research Institute did a comprehensive report on the effects of gravel removal from streams in Oregon, entitled *Gravel Disturbance Impacts on Salmon Habitat and Stream Health* in 1995. This study noted that in the Chetco River near Brookings, Oregon:

> Excessive gravel removal from streams can adversely affect stream health through a variety of physical and biological impacts. Except for isolated sites of permitted deep water dredging, streams should be managed so that gravel removal rates are less than natural gravel recruitment rates in order to maintain or re-establish aquatic habitat.
>
> Material removal from streams does not appear to result in any general ecosystem benefits.
>
> The potential indirect (off-site, multiple-causes, long-term, cumulative) impacts of removal-fill operations are a threat to the sustained health of Oregon's streams. Typical impacts include aggregate siltation and changes in size distribution, altered channel morphology, lost diversity of habitat, and reduction of bed elevation.
>
> Generation of fine material and resulting sedimentation from gravel removal can range from minimal to extensive. Gravel removal from those parts of channels where fines tend to accumulate, such as on upper portions of channel bars and the margins of streams, tends to create siltation problems because of the large quantities of entrapped fine materials released. Sedimentation may be a delayed impact because gravel removal typically occurs at low flow when the stream has the least capacity to transport the fines out of the system.
>
> Gravel recruitment from streams in excess of natural recruitment is likely to cause log-term shifts in-channel morphology, channel diversity, and lowered bed elevation (Oregon Water Resources Research Institute, 1995).

However, there are some important differences between the rivers in Oregon and the Kadleroshilik River on the North Slope of Alaska:

The coastal river systems in Oregon are regulated by both surface runoff and groundwater input. Flow conditions are higher between November to March. In contrast, the Kadleroshilik River is a braided stream whose flow is entirely regulated by surface runoff, as the groundwater is sequestered in permafrost. The stream flow for the Kadleroshilik River reaches a maximum for a short period of time during early summer as a result of snowmelt and is very low or nil through for most of the winter. Annual spring flooding carries a high bed load down braided stream channels that actively migrate across wide floodplains. In contrast, rivers and streams in coastal Oregon have more stable channels, lower seasonal variations in flow velocity, and consequently have less variation in water depth and sediment load. Because they are more stable, rivers in Oregon are likely to show direct impacts from activities that disrupt this equilibrium.

The coastal rivers in Oregon clearly have multiple user groups focused on different segments of the river systems. In the winter, the Chetco River offers salmon and steelhead fishing and whitewater kayaking. In the summer, it offers fishing, four-wheel driving, swimming, boating, camping, sightseeing, and picnicking (USDOI, National Park Service, 2000). In contrast, North Slope rivers have far fewer potential user conflicts. Construction would occur during the winter when the nearby river flow is very low or nil, making it unlikely that fish would be present. It is unlikely that anadromous fish (salmon) use the Kadleroshilik River system or would be present during mining activities in the winter. There is no known recreational fishing or other planned developments on the Kadleroshilik River.

The extent of the Kadleroshilik River is short compared to the much larger nearby rivers (Kadleroshilik and Canning). The relative importance of the Kadleroshilik River to the overall hydrologic system on the North Slope is likely to be commensurate with its length and discharge. The concern a mine site less than one-half mile long could somehow change the bed elevation and affect a braided river in the Arctic is very tenuous.

While the Oregon study concludes that gravel mining in Oregon results in "major changes in natural river processes," the rivers in Oregon and on the North Slope of Alaska are very different in hydrology, biology, or multiple-use demand. The Environmental Protection Agency is concerned that information about rivers in other states indicates the effects of mining in North Slope rivers may be substantial. Alaska Department of Fish and Game indicates the proposed gravel mining operation in the Kadleroshilik River could result in temporary local effects some distance up- and down-stream from the mine site. (Ott, 2000, pers. commun.). The Alaska Department of Fish and Game will be publishing additional information early in 2001, which along with other applicable information from other states can be incorporated in the Final EIS.

a. Threatened and Endangered Species

(1) Bowhead Whales

No effects to bowhead whales are expected from gravel mining.

(2) Eiders

Specific Effects: The Liberty gravel mine would disturb a sparsely vegetated gravel island in the lower Kadleroshilik River. Where vegetation occurs, dry dwarf shrub/lichen tundra and dry barren/dwarf shrub are dominate. Because eiders nest in wetland tundra habitats rather than the dry habitats that characterize the island, they are not likely to nest there so removal of the island is expected to have a negligible effect on the coastal plain population. Broodrearing eiders may use coastal saltmarsh habitat and gravel bar areas in the river delta (Johnson, 1994a,b; see also Sec. VI.A.1.a(2)), but the mine site is 1.4 miles upstream from such potential use areas. Displacement of a few eiders from this general area due to disturbance from summer activity could cause a slight loss of productivity, but this would represent a negligible population effect. A pond would remain after gravel is removed; part of its shore area is expected to be graded to a shallow slope and vegetated to provide enhanced waterfowl habitat after mining is completed. Overall benefit of rehabilitation for eiders is expected to be negligible. Rehabilitation activities could disturb any eiders nesting in adjacent wet tundra areas, but this activity is planned to be limited to one summer season. Steller's eiders are not expected to occur in the Liberty Prospect area.

b. Seals and Polar Bears

Specific Effects: A few polar bears could be disturbed by gravel mining operations near the coast along the Kadleroshilik River. Mining operations would include some blasting that probably could displace a few bears near the mine site. The disturbance of a denning female with cubs could result in the death of the cubs, if they are forced to abandon the den when the cubs are too young to survive outside of the den. Displacement probably would persist throughout the winter season but would not affect the bear population or distribution. No recent polar bear denning has occurred near the proposed mine site (see Map 2B). No seals are expected to be exposed to or be affected by gravel mining onshore.

c. Marine and Coastal Birds

Specific Effects: The Liberty gravel mine would disturb a sparsely vegetated gravel island on the lower Kadleroshilik River. Where vegetation occurs, dry dwarf shrub/lichen tundra and dry barren/dwarf shrub are dominate. Most species nesting in the general area, including waterfowl, shorebirds, and passerines, are expected to occupy wetland tundra habitats. Because few species are likely to nest on the island, and those using it would have similar habitat available in the area, disturbance of this island is expected to have a minor effect on bird populations (displacement of fewer than 10 pairs each of the several species that might be expected to occur). Broodrearing snow geese and brant, tundra swans, greater white-fronted geese, Canada geese, ducks, shorebirds, and a few songbirds are known to use coastal saltmarsh habitat and gravel bar areas in the river delta (Johnson, 1994a,b; see also Sec. VI.A.3), but the mine site is 1.4 miles upstream from most such potential use areas. Barrens, which would include unvegetated to sparsely vegetated river gravel bars, generally receive low to incidental use by birds (Meehan and Jennings, 1988). Part of the shore area of a large pond remaining after gravel removal is expected to be graded to a shallow slope and vegetated to provide enhanced waterfowl and shorebird habitat after mining is completed. For example, broodrearing geese may use the shore for grazing, but the overall benefit of rehabilitation for birds is likely to be negligible. Rehabilitation activities could disturb birds

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nesting in adjacent wet tundra areas, but this activity is planned to be limited to one summer season.

d. Terrestrial Mammals

Specific Effects: About 53 acres of river habitat would be altered. However, this habitat is sparsely vegetated, and its alteration likely would not affect caribou and muskoxen foraging. Caribou generally migrate south to the Brooks Range during winter months, when gravel mining is expected to occur; however, small bands of caribou may be present in the mining area during winter months. These bands of caribou could be displaced within a few miles of mining operations and be displaced temporarily along onshore ice roads when exposed to traffic going to and from the mine and other facilities.

Muskoxen recently have been sighted along the Kadleroshilik River, but few have been seen during the winter (LGL Alaska Research Assocs., Inc., Woodward-Clyde Consultants, and .Applied Sociocultural Research, 1998) when gravel extraction is expected to take place. Mining operations that include some blasting could displace some small groups of muskoxen within a few miles of the mine site and along onshore ice roads with traffic going to and from the mine and other facilities.

There are no known grizzly bear dens near the Kadleroshilik River gravel mining site (Map 2A). Grizzly bears would be denning during the winter months and are not likely to be exposed to mining operations and ice-road traffic.

The overall distribution and abundance of terrestrial mammals would not be affected.

e. Lower-Trophic-Level Organisms

The mine site would be in a freshwater environment. If the mine filled with water, plants and invertebrates probably would grow in it, and they might be preyed upon by higher trophic-level organisms, including fish and birds. However, because of the small scale of the proposed gravel mine, it is not expected to measurably affect lower trophic-level organisms.

f. Fishes and Essential Fish Habitat

(1) Fishes

Specific Effects: Overwintering habitat is very limited on the Arctic Coastal Plain, and gravel mining could benefit some migratory and freshwater fishes. The gravel mine site on the Kadleroshilik River would have a surface area of 31 acres and a depth of 40 feet upon completion. The river would flow into this area during spring and summer following construction. The site would provide a deepwater area suitable for overwintering that, as far as we know, does not exist in the Kadleroshilik River. In summer, arctic grayling and Dolly Varden char use the river. These fishes, ninespine stickleback, and broad whitefish eventually may overwinter in the gravel mine site. The design of this site is different from previous river gravel mine sites of the North Slope, because BPXA would remove most of the site's east wall. This would allow fish easy access to the site and possibly promote their use of it for overwintering, which would help increase their numbers.

(2) Essential Fish Habitat

Gravel is proposed to be obtained from an approximately 45-acre site located on an island in the Kadleroshilik River floodplain about 1.4 miles upstream of the Beaufort Sea. None of the lifestages of salmon have been documented to use or inhabit the areas of salmon essential fish habitat associated with the Kadleroshilik River, its tributaries, or in the adjacent Beaufort Sea. Fish, including arctic grayling and Dolly Varden char, that are potential prey for salmon are not known to use the river for overwintering. Thus, salmon would not be expected to be directly affected by mining operations, which would take place exclusively during the winter. The gravel quarry is expected to cover approximately 31 acres and, upon completion, be 40 feet deep.

BPXA is expected to remove most of the east wall of the mine, allowing exchange of water and fish between the river and mine pit. That action could encourage potential salmon prey species to use the site for overwintering, which could help increase their abundance (see Sec. III.D.2.f(1)) and, thereby, have a potential positive effect on essential fish habitat. Although some upland vegetation would be removed during excavation, it would be unlikely to have an effect on essential fish habitat (Sec. III.D.2.g). Flooding of the quarry following abandonment might increase the turbidity of the river downstream from the mine site (Sec. III.D.2.l). Water flowing though the quarry could suspend loose, fine-grained materials and carry them downstream. Other particles could be suspended and transported downstream as a result of wave action, if the mine were flooded during a storm surge. Some of the fine-grained materials would be deposited on the delta. Any of the particles from the mine that are carried in suspension into the coastal waters would mix with suspended particles from a variety of other sources and disperse. If deposition of sediment on the delta or suspension of particles in coastal waters caused deaths or disruptions of potential prey or associated vegetation life cycles, essential fish habitat would be adversely affected.

g. Vegetation-Wetland Habitats

Specific Effects: Any need for gravel fill resulting from Liberty development is assumed to be met by using a gravel source on the Kadleroshilik River (Map 1). Vegetation would be excavated or buried at the borrow pit itself and where the overburden is stockpiled. Removal of about 31 acres of sparsely vegetated river-barrens land cover and about 7 acres of reserve area would occur at the gravel mining site. (The total mine site would cover about 53 acres). The primary mine site would affect 15.1 acres of dry dwarf shrub/lichen cover; 7.6 acres of dry barren/dwarf shrub, forb grass cover; 3.8 acres of dry barren forb cover; and 11.4 acres of river gravel (LGL Alaska Research Assocs., Inc.; Woodward-Clyde Consultants, and Applied Sociocultural Research, 1998). LGL did not identify any rare or unusual vegetation on the sparsely vegetated mine site. Effects on hydrology would be addressed in the Corp. of Engineers 404 permit process. Soils at the mine site contain 2-8 centimeters of organic material, 2-25 centimeters of fine silt to mixed sand/silt, and less than 27-36 centimeters of gravel or mixed gravel and sand (Noel, 1998).

We assume that all associated work would occur in winter, resulting in little or no dust on adjacent vegetation. Any moisture-regime changes as a result of snow drifting would be confined to less than 20 acres at the mine site. Conducting mining operations during winter would lessen impacts on vegetation and wetland habitats. Winter operations and the use of ice roads for transporting the gravel would avoid the need to build gravel roads that would increase effects on tundra vegetation along any onshore transportation routes. Rehabilitation of the mine site would include flooding of the mine pit by connecting it with a river channel. The pit also would be used as a source of water for the construction of ice roads during winter.

Gravel mining is likely to have a minimal effect on overall vegetation-wetland habitats in the project area. The gravel mining operations on State land will be required to have Section 404/10 permit and approval by the Corps of Engineers, as stated in BPXA’s Development Project Development and Production Plan (BPXA, 2000a). The permit and approval process is expected to minimize adverse effects on wetlands.

h. Subsistence-Harvest Patterns

Specific Effects: Localized disturbance and small habitat loss to polar bears, caribou, muskoxen, fishes, and birds are expected from gravel mining activities but with no accompanying population and distribution effects. Gravel mining effects to subsistence *resources* of bowhead whales and seals are expected to be negligible. No subsistence resources would experience overall distribution or abundance effects from gravel mining activity, and fish and bird resources actually could be enhanced by habitat produced by mining.

Historically, the Kadleroshilik River is close to the easterly limits reached by subsistence hunters pursuing caribou and other mammals. Potential adverse or enhancement effects periodically would affect subsistence *resources*, but no discernable effects on subsistence *harvests* are expected.

i. Sociocultural Systems

Specific Effects: Economic effects from gravel mining would be the same as discussed in Section III.C.3.i. No subsistence *resources* would experience effects to overall distribution or abundance from gravel mining activity. Additionally, the Kadleroshilik River area is little used by present-day subsistence hunters.

Subsistence *harvests* would not be affected by gravel mining, and we expect no discernable disruption to sociocultural systems.

j. Archaeological Resources

Effects of gravel mining would be similar to any surface-disturbing activities, such as those discussed in Section III.C.3.j. An onshore archaeological survey of this area was conducted during August/September 1998, and the results would be used by the State Historic Preservation Officer to assess the potential impacts to archaeological resources and to develop mitigation, if necessary, within the onshore portion of the project area. The report (Lobdell, 1998b), dated November 17, 1998, was received by MMS on December 22, 1998. The proposed gravel material site was surveyed and no archaeological sites were present.

k. Economy

Gravel mining would not affect the economy in any way differently than discussed in Section III.C.3.k.

l. Water Quality

Specific Effects: Mining of the gravel for Liberty Island would be conducted in the winter (BPXA, 1998a). After the gravel needed for the island has been removed, unusable material that was stockpiled would be placed in the excavation. The backfilled materials would be used to contour the sides or bottom of the site for future habitat potential. When this work is complete, the mine site would be connected to the active channel of the Kadleroshilik River. In spring, the site would flood with freshwater. Sea-level rises during storm surges may flood the mine site with seawater and turn the water brackish.

Flooding of the mine may increase the turbidity of the river downstream from the mine site. Water flowing into the site would suspend loose, fine-grained material and carry it downstream. If the reclaimed mine site is flooded during a storm surge, waves also might resuspend some fine-grained particles. The rivers flowing into the Beaufort Sea carry varying amounts of suspended particles. Some of the fine-grained sediment would be deposited on the delta. In mid-June through early July, runoff from the rivers carry their highest levels of suspended particles (Sec VI.C.2.b(1)). If the river's headwaters are in the Brooks Range or foothills, heavy rains in these areas result in a temporary increase in the level of suspended particles in the river. Any particles from the mine site that are carried in suspension into the coastal waters would mix with other suspended sediment and disperse.

The gravel mining and reclamation activities are not expected to introduce or add any chemical contaminants.

m. Air Quality

Specific Effects: Only small, localized emissions from excavation equipment and haul vehicles used in gravel mining, and fugitive dust are expected. Air-quality impacts would be very low.

n. Effectiveness of Mitigating Measure on Recovery and Reuse of Gravel from Abandoned Pad, Roads, and/or Airstrips

This mitigating measure was proposed by members of the Interagency Team as a way to reduce the loss of wetlands from either gravel mining or pad construction activities associated with the development of the Liberty Prospect.

(1) Effectiveness of this Mitigating Measure

This mitigating measure would be effective in offsetting the net loss of wetland habitat. While this measure does not eliminate or reduce the potential effects of wetland loss at the potential gravel mine or gravel pad construction, it does provide an offset and would help the project meet the national goal of "no net wetland loss." The recovery of gravel and rehabilitation of the abandoned gravel sites would provide habitat that might return wetlands to size equal to or greater than the area lost to gravel mining and or gravel pad construction.

The time required to bring restored wetland site(s) is unknown. "The time required to restore gravel recovery-reuse sites to productive fish and wildlife habitats is dependent upon site specific hydrology, adjacent vegetation, and methods of rehabilitation. Natural re-vegetation of gravel recovery-reuse sites to approximate pre-disturbance vegetative cover classes will require at least 20 years" (Jorgenson, 1997).

(2) Evaluation of Need for Mitigating Measure

The development of the BPXA proposed Kadleroshilik Mine and pipeline tie-in pads would result in a loss of wetlands. The estimated area of wetlands lost at the Kadleroshilik River Mine would be about 24.3 acres. The proposed landfall (0.3 acre) and Badami tie-in pads (0.5 acres) would add another 0.8 acre, for a total wetland loss of 25.2 acres. The reserve area at the mine site would add an additional 16.77 acres and bring the total wetland loss to 42 acres. This mitigating measure could offset those losses.

3. Effects of Small Oil Spills from Liberty Facilities

This introduction summarizes the key points of small oil spills that we use for analysis. For details on any of these points, please refer to Appendix A, which describes the oil-spill-risk analysis. Sections III.D.3.a through 3.m discuss the effects of small oil spills on particular resource categories.

Analysis of Small Spills from the Offshore Gravel Island and Pipeline and the Onshore Pipeline: We analyze the consequences of small spills of crude and refined oil to address people's concern about chronic effects from numerous small spills. For purposes of analysis, we assume the following spill sizes:

Offshore or onshore crude oil:
- 17 spills less than 1 barrel and
- 6 spills greater than or equal to 1 barrel and less than 25 barrels.

Onshore or offshore refined oil:
- 53 spills of 0.7 barrels each (29 gallons).

We assume:
- Offshore crude spills can begin anywhere on the Liberty gravel island or along the offshore pipeline.
- Small spills on the Liberty gravel island are into containment or cleaned up and do not reach the water.
- Onshore crude spills can begin anywhere along the onshore pipeline.
- Onshore or offshore refined oil spills can occur along the ice road, from barges, from helicopters, from the gravel island, or from trucks along the road system.
- Most of these spills are contained or cleaned up.

The typical refined products that spill on the Alaskan North Slope are aviation fuel, diesel fuel, engine lube oil, fuel oil, gasoline, grease, hydraulic oil, transformer oil, and transmission oil. Diesel spills on the Alaskan North Slope are 61% of refined oil spills by frequency and 75% by volume (USDOI, BLM and MMS, 1998).

For further information on how we derive these assumptions, please see Appendix A to this EIS.

a. Threatened and Endangered Species

(1) Bowhead Whales

(a) Summary and Conclusion for Effects of Small Oil Spills on Bowhead Whales

Small spills are unlikely to affect bowhead whales, because they cover a smaller area, are less likely to persist, and are unlikely to contact whale habitat..

(b) Details on How Small Oil Spills May Affect Bowhead Whales

Small offshore oil spills are estimated to have a total volume of about 68 barrels from an estimated 23 spills (Table A-29). Approximately 56% of a spill less than 125 barrels during the open-water period would remain after 30 days, covering a discontinuous area of 51square kilometers (Table A-8). The same spill less than 125 barrels in winter broken ice would have approximately 83% of the oil remaining after 30 days, covering a discontinuous area of 84 square kilometers (Table A-8). The Oil-Spill-Risk Assessment model indicates that larger spills, such as a 2,956-barrel spill, have a small probability of reaching their habitat (Sec. III.C.2.a.(1)). Small spills cover a smaller area and are less likely to persist, and they are less likely to contact whale habitat than a larger spill. Most of these spills are contained or cleaned up.

(2) Eiders

(a) Summary and Conclusion for Effects of Small Oil Spills on Spectacled and Steller's Eiders

We expect absorption of small onshore spills by vegetation covering most tundra habitats to limit the spread of oil. A spill near a spectacled eider nest could result in contact with the female, but nests and individuals are widely scattered, and contact is unlikely. If oil enters streams or lakes, the chance of contacting one or more eiders is greater, but their scattered distribution would limit this possibility. Although few eiders are expected to be contacted and the overall effect not significant, any mortality could interfere with recovery from declines of the relatively small regional population. Flocks of eiders staging before migration could experience some mortality from small offshore spills; these losses also could interfere with recovery of the regional population. However, a Fish and Wildlife Service model estimates very low mortality for this species from an oil spill. Steller's eiders are not expected to occur in the Liberty Project area.

(b) Details on How Small Oil Spills May Affect Spectacled Eiders

1) General Effects of Offshore Spills

Small offshore spills from the pipeline or Liberty Island potentially could contact flocks of eiders staging in nearshore or offshore waters before migration, and juveniles in coastal habitats. However, the small estimated slick area, the scattering of the small quantity of oil spilled in the water, and weathering of the oil, are expected to reduce the numbers of individuals that would be killed. Aerial surveys conducted by the Fish and Wildlife Service located few spectacled eiders offshore in all but two subareas, thus a model developed by the Fish and Wildlife Service estimates very low mortality from an oil spill for this species (Stehn and Platte, 2000). Losses resulting from contact of flocks staging before migration could interfere with recovery of a declining regional population, but is not expected to be a significant effect.

2) General Effects of Onshore Spills

Small onshore spills of oil from the pipeline or fuel from storage tanks are likely to contact less than 1 acre of tundra and are expected to be absorbed by vegetation covering most tundra habitats. Sightings of eiders or nests along the proposed pipeline route have been scattered and few (Map 5), and the chance of contacting either is low. If a spill enters streams or lakes, it could spread over a larger area where nesting or broodrearing eiders may be contacted. Because a relatively small regional population exists in the Liberty area, any mortality could interfere with recovery from a population declines.

b. Seals and Polar Bears

(1) Summary and Conclusion for Effects of Small Oil Spills on Seals and Polar Bears

Ringed and bearded seal and polar bear populations are not likely to be affected by these small spills.

(2) Details on How Small Oil Spills May Affect Seals and Polar Bears

(a) General Effects of Offshore Spills

These spills are assumed to occur offshore during development and production . The potential effects of these spills could be the loss of perhaps a few polar bears and a small number of seals and temporary contamination of some coastal habitats probably for one season or year, but they would have no lasting effect on the habitat. The overall effect is likely to be short term (1 year or less) and would not affect the overall abundance and distribution of seals and polar bears in Foggy Island Bay/Liberty Island.

(b) General Effects of Onshore Spills

A few polar bears could be adversely affected by onshore spills that occur near the coast. These small, chronic spills could expose some polar bears to potential effects. It is likely that control and cleanup operations (ground and air traffic and personnel) at the spill site would frighten polar bears away from the spill and prevent the possibility of these animals becoming oiled and ingesting oil. One to a few bears possibly may encounter the spill before control and cleanup crews arrive on the scene. In a severe situation, these bears could be killed if they were oiled and ingested the oil, but the polar bear population would not be affected.

c. Marine and Coastal Birds

(1) Summary and Conclusion for Effects of Small Oil Spills on Marine and Coastal Birds

We expect absorption of small onshore spills by vegetation covering most tundra habitats to limit the spread of oil. A spill near a waterfowl, shorebird, or songbird nest could result in contact with an adult, but nests and individuals are scattered, and contact with substantial numbers is unlikely. If oil enters streams or lakes, the chance of contacting one or more individuals is greater, but their scattered distribution would limit the numbers. Although few birds are expected to be contacted by small spills, any mortality would be additive to natural mortality and could interfere with recovery of any declining regional populations. Flocks of waterfowl staging before migration could experience some mortality from small offshore spills; these losses also could interfere with recovery of any regional populations that have declined. However, oldsquaw and most other waterfowl and shorebird species are not expected to experience substantial mortality from small offshore spills. A Fish and Wildlife Service model (Stehn and Platte, 2000) also estimates low mortality from an oil spill, substantially larger than the small spill considered here, for most loon and waterfowl species included in the modeling study.

(2) Details on How Small Oil Spills May Affect Marine and Coastal Birds

(a) General Effects of Offshore Spills

Small offshore spills from the pipeline or Liberty Island potentially could contact flocks of oldsquaw, eiders, or other species foraging in lagoon or offshore waters, and waterfowl and shorebirds in coastal habitats. However, the small estimated slick area, the scattering of the small quantity of oil in the water, and weathering of the oil are expected to reduce the numbers of individuals that would be killed. Aerial surveys conducted by the U.S. Fish and Wildlife Service located substantial numbers of several sea duck species and low numbers of other species of loons and waterfowl in offshore waters. Thus a model developed by the Fish and Wildlife Service estimates low mortality (0-172 individuals) from an oil spill, substantially larger than the small spill considered here, for eight of nine species included in the modeling effort (Stehn and Platte, 2000). No population effects are expected to result from small offshore spills.

(b) General Effects of Onshore Spills

Small onshore spills of oil from the pipeline or fuel from a storage tank are likely to contact less than 1 acre of tundra where small numbers of waterfowl, shorebirds, and songbirds are nesting (0.28 nests per acre; TERA, 1995b). These are expected to be absorbed by vegetation covering most tundra habitats. Only the most abundant species (for example, semipalmated sandpiper, pectoral sandpiper, phalaropes, and Lapland longspur) have nest densities sufficiently large that some nest contact might be expected in such a small area. If a spill enters, streams or lakes it could spread over a larger area where broodrearing or molting waterfowl or shorebirds may be contacted. Mortality in species whose populations are small or status is unknown (for example, white-rumped sandpiper) is likely to be more important than in abundant species and could interfere with recovery of declining populations.

d. Terrestrial Mammals

(1) Summary and Conclusion for Effects of Small Oil Spills on Terrestrial Mammals

For the most part, onshore oil spills would be very local (1-2 acres) in their effects and would not be expected to significantly contaminate or alter caribou, moose, arctic fox, and muskoxen habitat. Spills that occur within or near streams and lakes may affect foraging habitat over larger areas. . If a 125-barrel spill occurs, very few caribou and other terrestrial mammals are expected to be affected because only 9 kilometers of coastline would be oiled (Table A-8).

Small offshore spills are not likely to affect terrestrial mammals.

(2) Details on How Small Oil Spills May Affect Terrestrial Mammals

(a) General Effects of Small Offshore Spills

Small offshore oil spills are likely to disperse quickly during the summer open-water season, when terrestrial mammals might be exposed to the spills. Coastal habitats in Foggy Island Bay are not likely to be contaminated by these spills. Few, if any, terrestrial mammals are likely to be exposed to the spills or affected by them. A few arctic foxes may be exposed to small spills that occur during winter, but cleanup efforts are likely to prevent any significant effects on foxes. If a 125-barrel spill occurs, very few caribou and other terrestrial mammals are expected to be affected because only 9 kilometers of coastline would be oiled (Table A-8).

(b) General Effects of Small Onshore Spills

Small onshore spills are likely to have local effects on less than 1 to a few acres of tundra habitat at the spill sites but have negligible effects on caribou, muskoxen, and other terrestrial mammals. An estimated 53 refined product spills (an average of 0.7 barrels each for a total of 29 barrels) and some small spills from the pipeline are assumed to occur onshore over the production life of the project (Tables A-1, A-2, and A-8). These small, chronic spills expose some caribou and other terrestrial mammals to potential effects and contaminate a few acres of tundra habitat along the pipeline corridor.

If the onshore small pipeline spills occurred during the summer season, some tundra vegetation within the pipeline corridor would become contaminated. However, caribou and probably muskoxen would not ingest oiled vegetation, because they tend to be selective grazers and are particular about the plants they consume (Kuropat and Bryant, 1980). It also is likely that control and cleanup operations (ground and air traffic and personnel) at the spill site would frighten caribou and muskoxen away from the spill and prevent the possibility of these animals grazing on the oiled vegetation. Complete recovery of oiled tundra vegetation is expected within a few years to no more than 2 decades. However, this habitat effect would be very local and of no significant consequence to caribou, muskoxen, or other terrestrial mammals.

e. Lower Trophic-Level Organisms

Several small spills of less than 1 barrel of refined oil and 25 barrels of crude oil probably would affect any new kelp that colonizes the concrete blocks of the island's slope-protection system (Sec. III.C.3.e and Figs. II.A-3, and 5). However, the concrete blocks would be a temporary habitat, because they probably would be eliminated entirely during abandonment.

Several small spills also would affect the planktonic communities around the island. However, we know of no reports of major harm to plankton during an actual oil spill (National Research Council, 1985). Studies conducted after oil spills commonly show no major effect on plankton populations. Even if we assume an oil spill in the open ocean contacts many phytoplankton, the regeneration time of the cells (9-12 hours) and the rapid replacement of cells from nearby waters should keep major effects to a minimum (National Research Council, 1985).

Small spills would neither mix deep enough in the water column to affect the Boulder Patch and other benthos nor persist long enough to reach the coastline. Overall, small oil spills are not expected to have measurable effects on lower trophic-level organisms.

f. Fishes and Essential Fish Habitat

(1) Fishes

(a) Summary and Conclusion for Effects of Small Oil Spills on Fishes

Small oil spills are expected to have no measurable effect on fish populations.

(b) Details on How Small Oil Spills May Affect Fishes

The effects on arctic fishes (including incidental anadromous species) from oil spills would depend on the season and location of the spill, the lifestage of the fishes (adult, juvenile, larval, or egg), the toxicity of the oil when contacted, and the duration of contact. During the open-water period, the nearshore area of the Beaufort Sea is used for feeding and migration by marine and migratory fishes. Hence, the occurrence of an offshore oil spill likely would have its greatest potential effect in the nearshore area. However, due to the small amount of oil involved, small offshore spills are not expected to contact the nearshore area or harm any fishes in the offshore area.

Small onshore spills in summer would not have any effect on fishes, unless they occurred in or flowed into waters containing fish. If a small spill were to occur, some fish and food resources in the immediate area may be harmed or killed. However, due to the small amount of oil involved, the low diversity and abundance of fish in most of the onshore area, and the unlikelihood of spills blocking fish migrations or occurring in small waterbodies with restricted water exchange, small onshore oil spills are not expected to have a measurable effect on fish populations. A winter spill also likely would have no measurable effect on fishes, because the oil would spill on the ice above the waterways, would be cleaned up, and would not come in contact with fishes or their habitat.

(2) Essential Fish Habitat

The effects of small oil spills on essential fish habitat are essentially the same as the effects of large oil spills, except the geographic extent of the effect is likely to be smaller and the duration shorter term (see Sec. III.C.2.f(1)). In brief, no salmon of any lifestage likely would be affected. Some potential prey could be killed or disrupted, limited damage could be done to marine algae, and water quality could be locally and temporarily degraded. The area affected and duration of the effects of an oil spill would be determined, for example, by the specific location of the spill, quantity of oil spilled, type of oil, time of year, and various other factors (see, for example, Secs. III.C.2, IX.A, and Appendix A.).

g. Vegetation-Wetland Habitats

(1) Summary and Conclusion for Effects of Small Oil Spills on Vegetation-Wetland Habitats

Coastal habitats in Foggy Island Bay are not likely to be contaminated by small offshore spills, because these spills would disperse quickly during the summer open-water season when coastal vegetation-wetlands might be exposed to the spills. . If a small offshore spill occurs, few wetlands and coastal vegetation are expected to be affected because only 9 kilometers of coastline would be oiled (Table A-8). The spilled oil that contacts coastal vegetation is likely to cause very minor ecological harm, and complete vegetation recovery is expected within a few years to no more than perhaps 20 years. A few acres of vegetation within the project area would be affected by small onshore spills. The spilled oil that contacts the tundra would cause very minor ecological harm, and complete vegetation recovery is expected within a few years to no more than perhaps 20 years.

(2) Details on How Small Oil Spills May Affect Vegetation-Wetland Habitats

General Effects of Small Spills: If a small offshore spill occurs, few coastal wetlands and vegetation are expected to be affected because only 9 kilometers of coastline would be oiled (Table A-8). The spilled oil that contacts coastal vegetation is likely to cause very minor ecological harm, and complete vegetation recovery is expected within a few years to no more than perhaps 20 years.

An estimated 53 refined product spills (an average of 0.7 barrels each for a total of 29 barrels) from the pipeline are assumed to occur onshore over the production life of the project (Tables A-1,). All of these small spills would oil less than 1 to a few acres of vegetation-wetlands along the pipeline corridor.

Most onshore spills occur on gravel pads and, consequently, their effects do not reach the vegetation. About 20-35% of past crude oil spills have reached areas beyond pads (USDOI, BLM and MMS 1998). The corresponding proportion for refined oil spills probably is much less. However, for this analysis we assume that 35% of all onshore spills that occur would reach beyond gravel pads. Because winter spans the majority of each year, most spills happen when there is sufficient snow cover that cleanup efforts occur before the oil reaches the vegetation; this situation probably occurs during about 60% of the year. Thus, for this analysis, we estimate that 11% of all onshore spills would affect vegetation. Most spills cover less than 500 square feet (less than 0.01 acres), with a maximum coverage of 4.8 acres, if the spill is a windblown mist (USDOI, BLM and MMS 1998). For this analysis, we assume that the most likely area covered by a spill would be about 0.01 acre (98% at 0.01 acre, 2% at 4.8 acres). Under the Proposal, no more than a few acres of vegetation would be impacted by spilled oil over the lifetime of developed oil fields.

Overall, past spills on Alaska's North Slope have caused minor ecological damage, and ecosystems have shown a good potential for recovery (Jorgenson, 1997).

h. Subsistence-Harvest Patterns

(1) Summary and Conclusion for Effects of Small Oil Spills on Subsistence-Harvest Patterns

Negligible effects are expected on bowhead whales. Because no subsistence resources would experience population or distribution effects from small oil spills, periodic adverse effects on subsistence resources are expected, but no discernable effects on subsistence harvests are expected.

(2) Details of How Small Oil Spills May Affect Subsistence-Harvest Patterns

General Effects of Small Offshore Oil Spills: Small, short-term losses to seals and polar bears are expected from small offshore spills, but there would be no effects to overall abundance and distribution of these populations. Small oil spills are not expected to affect caribou and other terrestrial mammals, and no measurable effects are expected on fish populations. Flocks of waterfowl staging before migration could experience some mortality from small offshore spills; such losses could interfere with recovery of any regional populations that have declined. However, oldsquaw and most other waterfowl and shorebird species are not expected to experience substantial mortality from small offshore spills. Small spills are unlikely to affect bowhead whales since they cover a smaller area, are less likely to persist, and are unlikely to contact whale habitat.

i. Sociocultural Systems

General Effects: Because no economic effects are expected and no subsistence resources would experience population or distribution effects from small oil spills, there would be no discernable disruption to sociocultural systems.

j. Archaeological Resources

Small spills could affect archaeological resources by increasing the risk of damage from cleanup activities and vandalism from increased human traffic, as discussed in Section III.C.2.j.

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k. Economy

Small spills would not affect the economy. Personnel already working in the area would clean up small spills. Therefore, small spills would not generate any additional employment or other economic effects.

l. Water Quality

(1) Summary and Conclusion for Effects of Small Oil Spills on Water Quality

Hydrocarbons from small oil spills (3 barrels) could exceed the 0.015-parts per million chronic criterion for less than a day or two in an area less than 3 square kilometers (1.2 square miles)—perhaps only a few tens of square kilometers. Small oil spills are not expected to have any long-term degradational effects on the overall water quality of Foggy Island Bay.

(2) Details on How Small Oil Spills May Affect Water Quality

(a) General Effects from Developing the Liberty Prospect

The general effects of small oil spills (less than 500 barrels) on water quality would be similar to those described for large oil spills (greater than or equal to 1,000 barrel spills) in Section III.C.2.l. We would expect an increase in the concentration of petroleum hydrocarbons in the water column. Aromatic compounds are the most toxic constituents of crude oil, partly because they are the most soluble constituents. The highest rates of dissolution of aromatics from a slick and, consequently, accumulation in underlying water occur in the first few hours after a spill (Sec. III.C.2.l). However, the bulk of these volatile compounds are lost in less than 3 days.

(b) Specific Effects of Small Spills from Liberty Development

This analysis considers the effects small spills could have on water quality. During Liberty development and production there is estimated to be 17 crude or diesel oil spills of less than one barrel per spill and 6 spills of ranging from greater than 1 barrel to less than 25 barrels per spill (Appendix A, Table A-1). Most of the oil in these spills, and spills of refined products, would be confined to the Liberty Island and not reach the marine environment. The analysis also considers the effects of a 125-barrel pipeline leak over 24 hours; the leak is detected by the LEOS leak-detection system as described in Section II.A.1.b(3)(d)3).

During open water in Foggy Island Bay, the concentration of oil in the water column after the first day of a 125-barrel spill is estimated to be 0.510 parts per million (Table III.C-5).

The concentrations after the first day is greater than the 0.015 parts per million that was assumed to be the total hydrocarbon chronic criterion (Sec III.C.2.l(2)(a). In general dispersion continues to reduce the concentration of the oil in the water. However, even after 3 days, the concentrations from the spills might be greater than the chronic criterion (Table III.C-5). The time required for the dispersed hydrocarbons to decrease to concentrations below the chronic criterion could be about 10 days or longer (Table III.C-5).

One of the factors limiting dispersion, and lowering of the concentration of oil dispersed in the water column, in Foggy Island Bay is water depth. In the bay water depths generally are less than 20 feet. Outside the bay beyond the barrier islands, water depths increase from 20 to 40 feet within several miles of the islands. As noted in Section III.C.2.l(2)(b) the circulation in Foggy Island Bay primarily is wind driven. Depending on wind direction and speed, water in the vicinity of Liberty Island could be transported through the barrier islands within one to two days. Table III.C-7 shows the distances from Liberty Island to the channels between the barrier islands and the travel times based on a 0.3 knot current as driven by a 10-knot wind. (The relationship between wind speed and surface current velocity is described in Section III.C.2.l(2)(b)),

The effect that water depth has on dispersion of hydrocarbons is shown in Table III.C-5. For example, the concentration of hydrocarbons from the 125-barrel spill dispersed to a depth of 10 feet in Foggy Island Bay 3 days after the spill is estimated to be 0.124 parts per million. In waters 33 deep in the Beaufort Sea, the concentration is estimated to be 0.038 parts per million. As the watermass containing the spilled oil passes through the barrier islands and into the Beaufort Sea, the rate of dispersion probably would increase because of greater water depths and effect the wind has on the water due to the greater fetch, the distance over which the wind blows. The time for the concentration of dispersed oil to go below the chronic criterion, 0.015 parts per million, would be less in the Beaufort Sea than in Foggy Island Bay. Concentrations greater than 0.015 parts per million could affect an area of 0.6-2.6 square kilometers (about 0.2-1.0 square miles) for 1-3 days.

For spills occurring under broken-ice or meltout conditions, more oil remains in the water compared to the same time intervals for the open-water spills (Table A-8); the concentrations of oil in the water are shown in Table III.C-5. Under these conditions, the effects of the spills would last longer than for the open-water spills. If the spill occurred in broken-ice conditions as the winter season is beginning or developing, oil from the spills would be frozen into the ice. When melting begins, the unweathered oil would enter the water column. The effects on the amount of oil dispersed in the water column would be reduced in proportion to the amount of oil that evaporated and dispersed before freezeup.

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A meltout spill occurs during the transition period from frozen to open-water conditions. During the initial part of this transition period, evaporation and dispersion rates are estimated to be similar to those shown in Appendix A, Table A-8. As the ice melts, water temperatures increase and the winds play an increasing role in generating currents and waves because of more open water. With these changes, oil evaporation and dispersion rates would approach those of the open-water conditions. As this happens, the concentration of hydrocarbons dispersed in the water may be relatively constant, or might increase, before decreasing. For a given volume of oil spilled, the concentration of hydrocarbons dispersed in the water is expected to decrease with time, and this is the scenario shown for conditions that remain constant over some period of time as depicted in Table A-8.

If a spill occurs under the ice, we assume the oil would become frozen into the ice and not weather until meltout begins. The processes affecting oil and the concentrations of hydrocarbons dispersed in the water would be the same as those described for a meltout spill. For smaller spills, less than 125 barrels, hydrocarbon concentrations that exceed the acute (1.5 parts per million) or the chronic (0.015 parts per million) criteria are expected to occur in smaller areas than were estimated for larger spills and for shorter periods of time.

m. Air Quality

Small oil spills would cause a small, very localized increase in concentration of hydrocarbons. Air-quality impacts would be very low.

4.Seawater Intake

a. Fishes

BPXA plans to locate a vertical intake pipe for a seawater treatment plant on the south side of Liberty Island. The pipe would have an opening 8 feet by 5.67 feet and would be located approximately 7.5 feet below the mean low-water level. Recirculation pipes located just inside the opening would help to keep large fish, other animals, and debris out of the intake. Two vertically parallel screens (6 inches apart) would be located in the intake pipe above the intake opening. They would have a mesh size of 1 inch by 1/4 inch. Maximum water velocity would be 0.29 feet per second at the first screen and 0.33 feet per second at the second screen. These velocities typically would occur only for a few hours each week while testing the fire-control water system. At other times, the velocities would be considerably less. The screens periodically would be removed, cleaned, and replaced.

Liberty's proposed seawater-intake structure (Fig. III.D-1) is likely to harm or kill some young-of-the-year arctic cisco during the summer migration period, and some eggs and fry of other species in the immediate vicinity of the intake. Young-of-the-year arctic cisco, typically 70-100 millimeters in length (Fechhelm and Griffiths, 1990), migrate from Canada's MacKenzie River along the Beaufort Sea coast in the open-water season. Their migration corridor is estimated to be about 15 miles wide in the Liberty Island area (U.S. Army Corps of Engineers, 1998:Fig. 6.4-1). Liberty Island would occupy only a small fraction of that corridor (about 750 feet, or about .009%). The intake structure is not expected to have any effect on fishes in the migratory corridor beyond the width of the island. Some young-of-the-year arctic cisco that move into the immediate vicinity of the intake structure may be harmed or killed, but most are expected to avoid it. Less than 1% of the arctic cisco in the Liberty area are likely to be harmed or killed by the intake structure. Hence, the intake structure is not expected to have a measurable effect on young-of-the-year arctic cisco in the migration corridor. Due to the wide distribution and low density of other marine (for example, arctic cod, arctic flounder, and snailfish), and migratory fish (for example, Dolly Varden char and broad whitefish), the intake structure is expected to have even less of an effect on their populations. Some eggs, larva, and fry may be harmed or killed in the immediate vicinity of the intake structure. Nevertheless, we do not expect a measurable effect on any marine or migratory fish population.

b. Essential Fish Habitat

Because none of the lifestages of salmon have been documented to use or inhabit the waters where the Liberty Island seawater intake is expected to be located, salmon are not likely to be killed or otherwise affected. Neither algae nor the quality of marine water are likely to be affected by the passage of water into the seawater intake. The extent to which water quality is affected by the seawater treatment plant is discussed in the section on discharges (Sec. III.D.1.l). Access to the intake pipe is blocked by screens that have a relatively small mesh size (1 inch by ¼ inch). The small size of the mesh would be expected to prevent all but the smallest of the potential prey of salmon being sucked into the intake pipe. However, essential fish habitat would be adversely affected, because it is expected that zooplankton and fish in their early lifestages (juveniles, eggs, and larvae) could be killed in the intake.

5. Economic Effects

a. Summary and Conclusion for Economic Effects of the Proposed Action

The Liberty Project would generate approximately the following economic benefits:

- $100 million in wages and 870 full-time equivalent construction jobs for 1 year in Alaska during 14-18 months of construction
- $4.2 million in wages and 50 jobs annually for operations for 16 years in Alaska
- 1,248 indirect full-time equivalent jobs during the 14-18 months of construction
- 78 indirect full-time equivalent jobs each year for 16 years of operations
- $480 million capital expenditure, $240 million operating expenditures
- $344 million total Federal revenue
- $63 million total State revenue $5 million ad valorem tax to the North Slope Borough
- $114 million net present value of receipts to Federal and State governments

b. Details on How the Proposal May Affect Economics

(1) Effects on Employment and Wages

General/Specific Effects: Employment and wages are a function of the amount of pipeline and material needed for a gravel island or the cost of another type of platform in deeper water. Other developments in the Beaufort Sea with the same amount of pipeline and the same size of gravel island would have the same effects as described below and these would be general effects. Compared to other developments with different pipeline length and size of gravel island or different platform, specific effects would be different than the Proposal.

The Proposal would generate $100 million in wages and 870 full-time equivalent construction jobs for 1 year, resulting in 1.7 million direct labor hours (see Table III.D-3). Table III.D-3 lists the workforce's location as the North Slope; this means the location where they work. Most of these workers would reside in Southcentral Alaska and the Fairbanks area. The Proposal (western pipeline route) is projected to generate about 300 construction jobs and 100 drilling jobs. BPXA would construct the island and pipeline, assemble buildings and equipment, and drill and process onsite on the North Slope. Anchorage would be the site of most engineering, fabrication of modules and other materials, and mobilization of the sealift to the work site on the North Slope. Workers may construct the module for permanent living quarters in Wasilla and manufacture pipe and insulation in Fairbanks. BPXA would buy equipment from the lower-48 States only when it is not manufactured or available in Alaska. Examples of such equipment are generators, separators, pumps, compressors, process heaters, etc. (BPXA, 1998a:5-62).

Drilling would be continuous for about 18 months. BPXA expects two crews to be on the island at any time, and they would work 12-hour shifts and rotate every 14 days. Thus, 25 workers would be drilling at any given time, and each drilling position would employ 4 full-time workers. For construction, one shift would be at the worksite and one out on break. Construction would last 14-18 months, from making modules to completing the pipeline (BPXA, 1998a:5-62).

The operations would generate $4.2 million in wages and 128,000 direct labor hours annually for 16 years in Alaska, based on a monthly average of 25 persons at Liberty and 25 at Anchorage (see Table III.D-4). Table III.D-4 lists the workforce's location as the North Slope; this means the location where they work. Most workers would live in Southcentral Alaska and the Fairbanks area. Once production starts, a single operation crew would be on the island at any time, with one out on break.

These construction and operations jobs directly in the oil industry would generate additional "indirect" jobs through spending by the oil industry employees. Liberty's direct employment during construction would generate 1,248 indirect full-time-equivalent jobs for 1 year. The actual construction period would be spread over 14-18 months. Liberty's direct employment during operations would generate 78 indirect full-time-equivalent jobs for 16 years. We have used the IMPLAN econometric model to estimate these indirect jobs (University of Minnesota, 1989).

(2) Effects on Hire of Native People in the North Slope's Oil Industry

General Effects: BPXA has committed to hiring local workers on the North Slope and within Alaska. However, the oil industry employs few village residents, even though they try to recruit and provide training programs. Many of the contractors BPXA hires (design, construction, drilling, operations) are Native Corporations, subsidiaries of such corporations, or otherwise affiliated with such corporations through joint ventures or other relationships. This relationship should significantly benefit the local economy (BPXA, 1998a:5-62).

The North Slope Borough has tried to improve employment of its Inupiat people in the oil industry at Prudhoe Bay. The Borough believes the oil industry hasn't done enough to train unskilled laborers or to allow them to go subsistence hunting, which is central to their traditional culture. The Borough also is concerned that the oil industry uses recruiting methods common to Western industry and would like to see the industry become more serious about hiring its residents, (Nageak, 1998, pers. commun.).

The purpose of BPXA's Itqanaiyagvik Program is to increase North Slope Borough Native employment. It is a joint venture with the Arctic Slope Regional Corporation and its oil field subsidiaries and is being coordinated with the North Slope Borough and the Borough School District (BPXA, 1998c).

North Slope Borough Mayor George Ahmaogak, Sr., has expressed concerns that North Star development is hiring workers from the lower 48 states while the oil industry is ignoring local Inupiat workers (Ahmaogak, as cited in USDOI, MMS, Alaska OCS Region, 2000). Joseph Eriklook and Johnny Adams have expressed concern about the lack of employment opportunities with the North Slope oil industry (Eriklook and Adams, as cited in Dames and Moore, 1998). Ronald H. Brower Sr., has expressed a similar concern about employment opportunity. He sees very few, if any, Inupiat in the North Slope oil industry positions which require advanced education, such as engineers or nurses (Brower, as cited in USDOI, MMS, Alaska OCS Region, 2000).

(3) Effects from Capital and Operating Expenditures

General and Specific Effects: See the previous discussion on the effect on employment and wages (III.D.5.b.(1)).

For the life of the Liberty Project, capital expenditures would total $480 million, and operating expenditures would be $240 million. For annual capital and operating expenditures, see Table III.D-5.

(4) Effects on Federal, State, and Borough Revenue

General and Specific Effects: For a development with the same employment and wages the effects on income taxes would be the same. See the previous discussion for effects on employment and wages (III.D.5.b(1)). Royalty and spill and conservation taxes are a function of production. Developments with the same production will have the same royalty. Developments with different production will have more or less royalty. Ad valorem tax is a function of the value of onshore infrastructure. Developments with the same infrastructure will have the same ad valorem tax. Developments with different onshore infrastructure value will have more or less ad valorem tax.

Total Federal revenue during construction and through the life of the project is estimated to be $344 million ($33 million income tax during construction and $311 million total Federal revenue during the life of the project; Table III.D-5). During construction, $99.7 million will be spent on wages (Table III.D-3). The estimates personal income tax on these wages is $33 million.

Over the life of the Liberty Project, the State should receive $63 million from its share of Federal royalties, income tax, and spill and conservation tax. The local governments most affected by Liberty development—the North Slope Borough and Nuiqsut—would have an opportunity to seek a share of that revenue from the State.

Total royalties and taxes for the life of the project and annual estimates for these revenues are in Table III.D-5.

Ronald Brower Sr. had indicated that the Federal Government should set aside funds from Federal offshore leases for the North Slope Borough. The Mayor wants the money to employ more Inupiat workers and to compensate the North Slope Borough and Inupiat people for socioeconomic losses (Brower, as cited in USDOI, MMS, Alaska OCS Region, 2000).

(5) Effects on Net Present Value to the Government

The net present value of receipts to the Federal and State governments, is $114 million (Appendix D-1).

(6) Effects of Subsistence Disruptions on the North Slope Borough's Economy

Disruptions to the harvest of subsistence resources could affect the economic well-being of North Slope Borough residents mainly by the loss of some part of those resources. See Section III.C.2.k for effects of oil spills and Section III.C.3.h for effects of disturbances on subsistence-harvest patterns.

6. Abandonment of the Project

Exact abandonment procedures of the Liberty Project would be developed before the end of the project's life. A goal for restoration of any project is to restore the affected environment to its original condition. However, in our effort to achieve that goal, we do not want to cause additional environmental effects. At the time of abandonment, we likely would have new technologies, and we expect to have additional environmental information concerning the area and its resources. We want to evaluate both the new technologies and the additional environmental data in the abandonment plan. Therefore, we do not evaluate all the specific items of abandonment at this time. Those specific items would be evaluated in the environmental assessment on the abandonment plan that would be required at the end of the project. All environmental regulations in place at that time will be enforced. The MMS, Corps of Engineers, and applicable State agencies would review BPXA's abandonment plan and decide what actions are appropriate at the end of the project.

The current language on Corps of Engineers' permits pertaining to abandonment states:

> Should you wish to cease to maintain the authorized activity or should you desire to abandon it without a good faith transfer, you must obtain a modification of this permit from this office, which may require restoration of the area.

For the present analysis, we assume that most abandonment activities would occur during the winter to lessen effects to the environment. We anticipate that all equipment; the upper slope-protection system, including the gravel bags or steel sheetpile; and structures would be removed from the island. The gravel from the slope-protection system would be dumped on the island surface. The pipeline riser and well casings would be removed below the seafloor, and all wells would be permanently sealed and abandoned. Pipeline removal would be evaluated at that time. The MMS regulations require that pipelines abandoned by removal must be pigged, if practical, and flushed with water before removal. Pipelines abandoned in place must be flushed, filled with seawater, cut, and plugged with the ends buried to at least 3 feet. BPXA could be required to remove the remainder of the island or leave it to erode naturally over time.

Abandonment activities would occur during the winter, unless a summer sealift is necessary to remove the facilities. If a summer sealift is necessary, it would be coordinated with other incoming sealift plans and likely would use the same barges and vessels.

a. Threatened and Endangered Species

(1) Bowhead Whales

General Effects: Abandonment activities would not affect bowhead whales. Whales are unlikely to hear noise from removal of facilities and slope-protection materials, because this noise would not be above ambient noise levels beyond a few kilometers from Liberty Island. Few bowheads are likely to come that close to the island.

(2) Eiders

General Effects: We expect no population effects to eiders from abandonment. Disturbance of eiders in the Liberty Island area is expected to be negligible while structures, equipment, island-protection systems, and pipelines are removed. Some individuals may avoid the immediate area of activity, moving to other comparable areas.

b. Seals and Polar Bears

General Effects: Abandonment could temporarily displace a few seals and polar bears near removal operations. Seal and polar bear populations would not be affected.

c. Marine and Coastal Birds

General Effects: We expect no population effects to marine and coastal birds from abandonment. Disturbance of birds in the Liberty Island area is expected to be negligible while structures, equipment, island-protection systems, and pipelines are removed. Some individuals may avoid the immediate area of activity, moving to other comparable areas.

d. Terrestrial Mammals

General Effects: Abandonment activities are likely to temporarily displace some caribou, muskoxen, and grizzly bears within 1 mile of the operations, but would have negligible effects on terrestrial mammal populations.

e. Lower-Trophic-Level Organisms

(1) Effects on the Boulder Patch

Because of the prevailing wind and water currents in this area, the plume from the removal of slope-protection materials and underlying gravel is likely to move westward towards the Boulder Patch area. Because the more productive areas of the Boulder Patch (rocky areas) are widely scattered, most are not likely to be affected by the plume. Additionally, the heavier sediments are expected to settle out within one-half mile of the island and are not expected to reach the Boulder Patch area. The sediment plume temporarily would reduce the amount of available light for the marine kelp that lives in the rocky bottom areas of the Boulder Patch. However, the waters of this area during summer are laden with heavy sediment loads from storms and sediment-laden freshwater discharges from rivers. Environmental conditions such as these vary annually and result in fluctuating growth rates of Boulder Patch kelp communities. The additional sediment due to abandonment activities is not expected to have a measurable effect on kelp growth and would be within the range of natural variation that kelp communities in this area routinely experience. Any sediment accumulating on kelp communities from abandonment-related activities is likely to be removed by currents and wave action such as occurs to sediment accumulations resulting from natural events. Hence, the sediment plume from island abandonment activities should not measurably affect Boulder Patch kelp communities.

(2) Effects of Concrete Mat Removal

Unlike the scattered areas of productive habitat in the Boulder Patch, most of the underwater slope of Liberty Island is likely to be to much more productive by comparison. The removal of the slope-protection materials from Liberty Island would eliminate this habitat and would result in a measurable reduction in the overall productivity of the Boulder Patch area. The establishment of these Boulder Patch-like communities around Liberty Island would depend on the slope-protection materials. However, the removal of these materials permanently would eliminate the Boulder Patch-like communities on the island's underwater slope and any chance for the recovery of those communities.

f. Fishes and Essential Fish Habitat

(1) Fishes

Removing the island and the undersea pipeline would increase the amount of suspended matter in the water, which could affect fishes. Typically, when island slope-protection materials are removed, waves, ice, and currents erode its surface extensively and, within a few years, the island is below sea level. If abandonment activities remove the concrete armor on the islands underwater slope, the amount of fish habitat and fish food resources would be reduced, which would reduce fish populations in the island area. However, present abandonment plans include only capping wells, terminating wells below sea level, and removing equipment and facilities from the island. BPXA plans to remove the island's gravel bags at the same time as other abandonment activities occur. This would be done either by opening the bags, dumping out the gravel on the island surface, and removing the bag material or removing the entire bag from the site. None of these abandonment related activities are expected to have a measurable effect on arctic fish populations.

(2) Essential Fish Habitat

Because none of the lifestages of salmon have been documented to use or inhabit the waters where Liberty Island is expected to be located, salmon are not likely to be killed or otherwise affected. When Liberty Island is abandoned, it is anticipated that the upper slope-protection system, including the sheetpile and gravel bags, would be removed and that the pipeline might be removed or, possibly, plugged and abandoned. These actions may expose the side of the island to erosive forces or otherwise could increase the turbidity in the water column near the island (see Sec. III.D.6.l). Due to the prevailing wind and water currents in the area, some light material would be expected to be carried as far as the Boulder Patch, where it could settle and temporarily coat resident algae and associated substrate. This coating would be light and short lived and, thus, would not be expected to have a measurable effect on resident algae or associated fish populations (see Sec. III.D.6.1). Increased turbidity in the immediate vicinity of the island is not expected to have a measurable effect on fish that are potential prey for salmon (Sec. III.D.6.1). Thus, the only adverse effect expected on essential fish habitat for salmon would be a slight, temporary degradation of marine water quality.

g. Vegetation-Wetland Habitats

Specific Effects: Abandonment activities are likely to have minor local effects on vegetation and would not be significant to vegetation-wetland communities in the Liberty Project area. Removing the onshore pipeline would disturb less than 1 acre of tundra vegetation near the pipeline's support members and at the valve station and helicopter gravel pads. BPXA may rehabilitate the pad sites by removing gravel, fertilizing the site, and planting seeds.

h. Subsistence-Harvest Patterns

General Effects: Because only short-term, localized displacement and disturbance are expected to seals, polar bears, caribou, and fish, and negligible effects are expected on bowhead whales and birds, no subsistence resources would experience population or distribution effects from the abandonment of the Liberty Project gravel island.

i. Sociocultural Systems

General Effects: Economic effects from abandoning the Liberty Project are expected to create jobs for approximately 52 workers that would last, on the average, 2 years. and extend each year through all four seasons. Overall economic impacts on sociocultural systems would be minimal. In addition, no subsistence resources would experience population or distribution effects from abandoning the Liberty Project gravel island.

j. Archaeological Resources

Abandonment would not affect archaeological resources.

k. Economy

General Effects: Abandoning the Liberty Project would generate jobs for 52 workers on the average lasting 2 years working through all four seasons. Abandonment would generate $12 million in wages and $6 million for equipment and other. These estimates are based in part on information in Appendix D-1 regarding abandonment.

l. Water Quality

(1) Summary and Conclusion for Effects of Abandonment on Water Quality

The greatest effect on water quality from abandonment activities would be additional turbidity caused by increases in suspended particles in the water column. Increases in turbidity generally are expected to be considerably less than the 7,500 parts per million suspended solids used in the analysis as an acute (toxic) criterion for water quality (Sec. III.C.3.l(2)); exceptions may occur within the immediate vicinity of the construction activity. Turbidity increases from abandonment activities generally are temporary and expected to occur during the winter and end within a few days after construction stops. Abandonment activities are not expected to introduce or add any chemical pollutants.

(2) Details on How Abandonment May Affect Water Quality

(a) General Effects from Developing the Liberty Prospect

The effect on water quality from abandonment activities could be additional turbidity caused by increases in suspended particles in the water. The types of effects could be similar to those described for island and pipeline construction activities in Section III.C.3.l.

(b) Specific Effects of Abandonment of Liberty Development

Abandonment activities that expose the side of the island to erosion by waves and currents and ice would suspend exposed fine-grained materials and increase the turbidity in the water column adjacent to the island. Waves and currents would mix and disperse the suspended material so that concentrations would decrease downstream from the island.

All island fill material that has been contaminated from spilled pollutants would be removed from the island for disposal. (Immediate cleanup of spills and contaminated material is required, so that the amount of material that might have to be removed during abandonment is expected to be small.)

If the gravel used to build the island has to be removed, dredging would expose fine-grained particles to suspension in the water. Concentration of suspended particles would be similar to those estimated during construction of the island. The suspended sediment concentration in the immediate vicinity of the dredging activity is estimated to be 250 milligrams per liter (Sec. III.C.3.l(2)(b)). The concentration of particles suspended in the water decreases with distance from the source. The larger and/or denser particles in the plume would settle closer to the island than the smaller and/or less dense particles farther away. If the current speed is 2 centimeters per second (0.04 knot), the concentration of suspended particles would be reduced to 50 milligrams per liter at a distance of 0.5 kilometer (0.3 mile) from the construction site, 20 milligrams per liter at 1.25 kilometers (0.78 mile) distance and 10 milligrams per liter at 1.5 kilometers (0.93 mile) downcurrent.

Also, dredging would have to be done if abandonment includes removal of the pipeline. Concentration of suspended particles would be similar to those estimated during pipeline construction. Trenching would disturb and resuspend the seafloor sediments (Sec III.C.3.l(2) (b)2). Dumping excavated material to fill the trench also would cause some of the fine-grained particles to separate from the moved sediment mass and remain in suspension. Suspended-sediment concentrations in the water column greater than 100 milligrams per liter are estimated to occur within 0.75 kilometer (0.46 mile) of the trench, based on excavating 724,000 cubic yards. The amount of suspended particles in the water column would decrease with distance from the trench area. Concentrations of 20 and 10 milligrams per liter are estimated to be reached at distances of about 1 kilometer (0.62 mile) and 10 kilometers (6.2 miles), respectively, from the trench. These estimates are based on an initial suspended-sediment concentration of l,000 milligrams per liter and a current velocity of 0.02 meter per second (0.04 knot) that carries the sediment to the northwest.

Increases in turbidity generally should be considerably less than the 7,500-parts per million suspended solids used in the analysis as an acute (toxic) criterion for water quality. The abandonment activities are not expected to introduce or add any chemical contaminants.

m. Air Quality

The only effects on air quality from abandonment operations would be the emissions from engines being run to remove some equipment or materials or to transport people or equipment. Abandonment would cause much higher vehicular traffic by trucks and barges, and also more heavy equipment operations than during the production phase of operations, but effects probably would be quite similar to the construction phase of operations. Because abandonment operations would last perhaps a maximum of 10-15% (2 years) of the total project operations timeframe (16-18 years) and would include no activities that should affect air quality more significantly than previously discussed (see Sec. III.D.1.m), we conclude that these operations would cause insignificant effects on air quality.

7. Unavoidable Adverse Effects

This section summarizes the unavoidable effects of both the proposed construction and production phases. (During the eventual abandonment phase, the unavoidable effects would be similar to those for the construction phase.) Effects during the construction and production phases would arise from disturbance. Most disturbance effects can be avoided through active planning and compliance with regulations and stipulations

a. Threatened and Endangered Species

Most effects on bowhead whales probably are avoidable, if the construction schedule is adhered to. The marine sealift probably has the highest potential for disturbance to bowhead whales if it is not completed prior to the beginning of the bowhead whale fall migration.

Some minor disturbance of spectacled eiders offshore of Foggy Island Bay-eastern Sagavanirktok River Delta from mid-June to September by helicopters is expected to occur when birds are present during the nesting season. The adverse effect of disturbance on eiders could interfere with this species' recovery from threatened status. This is because recruitment of individuals into the population generally is low, and decreased productivity by disturbed nesting pairs or lowered survival of any age group is expected to increase the length of time required for recovery to former population levels (Sec. III.C.3.a(2)(b)).

b. Seals and Polar Bears

Most types of disturbance (for example, from aircraft noise) are considered avoidable through compliance with provisions of the Marine Mammal Protection Act and Letters of Authorization that direct lessees to avoid disturbance and require using nonlethal means to avoid human-bear interactions. Air, vessel, and ice-road traffic and construction activities unavoidably would disturb small numbers of seals and perhaps a few polar bears, but this effect would be very brief and would not affect seal and bear population abundance and/or overall distribution in the Liberty Project area.

c. Marine and Coastal Birds

Waterfowl and other aquatic birds in nearshore Foggy Island Bay and the eastern Sagavanirktok River Delta are vulnerable to disturbance by aircraft and human activity. This includes broodrearing, molting, or staging brant and snow geese and several thousand shorebirds in shoreline habitats during the migration period. Disturbance may cause expenditure of extra energy and time needed to find alternate areas, causing fitness of disturbed individuals to decline and lower their survival rate.

d. Terrestrial Mammals

Some disturbance of terrestrial mammals by air and ice-road traffic and by construction activities is considered unavoidable but would be short-term (less than 1 year) and local (within less than 1 mile of the activity) and would not affect population distribution and abundance.

e. Lower Trophic-Level Organisms

These organisms would be unavoidably affected by construction. Placement of gravel for the Liberty Island construction would have lethal effects on the benthic organisms within 28 acres (Sec. III.C.3.e (2)(b)). Pipeline trenching would bury up to 14 acres with very low (1%) coverage of kelp, boulders and suitable substrate. The lost kelp biomass and production probably would be less than 0.01% of the Boulder Patch totals, but the effect (substrate burial) would last forever.

f. Fishes and Essential Fish Habitat

(1) Fishes

The probability of a disturbance contacting nearshore waters where fish concentrate to feed and migrate is low.

(2) Essential Fish Habitat

Because none of the lifestages of salmon have been documented to use or inhabit the waters near where Liberty Island is expected to be located, salmon are not likely to suffer any unavoidable adverse effects. However, salmon prey, and the algae they depend on, could be killed or have their lifecycles disrupted due to mechanical removal or sedimentation caused by construction activities associated with island construction, gravel quarrying, and pipeline construction. Zooplankton and early lifestages of fish that are used by salmon as prey could be killed by the seawater-intake system of the seawater-treatment plant. Water quality could be locally and temporarily degraded due to several causes:

- Discharges of water from operations on Liberty Island are expected to cause slight increases in the temperature, salinity, and turbidity of the water they mix with in Foggy Island Bay.
- Construction of Liberty Island and the associated pipeline would cause localized, temporary increases in water turbidity.
- Abandonment of the Kadleroshilik River gravel mine could lead to temporary increases in turbidity of river or marine waters downstream of the quarry.
- Chronic discharges of contaminants entrained in ice roads, including contaminants from vehicle exhaust, grease, antifreeze, oil, and other vehicle-related fluids,

would pass into the Beaufort Sea system at each breakup.

g. Vegetation-Wetland Habitats

A few acres of tundra habitat would be unavoidably destroyed or altered for the pipeline-valve pads and at the 53-acre gravel mine in the Kadleroshilik River bed.

h. Subsistence-Harvest Patterns

Seals, polar bears, caribou, fish, birds, and especially bowhead whales are important subsistence resources. Disturbance from aircraft and construction activities, should it occur, could affect subsistence resources periodically in the communities of Nuiqsut and Kaktovik. Additionally, disturbance could cause potential short-term but adverse effects to oldsquaw and king and common eider populations and affect local fish populations. A potential disturbance to polar bears could reduce their availability locally to subsistence users, although they are seldom hunted by Nuiqsut hunters except opportunistically while in pursuit of more preferred subsistence resources. No harvest areas would become unavailable for use. Even though traditional practices for harvesting, sharing, and processing subsistence resources should continue, some resource populations could suffer losses, or could be rendered culturally unavailable for use, causing potentially significant unavoidable effects on the subsistence harvest (Sec.III.C.3.h).

i. Sociocultural Systems

We do not expect disturbance to displace ongoing sociocultural systems or community activities. However, the inability to harvest sufficient quantities of bowhead whale due to disturbance issues could cause unavoidable effects on Inupiat traditional practices of harvesting and sharing, and processing subsistence resources. Unavoidable effects on sociocultural systems are expected from construction noise. However, these would not displace ongoing sociocultural systems or community activities (Sec. III.C.3.i).

j. Archaeological Resources

Section C.2.c of the Prehistoric Resource Analysis concludes that preserved prehistoric archaeological sites may occur within the project area. Because the exact sites are not well known, the possibility of their disturbance cannot be entirely avoided. As a result of the analysis, we have requested that an archaeological report based on geophysical data be prepared by BPXA in accordance with 30 CFR 250.26. As we receive the data, we will review the geophysical survey data from this leased block and prepare an archaeological report to address whether the data show any evidence of areas having prehistoric site potential. Based on the results of this analysis, we will require that any areas of prehistoric site potential either be investigated further to determine conclusively whether a site exists at the location, or that the area of any potential sites be avoided by all bottom-disturbing activities. It is not anticipated that there will be any effects to historic resources. The additional investigations will help to ensure that there are no unavoidable effects on archaeological resources.

k. Economy

Unavoidable effects employment, associated wages, capital expenditures, operating expenditures, and Federal, State and local revenues (Sec. III.D.5). Most people consider these effects as positive.

l. Water Quality

Discharges associated with the project would include: (1) continuous discharges from the backwash from the seawater-treatment plant, brine from the potable-water desalination system, and the continuous-flush system and (2) temporary or intermittent discharges from sanitary and domestic wastewater systems, fire-control test water, deck drainage, and construction dewatering. These discharges would be limited by other Federal and State permits and would not be expected to add toxic or hazardous materials to the receiving environment. There would be no discharges of drill fluids, cuttings, or produced water from the project.

m. Air Quality

The Liberty Project would cause a small, local increase in the concentrations of criteria pollutants. Concentrations would be within the Prevention of Significant Deterioration Class II limits and National Air Quality Standards. Therefore, significant effects would be avoidable.

8. Relationship between Local Short-Term Uses and Maintenance and Enhancement of Long-Term Productivity

In general, “short term” refers to the useful lifetime of actions under the Proposal. “Long term” refers to time beyond the development’s estimated lifetime. We estimate the Liberty field would produce for 15 years, with structures and pipelines designed to operate for at least 20 years (BPXA, 2000a). Most of the effects discussed in Section III are considered to be short term (being greatest during construction).

a. Effects on Biological Populations and Habitats

The plan for the proposed gravel mine site in the Kadleroshilik River Delta (BPXA, 1998a:Sec. 2.1.2) includes breach construction and flooding to reclaim the pit. The flooded pit probably would add to the overwintering fish habitat, thereby slightly enhancing the environment's long-term productivity.

Noise disturbance and construction activities temporarily would affect biological populations and their habitats and may result in local long-term effects. Disturbances and altered habitat may result in local displacement, mortality, stress, decreases or reductions of populations or species, and changes in survival patterns. Effects may last over the long term, if recovery from the short-term effects extended beyond the field's estimated useful life.

b. Effects on Subsistence-Harvest Patterns

In the short term, redistributing, reducing, tainting or displacing subsistence species could affect regional subsistence-harvest patterns. Such short-term effects should not have long-term consequences, except that they may disrupt social systems or resources if they are chronic over the project's life. Destroying habitat also may locally reduce subsistence species, which could affect the regional economy (Sec. III.C.2.h and Sec. III.C.3.h).

c. Effects on Native Communities

Increased population and industrial activity and minor gains in revenues may disrupt Native communities in the short term. Other changes resulting from other operations and lease sales could add to the long-term consequences for Native social and cultural systems.

Although construction is not likely to improve access to remote areas because it relies on temporary ice roads, the wilderness quality of the area being developed would decrease as land uses increase. Archaeological and historic items discovered before development would enhance long-term knowledge. Such finds could help fill the gaps in our knowledge of early inhabitants. Any destruction of archaeological sites or unauthorized removal of artifacts, however, would represent long-term losses.

Land use changes would occur onshore along pipeline routes, probably shifting from subsistence to industrial activities throughout the life of the field. These changes could be short term if, after production ends, the land goes back to previous uses. These changes would become long term, if people continue to use buildings and other infrastructure after the field's estimated useful life. For example, resource developers, residents, or others could use infrastructure that had become convenient and common to them Sec. III.C.2.i and Sec. III.C.3.i.

d. Effects on Energy Development versus Environmental Productivity

Producing oil from the Liberty field would provide short-term energy and perhaps time to develop alternative sources of energy or substitutes for petroleum feedstocks. Economic, political, and social benefits (mostly short term) would accrue if this oil decreases the Nation's dependency on oil imports. Liberty production would extend the operational lifespan of the Trans-Alaska Pipeline System. Regional planning could help control changing economic conditions and populations and, thus, help lessen harm to social and cultural systems. If companies discover and develop other resources, the proposed production system may help extract those resources. However, consuming offshore oil would deplete nonrenewable resources.

After the production phase, oil spills and their effects would not occur; we expect the marine environment to remain at or return to its previous condition and productivity. To date, we have not seen decreases in long-term productivity in outer continental shelf areas where oil have been produced for many years. In areas that have experienced oil spills, such as the 1989 *Exxon Valdez* spill in Prince William Sound, or where oil pollution appears to have increased, some effects may be long term. A recent summary report by the *Exxon Valdez* Oil Spill Trustee Council (1998) assigns species to one of four levels of recovery: Recovered (bald eagle); Recovering (common murre, pink and sockeye salmon, mussels, and intertidal and subtidal communities); Not Recovering (killer whale, harbor seal, sea otter, cormorants, harlequin duck, marbled murrelet, pigeon guillemot, and herring); and Recovery Unknown (several other species). Until we have better data, we cannot project the long-term effects of chronic and major spills or the time needed for complete recovery. For now, we assume long-term productivity may decrease if the Liberty Project causes chronic or major oil spills.

e. Economy

Increases in employment, associated wages, capital and operating expenditures, and revenues to the Federal, State and local governments would occur over the life of the project (15-20 years). However, none of these increases would be long term. Capital expenditures could result in infrastructure that would enhance long term productivity of oil and gas exploration, development, and production.

Contents

9. Irreversible and Irretrievable Commitment of Resources

The guidelines prepared by the Council on Environmental Quality specify that the EIS include a discussion about any irreversible and irretrievable commitments of environmental resources that would be involved in the Proposal, should it be implemented (40 CFR Ch. V, 1502.16). The Proposal would have irreversible and irretrievable effects on:

- the Liberty hydrocarbon reservoir,
- gravel from the mine site and the seafloor under the gravel island,
- marine and coastal birds, including the threatened spectacled eider,
- vegetation-wetland habitats at the mine site and valve stations,
- terrestrial-mammal habitat at the mine site and valve stations, and
- possibly on archaeological resources.

The following paragraphs are resource-specific summaries of the irreversible and irretrievable commitment of environmental resources.

a. Threatened and Endangered Species

If whales were exposed to freshly spilled oil for a prolonged time, a few probably would be killed. However, this population of whales is growing (Sec. VI.A.1.a) and probably would recover, making the effects temporary and reversible. Oil-spill caused mortality of spectacled eiders staging in the Liberty area could be long term, because natural recruitment into the population is low and such losses would not be replaced quickly (Sec III.C.3.a(2)).

b. Seals and Polar Bears

While small numbers of seals and/or polar bears might be disturbed, the populations would recover (the individuals would be replaced) within a year (Sec. III.C.2.b). The projected recovery rate means that the effect would not be irreversible or irretrievable.

c. Marine and Coastal Birds

The development of any project alternatives would require permanent alteration of potential bird habitat at the gravel mine and where small areas of tundra are filled for the valve station. These activities would result in the loss of an insignificant proportion of available nesting habitat (Secs. III.D.1.c and III.D.6.c) and are considered an irreversible commitment of resources.

d. Terrestrial Mammals

An irreversible effect would be a commitment of about 45 acres of potential habitat at the mine site and valve stations. Other effects would be reversible, including the possible disturbance of terrestrial mammals by air and ice-road traffic and by construction activities (Sec III. C.3.d).

e. Lower Trophic-Level Organisms

The construction of the offshore island and pipeline trenching would have irreversible effects on the benthic habitat. Other effects would be reversible within 10 years (Sec. III.C.3.e).

f. Fishes and Essential Fish Habitat

(1) Fishes

Fishes in the Beaufort Sea probably would experience direct and indirect effects from noises and disturbances during Liberty’s development and production. These effects could result from vessel and aircraft traffic, construction and drilling activities, and degradation or loss of habitat due to facility developments. Some effects may be significant but are not likely to be irreversible and irretrievable. Given enough time, in some cases many years, fishes likely would recover.

(2) Essential Fish Habitat

Because none of the lifestages of salmon have been documented to use or inhabit the waters near where Liberty Island is expected to be located, salmon are not likely to be killed or otherwise affected. However, salmon prey, and the algae they depend on, could be killed or have their lifecycles disrupted due to mechanical removal or sedimentation caused by construction activities associated with island construction, gravel quarrying, and pipeline construction. Zooplankton and early lifestages of fish that are used by salmon as prey could be killed by the seawater-intake system of the seawater-treatment plant. Although essential fish habitat would be adversely affected through these mechanisms, these biological resources would be expected to recover quickly at the end of the disturbance.

g. Vegetation-Wetland Habitats

About 1.3 acres of tundra habitat would be irreversibly altered by gravel fill at the pipeline-valve pads, and the 45 acres of river-bar habitat would be irreversibly altered at the gravel mine site on the Kadleroshilik River bed.

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h. Subsistence-Harvest Patterns

Disturbance issues could affect subsistence resources periodically in the communities of Nuiqsut and Kaktovik. In fact, even if whales were available for the spring and fall seasons, a perception of disturbance could make bowheads less desirable and alter or stop the subsistence harvest. Virtually every family on the North Slope participates in the hunting of the bowhead whale and the sharing of its meat. The inability to harvest sufficient quantities of this resource would be an irreversible and irretrievable loss to the Inupiat diet, to Inupiat traditional practices of sharing and reciprocity, and to fundamental aspects of Inupiat identity.

A pattern of unsuccessful annual harvests caused by noise from construction, operation, or maintenance would be an irretrievable and irreversible loss of the bowhead subsistence resource. However, the Liberty Project would be far enough away from the migration corridor that it would not cause a pattern of unsuccessful harvests, and there would be no irreversible effects.

i. Sociocultural Systems

We do not expect disturbance issues or construction noise to displace ongoing sociocultural systems or community activities, but the inability to harvest sufficient quantities of bowhead whale would be an irreversible and irretrievable loss to Inupiat traditional practices of harvesting and sharing, and processing subsistence resources.

j. Archaeological Resources

Disturbance of archaeological sites would cause irreversible losses, because no one can recreate them. Any bottom- or surface-disturbing activity, such as pipeline construction, island installation, anchoring of vessels, or oil-spill-cleanup activities could damage previously unidentified archaeological sites. See Section III.C.3.j for further discussion.

k. Economy

Increases in employment, associated wages, capital and operating expenditures, and revenues to the Federal, State and local governments would occur over the life of the project (15-20 years). These would constitute irreversible and irretrievable commitment of resources. Capital expenditures could result in infrastructure but that infrastructure could be removed.

l. Water Quality

The proposed project would cause a limited disturbance of the water quality from the discharge of materials during island construction and abandonment and during pipeline trenching and backfilling activities. These effects would be short term and reversible.

m. Air Quality

The Liberty Project would cause a small, local increase in the concentrations of criteria pollutants. Concentrations would be within the Prevention of Significant Deterioration Class II limits and National Ambient Air Quality Standards. Therefore, effects would be low and reversible.

10. Global Climate Change and Alternative Energy Sources

Global climate change and alternative energy sources are addressed in the MMS Outer Continental Shelf Oil and Gas Leasing Program and are incorporated here by reference. In addition, the Council on Environmental Quality, in its *Draft Guidance Regarding Consideration of Global Climate Change in Environmental Documents Prepared Pursuant to the National Environmental Policy Act*, October 8, 1997, recommends addressing this issue at the program level rather than at the project level.

Global climate change as discussed in the 5-year 1997-2002 Final EIS (USDOI, MMS, Herndon, 1996a:IV-63-68) describes issues related to the potential for contribution to global climate change as a result of greenhouse gas emissions. Based on current scientific research, there is a growing concern about the potential effects of primary greenhouse gases (carbon dioxide, methane, nitrous oxide, ozone, water vapor, and chlorofluorocarbons) on global climate. Through many complex interactions, both on a regional and global scale, the lower layers of the atmosphere experience a net warming effect. However, these trends could be caused by greenhouse warming or natural fluctuations in the climate—an ongoing scientific debate. The assessment of the impacts of climate change is in its formative phase, and it is not yet possible to know with confidence the net impact of such change; however, potential effects could alter water supply, food security, sea-level fluctuations, and natural variances in the ecosystem. Activities associated with exploration, development, and production of oil and gas resources from the outer continental shelf program result in emissions of some of the greenhouse gases discussed, primarily as a result of power requirements and fuel consumption, which produce carbon dioxide. There is some uncertainty in the estimates of greenhouse gas emissions as power requirements and fuel consumption vary substantially from one geographic area to another, and even for different projects within the same geographic area. Because the issue of climate change must be viewed from a global perspective, the magnitude of the emissions contributed by the outer continental shelf program also must be viewed in that context. Methodology is not available that will allow the determination of the marginal effect of the limited contributions of the outer continental shelf program to the probability, extent, or imminence of global climate change or, more importantly, the consequent social, economic, or environmental impacts. However, because the incremental contribution of greenhouse gases from the proposed outer continental shelf program are negligible when compared to total greenhouse gas contributions, they cannot be expected to have a significant effect on climate change.

Alternative energy resources, different from those chosen by the market—exploration, development, and production of oil and gas resources—are discussed in the 5-year 1997-2002 Final EIS (USDOI, MMS, Herndon, 1996a:IV-482-489). This could mean “energy conservation” or switching fuel in transportation-vehicles from a oil-based products to renewable fuels (i.e., ethanol), and conservation measures, such as more efficient vehicles (engine design) and transportation systems (mass transit). This also could mean generating electricity using, for example, the following: nuclear or hydroelectric power; geothermal, wind, solar, and tidal energy, or ocean currents and biomass sources. The advantages and disadvantages of each are discussed. More efficient generation, transmission, and use of current fuels in generating electricity and in other industry sectors and in the residential and commercial sector, is encouraged as a conservation measure. It is noted that conservation measures may have some negative environmental impacts for any new equipment required to achieve this efficiency; however, the net effect of these measures generally would be positive from an environmental point of view. Unfortunately, conservation has an upward sloping supply curve just as most goods and services do; saving more energy eventually becomes too expensive to continue. Conservation then can be an important part of a rational future energy plan, but it can only be one of several alternatives adopted to meet future energy demands.

As noted in the analysis of the No Action Alternative, Section IV.B, the oil produced from the Proposal primarily would offset imported oil. The amount of oil and gas consumed in the United States, with or without this Proposal, would not change. While the Proposal may have a minimal effect on the amount of oil imported annually into the United States, the effect of the Proposal on climate change seems negligible.

The Liberty Project likely would not have a significant effect on climate change. If the 120 million barrels of Liberty resources were not produced, the U.S. would import most of that by tanker. Furthermore, the life of this project is relatively short, and the effects of major climate warming remain long term.

The plan includes regular monitoring and maintenance of the pipeline and island and would ensure that adequate corrective action is taken to maintain their integrity. If an immediate threat is encountered, the flow through the pipeline could be stopped, the wells and the facility could be shut down and, if necessary, the island could be vacated. Corrective actions could be made to the island, shore crossing, and onshore pads as needed, and production could then resume.

11. Effects of the Proposed Project on National Security and Navigation

Federal regulations, 33 CFR 322.5(f), require an analysis of the impacts to National Security and Navigation.

a. Effects of the Liberty Project on National Security

The proposed Liberty Project would make a significant contribution towards the enhancement of national security. Oil from this project, when combined with other existing and anticipated domestic production, would advance the national goal of limiting and ultimately decreasing the Nation’s dependence on oil imports from unstable foreign sources. In this case, the proposed Liberty Project would result in production of 120 million barrels of oil. The Liberty Project would help satisfy the growing demand for oil at a time when domestic production is in decline. The project is located just 5 miles offshore Alaska and is within the barrier islands. It would use the existing infrastructure of pipelines (Badami, Endicott, and the Trans-Alaska Pipeline) to transport the oil south to the Port of Valdez, where oil tankers routinely transport oil to markets on the west coast of the United States. Because the transportation network is already in place, this project would not introduce any risks to national security.

b. Effects of the Liberty Project on Navigation

If the Liberty project is authorized, special conditions would be included on the authorization that would require BPXA to install and maintain, at their expense, any safety lights and signals prescribed by the U.S. Coast Guard, through regulations or otherwise, for the gravel island to maintain safe navigation; and the activity must not interfere with the public's right to free navigation on all navigable waters of the United States. BPXA also would be required to notify the National Ocean Service in writing at least 2 weeks before initiating work and on completion of the activity. Notification procedures also would be undertaken with National Oceanographic and Atmospheric Administration, Charting and Geodetic Services, and the Defense Mapping Agency (Hydrographic Center).

For the Liberty Project, marine support and supply would consist of the sealift of production modules during the first and second construction seasons and general logistics operations (personnel and material movement by supply boats). The effects of these vessel movements on commercial and other types of marine-vessel operations would be expected to be low, because the vessel traffic associated with Liberty would be light. Please see Table V.B-8.a for Liberty related marine and other transportation assumptions. The Alaskan Beaufort Sea is not used extensively by commercial marine transport. Fuel and resupply barges make summer trips to villages along the arctic coast, and military and science vessels occasionally would travel the Beaufort through the Northwest Passage. We do not expect the movement of sealift modules and supply boats to adversely affect the navigational safety of transiting commercial ship traffic.

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SECTION IV

EFFECTS

OF THE

ALTERNATIVES

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IV. Effects of the Alternatives

A. INTRODUCTION

1. Review of the Concept of Component Alternatives and Combination Alternatives

We introduced the topic of component and combination alternatives in Sections I.F and H and again in the beginning of Section II. Sections II.C and D give a full description of each alternative. Table I-1 shows the relationship between these two types of alternatives. You may want to turn back to these sections and tables to refresh your understanding of the underlying concept and rationale for them. In this section (Sec. IV), Table IV.A-1 shows where in the EIS you can find the detailed description and the applicable analyses of the environmental impacts of each alternative.

a. Component Alternatives

The five sets of component alternatives are:

Alternative Drilling and Production Island Locations and Pipeline Routes
- Alternative I - Use Liberty Island Location and Pipeline Route
- Alternative III.A - Use Southern Island Location and Eastern Pipeline Route
- Alternative III.B - Use Tern Island Location and Pipeline Route

Alternative Pipeline Designs
- Alternative I - Use Single-Wall Pipe System
- Alternative IV.A - Use Pipe-in-Pipe System
- Alternative IV.B - Use Pipe-in-HDPE System
- Alternative IV.C - Use Flexible Pipe System

Alternative Upper Island Slope-Protection Systems
- Alternative I - Use Gravel Bags
- Alternative V - Use Steel Sheetpile

Alternative Gravel Mine Sites
- Alternative I - Use Kadleroshilik River Mine
- Alternative VI - Use Duck Island Gravel Mine

Alternative Pipeline Burial Depths
- Alternative I - Use a 7-Foot Burial Depth
- Alternative VII - Use a 15-Foot Trench Depth

b. Combination Alternatives

The three component alternatives and the BPXA Proposal are made up of the following component:

Combination Alternative A
- The Liberty Island and Liberty Pipeline Route (Alternative I)
- Steel Pipe-in-Steel Pipe Pipeline Design (Alternative IV.A)
- Steel Sheetpile for Upper Slope Protection (Alternative V)
- The Duck Island Mine Site (Alternative VI)
- A 7-Foot Burial Depth (Alternative I).

Combination Alternative B
- Gravel Bag for Upper Slope Protection (Alternative I)
- The Kadleroshilik River Mine Site (Alternative I)
- The Southern Island and Eastern Pipeline Route (Alternative III.A)
- Steel Pipe-in-HDPE Pipeline Design (Alternative IV.B)
- The 6-Foot Burial Depth (Alternative IV.B) as designed by for the Steel Pipe-in-HDPE pipeline design.

Combination Alternative C
- The Tern Island and Tern Pipeline Route (Alternative III.B)
- Steel Pipe-in-Steel Pipe Pipeline Design (Alternative IV.A)
- Steel Sheetpile for Upper Slope Protection (Alternative V)
- The Duck Island Mine Site (Alternative VI
- A 15-foot Trench Depth (Alternative VII).

BPXA Proposal (Liberty Development and Production Plan)

- The Liberty Island and Liberty Pipeline Route
- Single-Wall Pipeline Design
- Gravel Bags for Upper Slope Protection
- The Kadleroshilik River Mine Site
- A 7-Foot Burial Depth

Section IV devotes extensive text to the effects of the component alternatives but includes only the highlights of the effects of the combination alternatives. Our rationale for this is that the component alternatives are the building blocks for the combination alternatives. With a through understanding of the building blocks, the reader or decisionmaker can more easily review the combination alternatives formulated by the Liberty Interagency Team or use the blocks to construct what ever combination is preferred.

Some of the alternatives (Island Location and Pipeline Route or Pipeline Design), if chosen, may result in delays in the Liberty Project of 18-24 months to collect additional engineering data and allow time for specific design and testing work. This information would be necessary for technical approval of the project, but is not expected to change the environment effects. For purposes of analysis in the EIS, we have not adjusted the timelines for starting the different alternatives. Therefore, all the alternatives are on the same footing for the analysis of environmental effects.

2. Common Elements for All Alternatives

A complex project such as the Liberty Development and Production Plan is comprised of many different elements. Most of the project elements that describe Alternative I (the Liberty Development and Production Plan) are shared by (the same for) all of the alternatives. These shared elements, such as the configuration of a gravel island, and the particular equipment on the island, include some very precise elements, such as a production island working surface that is 345 feet by 680 feet with an elevation that is 15 feet above sea level. A more detailed list of the shared elements can be found in Sections II.C.1.a, II.C.2.a, II.C.3.a, II.C.4.a, II.C.5.a., and IV.D.2

Other elements, such as island footprint on the seafloor and change for each island location, are not the same for all alternatives.

3. General Effects Verses Specific Effects

In the analysis of effects in Section III, we have identified two types of impacts. The first impact type, "general effects," is general and applies to all of the alternatives. Table IV.A-2 shows where in this EIS the reader can find the "general impacts" effects of large oil spills, disturbances, discharges, small oil spills, and abandonment. They are the result of developing the hydrocarbon resources in the Liberty Prospect and they are the same for all alternatives. The effect on caribou of constructing an offshore gravel island in the winter is an example of a "general effect." That is, for all alternatives in this EIS, we cannot determine any difference in effects among the alternative island locations to caribou from construction of a gravel island in the winter.

We use the term, "specific effects" to apply to those effects that differ among alternatives. You will see below in each subsection for each resource that, instead of repeating the general effects over and over, we routinely we refer the reader back to the general effects in section III, provide a summary of effects and then discuss the specific effects in detail.

4. Alternative Development

Information about other possible alternatives that were raised during scoping, considered and evaluated but not analyzed further in this section, are described in Section I.H.5.

This EIS and the alternatives evaluated reflect the many constraints of a development proposal.

- The hydrocarbon resources are located where they were discovered. They cannot be moved to another location that may have fewer environmental effects.
- Some activities can take place only during specific seasons in the Arctic; for example, sealifts can take place only during the summer in open water.
- National Environmental Policy Act guidance indicates that alternatives should be "reasonable" and economically and technically feasible. They also should be environmentally sound. Alternatives should allow for the full, or nearly full, development of the field to meet MMS's conservation of resources responsibilities (See Sec. I.H.5). Alternatives that increase the risks and costs to a level where the financial rate to the company is near or below zero are not considered, because BPXA would never proceed with a project that would cost more than it would earn. These are not reasonable alternatives. In effect, such alternatives would become the same as the No Action Alternative.

5. Use of the Term "the Same As"

This EIS uses the comparative term "the same as" to indicate that an impact is identical or essentially the same as noted for another alternative. Within the EIS analysis, we use the term "the same as" to indicate to the reader that two impacts are considered to be equal. We do not intend this in

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the pure or mathematical sense. We are not saying two items are exactly identical. Rather, we use the phrase to indicate that two impacts are so close, that finding a difference between them is beyond our analytical ability to measure or analyze.

6. Precision of Calculations

The precision of many calculations from the INTEC, C-CORE, Stress, and Fleet engineering studies does not express the uncertainty associated with our estimation of the size of an oil spill that may occur during the life of the project. Typically, we would round the assumed spill volumes to the nearest hundred or thousand barrels to represent the uncertainty in our estimation of spill size. However, for this Liberty EIS, where engineering calculations from these studies have been used, we have kept the exact calculation to maintain consistency between documents related to the project and reduce confusion.

7. Other Important Information about Alternatives

Lease Y-01685 includes several Stipulations to mitigate possible adverse effects (see Sec. I.H.6.b, including Lease Sale Stipulation No. 1, Protection of Biological Resources. The stipulation explains that we may require additional biological surveys and, based on those surveys, may require the lessee to "modify operations to ensure that significant biological populations or habitats deserving protection are not adversely affected." This stipulation may be used to help mitigate potential effects from either the Proposal or alternatives, if unanticipated effects on resources such as kelp, are identified during the life of the project.

If an alternative drilling and production island location or pipeline route other than Alternative I (Liberty Island and Pipeline Route) is selected, BPXA would be required to submit for our review additional geophysical survey data that sufficiently cover the proposed area of offshore disturbance. An archaeological report would be prepared to address whether the data provided any evidence of areas having prehistoric or historic site potential. Based on this analysis, we would require that any areas of potential archaeological sites either be investigated further to determine conclusively whether a site exists at the location or that the area of the potential site be avoided by all bottom-disturbing activities.

B. ALTERNATIVE II – No Action

Under this alternative, the Liberty Development and Production Plan would not be approved. If development does not occur, there would be no Liberty Island construction; mining of gravel for island, pipeline, or onshore pad construction; pipeline construction (excavation and backfilling); ice-road construction in support of island and pipeline construction; and surface, aircraft, or marine transportation of equipment, supplies and personnel in support of construction and facility operations. None of the potential 120 million barrels of oil would be produced, and there would be no potential oil spills and no effects to the flora and fauna in the Foggy Island Bay. There would be no noise, habitat disturbance and alteration, or water discharges and air emissions from the activities associated with island and pipeline construction and operation, from drilling and production operations. The economic benefits, royalties, and taxes to the Federal and State governments would be forgone.

To replace the potential 120 million barrels of oil not developed from Liberty, a large portion of the oil would be imported from other countries. The associated environmental impacts from producing oil and transporting it to market still would occur. These imports have attendant environmental effects and negative effects on the Nation's balance of trade.

1. The Most Important Substitutes for Lost Production

The energy that would have flowed into the United States' economy from this development would need to be provided from a substitute source. Possible sources include:

- Other domestic oil production
- Imported oil production
- Other alternative energy sources such as
  - Imported Methanol
  - Gasohol
  - Compressed Natural Gas
  - Electricity
- Conservation in the areas of transportation, heating, or reduced consumption of plastics
- Fuel switching
- Reduction in the consumption of energy

If the Plan is denied, substitute energy likely would be a mix of the above sources largely from imported oil production followed by conservation, additional domestic production, and fuel switching.

A paper from the 1997-2002 5-Year OCS Oil and Gas Program entitled *Energy Alternative and the Environment* (USDOI, MMS, Herndon, 1996b), which is incorporated here by reference, discusses a long list of potential alternatives to oil and natural gas and evaluates their potential to replace a critical part of our county's energy sources. The costs and reliability of these alternative sources make them less viable than oil and gas resources. It seems very likely that during the life of this project, oil and gas resources at or above the current levels will be used in the United States and the world to fuel our economies.

This paper also indicates that imports and additional domestic production will replace most of the lost oil production, while conservation and fuel switching will decrease the demand for fuel. Every fuel alternative, however, imposes its own negative environmental effects. The following list shows the approximate percent and quantity we expect would substitute for the lost oil (120 million barrels). The quantity of conservation and fuel switching are in barrels of oil equivalent.

- Additional imports: 88% of the loss of production equivalent to 105 million barrels.
- Conservation: 5% of the loss in production equivalent to 6 million barrels.
- Additional domestic production: 4% of the loss in production equivalent to 5 million barrels.
- Fuel switching: 3% of the loss in production equivalent to 4 million barrels.

2. Environmental Impacts from the Most Important Substitutes

a. Additional Oil Imports

Energy Alternatives and the Environment (USDOI, MMS, Herndon, 1996b) indicates that if imports are increased to satisfy the demand for oil, the effects to the environment would be similar in kind to those of the Proposal but would occur in a different location. The species of animals and plants affected may be different, depending on the location of the development. Some of these effects still could occur within the United States from accidental or intentional discharges of oil, whether from tanker or pipeline spills. These events would:

- generate greenhouse gases and air pollutants from transportation and dockside activities;
- degrade air quality from emissions of nitrogen oxides and volatile organic compounds;
- degraded water quality; and
- destroy flora and fauna and water.

The impacts of oil spills from additional imported oil are not likely to occur on the shores of the Arctic Ocean or, for the most part, in Alaska. Imported oil imposes negative environmental impacts in producing countries and in countries along trade routes. By not producing our own domestic oil and gas resources and relying on imported oil we are exporting, from a global perspective, at least a sizeable portion of the environmental impacts to those countries from which the United States imports and through or by which our imported oil is transported.

b. Conservation

Substituting energy-saving technology (adding insulation or more efficient engines) or consuming less energy (lowering thermostat settings during the winter; using public transportation rather than private automobiles) will conserve energy. The former will tend to result in positive net gains to the environment but may require additional manufacturing. The amount of gain will depend on the extent of negative impacts from capital-equipment fabrication. Consuming less of an energy service generally would have a positive environmental effect.

c. Additional Domestic Production

Onshore oil production has notable negative impacts on surface water, groundwater, and wildlife. It also can cause negative impacts on soils, air quality, and vegetation and cause or increase noise and odors.

Offshore oil production may result in impacts similar to those of the Proposal, but they would occur in a different location. To the extent other offshore production offsets the potential loss of these resources, the effects will be similar to those of the Proposal, but would occur in a different location. Offshore activities also may have adverse impacts to subsistence activities, recreation, and tourism.

d. Fuel Switching

Consumers probably could switch to natural gas to heat their homes and businesses or for industrial uses. While natural gas production will create environmental impacts, they will be at a lower level than those impacts normally associated with oil spills. Other alternative transportation fuels may constitute part of the fuel-substitution mix noted above in Section IV.B.2.d. This mix depends on future technical and economic advances. At this time, no single alternative fuel appears to have the advantage.

e. Other Substitutes

The Federal Government could impose regulations mandating other substitutes for oil. The most likely sectors to target would be transportation, electricity generation, or various chemical processes; however, there are many possibilities. The reader is referred to the paper *Energy Alternatives and the Environment* (USDOI, MMS, Herndon, 1996b), which discusses many of the alternatives at too great a level of detail to reproduce in this report.

If this alternative (No Action) is adopted or if the project is withdrawn, the projected effects of the Proposal would not occur. Similar effects would occur elsewhere, but they would be in a different location and probably of a different magnitude. The Arctic Ocean, Beaufort Sea and, to more limited extent, Foggy Bay natural resources still would be exposed to other ongoing oil and gas activities in the area, as analyzed in Section V, the cumulative impacts.

C. EFFECTS OF COMPONENT ALTERNATIVES

This section evaluates the five sets of component alternatives, including the component proposed by BPXA. Table I-1 lists the component alternatives and shows the relationships between the component alternatives and the combination alternatives.

1. Effects of Alternative Drilling and Production Island Locations and Pipeline Routes

This set of component alternatives evaluates the different impacts of using three different island locations and their corresponding pipeline routes (see Map 1):

- Alternative I – Use the Liberty Island and Pipeline Route (proposed in the Liberty Development and Production Plan)
- Alternative III.A – Use The Southern Island Location and Eastern Pipeline Route
- Alternative III.B – Use Tern Island Location and Pipeline Route

The Eastern and Tern Pipeline Routes share the same shoreline crossing and nearshore disposal site (Zone 3) as well as the onshore pipeline route. These alternatives are described below and in Section II.C.

If either Alternative III.A or III.B is selected, BPXA would be required to submit additional geophysical survey data that sufficiently cover the proposed area of offshore disturbance for our review. An archaeological report would be prepared to address whether the data show any evidence of areas having prehistoric or historic site potential. Based on this analysis, we would require that any areas of archaeological site potential either be investigated further to determine conclusively whether a site exists at the location or that the area of the potential site be avoided by all bottom-disturbing activities.

a. Shared Project Elements for All Drilling and Production Island Location and Pipeline Route Alternatives

All three component alternatives share the project parts listed below:

The gravel island would be constructed during Year 2 (the first construction season), and the offshore pipeline would be constructed the next year. If construction of the gravel island were to be delayed for some reason, construction of both the island and pipeline would occur at the same time in Year 3. To the extent possible, construction of the gravel island and pipeline would occur during the winter.

All gravel islands would have the same working surface size of 345 feet by 680 feet. The working surfaces would be 15 feet above sea level. A helicopter landing pad and dock would be constructed with steel sheetpile. The dock/helipad would be approximately 150 feet by 160 feet. All of the islands would be designed to operate safely the Arctic offshore conditions, including potential ice and wave events. Figure II.A-4 presents a schematic overview of the expected complement of facilities that would be on all the islands. The total mass of the island (gravel fill and production facilities) is intended to provide sufficient resistance to lateral movement under maximum ice loads.

Ice roads would provide seasonal vehicular access to the island during the winter months. Boats or vessels may be used during open water periods. Helicopters may be used year round as needed.

Gravel would be mined onshore and transported by trucks using ice roads to the island location. The process of placing gravel involves using conventional ditch witches (chain trenchers) and backhoes to cut and remove blocks of ice from the construction site. The hole left by the removed ice blocks would be enlarged and filled with gravel hauled in by conventional belly-dump trucks. This process would continue until the total volume of gravel fill material has been placed.

Once the gravel fill is in place, the workers would grade and reshape the island to the final design. This work would continue through ice breakup. When the majority of the island is completed, materials for foundations and sheetwalls would be transported to the island by ice road or barge. The precast concrete mats would be constructed offsite and trucked to the island. Following breakup, the filter cloth and slope protection (concrete mats) would be installed. The concrete foundations would then be installed. All other remaining island construction work would be completed in early to mid-August before the arrival of the sealift in Year 2. During construction of the island, conductor pipes would be installed for each well, which would be a source of additional noise. These conductor pipes would be driven into the island using impact hammers, in a period of 1-2 consecutive weeks in June or July of Year 2 (BPXA, 2000a).

The bottom part of the island would be protected by interconnected concrete blocks (4 feet x 4 feet x 9 inches). These blocks would line the island from the sea floor to the 5-feet above sea level. These concrete block would all protect the berm of the island. Steel sheetpile would be placed around the dock and helicopter area (150 feet x 160 feet).

The 40-foot gravel bench on the island would be covered with concrete mats. These concrete mats would extend from base of the gravel bags to the sea surface. The mats dampen wave energy approaching the island and induce natural formation of ice rubble. Overlapping gravel bags would be used in the upper portion of the island slope starting at 7-8 feet above sea level and continuing to the top of the berm, which is 23 feet above sea level and 8 feet above the working surface of the island. The bags provide additional frictional resistance in the unlikely event of ice rideup past the 40-foot bench. The gravel bags would be used only in the upper portion of the island to avoid direct forces from ice or wave action.

For analysis of this set of component alternatives, the EIS assumes the trenching, excavation, and backfill quantities for a seven foot minimum depth of cover. We also assume all the pipelines systems have the same shore crossing, shore pad, onshore pipeline, and Badami tie-in pad. Other alternatives (IV.A., IV.B, IV.C, and VI) evaluate effects of different burial and trench depths.

All gravel islands would be oblong and oriented so that the narrower end of the island would be facing north to lessen exposure to potential ice and wave forces. Production modules and wells would be positioned away from the north face of the island and towards the center of the island to further lessen potential exposure to ice override onto the working surface of the island. The surface of the island would be contoured, so that runoff flows into sumps away from production facilities.

The individual concrete blocks (Fig. II.A-5) on the gravel island would be linked together with stout chain and shackles (Fig. II.A-6) and secured with anchors placed in the island gravel fill.

Construction of the islands would occur during Years 2 through 4 and would be staged from existing or onsite facilities. The majority of the workforce would be housed in existing onshore facilities until the infrastructure sealift could provide onsite facilities in the summer of Year 2. A construction barge may be moored near the island during the summer of Year 3. It would be about 150 feet by 380 feet (possibly two connected barges), and would have camp facilities mounted on the barge deck. It could house between 125 and 200 persons and would be used to support construction and possibly drilling. The camp could be overwintered at the site and remain there until summer of Year 4. Any fuel stored on board would be stored in accordance with U.S. Coast Guard Regulations (33 CFR Subpart C) and best industry standards. Wastewater from the camp would be treated onboard and discharged in accordance the Arctic General National Pollutant Discharge Elimination System permit. Solid waste from the camp likely would be hauled back to Prudhoe Bay for recycling, treatment, or disposal in existing approved facilities.

Diesel fuel would be used for power generation for construction activities and drilling until fuel gas is available on the island. All tanks would be double-walled with 10% containment capacity in the interstitial space. There would be a permanent 3,000-barrel diesel storage tank on the island. This tank would be located on a raised platform with a seal-welded floor and a seal-welded 6-inch-high toeboard that would provide in excess of 100 barrels of containment. Two other tanks, a 2000-barrel and a 5,000-barrel tank, would be used for diesel storage until the fuel gas is available. After fuel gas is available, these tanks would be converted to other uses, such as a produced water tank or a slop-oil tank. After Year 3, they would no longer be used for diesel storage. The 2,000-barrel and 5,000-barrel tanks would be located outside on a timber mat foundation on a geotechnical liner for additional containment. Seventeen smaller, temporary diesel fuel tanks would be used during construction and drilling and removed after gas from the project is available. The temporary tanks would be located in a lined, gravel-bermed area with a containment capacity of 550 barrels. Fuel gas would be available in the fourth quarter of Year 3 after the facilities have been installed.

b. Resource Effects that are the Same for All Drilling and Production Island Location and Pipeline Route Alternatives

All of the island locations and pipeline routes share the common elements noted above. The differences in island locations and pipeline routes for Alternatives I, III.A, and III.B do not provide measurable differences to the following resources for the following reasons.

- **Bowhead Whales.** Noise from operations is not likely to be detectable by bowhead whales beyond about 9 kilometers. All of the island locations are more than 10 kilometers from the Barrier Islands, and the whale migration route is even farther away. The effects from possible oil spills would be similar to bowhead whales are also essentially the same. Differences in island location and pipeline routes do not provide measurable differences in effects to bowhead whales.
- **Seals and Polar Bears.** Approximately the same level of activities would occur during the same time periods.
- **Fishes and Essential Fish Habitat.** While offshore trenching would be reduced, onshore pipeline construction would be increased. The sizes of the island footprints do not result in measurable difference result in measurable differences in effects on fishes.
- **Subsistence-Harvest Patterns.** The possible impact-causing activities that could affect subsistence harvest resources would not be changed measurably by the different island location and pipeline route. Therefore, the impacts to subsistence-harvest patterns would be essentially the same for all alternatives.

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- **Sociocultural Systems.** The possible impact-causing activities that would affect sociocultural systems would be about the same for all alternatives.
- **Archaeological Resources.** Effects of surface disturbance and oil-spill cleanup on archaeological resources would be the same as those discussed in Sections III.C.2.j and III.C.3.j for all alternatives. All known onshore and offshore archaeological sites are outside of the proposed onshore pipeline routes. All alternatives would have essentially the same effects.
- **Air Quality.** While some island locations have less air emission from construction because they need less gravel, they require greater drilling distances, which would increase air emissions. Overall, the effects to air quality would be essentially the same for all alternatives

For the reasons stated, the island locations and pipeline route alternatives analysis that follows will not include effects to these resources.

c. Alternative I – Use Liberty Island Location and Pipeline Route (Liberty Development and Production Plan)

Section IV.C.1.a describes the common elements shared by the alternatives in this component set. Those common elements, plus the components that follow describe this Alternative.

Alternative I (the Liberty Development and Production Plan) (see Map 1) is the Liberty Island location and Liberty Pipeline Route proposed by BPXA. Liberty Island is in about 22 feet of water. The proposed Liberty gravel island would be centered above the Liberty reservoir. This location would minimize the number of high-departure wells needed to develop the reservoir and maximize the total oil recovered. The present island location had no observed permafrost to a minimum of 50 feet below the island location.

The Liberty Island is about 5 miles from shore (BPXA 2000a). The water depth is about 22 feet. The distance for hauling the gravel is about 7 miles. The island location is about 1-mile southeast of the boulder patch. Liberty pipeline route would go southwest to shore. For purposes of analysis, we assume a pipeline with a 7-foot minimum burial depth. In addition to the construction elements shared by all alternatives in this component set as noted in Section II.C.1.a, construction of the Liberty island and pipeline include the following:

- 773,000 cubic yards of gravel fill for the island.
- 17,000 interlinked concrete mats (4 feet x 4 feet x 9 inches) (Fig. II.A-5) placed from the base of the gravel bags to the seafloor (Fig. II.A-3) and secured with anchors placed in the island gravel fill. About 7,600 cubic yards of gravel would be needed to make the concrete mats.
- 4,200 polyester gravel bags (4 cubic yards) placed on the upper slope of the island from 7-23 feet above sea level (Fig. II.A-3) using an additional 17,000 cubic yards of gravel.
- Gravel bags would be filled from excess gravel at the island construction site.
- 797,600 cubic yards of gravel would be needed for constructing the island.
- Gravel would be hauled over the ice road for about 45-60 days but should be in place at the island construction site by the end of April of Year 2.
- A maximum footprint would be 835 feet by 1170 feet, which is about 22.4 acres. The perimeter berm rises to 23 feet above sea level, which is 8 feet above the working surface.

The 40-foot gravel bench on the island (Fig. II.A-3) would be covered with concrete mats. These concrete mats would extend from base of the gravel bags to the sea surface. The mats dampen wave energy approaching the island and induce natural formation of ice rubble. Overlapping gravel bags would be used in the upper portion of the island slope starting at 7-8 feet above sea level and continuing to the top of the berm, which is 23 feet above sea level and 8 feet above the working surface of the island. The bags provide additional frictional resistance in the unlikely event of ice rideup past the 40-foot bench. The gravel bags would be used only in the upper portion of the island to avoid direct forces from ice or wave action.

The overall pipeline length from the Liberty island to the Badami tie-in would be 7.6 miles (12.2 kilometers). Table II.A-2 shows the trenching, excavation, and backfill quantities for this alternative.

This pipeline would use two ocean disposal sites, Zone 1 and 2 (Fig. II.A-18). Zone 1 is a temporary on-ice storage area. It is a contingent disposal location for excess trench materials, should weather or ice conditions cause operations to be abandoned before completion. The maximum quantity of excess trench materials stockpiled or left for disposal on this site at any one time would not exceed 10,000 cubic yards. Excess trench material in water depths greater than 16 feet would be stacked or groomed to maintain an approximate depth of less than 1 foot. Excess trench material placed where the water depths are less than 16 feet, would be stacked or groomed to a height not to exceed 2 feet. During pipeline construction, the plan is to clear excess material stacked in Zone 1 of all excess dredged material/spoils by spring breakup. This would be done by scraping the ice with heavy equipment, leaving at most a veneer of dirty ice (a very small amount of sediment remaining in the frozen matrix).

As noted in Section IV.C.1.b, the effects to several resources are the same for all of the island locations or pipelines routes. The specific components of the Liberty Island Location and Pipeline Route as described above would change the impacts to the following resources in the ways described in the analyses that follow:

- Eiders
- Marine and Coastal Birds
- Terrestrial Mammals
- Lower Trophic-Level Organisms
- Vegetation-Wetland Habitats
- Archaeological Resources
- Economy
- Water Quality

(1) Effects on Threatened and Endangered Species - Eiders

(a) Large Oil Spills

The general effects of a large spill and the effects of oil-spill-cleanup activities are analyzed in Section III.C.2.a(2)(b)1).

1) Summary and Conclusion for Effects of a Large Oil Spill on Eiders

An oil spill from Liberty Island or associated marine pipeline would have the highest probability of contacting nearshore and offshore areas of Foggy Island Bay and the eastern Sagavanirktok River Delta, where spectacled eiders may be staging before migration. Oil could contact these eiders from early June to September, although mortality from a spill that moves offshore would be difficult to estimate. Any losses would be considered a take under the Endangered Species Act. Aerial surveys conducted by the Fish and Wildlife Service from Harrison Bay to Brownlow Point located few spectacled eiders in offshore waters, except in central and western subareas; thus, a model developed by the Fish and Wildlife Service estimates very low mortality from an oil spill for this species. A spill that enters open water off river deltas in spring could contact any migrant eiders present. Recovery of the spectacled eider population from even small losses is not likely to occur quickly. Any substantial spill-related losses could have serious consequences for this population, Potentially one or two spectacled eiders and their productivity could be lost as a result of an onshore spill.

Although Fish and Wildlife Service survey data do not show a significant decline in the coastal plain spectacled eider population, a significant adverse effect would result from substantial oil spill losses , particularly from that segment nesting in the eastern portion of the range.

2) Details on How a Large Oil Spill May Affect Eiders – Specific Effects

a) Vulnerability of Eiders to Oil or Diesel Fuel Spills

The Oil-Spill-Risk Assessment model predicts relatively high probabilities of a spill from Liberty Island or from the buried pipeline contacting and entering offshore waters in Foggy Island Bay and the eastern Sagavanirktok River Delta. Spectacled eiders would be most vulnerable to a such a spill from early June to September while they were staging before migration. Locations determined from satellite-tagged individuals suggest that males migrate offshore a median distance of 6.6 (average = 10.1) kilometers and females a median distance of 16.5 (average = 21.8) kilometers (Petersen, Larned, and Douglas, 1999; TERA, 1999), There have been relatively few returns from individuals staging in nearshore areas. The Oil-Spill-Risk Assessment model estimates that the probability of contact within 30 days for oil released at Liberty Island in the summer open-water season would range from 17% in nearshore Foggy Island Bay (Land Segment 26, Environmental Resource Areas 34 and 36) to 60% in mid-bay (Environmental Resource Area 33), and 12-22% in the eastern Sagavanirktok River Delta (Environmental Resource Area 57, Land Segment 25) (Map A-2, Table A-12). These areas range from 3-10 kilometers offshore. Farther offshore, contact declines to 15% or less (Table A-12) in Environmental Resource Areas 31, 58, 37 60, 30. 39, 8, and 9 (Map A-2), which range from 13-53 kilometers offshore. Eiders may be found at any of these distances offshore. To the west, repeated satellite transmitter locations were recorded in the Simpson Lagoon and Harrison Bay areas (Petersen, Douglas and Mulcahy, 1995; TERA, 1999) where spill contact probabilities for 30 days in summer (Table A-12) are less than 10% (Environmental Resource Areas 20-24 and 48-52, Map A-3) and less than 3% (Environmental Resource Areas 14-19, Map A-3), respectively. Even such low probabilities of contact would represent significant spectacled eider losses, given the apparent importance of these two areas.

b) Mortality from an Oil or Diesel Fuel Spill

An oil spill from early June to September that reaches Foggy Island Bay and areas to the east and west could contact spectacled eiders staging before migration (Petersen, 1997, pers. commun.). Because aerial surveys in the central Beaufort Sea from Harrison Bay to Brownlow Point conducted by the Fish and Wildlife Service in 1999 and 2000 located few spectacled eiders, except in central and wetern offshore subareas, modeling efforts by Fish and Wildlife Service biologists (Stehn and Platte, 2000) yielded low estimates of exposure of birds to oil (assumed mortality). The authors state that the predictive value of their model was constrained by the incorporation of a number of important assumptions which would have considerable potential to influence the number of deaths predicted to result from the oil spill scenarios analyzed. Using average estimated bird density and average to maximum spill trajectory severity, the model estimates that numbers of spectacled eiders exposed to the larger spill would range from 2-52 in July, and 0 in August. Spectacled eider numbers on the coastal plain appear generally to be stable or declining at an insignificant rate. If oil or diesel fuel enters open water off river deltas (such as the

Kadleroshilik) in spring, or is released into it from melting ice, migrant eiders that gather in such open areas before moving to nesting areas could contact oil. Although diesel fuel is more toxic than oil, a diesel spill (estimated 1,500 barrels) is likely to contact fewer eiders than an oil spill of the same size, because it would disperse in the water and dissipate more quickly, with less than 10% remaining after 6 days.

c) Population Effects

The relatively small loss of spectacled eiders likely to result from an oil or fuel spill in the Liberty area, where so far there is little indication of large numbers gathering in offshore waters, may be difficult to separate from natural variation in population numbers (see Sec. III.c.2.a(2) eiders). Regardless of the factors involved in causing mortality, recovery of the coastal plain spectacled eider population from even small losses is not likely to occur quickly, because population increase is slow or not occurring and nesting density, and probably overall productivity, is extremely low. Losses from spill mortality, intensified by decreased productivity of nesting pairs disturbed by spill-related activities or lowered survival of any age groups, is expected to increase the length of time required for recovery to former population levels. The overall effect of any substantial spill-related losses would represent significant adverse consequences on the spectacled eider population until it recovers from its threatened status.

d) Onshore Spill

A leak in the onshore portion of the pipeline is estimated to release 720-1,142 barrels of oil. If it occurs on a pad, the extent of a spill is likely to be restricted by containment berms and procedures. If the spill occurs along the offpad portion of the pipeline, the area covered is estimated to be about 2.2-3.5 acres or 0.01 square kilometer. Limited survey data for the Kadleroshilik River area in 1994 (TERA, 1995b) indicates that eider density probably is relatively low (average 0.4 birds per square kilometer, range 0.0-1.7 birds per square kilometer) throughout the area during summer. This suggests that a spill during the breeding season may result in only one bird becoming oiled, although both members of a pair could be oiled for a brief period in June if a spill entered the area near a nest.. If strong winds occur while oil is leaking from an elevated pipeline oil may mist over a much larger area, on the order of tens of acres to over 100 acres (1 square kilometer = 247 acres) depending on the volume of oil released. Also, if the spill enters streams or lakes, a greater area could be affected as the oil spreads over a water surface or is carried down a watercourse, including areas used by broodrearing females (although no females with broods were recorded from this study area in 1994; TERA, 1995b); however, losses still are likely to be low because of generally low bird density in the area.

(b) Disturbances

The general effects of disturbances are analyzed in Section III.C.3.a.(2)(b)1).

1) Summary and Conclusion for Effects of Disturbances on Eiders

Disturbance of nesting or broodrearing eiders may result in loss of eggs or young to predators; however, displacement of more than a few eiders (or females with broods) by onshore facilities or activity is considered unlikely. Such disturbance effects would be a take under the Endangered Species Act. Because of the large amount of breeding and foraging habitat available in this region, significant effects from displacement of a few eiders away from activity sites is not considered likely. Significant adverse population effects are not expected to occur as a result of disturbance.

2) Details on How Disturbances May Affect Eiders - Specific Effects

Frequent flights over nesting or broodrearing eiders may cause them to relocate in less favorable habitat; eiders that abandon a nest probably will not renest. Females temporarily displaced from a nest by occasional onshore pipeline inspection flights may expose eggs to predation. Either situation may result in fewer young produced. Most onshore activities in the Liberty area are likely to affect at most only a few individuals. Spill-cleanup activities may disturb nesting, broodrearing, or staging eiders or juveniles occupying coastal habitats, resulting in decreased survival. Displacement of eiders from the vicinity of disturbing activities would eliminate them from only a small proportion of available similar habitat. This likely would be a minor effect, unless it results in decreased survival either by itself or in combination with other factors (see Sec.III.C.3.a(2)).

Because of the relatively large expanse of foraging habitat available within eider diving capability in the Beaufort region, the area available is not expected to be significantly decreased by disturbance of potential bottom-foraging habitat along the pipeline routes, burial at any island or gravel storage sites, or smothering of bottom organisms by sediment settling,. Likewise, the hazing displacement effect of frequent air traffic to Liberty Island (10-20 per day) is not expected to significantly decrease foraging opportunities. Displacement of eiders from limited open-water marine foraging areas following spring migration could result in more substantial effects. Development of the Liberty Prospect is expected to result in an insignificant loss of onshore habitat, which is unlikely to cause the displacement of more than one eider to an alternate nesting or broodrearing site. Routine trips by supply vessels, including an estimated 150 trips per summer (estimate 1-2 per day) within the barrier island/Foggy Island Bay area, would disrupt feeding in the area, but the disturbance probably would increase the birds’ energy use only slightly.

(2) Effects on Marine and Coastal Birds

(a) Large Oil Spills

The general effects of a large spill and the effects of oil-spill-cleanup activities are analyzed in Section III.C.2.c(2)(a).

1) Summary and Conclusion for Effects of a Large Oil Spill on Marine and Coastal Birds

A large oil spill from Liberty Island or associated marine pipeline would have the highest probability of contacting nearshore and offshore areas of Foggy Island Bay and the eastern Sagavanirktok River Delta where **waterfowl** and other aquatic birds may be molting or staging before migration. Mortality from a spill contacting **long-tailed ducks** in lagoons or other protected nearshore areas where the entire regional population molts is estimated to exceed 1,200 individuals (equivalent to about 1% of the average coastal plain population) at average bird densities. Total kill potentially could exceed 10% of this population, if oil were to contact areas of high bird density. A model developed at the Fish and Wildlife Service estimates mortality exceeding 1,400 individuals at average bird densities. The minimum estimate above would represent a significant adverse effect on population numbers and productivity, especially if many of those molting in this area come from declining subpopulations. **Long-tailed duck** mortality from spill contact outside barrier islands is likely to be considerably lower than this number due to low bird density. Oil could contact flocks of **king** and **common eiders** offshore from mid-June to September, although mortality from a spill that moves offshore would be difficult to estimate. **King** and **common eider** populations have declined 50% in the past 20 years, and substantial oil-spill mortality would aggravate this effect, and represent a significant impact for the common eider population. For most species, the relatively small losses likely to result from a spill may be difficult to separate from natural variation in population numbers, but their populations are not expected to require lengthy recovery periods. Species that are declining in numbers, such as **king** and **common eiders** and **red-throated loon**, or have limited capacity for population growth such as **loons** and **seaducks**, are expected to recover from oil spill mortality slowly. A spill that enters open water off river deltas in spring could contact migrant **loons**, **swans**, **long-tailed ducks**, **eiders**, **glaucous gulls**, and **arctic terns**. Some of the several hundred **brant** and **snow geese** present in this area could contact oil in coastal habitats. Also, several thousand **shorebirds** could ecounter oil in shoreline habitats, and rapid turnover during migration suggests many more could be exposed. An onshore pipeline spill in summer probably would affect only a few nests, even considering all species. If the oil spread to streams and lakes, **long-tailed ducks**, **brant**, and **greater white-fronted geese** that gather on lakes to molt could be adversely affected in larger numbers. Losses of oiled birds in this case could range up to a few hundred individuals, a minor effect for species (for example, northern pintail, geese, glaucous gull, most shorebirds, songbirds) whose populations are relatively abundant and stable or increasing.

2) Details on How a Large Oil Spill May Affect Marine and Coastal Birds - Specific Effects

a) Vulnerability of Birds to Oil or Diesel Fuel Spills

The Oil-Spill-Risk Assessment model predicts relatively high probabilities of a spill from Liberty Island or from the buried pipeline contacting and entering offshore waters in Foggy Island Bay and the eastern Sagavanirktok River Delta. **Waterfowl** and other aquatic birds are most vulnerable to a such a spill while occupying shoreline habitats, lagoons, or other nearshore waters. After nesting in tundra habitats is completed, many **shorebirds** and **waterfowl** move to coastal feeding areas from mid-June through September to rear their broods, molt, and put on fat reserves for migration. The Oil-Spill-Risk Assessment model estimates that the probability of contact within 30 days for oil released from Liberty Island or subsea pipeline in the summer open-water season (Tables A-12, -13) would range from 17-26% in nearshore Foggy Island Bay (Land Segment 26, Environmental Resource Areas 34 and 36) to 12-22% (Sagavanirktok River Delta, Land Segment 25, Environmental Resource Areas 27 and 57; Map A-2, Table A-12). These areas range from 3-10 kilometers offshore. Farther offshore, contact declines to 15% or less (Table A-12) in Environmental Resource Areas 31, 58, 37 60, 30. 39, 8, and 9 (Map A-2), which range from 13-53 kilometers offshore. Substantial numbers of **loons**, **waterfowl**, **phalaropes** and **seabirds** can be found at any of these distances. Offshore near Liberty Island (Environmental Resource Areas 33, 35), the model estimates that probability of spill contact is 34-60% (Table A-12). **Gulls**, **ravens**, **sea ducks**, and **phalaropes** would be vulnerable to a spill here if they are attracted to Liberty Island.

b) Mortality from an Oil or Diesel Fuel Spill

The effect of substantial oil-spill losses on populations that have undergone recent declines (**long-tailed duck**, **king** and **common eiders**, and **red-throated loon**) may interfere with their recovery from oil spill-related mortality. Such mortality of long-tailed ducks and common eiders would represent a significant effect. Impacts on these declining species are expected to be greater than for most other species (for example, **northern pintail**, **geese**, **glaucous gull**, most **shorebirds**, **songbirds**) whose populations are stable or increasing. Losses by the latter groups from an oil spill are not expected to require lengthy recovery periods.

An oil spill that reaches shoreline habitats in Foggy Island Bay and areas to the west in July or August would contact some of the several hundred broodrearing **brant**, **snow geese**, or **tundra swans**, and staging or molting birds (Johnson, 1991; Stickney and Ritchie, 1996). Staging **shorebirds** also are vulnerable in these habitats. For

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example, the numbers of post-nesting **shorebirds** on the Sagavanirktok and Colville River deltas may range from 62-150 birds per kilometer of shoreline and as high as 800 birds per square kilometer (Andres, 1994; Troy, 1982). If oil spreads along 21-30 kilometers of shoreline (Table A-7), it could be encountered by several thousand shorebirds. Many more may be exposed to oil because turnover of the migrating populations in a given area may occur every 7 days, continuously exposing new arrivals (Andres, 1994).

In lagoons and other nearshore waters, large numbers of **long-tailed duck** and smaller flocks of other **waterfowl** and **phalaropes** are likely to be present in July or August . Densities of 40-275 **long-tailed ducks** per square kilometer (Map 6) have been observed in lagoons to the east and west of Liberty (Noel, 1999). Such values suggest a spill that enters a barrier island lagoon or bay during those months could kill in the range of 1,204-12,365 birds in the area traveled by a slick in 10 days (discontinuous area = 30-45 square kilometers, Table A-7). This would represent a significant loss (1-11% of the 14-year average estimated Arctic Coastal Plain population from breeding pair surveys = 115,515; Mallek and King, 2000). Modeling efforts by Fish and Wildlife biologists (Stehn and Platte, 2000), using average estimated bird densities derived from Fish and Wildlife Service aerial survey counts in the central Beaufort Sea area (Harrison Bay to Brownlow Point) in 1999 and 2000 and average to maximum spill trajectory severity, the model estimates that numbers of **long-tailed ducks** exposed to a large spill would range from 1,443-6,498 in July, and 2,062-13,281 in August (representing 1-12% of average coastal plain population).

Counts of **King eiders** and **common eiders** migrating past Point Barrow have declined by about 50% since 1976 (Suydam et al., 1997). Thus, substantial oil-spill mortality in either species could result in a serious long-term population effect (Dickson, 1997; U.S. Army Corps of Engineers, 1998). Using Fish and Wildlife Service average estimated bird density and average to maximum spill trajectory severity, the model estimates that the highest numbers of **king eider** exposed to a large spill would range from 232-3,102 in July. The highest numbers for **common eider** in August would range from 125-1,272, representing up to 19% and 86% of the populations surveyed in this central Beaufort Sea area, a significant effect. Exposure of **king eiders** to oil determined by the model was relatively low due to their offshore distribution. The uncertainty of final model estimates of numbers of birds exposed to oil include errors inherent in estimating numbers of birds present in or passing through a prescribed area during aerial surveys performed at one point in time, turnover rates (duration of time a bird spends on the water at a specific site), and whether the sampled areas accurately represent all areas occupied by birds. A spill entering an offshore lead during the spring migration period potentially could contact many more individuals than predicted by the Fish and Wildlife Service model, if it were used as a resting area for large flocks of migrating **king eiders,** as noted by Divoky (1984).

c) Onshore Spill

A 720-1,142 barrel onshore pipeline spill in summer probably would contact no more than a few acres, because of containment structures and procedures. Based on an estimated 72 nests per square kilometer (all species, including **waterfowl**, **shorebirds**, and **Lapland longspurs**) in a Kadleroshilik study area (TERA, 1995b), probably only one or two nest sites would be affected, although many individuals of various species traversing such an area over time could be affected. If the oil spread to aquatic habitats (lakes, ponds, and streams), especially **long-tailed duck**, **brant**, and **white-fronted geese** that gather on large lakes to molt could be affected. Such habitats also are used by substantial numbers of broodrearing **waterfowl** and **shorebirds**. Losses of oiled birds in this case could range up to a few hundred individuals, a minor effect for species whose populations are relatively abundant and stable or increasing.

(b) Disturbances

The general effects of disturbances are analyzed in Section III.C.3.c(2)(a).

1) Summary and Conclusion for Effects of Disturbances on Marine and Coastal Birds

Helicopter flights to Liberty Island may disturb some **loons** and **king** or **common eiders** feeding in open water off the Sagavanirktok River Delta during breakup or displace some **long-tailed ducks** and **eiders** from preferred marine foraging areas in summer, adversely affecting fitness. **Snow goose** and **brant** family groups could be displaced from coastal broodrearing areas, but alternative sites generally are available. Disturbance of nesting or broodrearing **waterfowl**, **shorebirds**, or **songbirds** may result in loss of eggs or young to predators; however, displacement of more than a few individuals (or females with broods) by onshore facilities or activity is considered unlikely. Spill-cleanup activities may displace some nesting, broodrearing, juvenile, or staging **waterfowl** and **shorebirds** from preferred habitats, resulting in lower fitness. The small losses and displacements likely to result from the above activities are expected to cause minor changes in numbers, and are not expected to require lengthy recovery periods. Any mortality resulting from the Liberty Project would be additive to natural mortality, and may interfere with the recovery of Arctic Coastal Plain populations should declines in these species (for example, **king** and **common eiders**) take place. Significant adverse population effects are not expected to occur as a result of disturbance.

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2) Details on How Disturbances May Affect Marine and Coastal Birds - Specific Effects

a) Effects from Aircraft Operations

During breakup helicopters may displace migrant **waterfowl** and **loons** from open-water foraging areas off the Sagavanirktok Delta, causing them to relocate to other areas of limited availability and potentially result in decreased survival. In July and later, birds foraging in offshore areas also could be displaced, but because displacement would eliminate a relatively small proportion of available foraging habitat effects are likely to be minor.

Frequent helicopter flights over nesting, broodrearing, or juvenile **waterfowl** and **shorebirds** on tundra and the Sagavanirktok River Delta or other coastal habitats may cause them to relocate in less favorable habitat. **Snow geese** at the Howe Island colony and **brant** on the delta are particularly sensitive to disturbance by aircraft, but planned flight precautions should lessen the effects on these and other species occurring in the same areas. Helicopters that fly at low altitudes during weekly inspections of the 1.5-mile onshore pipeline could displace nesting **shorebirds**, **passerines**, and **waterfowl** from areas near the pipeline for up to several hours. Temporary displacement of adults from nests may expose eggs or nestlings to predators, resulting in fewer young produced. For example, this could involve 2.4 **Pacific loon**, 3.1 ,long-tailed duck 29.0 **pectoral sandpiper**, and 60.4 **Lapland longspur** nests if a 0.5 km zone of disturbance on either side of the pipeline is assumed (calculated From TERA, 1995b). Any of these results may cause local declines in the number of young produced. However, most onshore activities in the Liberty area are likely to affect relatively few individuals given the small area and low nesting density likely to be involved, and effects are likely to be minor.

b) Effects from Construction and Vehicle Traffic

Construction of two small pads and pipeline and vehicle traffic in winter mainly would displace a few **ptarmigan** from the immediate work area or route of ice roads. We expect this effect to be negligible compared to seasonal changes in distribution. If open water occurs on the lee side of the production island, spring migratory **waterfowl** may use it as staging and foraging habitat.

c) Effects from Vessel Traffic

Supply vessels probably would disrupt local birds feeding near any routinely used route, a minor effect since alternate foraging areas are available. Also, long-tailed ducks were not seriously affected by systematic boat disturbance in Simpson Lagoon (Johnson and Richardson, 1981).

d) Effects from Spill Cleanup

Spill cleanup in coastal areas or on barrier islands may cause significant disturbance if it occurs while **waterfowl** or **shorebirds** are nesting, broodrearing, molting, or staging for migration, or juveniles are occupying coastal habitats. Predators may take some eggs or young while adults are displaced off their nests, and birds disturbed often during this activity may have lowered reproductive success or survival.

e) Effects from Disturbance of Habitats

Offshore construction would bury about 331acres of potential sea duck bottom foraging area, representing a very small proportion of the area where such habitat is available, and is expected to have a minimal effect on food intake by birds. Construction of small gravel pads where the pipeline comes ashore and connects to the Badami pipeline would bury less than 1 acre of tundra habitat. Such habitat is widespread in the area, so the few **shorebirds** and/or **songbirds** displaced (all species combined = 0.28 nests per square kilometer; TERA, 1995b) would have ready access to comparable nesting sites. Gravel mining is likely to displace only a few individuals from the mine-site vicinity. These losses are likely to represent a negligible reduction of available habitat.

(3) Effects on Terrestrial Mammals

(a) Large Oil Spills

The general effects of a large spill and the effects of oil-spill-cleanup activities are analyzed in Section III. C.2.d(2)(a).

1) Summary and Conclusion for Effects of a Large Spill on Terrestrial Mammals

Crude oil or diesel fuel is most likely to contact some coastal areas from the Sagavanirktok River Delta east to Mikkelsen Bay, regardless of which spill scenario is assumed (Table A-13; Land Segments 25, 26, and 27). Caribou may use some of these areas for relief from insects. The main potential effect on terrestrial mammals that contact spilled oil could be the loss of fewer than 100 caribou and a few muskoxen, grizzly bears, and arctic foxes. These losses are expected to be replaced by normal reproduction within about 1 year. A 1,500-barrel onshore pipeline spill could occur and oil less than 5 acres of vegetation along the pipeline landfall to the Badami tie in. Such a spill is not expected to directly affect caribou or other terrestrial mammals and would cause very minor ecological harm.

Secondary effects could come from disturbance associated with spill-cleanup activities and temporary local displacement of some caribou, muskoxen, grizzly bears, and foxes. These activities, however, would not affect the terrestrial mammals' movements or overall use of habitat. The general effects of a large spill and the effects of oil spill cleanup activities are analyzed in Section III.C.

2) Details on How A Large Spill May Affect Terrestrial Mammals

Specific Effects: Caribou, muskoxen, grizzly bears, and arctic foxes may frequent coastlines near the Liberty Project. The Oil-Spill-Risk Assessment model estimates an 11-26% chance of a spill starting at the Liberty location (L1) and contacting land along the coast of Foggy Island Bay-Mikkelsen Bay within 30 days during the summer open-water season (Tables A-13, Land Segments 25, 26, and 27). Overall, the Oil-Spill-Risk Assessment model estimates that there is an 87% chance that a spill starting at Liberty Island or along the buried pipeline contacts the shoreline (Table A12, contact to Land within 30 days during the summer). The Liberty Project is unlikely to produce a spill that would contact coastal areas east of there, such as Flaxman Island. Some Central Arctic Herd caribou could contact oil in coastal habitats from the Sagavanirktok River (east of Endicott causeway) east to about Mikkelsen Bay. Caribou move into these areas to escape insects. Even in a severe situation, however, fewer than 100 animals from the Central Arctic Herd (out of a population of 18,000) are likely to get the oil on their coats and die by inhaling and absorbing toxic hydrocarbons. We base this number on summer surveys of the caribou seen in marine waters (Pollard and Ballard, 1993). Normal reproduction is likely to replace this loss within about 1 year. Caribou could be scared away from the spill area by helicopters during cleanup; however, poor weather conditions may prevent helicopters from hazing caribou away from the spill.

A 1,500-barrel diesel spill would dissipate quickly and likely would not persist beyond about 6 days. The number of caribou and other terrestrial mammals affected is likely to be lower than that affected by a crude oil spill of the same size. The terrestrial mammal populations are expected to recover within 1 year.

(b) Disturbances

The general effects of disturbances are analyzed in Section III.C.3.d(2)(a).

Helicopter and ice-road traffic, encounters with people, and mining and construction operations could disturb individual or small groups of these mammals for a few minutes to a few days or no more than about 6 months within about 1 mile of these activities. These disturbances would not affect populations. This traffic could briefly disturb some caribou, muskoxen, and grizzly bears, when the aircraft pass overhead or nearby, but would not affect terrestrial mammal populations.

Traffic for constructing the ice roads, production island, pipeline, and gravel pads and to haul gravel and supplies could disturb some caribou and muskoxen along the ice roads during the 2 years of development and during other winters, when further work on the project is needed. This traffic would occur during December though early May, with more ice-road construction and traffic occurring during the 2 years of development. Some continued ice-road activity would occur during the 15 years of production to support project operations. These disturbances would have short-term effects on individual animals and would not affect populations. The general effects of disturbances are analyzed in Section III.C.

(4) Effects on Lower Trophic-Level Organisms

(a) Large Oil Spills

The general effects of a large spill and the effects of oil-spill-cleanup activities are analyzed in Section III.C.2.e(2)(a).

Lower trophic-level organisms would be affected by a large oil spill. It would have only short-term effects on plankton, including phytoplankton, zooplankton, and epontic species on the bottom of the ice cover, but longer term effects on the fouled coastlines. As documented in Section III.C.2.e(2)(c) and Appendix A, up to 15% of the sound’s coastline would be affected by a large spill. While the ice-gouged coastline is inhabited by mobile, seasonal invertebrate species that would recover within a year, fractions of the oil would persist in the sediments for about 5 years in most areas, and could persist up to 10 years in areas where water circulation is reduced. Very little of Liberty crude, which is highly viscous and particularly resistant to natural dispersion, would be dispersed down in the Stefansson Sound water column and affect deep benthic communities such as the Boulder Patch kelp habitat. However, diesel oil, which would be used on the island for startup and emergency fuel, could be dispersed down to the seafloor. If 1,500 barrels of diesel were spilled from a fuel-delivery barge at the island during the open-water season, the concentration would be toxic within an area of about 18 square kilometers (7 square miles), as noted in the water quality section (III.A.2 (l)). Such toxicity would probably stunt the seasonal growth of kelp plants and reduce the population size of associated invertebrates for several years. Oil-spill responses in general would have both beneficial effects of some and adverse effects on other lower trophic-level organisms.

(b) Disturbances

The general effects of disturbances are analyzed in Section III.C.3.e(2)(a).

1) Summary and Conclusions for Effects of Disturbances on Lower Trophic-level Organisms

Alternative I would disturb lower trophic-level organisms in two primary ways: (1) pipeline trenching would bury up to 14 acres with very low (1%) coverage of kelp, boulders and suitable substrate, and (2) sediment plumes would reduce Boulder Patch kelp production by up to 6% during one year. The buried 14 acres would equal less than 0.1% of the Boulder Patch kelp habitat. The density of the kelp, boulders and suitable substrate in the pipeline corridor is very low, averaging about 1% coverage, and the lost kelp biomass and production probably would be less than .01% of the Boulder Patch totals, but the effect (substrate burial) would last forever.

Some of the suspended sediment from pipeline trenching and island construction would drift over other parts of the Boulder Patch, reducing light penetration and kelp production during 1 year. This reduction is estimated to be less than 6%, about one-third of which would be due to the proximity between the Boulder Patch to the Zone 1 disposal area for excess sediments. However, in relation to the large range of natural variability, all of these suspended sediment effects would be barely detectable.

From 6 feet deep to the seafloor, the island's concrete slope would temporarily benefit kelp and other organisms that need a hard substrate for settlement. This portion of the concrete slope would be a temporary home for colonies of species similar to those of the Boulder Patch area. Upon abandonment, the concrete mats would probably be removed or would become buried naturally, eliminating the additional kelp habitat.

2) Details on How Disturbances May Affect Lower Trophic-Level Organisms

a) Specific Effects from Island Construction

Construction of Liberty Island would alter the seafloor habitat permanently and would kill the benthic animals living there. Underwater surveys show the seafloor at the Alternative 1 site is silty mud and contains less than 10% rock cover, similar to most of the Beaufort Sea's floor (Fig. III.C-1). Placing gravel to construct Liberty Island would kill the benthic invertebrates occupying about 28 acres of this habitat. Similar amounts of benthos were buried during construction of several exploration islands in Stefansson Sound during the past two decades, including Tern, Duck, Endeavor, BF-37, Niakuk, Goose, and Sag islands. The 28 acres would be relatively small compared to the area that was affected by the Endicott causeway and Northstar pipeline that were constructed within this same region and depth range. Liberty Island construction effects should be similar to the concluding statements in the Northstar EIS about the project effect on benthic infaunal and epifaunal invertebrates aside from those in the Boulder Patch kelp community:

> The trenching for the pipeline will impact both infauna and epifauna through direct physical disturbance, burial with sediment, or from increased turbidity in the surrounding water. Trenching the shallow waters of the lagoon would have a negligible effect on benthic invertebrates. Impact to marine invertebrates in deeper waters would be considered minor because of the rapid recolonization and geographic range of these species (U.S. Army Corps of Engineers, 1999:6-29).

Island construction also would increase the amount of under-ice suspended sediment in the water column. Because of the prevailing under-ice currents in this area, a sediment plume from island construction would drift east or west in line with the isobaths. If the plume drifted west, it would drift over the kelp in the Boulder Patch, depositing a thin blanket of sediment over the kelp and reducing the amount of light for growth (Fig. III.C-2). An under-ice plume from construction that drifted west toward the Boulder Patch probably would affect up to 105 acres (BPXA, 1998a:p. 5-8). Because the more productive rocky areas are widely scattered, the plume is likely to affect less than 105 acres of productive Boulder Patch habitat. The heavier sediments should settle out within one-half mile of the island and are not expected to reach the Boulder Patch. Sediments larger than clay-sized particles are likely to settle out within 3-7 miles of the construction area (USDOI, MMS, Alaska OCS Region, 1998a:8). Sediments that reach the Boulder Patch are likely to reduce the amount of light for marine kelp living in rocky bottom areas. This was the primary concern regarding the health and growth of Boulder Patch kelp communities during winter (USDOI, MMS, Alaska OCS Region, 1998a).

Storms and river discharges place a lot of sediment into the waters of the Boulder Patch area. These discharges, plus variations in snow cover, annually make up to two-thirds of the winter ice in this area uninhabitable for ice algae (there is not enough light). This results in naturally fluctuating growth rates for Boulder Patch kelp communities. The plume from construction could reduce kelp growth in some rocky bottom areas where clear-ice conditions exist. This possibility was considered in a recent analysis by Gallaway, Martin, and Dunton (1999:16-18), which is based partly on field observations during construction of the BF-37 gravel island. They concluded that under worst-case conditions:

- Island construction may reduce kelp production in the Boulder Patch by 2%.
- No changes are expected in the health or distribution of Boulder Patch communities.
- The effects of island construction would be limited to 1 year and would constitute short-term impacts.

We believe that the above conclusions are conservative, and that they were based on the appropriate model methods, calculations, and assumptions. Hence, any effects due to island construction are expected to fall within the range of natural variation for Boulder Patch kelp communities. Any reduction in the amount of light due to island construction is expected to be very small and is not expected to have a measurable effect on kelp communities in the Boulder Patch. Any sediment accumulating on kelp from construction would probably be washed away by currents, as observed natural sediment accumulations.

b) Specific Effects from Pipeline Construction

Pipeline construction would involve about 6 miles of trenching and backfilling in marine waters along the pipeline corridor. There would be alternative-specific effects from both suspended sediments and trenching.

Suspended Sediments: Pipeline construction also would increase the amount of suspended sediment in the water column during winter trenching and backfilling (Fig. III.C-3) and during the natural dispersal at breakup of any excess sediment that is stored on the ice (Fig. III.C-4 and -5). The dense part of the plume is predicted to move less than 1,000 feet along-shore to the west or east, as indicated partly by BP measurements during preparation of the Northstar test trench. The plume from pipeline construction could reduce kelp growth in some rocky bottom areas where clear-ice conditions exist. This scenario was considered also by Gallaway, Martin, and Dunton (1999) and Ban et al. (1999). They concluded that under worst-case conditions:

- Suspended sediments from pipeline trenching may reduce kelp production in the Boulder Patch by 4% (Fig. III.C-1), and the excess-sediment stockpiled on the ice cover (Fig. III.C-5) may reduce it by another 2%. In other words, about one-third of the effect would be due to the proximity between the Boulder Patch and disposal zone.
- No changes are expected in the health or distribution of Boulder Patch communities.
- The effects from construction would be limited to 1 year and would constitute short-term impacts.
- The effects of pipeline repair, if necessary, probably would be site specific and less than the construction effects.

The effects would probably be less than these worst-case predictions, as indicated by some recent field measurements during construction of Northstar pipeline in late April 2000 (Trefry, 2000, pers. commun.). The measurements were made at six sites in the Northstar area, two of which were within a couple hundred meters east and west of the pipeline corridor while the trench was being backfilled. The measurements included three water samples and a turbidity profile at each site. In spite of the backfilling, the sampled water appeared to be low with less than 0.5 milligrams per liter of sediment 2000 (Trefry, 2000, pers. commun.).

One reason that the measurements were lower than the predictions is that some of the dredged sediment probably froze before it was used as backfill over the pipeline. Hence, any effects due to suspended sediments from pipeline construction are expected to fall within the range of natural variation for Boulder Patch kelp communities.

Trenching: Some benthic plants and animals would be disturbed by pipeline trenching (Sec. II.A.1.b (3)(a)(4)). Most of the seafloor in the project area is covered with sandy/silty sediments that are disrupted naturally by the ice cover and strudel scour (BPXA, 1998a:4.6). The resident organisms in the silty/sandy sediments generally are small and short-lived, and Liberty pipeline trenching effects should be similar to those in the Northstar Final EIS that "natural re-population of the trench area by infaunal invertebrates is expected within a few years" (U.S. Army Corps of Engineers, 1999:6-26).

The BPXA Environmental Report also describes the Boulder Patch and the diverse community of organisms associated with the kelp and solid substrate. The report notes that there is diffuse kelp and solid substrate in the outer section of the pipeline corridor (BPXA, 1998a:4.6.3 and 5.2.5). The kelp and solid substrate occurs in a 4,700-foot section that is diagramed in Figures III.C-1and 5, Surveys for Boulders and Kelp. A similar map was prepared for a BPXA report on construction effects on Boulder Patch kelp production (Ban et al., 1999); the map clarifies the location and distribution of dense kelp near the Alternative 1 island site. The band's location and distribution indicate that the light kelp that is illustrated in Figure III.C-1 probably is the shoreward, marginal end of the dense band that is illustrated in the report by Ban et al. (1999). The map that was prepared by Ban et al. is redrawn as Figures III.C-2 through 4 and is used as the base map for our assessment of alternatives.

After the Environmental Report was prepared (BPXA, 1998ba, additional side-scan and video surveys were conducted along the 4,700-foot section. The investigators summarized the preliminary results during the MMS Arctic Kelp Workshop in May 1998 (USDOI, MMS, Alaska OCS Region, 1998a), and the final results were summarized in a July 1998 report to BPXA (Coastal Frontiers Corp., 1998). The report explains that the video detected scattered bivalve shells, pebbles, and rocks, some of which were found to have small pieces of kelp attached. It also explains that the "concentrations of these objects appeared to represent less than 1% of the sea bottom in most instances, and in no case greater than 2%" (Coastal Frontiers Corp., 1998:16). Figure III-C.2 shows that the distance to a portion of the Boulder Patch with a concentration over 10% is at least 1,600 feet (500 meters). So, the average density of kelp and solid substrate in the 4,700-foot long section was assumed to be 1% for the following assessment of trenching effects.

The width of the area that would be disturbed by trenching would be related mainly to the amount of slumping on the sides of the trench. The Development and Production Plan explains that the slump or slope angle would be 3:1 typically (extending three times the trench depth to each side) but that the excavation limits could be up to 5:1 in unconsolidated sediments (Fig. II.A-12 and BPXA, 2000a:Fig. 8-4 and p. 71). The 5:1 ratio means that the overall disturbed area could be up to 10 times the trench depth plus the bottom width of the trench. Therefore, the bottom of the trench for Alternative 1 would be up to 12 feet deep and 12 feet wide (Fig. II.A-12 and Table II.A-1), and the overall width at the top would be up to 132 feet.

The boulders with kelp near the center of the Boulder Patch lie at the sediment surface in a layer that is very thin, "no more than one boulder thick" (Dunton, Reimnitz, and Schonberg, 1982). We assume that the solid substrate with

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kelp that lies in the pipeline corridor is no different, that it also lies at the sediment surface in a layer that is very thin. After trenching, if the solid substrate could be returned to the sediment surface, it probably would be recolonized by kelp in a decade (Martin and Gallaway, 1994). However, the operation probably could not return the kelp and solid substrate to the sediment surface, and the only natural process that might return it to the surface would be gradual erosion over geological time scales.

In summary, trenching would bury up to 611,000 square feet or 14 acres of kelp and solid substrate at very light densities. The 14 acres can be compared with the total area of the adjacent Boulder Patch. The area in which kelp and solid substrate exceed 10% coverage recently was estimated as 64 square kilometers, or 15,871 acres (Ban et al., 1999). Therefore, the buried 14 acres would equal less than 0.1% of the Boulder Patch area. Furthermore, the concentration of kelp in the Boulder Patch is more than 10 times that in the pipeline corridor, so the lost kelp biomass and production probably would be less than 0.01% of the total.

The burial of kelp and solid substrate in the pipeline corridor would be mitigated partly by a countervailing effect—the creation of a new kelp habitat on the concrete blocks in the island's slope-protection system (Sections III.C.1.b(5) and III.D.3.e(2)(a)). The concrete blocks below the ice-scour depth (6 feet) would add about 3 acres of kelp habitat. However, this new kelp habitat might be temporary because the slope-protection materials might be removed during the abandonment phase in 15-20 years, as noted in Section 3.C.3.e(2)(b) of this EIS and Section 15 of the Development and Production Plan (BPXA, 2000a). BPXA could also mitigate some trenching effects if excess quarry boulders were placed on the backfill in the outer portion of the trench. The quarry boulders would probably reduce the longevity of trenching effects from permanent ones to decade-long ones because a Boulder Patch study showed that bare rocks were colonized by kelp within a decade. Future unanticipated effects on kelp could be moderated by Lease Sale Stipulation No. 1, Protection of Biological Resources. The stipulation explains that MMS may require additional biological surveys and, based on the surveys, may require the lessee to "modify operations to ensure that significant biological populations or habitats deserving protection are not adversely affected."

(5) Effects on Essential Fish Habitat

The general effects of a large spill and the effects of oil-spill-cleanup activities are analyzed in Section III.C.2.f(2) and the general effects of disturbances are analyzed in Section III.C.3.f(2). As a result of disturbances caused by Liberty Island construction and operation, fish and zooplankton might experience short-term, localized but unmeasurable effects.

(6) Effects on Vegetation-Wetland Habitat

(a) Large Oil Spills

The general effects of a large spill and the effects of oil-spill-cleanup activities are analyzed in Section III.C.2.g(2)(a).

1) Summary and Conclusion for Effects of a Large Spill on Coastal and Onshore Vegetation-Wetland Habitats

The main potential effects of a large offshore spill on vegetation and wetland include oil-fouling, smothering, asphyxiation, and poisoning of plants and associated insects and other small animals. In this case, complete recovery of moderately oiled wetlands of the Sagavanirktok River east to Mikkelsen Bay would take perhaps 10 years or longer. A second main effect is the disturbance of wetlands from cleanup activities. Complete recovery of heavily oiled coastal wetlands from these disturbances and oil could take several decades.

A large onshore spill would oil no more than 5 acres of vegetation along the pipeline landfall to the Badami tie-in would cause very minor ecological harm. Oiled vegetation should recover within a few years but may take more than 10 years to fully recover. The general effects of a large spill and the effects of oil spill cleanup activities are analyzed in Section III.C. The general effects of a large spill and the effects of oil spill cleanup activities are analyzed in Section III.C.

2) Details on How a Large Oil Spill May Affect Vegetation-Wetlands Habitats

a) Specific Effects of a Large Onshore Spill

We assume that if a large onshore pipeline spill occurred, it would oil less than 5 acres of vegetation along the pipeline landfall to the Badami tie-in. Such an onshore spill likely would occur on the gravel pad near the tie-in location and should have only a minimal effect on vegetation. About 20-35% of past crude oil spills reached areas beyond the pads (USDOI, BLM and MMS 1998). Because winter spans most of the year, spills happen about 60% of the time when workers can clean up oil on the snow cover before it reaches the vegetation (USDOI, BLM and MMS 1998). Most spills cover less than 500 square feet, or 0.01 acres, but may cover up to 4.8 acres if the spill is a windblown mist. Overall, past spills on Alaska's North Slope have caused minor ecological damage, and the ecosystem has shown a good potential for recovery (Jorgenson, 1997).

Rehabilitation of an oiled site on the Kuparuk oil field has resulted in the robust growth of grasses-sedges within 2 years, but recovery of shrubs has been slow—up to 7 years after the spill (Cater, Rossow, and Jorgenson, 1999).

b) Specific Effects of a Large Offshore Spill

The spill assumed to occur at Liberty Island or from the buried pipeline and enter offshore waters would contact coastal areas within 30 days from the Sagavanirktok River Delta and Endicott causeway east to Mikkelsen Bay, regardless of which spill scenario is assumed (Table A-1). These areas include wetlands and other vegetation cover (estimated 21-45 kilometers of coastline oiled from a crude oil spill Table A-7). We focus on effects expected should a spill contact vegetation and wetlands within 30 days during summer.

The conditional probability of an oil spill starting at Liberty Island or along the pipeline and contacting vegetation within 30 days during the summer open-water season are highest with wetlands in the Foggy Island Bay area west to the Sagavanirktok River Delta. The Oil-Spill-Risk Assessment model estimates an 11-26% chance of a spill starting at Liberty Island or subsea pipeline and entering offshore waters contacting land segments 27, 26, or 25 (Tables A-13 and A-19). Overall, the model estimates that there is an 87% conditional probability that a spill starting at Liberty Island (L1) or along the pipeline (P1 or P2) would contact land somewhere along the coast within 30 days during the summer (Table A-12 Land, all land segments, Map A-1). The spill could oil an estimated 21-30 kilometers of shoreline (Table A-7) and extend inshore a few feet to several yards, depending on tides and storm surges. A 1,500-barrel diesel spill would dissipate quickly and would not be expected to persist beyond about 6 days. The amount of wetlands contacted by diesel fuel is expected to be less than that contacted by crude oil. Coastal areas to the east, such as the Camden Bay shoreline, are unlikely to see oil spilled from the project area (1-2% conditional probability that a spill starting at Liberty Island (L1) or along the pipeline (P1 or P2) and contacting Land Segments 31-33, Tables A-13 and A-19, Map A-1). The shoreline of the Liberty Project area contains habitats with fairly high values (1 being the lowest and 10 being the highest) for oil-spill retention (lagoonal beaches have a value of 5 and peat shores have a value of 6) along the eastern Sagavanirktok River Delta and near the mouth of the Kadleroshilik River (Nummedal, 1980). Stranded oil on sheltered intertidal areas, especially along peat shorelines, is likely to persist for many years (Nummedal, 1980; Owens et al., 1983). Complete recovery of moderately oiled wetland in the Sagavanirktok River, Foggy Island Bay, and Mikkelsen Bay shorelines would take up to perhaps 10 years for crude oil and probably less than 5 years for diesel fuel.

(b) Disturbances

The general effects of disturbances are analyzed in Section III.C.3.g(2)(a). Disturbances mainly come from constructing gravel pads and ice roads and installing the onshore pipeline and tie-in with the Badami pipeline. Gravel pads, pipeline trench, and the 1.4-mile-long onshore pipeline would destroy only 0.8 acres of vegetation and affect a few acres of nearby vegetation and have only local effects on the tundra ecosystem. Ice roads would have local effects (compression of tundra under the ice roads) on vegetation, with recovery expected within a few years, and no vegetation would be killed. The construction and installation of the onshore pipeline and gravel pad on State land will be required to have a Section 404/10 permit and approval by the Corps of Engineers, as stated in the Liberty Development Project Development and Production Plan (BPXA, 2000a). The permit and approval process is expected to minimize adverse effects on wetlands.

(7) Effects on the Economy

The general effects of a large spill and the effects of oil-spill-cleanup activities are analyzed in Section III.C.2.k and the general effects of disturbances are analyzed in Section III.C.3.k. The Liberty Project would generate approximately the following economic benefits related to Alternative III:

- $100 million in wages and 870 full-time equivalent construction jobs for 1 year in Alaska during 14-18 months of construction;
- 1,248 indirect full-time equivalent jobs during the 14-18 months of construction; and
- $480 million capital expenditure.

(8) Effects on Water Quality

(a) Large Oil Spills

The general effects of a large spill and the effects of oil-spill-cleanup activities are analyzed in Section III.C.2.l(2)(a).

During open water, hydrocarbons dispersed in the water from a large (greater than 500 barrels) crude oil spill could exceed the 0.015-parts per million chronic criterion for 10-30 days in an area that ranges from 30-45 square kilometers (11.6-17.4 square miles) to 51-186 square kilometers (19.7-71.8 square miles). Hydrocarbons in the water could exceed the 1.5-parts per million acute (toxic) criterion during the first day in the immediate vicinity of the spill. A large crude oil spill in broken sea ice or when the sea ice melts could exceed the chronic criterion for several days in an area of about 7.6 square kilometers (2.9 square miles). Hydrocarbons from a large diesel spill during open water could exceed the acute (toxic) criterion for about 7 days in an area of about 18 square kilometers (7 square miles). During broken sea ice or melting ice conditions, a large diesel spill could exceed the acute (toxic) criterion for about 1 day in an area of about 1 square kilometers (0.4 square miles) and the chronic criterion for more than 30 days in an area of about 103 square kilometers (39.8 square miles). The effects from a spill occurring under the ice would be similar to those described for broken ice or melting conditions; the oil would be trapped and essentially remain unchanged until breakup occurred and the ice began to melt.

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A large crude or refined oil spill (greater than or equal to 500 barrels) would significantly affect water quality by increasing the concentration of hydrocarbons in the water column to levels that greatly exceed background concentrations; however, the chance of a large spill occurring and oil entering the offshore waters is estimated to be about 1%. Also, regional (more than 1,000 square kilometers [386 square miles]), long-term (more than 1 year) degradation of water quality to levels above State and Federal criteria because of hydrocarbon contamination is very unlikely.

(b) Disturbances

The general effects of disturbances are analyzed in Section III.C.3.l(2)(a).

1) Summary and Conclusions for Effects of Disturbances on Water Quality

The greatest effect on water quality from gravel island and pipeline construction would be additional turbidity caused by increases in suspended particles in the water column. Increases in turbidity generally are expected to be considerably less than the 7,500 parts per million suspended solids used in the analysis as an acute (toxic) criterion for water quality; exceptions may occur within the immediate vicinity of the construction activity. Turbidity increases from construction activities generally are temporary and expected to occur during the winter and end within a few days after construction stops. Material excavated from the pipeline trench but not used for backfill most likely would be left in an area where active erosion of sediment particles could occur during breakup and open water. This material would be similar in composition to seafloor sediments in the trenching and disposal areas, and its contribution to future turbidity from waves and currents is expected to be about the same as the sediments existing at the seafloor surface before pipeline construction. Construction activities are not expected to introduce or add any chemical pollutants.

2)Details on How Disturbance May Affect Water Quality

The following analysis is a summary of the effects Liberty Island and Pipeline construction would have on water quality in Foggy Island Bay and is based on the following information and analysis:

- scenario assumptions in Table II.A-1
- general effects of disturbances on water quality in Section III.C.3.l(2)(a)
- specific effects of disturbances on water quality in Section III.C.3.l(2)(b)

a) Specific Effects of Constructing the Production Island

The Liberty Island would be constructed in water about 21 feet deep using an estimated 773,000 cubic yards of gravel mined from a permitted site on the Kadleroshilik River floodplain; the gravel is not expected to contain any contaminated material. The gravel would be trucked to the Liberty site over ice roads and dumped into the water through openings cut in ice; this activity is estimated to take from 45-60 days. Dumping river gravel would affect water quality by increasing the amount of suspended-particulate matter in the water column in the area below the floating fast ice in several ways that include (1) suspension of sediments by currents generated from the gravel hitting the seafloor and (2) separation of fine-grained particles from the material falling through the water.

The effects of seafloor sediments suspended in the water column from dumping gravel and pipeline construction are assumed to be similar. The effects of suspending the seafloor sediments during pipeline construction are analyzed in Section III.C.3.l(2)(b)2). Seafloor sediments in Foggy Island Bay consist mainly of fine sand-, silt-, and clay-size particles (Sec. VI.C.1.c(2)). The concentration of suspended sediments associated with trench excavation and backfilling are estimated to range from 500-1,000 milligrams per liter near the seafloor and 50-100 milligrams per liter near the surface (URS Corporation, 2000). Concentrations of suspended particles generally decrease as the distance from the disturbance increases. The larger and/or denser particles settle closer to the source while the smaller and/or less dense particles are carried farther. Suspended sediment concentrations at 1 and 10 kilometers are expected to be less than 20 and 10 milligrams per liter, respectively. See Section III.C.3.l(2)(b)2) for a more complete analysis of the effects of suspending the seafloor sediments in Foggy Island Bay during pipeline construction.

When the dumped gravel forms the base of Liberty Island and covers the seafloor and as height of the build up increases the effects of gravel dumping on suspending seafloor sediments will decrease.

As the dumped gravel falls through the water column, some of the fine-grained particles would separate from the mass and remain suspended; this amount is estimated to range from 10-12%. Ice-bonding of particles will likely reduce the amount of fine-grained particles that actually separates from the dumped mass.

At the assumed maximum dumping rate of 20,000 cubic yards per day the suspended sediment concentration in the immediate vicinity of the dumping activity is estimated to be 250 milligrams per liter. The concentration of particles suspended in the water decreases with distance from the source. If the current speed is 2 centimeters per second (0.04 knot), the concentration of suspended particles would be reduced to 50 milligrams per liter at a distance of 0.5 kilometer (0.3 mile) from the construction site, 20 milligrams per liter at 1.25 kilometers (0.78 mile) distance and 10 milligrams per liter at 1.5 kilometers (0.93 mile). The suspended-sediment plume width at the 10-milligram-per-liter concentration interval is estimated to be 400 meters. The suspended-sediment plume is a temporary feature and would disappear within a few days after island construction is complete. The thickness of the depositional layer decreases with distance from the island construction site.

The increase in turbidity as a result of summer grading and shaping the island's surface and subsurface slope, placement of the slope-protection systems and maintenance of the slope-protection systems during the life of the island is expected to be short term, lasting only as long as the activity, and greatest in the vicinity of the island. Turbidity increases are not expected to be greater than the turbidity cased by currents and waves resuspending sediment particles in shallow water areas.

b) Specific Effects of Constructing the Pipeline

The pipeline trench, about 6.1 miles long, would be dug with backhoes in the winter from the sea ice covering Foggy Island Bay. The average trench depth would be 10.5 feet; the range would be from 8-12 feet. An estimated 724,000 cubic yards (design and excavation limit volumes, respectively) of sediments would be excavated from the trench, and most of it would be used as backfill. Pipeline trenching would take an estimated 49 days. Excavated material not used as backfill would be left on the ice to return to the seafloor by natural processes during spring breakup. Seafloor sediments in Foggy Island Bay consist mainly of fine sand-, silt-, and clay-size particles.

Pipeline construction would affect water quality by increasing suspended-particulate matter in the water column mainly in the area below the floating fast ice in the winter and in the vicinity of the area where excess trench material lies during the open-water period. Trenching would disturb and resuspend the seafloor sediments in those areas beneath the ice where the sea water has not frozen to the seafloor. Dumping excavated material into the water column to fill the trench also would cause some of the fine-grained particles to separate from the descending sediment mass and remain in suspension.

Both trenching and backfilling operations are likely to be performed at the same time along the pipeline route. In the floating fast-ice zone, suspended sediments generated from these operations could form a turbidity plume in the presence of currents in the water column between the bottom of the floating ice and the seafloor surface.

For one study, the initial suspended-sediment concentration in the water column during pipeline construction is estimated to be 1,000 milligrams per liter. The amount of suspended particles in the water column would decrease with distance from the construction area. If the current velocity is 0.02 meter per second (0.04 knot), suspended sediment concentrations greater than 100 milligrams per liter are estimated to occur within 0.75 kilometer (0.46 mile) of the trench. Concentrations of 20 and 10 milligrams per liter are estimated to be reached at distances of about 1 kilometer (0.62 mile) and 10 kilometers (6.2 miles), respectively, from the trench.

In another study, URS Corporation (2000) estimates initial suspended sediment concentrations from pipeline construction could range from 500-1,000 milligrams per liter near the seafloor and 50-100 milligrams per liter at the surface. (This study was done to improve the capability to predict the effects of Liberty development construction on the Boulder Patch community. The previous analysis assumed an initial suspended-sediment concentration of 1,000 milligrams per liter was uniform throughout the water column.) If the initial concentrations are less than 1,000 milligrams per liter, suspended-sediment concentrations at 1 and 10 kilometers could be less that the 20 and 10 milligrams, respectively, estimated previously. Fine-grained particles (silt- and clay-size particles) are estimated to comprise about 65 percent of the material excavated from the trench. Excavated trench material will be stored in two areas; a 230-acre site in waters 5-10 feet deep about 4 miles southwest of the Liberty site (Zone 1, Fig. II.A-18) and along the proposed pipeline route (Zone 2, Fig. II.A-18). Trench sediments would be stockpiled in different parts of the 230-acre site and graded to an average thickness of about 1 foot to minimize the potential for mounding on the seafloor.

After the pipeline has been buried, the amount of material stored on the ice is estimated to be about 100,000 cubic yards in the 230-acre site and 10,000 cubic yards along the northern part of the proposed pipeline route.

These sediments could return to the water column in any number of ways that might include:

- sinking to the seafloor directly beneath the ice pad as the ice melts in place;
- dumping into the water when the melting ice becomes unstable and overturns;
- eroding of particles by waves in open-water areas;
- melting and transporting of particles by meltwater in the frozen material; or
- melting, eroding, and transporting of particles during river flooding of the fast ice.

Depending on weather, ice conditions and breakup, and river flood stage, natural removal of the stockpiled sediments could take up to several weeks.

When the material stockpiled on the ice returns to the seafloor, some of the fine-grained material would be suspended in the water column. The effects on water column turbidity are estimated by assuming all stockpiled material falls from the ice in 24 hours, 10% of the material would be suspended in the water column, and a current of 0.05 meter per second (0.1 knot) transports the water in a northerly direction. Based on these assumptions, the suspended-sediment concentration below the 230-acre site is estimated to be 1,168 milligrams per liter, and below the storage area adjacent to the northern part of the proposed pipeline it is estimated to be 14 milligrams per liter. The suspended-sediment concentrations decrease with distance from the storage sites. Concentrations of 200, 20, and 10 milligrams per liter are estimated to occur at about 0.5 kilometer (0.3 miles, 2.75 kilometers (1.70 miles) and 7 kilometers (4.3 miles), respectively, from the 230-acre site. These estimates probably represent maximum suspended-sediment concentrations over 1 or 2 days. If the return of the stockpiled material takes more than a day, suspended-sediment concentrations could be reduced and/or last for a longer period. Also exposure to subfreezing temperatures would freeze the particles together and reduce some particle separation when the stockpiled material returns to the seafloor. The suspended concentration estimates are based on no ice bonding of particles and, thus, estimate possible maximum concentrations.

During broken-ice conditions or open water, winds from the east force the nearshore waters to move in a westerly direction parallel to the bathymetry; the characteristics of Beaufort Sea coastal winds are summarized in Section III.C.2.l(2)(a). Under these conditions, particles in the turbidity plume from the Zone 1 spoils area would be deposited in an area that extends in a northerly direction from the spoils site (Fig. III.C-5). Westerly winds force the nearshore waters to move in an easterly direction parallel to the bathymetry. Under these conditions, particles in the turbidity plume from the Zone 1 spoils area would be deposited in an area that extends in an easterly direction from the site of the excess trench material (Fig. III.C-5).

The thickness of the layer formed by excess trench material falling to the seafloor would be greatest in the vicinity of the storage area and would decrease with distance. The areal extent and thickness of this layer were calculated from a sediment deposition model (URS Greiner Woodward Clyde, 1998a). Within 400-530 meters of Zone 1, the layer formed by excess trench material falling to the seafloor would decrease to a thickness of 10 millimeters. The layer would have a thickness of 1 millimeter within 10-13 kilometers (6.2-8.1 miles) under easterly winds and within about 6.1 kilometers (3.8 miles) under westerly winds. Within 170-180 meters of Zone 3, the layer formed by excess trench material falling to the seafloor would decrease to a thickness of 1 millimeter.

The areal extent of the turbidity plume formed by the falling excess trench material could be approximated by considering where some of the smallest particles might be deposited. Particles 0.005 millimeter in diameter would be deposited at distances of about 13-18 kilometers (8-11 miles) from the Zone 1 site; the thickness of the deposits at these distances is calculated to be about 0.02 millimeter under easterly winds and 0.01 millimeter under westerly winds. Particles 0.005 millimeter in diameter would be deposited at distances of about 18-56.5 kilometers (11-35 miles) from the Zone 3 site; the thickness of the deposits at these distances is calculated to be about 0.001-0.002 millimeter under easterly winds and 0.001 millimeter under westerly winds.

Depending on wind and wave conditions, the fine-grained particles in the excess trench material on the seafloor could be resuspended. Foggy Island Bay is a dynamic environment where a number of phenomena interact to produce changes in the seafloor. These phenomena include winds and storms, sea ice, and river flooding of the nearshore ice. If all or most of the excess trench material returns to the seafloor in the vicinity of the storage site a layer, or scattered layers, or variable thickness could form. The layer(s) would consist of a heterogeneous mixture of clay, silt, sand and gravel-size particles similar to the grains-size composition of present-day surface sediments. Multiyear satellite images suggest the turbidity in coastal waters in mid- and late summer are, for the most part, associated with wave-induced resuspension of cohesionless muddy sediments from shallow-water regions. The contribution of the trench material to the background suspended-sediment concentration likely would be about the same as that of the area into which the sediments were dumped.

Pipeline trenching and backfilling are not likely to increase the amount of trace metals or hydrocarbons into the environment above the naturally occurring background concentrations.

c) Specific Effects of Repairing the Pipeline

Damage to the pipeline would require repairs, which would mean excavating the trench to expose the pipeline. Repair work most likely would be done in the winter when the ice is stable enough so that it can be thickened to support the repair equipment or during the open-water period (Table II.C-6).

The types of effects associated with excavating and backfilling would be the same as those analyzed for pipeline construction. These activities would affect water quality by increasing suspended-particulate matter in the water column in the area of the activity. In the winter, if the repair work takes place in the bottomfast-ice zone, there would be very little, if any, effects in the water column. If the repair work takes place in the floating fast-ice zone, the effects would be in the water column mainly in the area below the floating ice.

Depending on the type of repair, the amount of sediment excavated could range from 1,150-6,490 cubic yards. The rate at which the trench backfill material would be removed is likely to be less than the rate at which sediment was excavated to form the trench. An estimated 10-15 days would be required to excavate 6,490 cubic yards (Table II.C-7). Repair excavation would take place in a small area, and the size of the associated turbidity plume is expected to be smaller than the one formed during the initial trench excavation. In the winter, the excavated material would be stored on the ice and used as backfill when the pipeline repair is finished. During the open-water period, the excavated material would be placed on the seafloor alongside the trench and used as backfill when the pipeline repair is completed.

d. Alternative III.A – Use the Southern Island Location and Eastern Pipeline Route

Section IV.C.1.a describes the common elements shared by the alternatives in this component set. Those common elements, plus the components that follow, describe this Alternative.

Alternative III.A (see Map 1) assumes the drilling location is moved to the southeast edge of the lease, where it would be in shallower water (18 feet) and farther from both the Boulder Patch and the bowhead whales' fall migration than either Alternative III.B or Alternative I. The island would be about 2.5 miles (4 kilometers) from areas of dense boulders and kelp in the Boulder Patch.

This alternative was developed in response to scoping comments requesting analysis of island locations in shallower water to eliminate or reduce effects to bowhead whales.

This location offers greater protection from multiyear ice flows that originate outside the barrier islands. The island location would be about 1.5 miles (2.4 kilometers) south-southeast of BPXA's proposed location (Alternative I) (BPXA, 1998a). The pipeline route would follow BPXA's alternate eastern route, extending south-southeast from the southern island location to shore and then to the Badami pipeline (BPXA, 1998a). For purposes of analysis, we assume a trench with a 7-foot minimum burial depth. In addition to the construction elements shared by all alternatives in this component set as noted in Section II.A, construction of the southern island and eastern pipeline would have the include the following:

- 661,000 cubic yards of gravel fill for the island.
- 16,000 interlinked concrete mats (4 feet x 4 feet x 9 inches)(Figs. II.A-5 and II.A-6) placed from the base of the gravel bags to the seafloor and secured with anchors placed in the island gravel fill. It would take about 7,600 cubic yards of gravel to make the concrete mats.
- 4,200 polyester gravel bags (4 cubic yards) placed on the upper slope of the island from 7-23 feet above sea level using an additional 17,000 cubic yards of gravel.
- Gravel bags would be filled from excess gravel at the island construction site.
- 684,800 cubic yards of gravel would be needed for constructing the island.
- Gravel would be hauled over the ice road for about 42-55 days but should be in place at the island construction site by the end of April of Year 2.
- A maximum footprint would be 825 feet by 1,155 feet, which is about 21.9 acres. The perimeter berm rises to 23 feet above sea level, which is 8 feet above the working surface.

The overall pipeline length from Liberty Island to the Badami tie-in would be 7.3 miles (11.7 kilometers). Table II.A-2 shows the trenching, excavation, and backfill quantities for this alternative.

While the offshore pipeline routes for Alternatives III.A and III.B start at different locations (see Map 1), they share the same shore-crossing and onshore pipeline route to Badami. The rate of shore erosion for this alternative's shore crossing is higher (2.7 feet per year) than the rate of erosion at the shore-crossing location for the Alternative I (2.0 feet per year.) (BPXA, 1998a) The onshore gravel pad has been moved farther inland and is located 205 feet from the shoreline. This would increase the length of the shore-crossing trench by 55 feet more than the Proposal, and it would increase by one-third the shoreline area disturbed.

Pipeline construction would require using temporary storage sites for excess trenching material. This requires an Ocean Water Disposal of Dredged Material permit. Each pipeline route would need two on-ice disposal sites, one nearshore and one along the side the pipeline. Both pipeline routes (Eastern and Tern) would use the same nearshore site, Zone 3 (Fig. II.C-1). Zone 3 is comparable in size, bathymetry location, and purpose to Zone 1 in Alternative I. Zone 3 is located on the western side of the pipeline right-of-way on grounded sea ice outside the 5-foot isobath. Maximum dimensions of the site would be 5,000 by 2,000 feet (230 acres). Zone 3 would serve as the primary temporary storage location of all excavated materials that cannot be directly transported for backfill along the pipeline. For excess trench material that cannot be used as backfill, Zone 3 would serve as the designated disposal site. Table II.A-2 shows the trenching, excavation, and backfill quantities for this alternative.

Excess trench material placed in Zone 3 would be groomed to a height not to exceed 1 foot to minimize the potential for mounding on the seafloor. The entire site would not be used for disposal. Material would be stacked on portions of the site over deeper water first and then over shallower water. The maximum quantity of spoils stockpiled or left for disposal on this site at any one time would not exceed 100,000 cubic yards. Assuming this maximum quantity is placed in stacks 1 foot high, about 27% of Zone 3 (about 62 acres) would be used for actual disposal (see Fig. II.C-1).

The Eastern Pipeline has a second disposal site, Zone 4 (Fig. II.C-1), which is comparable in purpose to Zone 2 in Alternative I. Zone 4 is 4.2 miles long. Zone 4 is 200 feet wide on the western side of the pipeline trench from the island to shore. About 0.1 mile of Zone 4 is seaward of the 3-mile boundary, and the remaining 4.1 miles are shoreward of the 3-mile boundary.

Zone 4 is a temporary on-ice storage area. It also is a contingent disposal location for excess trench materials, should weather or ice conditions cause operations to be abandoned before completion. The maximum quantity of excess trench materials stockpiled or left for disposal on

Zone 4 at any one time would not exceed 10,000 cubic yards. Excess trench material in water depths greater than16 feet would be stacked or groomed to maintain an approximate depth of less than 1 foot. Excess trench material placed where the water depths are less than 16 feet, would be stacked or groomed to a height not to exceed 2 feet. During pipeline construction, the plan is to clear excess material stacked in Zone 4 of all excess dredged material/spoils by spring breakup. This would be done by scraping the ice with heavy equipment, leaving at most a veneer of dirty ice (a very small amount of sediment remaining in the frozen matrix).

As noted above in Section IV.C.1.b, the effects to the following resources are the same for any of the island locations or pipelines routes. The specific components of the Southern Island and Eastern Pipeline Route as previously described would change the impacts to the following resources in the ways described in the analyses that follow:

- Eiders
- Marine and Coastal Birds
- Terrestrial Mammals
- Lower Trophic-Level Organisms
- Vegetation-Wetland Habitats
- Archaeological Resources
- Economy
- Water Quality

(1) Effects on Threatened and Endangered Species - Eiders

(a) Large Oil Spills

The general effects of a large spill and the effects of oil-spill-cleanup activities are analyzed in Section III.C.2.a.(2)(b)1).

1) Summary and Conclusion for Effects of a Large Oil Spill on Eiders

The probability of oil-spill contact and potential effects in most environmental resource areas or land segments from Alternative I (Sec. IV.C.1.c) and Alternative III.A island sites and offshore pipeline spill points are essentially the same, including the probability of contact in the western Simpson Lagoon area, where spectacled eider use is documented. There is a difference in probability of contact in the southern Foggy Island Bay area due to island location, which suggests that there is a somewhat greater potential for oil-spill contact with eiders from this Alternative than from Alternative I. However, we conclude that effects, though different, would not be significantly different, because the difference between this Alternative and Alternative I in probability of oil contacting any spectacled eiders that may occur in southern Foggy Island Bay is not substantial, and the extent of eider use of this area is uncertain.

2) Details on How a Large Oil Spill May Affect Eiders

Specific Effects: The chance of an oil spill from the Alternative III.A island locations (AP1; Map A-6) contacting spectacled eiders in most environmental resource areas or land segments is similar (within 3%, Tables A-12, A-20) to that for Alternative I (L1). Also, the probability of-oil spill contact with shore habitats (for example, Land Segment 26) within 30 days in summer is within 5% for the two island locations (26-30%, Tables A-13, A-23). The probability of eider contact by a spill at an offshore location along the pipeline route for Alternative III.A (AP1; Table A-20) is 19-27%, similar to the 22-24% that exists along the Alternative I pipeline route (PP1; Table A-16). To the west, oil-spill contact with the western Simpson Lagoon area and western Harrison Bay (Environmental Resource Areas 48-50 and 14-16), where the presence of male eiders has been documented (Petersen, Larned, and Douglas, 1999), is similar or the same from both island locations (Alternative III.A location, 1-3% and less than 0.5%; Alternative I Liberty Island location, 2-4% and less than 0.5%; Tables A-12, A-20) and identical from all pipeline locations (1-3% and less than 0.5%; Tables A-16, A-20). These very low and similar or identical probabilities of spill contact from Alternative III.A and Alternative I islands or pipelines indicate that effects on eiders in these areas from a spill in either location would be the same.

The chance of an oil spill from the Alternative III.A island location (AP1; Map A-6) contacting spectacled eiders in southern Foggy Island Bay (Environmental Resource Areas 34, 36; Map A-2) within 30 days during the summer season (19-27%; Table A-20) is greater than for the Alternative I Liberty Island (17% from L1; Table A-12). The presence of this species is not documented here, but it may occur when moving from nesting or broodrearing areas to marine habitat or during migration. Overlapping ranges of contact probability at local Environmental Resource Areas (34,36) for a spill from a nearshore pipeline leak are 33-40% for the Alternative III.A route (from AP2; Table A-20) and 19-52% for Alternative I (from PP2; Table A-16.

(b) Disturbances

The general effects from disturbance are analyzed in Section III.C.3.a.(2)(b)1).

1) Summary and Conclusion for Effects of Disturbances on Eiders

Disturbance effects from Alternative III.A and Alternative I (Sec. IV.C.1.c) are expected to be the same, except for those resulting from aerial inspection of the onshore portion of the pipeline. Such traffic potentially would disturb more eiders along the greater onshore length of the Alternative III.A pipeline than along the Alternative I pipeline. This is not viewed as a significant difference.

2) Details on How Disturbances May Affect Eiders

Specific Effects: Disturbance effects from the Alternative III.A and Alternative I (Liberty) island locations (see Sec.III.c.3.a(2)) and inspections of associated marine pipeline routes are expected to be the same. Disturbance from other helicopter traffic and vessels servicing the Alternative III.A island is expected to be essentially the same as described for the Alternative I location. However, disturbance of nesting or broodrearing eiders (Map 5) from pipeline inspections is more likely along the Alternative III.A pipeline route because of its greater onshore length. Available data (0.3 nest per square kilometer) suggests approximately 0.75 nest might be disturbed along the onshore pipeline route for Alternative I and 1.5 nests along the route for Alternative III.A.

(2) Effects on Marine and Coastal Birds

(a) Large Oil Spills

The general effects of a large spill and the effects of oil-spill-cleanup activities are analyzed in Section III.C.2.c(2)(a).

1) Summary and Conclusion for Effects of a Large Oil Spill on Marine and Coastal Birds

The probability of oil-spill contact and potential effects on loons, waterfowl, shorebirds, and seabirds in most environmental resource areas or land segments from Alternative I (Sec. IV.C.1.c) and Alternative III.A island sites and offshore pipeline spill points is essentially the same. There is a difference in probability of contact in the southern Foggy Island Bay area due to island location, which suggests that there is a somewhat greater potential for an oil spill to contact waterbirds from this Alternative than from Alternative I. However, we conclude that effects, though different, would not be significantly different, because the difference between this Alternative and Alternative I in probability of oil contacting any waterbirds that may occur in southern Foggy Island Bay is not substantial, and the extent of waterbird use of this area is uncertain. Also, Alternative III.A slightly increases risk to waterbirds in eastern Foggy Island Bay and Alternative I increases risk in the western bay and Sagavanirktok River Delta due to relative pipeline positions.

2) Details on How a Large Oil Spill May Affect Marine and Coastal Birds

Specific Effects: The chance of an oil spill from the Alternative III.A island locations (AP1; Map A-6) contacting waterbirds in most environmental resource areas or land segments is similar (within 3%, Tables A-12, A-20) to that for Alternative I (L1). Also, the probability of oil-spill contact with shore habitats (for example, Land Segment 26) within 30 days in summer is within 5% for the two island locations (26-30%, Tables A-13, A-23). The probability of waterbird contact by a spill at an offshore location along the pipeline route for Alternative III.A (AP1; Table A-20) is 19-27%, similar to the 22-24% that exists along the Alternative I pipeline route (PP1; Table A-16). To the west, oil-spill contact with the western Simpson Lagoon area and western Harrison Bay (Environmental Resource Areas 48-50 and 14-16), where loon and waterfowl presence has been documented (Tiplady, 1999, pers. commun.), is similar or the same from both island locations (Alternative III.A location, 1-3% and less than 0.5%; Alternative I Liberty Island location, 2-4% and less than 0.5%; Tables A-12, A-20) and identical from all pipeline locations (1-3% and less than 0.5%; Tables A-16, A-20). These very low and similar or identical probabilities of spill contact from Alternative III.A and Alternative I islands or pipelines indicate that effects on waterbirds in these areas from a spill in either location would be the same.

The chance of an oil spill from the Alternative III.A island location (AP1; Map A-6) contacting waterbirds in southern Foggy Island Bay (Environmental Resource Areas 34, 36; Map A-2) within 30 days during the summer season (19-27%; Table A-20) is greater than for the Alternative I Liberty Island (17% from L1; Table A-12). The presence of most species is not documented here but may be assumed from observations during postbreeding, broodrearing, or migration periods made in nearby areas with similar habitats available (for example, Johnson and Richardson, 1981). The Alternative III.A pipeline route slightly increases the risk to any birds in the eastern portion of Foggy Island Bay (Environmental Resource Area 36), because of the eastern pipeline position. The Alternative I route slightly increases the risk in the western bay and Sagavanirktok River Delta (Environmental Resource Area 34), because of the western pipeline position. Overlapping ranges of contact probability at local environmental resource areas (34,36) for a spill from a nearshore pipeline leak are 33-40% for the Alternative III.A route (from AP2; Table A-20) and 19-52% for Alternative I (from PP2; Table A-16).

(b) Disturbances

The general effects of disturbances are analyzed in Section III.C.3.c(2)(a).

1) Summary and Conclusion for Effects of Disturbances on Marine and Coastal Birds

Disturbance effects from Alternative III.A and Alternative I (Sec. IV.C.1.c) are expected to be the same except for those resulting from aerial inspection of the onshore portion of the pipeline. Such traffic potentially would disturb approximately twice as many nesting or broodrearing loons, waterfowl or shorebirds along the greater onshore length of the Alternative III.A pipeline than along the Alternative I pipeline. Because of the population size and status of species most likely to be involved, this is not viewed as a significant difference.

2) Details on How Disturbances May Affect Marine and Coastal Birds

Specific Effects: Disturbance effects from the Alternative III.A and Alternative I (Liberty) island locations (see Sec.III.C.3c(2)) and inspections of associated marine pipeline routes are expected to be the same. Disturbance from other helicopter traffic and vessels servicing the Alternative III.A island is expected to be essentially the same as described for the Alternative I location. However, disturbance of nesting or broodrearing loons, waterfowl, or shorebirds from pipeline inspections is more likely along the Alternative III.A pipeline route because of its greater onshore length. This could involve, for example, 5.0 Pacific loon, 6.5 oldsquaw, 59.9 pectoral sandpiper, and 124.7 Lapland longspur nests if a 0.5 kilometer zone of disturbance on either side of the pipeline and presence of appropriate nesting habitat for these species is assumed (calculated from TERA, 1995b). This is approximately twice the number that might be disturbed under similar conditions along the Alternative I pipeline route.

(3) Effects on Terrestrial Mammals

(a) Large Oil Spills

The general effects of a large spill and the effects of oil-spill-cleanup activities are analyzed in Section III.C.2.d(2)(a).

1) Summary and Conclusion for Effects of a Large Spill on Terrestrial Mammals

Under this alternative, caribou, muskoxen, grizzly bears, and arctic foxes may be more likely to encounter an oil spill from the south production island, should it occur, because the island would be located closer to shore. Crude oil or diesel fuel is most likely to contact some coastal areas from the Sagavanirktok River Delta east to Mikkelsen Bay, regardless of which spill scenario is assumed (Table A-13; Land Segments 25, 26, and 27). Caribou may use some of these areas for relief from insects. The main potential effect on terrestrial mammals that contact spilled oil could be the loss of fewer than 100 caribou and a few muskoxen, grizzly bears, and arctic foxes. These losses are expected to be replaced by normal reproduction within about 1 year. A 1,500-barrel onshore pipeline spill could occur and oil less than 5 acres of vegetation along the pipeline landfall to the Badami tie-in. Such a spill is not expected to directly affect caribou or other terrestrial mammals and would cause very minor ecological harm.

2) Details on How A Large Spill May Affect Terrestrial Mammals

Specific Effects: Caribou, muskoxen, grizzly bears, and arctic foxes may frequent coastlines near the Liberty Project. The Oil-Spill-Risk Assessment model estimates a 12-30% chance of a spill starting at the south island location (AP1) and contacting land along the coast of Foggy Island Bay-Mikkelsen Bay within 30 days during the summer open-water season compared to an estimated 12-26% from the Liberty Island location (Tables A-23, and A-13 respectively Land Segments 25, 26, and 27). Overall, the Oil-Spill-Risk Assessment model estimates that here is an 88% chance that a spill starting at the south island location contacts the shoreline compared to 87% from the Liberty Island location (Tables A-20, and A-12, respectively, contact to Land within 30 days during the summer). Caribou move into these areas to escape insects. Even in a severe situation, however, fewer than 100 animals from the Central Arctic Herd (out of a population of 18,000) are likely to get the oil on their coats and die by inhaling and absorbing toxic hydrocarbons. We base this number on summer surveys of the caribou seen in marine waters (Pollard and Ballard, 1993). Normal reproduction is likely to replace this loss within about 1 year. Caribou could be scared away from the spill area by helicopters during cleanup; however, poor weather conditions may prevent helicopters from hazing caribou away from the spill.

A 1,500-barrel diesel spill would dissipate quickly and likely would not persist beyond about 6 days. The number of caribou and other terrestrial mammals affected is likely to be lower than that affected by a crude oil spill of the same size. The terrestrial mammal populations are expected to recover within 1 year.

(b) Disturbances

The general effects of disturbances are analyzed in Section III.C.3.d(2)(a).

Effects of disturbances on terrestrial mammals under Alternative III.A are expected to be the same as for Alternative I (Sec. IV.C.3.b). Moving the production island a little closer to shore is not expected to increase the amount of disturbance of terrestrial mammals that they would be exposed to under Alternative I.

(4) Effects on Lower Trophic-Level Organisms

(a) Large Oil Spills

The general effects of a large spill and the effects of oil-spill-cleanup activities are analyzed in Section III.C.2.e(2)(a).

Diesel Fuel Spills: There might be specific differences in the effects of diesel fuel spills because of the longer distance between the alternative island site and the Boulder Patch kelp habitat. In the unlikely event of a diesel spill, the longer distance would reduce slightly the risk of diesel effects to the kelp community.

(b) Disturbances

The general effects of disturbance are analyzed in Section III.C.3.e(2)(a).

1) Summary and Conclusion for Effects of Disturbances on Lower Trophic-Level Organisms

There would be specific differences in disturbance effects. The disturbance effects under this alternative would be lower than for Alternative I for two reasons. (1) There is no kelp in the Eastern Pipeline Route; therefore, trenching would not eliminate kelp habitat, causing only minor, short-term effects only to the silty/sandy sediments. This conclusion would be the same regardless of pipeline burial depth in the alternative pipeline route; however, fewer survey data are available for the alternative route, so we are less certain about these conclusions than for Alternative I. (2) The shorter pipeline length and the shallower water depth for the island would reduce the footprint of the project and the amount of turbidity caused by construction activity. A smaller sediment plume still would drift northwest over the Boulder Patch, reducing light levels and kelp production by an estimated 5% during construction (Fig. IV.C-1). However, in relation to the large range of natural variability, the disturbance effects on lower trophic-level organisms would be barely detectable.

2) Details On How Disturbances May Affect Lower Trophic-Level Organisms

Specific Effects: We concluded in Section III.C.3.e(3) that trenching for Alternative I would eliminate up to 14 acres of very diffuse kelp, boulders, and suitable substrate. In that section, we also noted that the kelp and solid substrate in the proposed pipeline corridor appears to form the southeastern tip of a band of dense kelp (Fig. III.C-1, BPXA, 2000a:Exhibit A; and Ban et al., 1999:Fig. 1-1). Consequently, any pipeline corridor farther east, such as this alternative pipeline route, probably would not eliminate kelp habitat, causing minor, short-term effects to only the silty/sandy sediments. This conclusion probably would be the same regardless of the pipeline burial depth in the Eastern Pipeline Route. We note that the Northstar Final EIS also concluded the impacts of pipeline trenching in silty/sandy sediments would be short term and minor (U.S. Army Corps of Engineers, 1999:6-27). If the alternative of an eastern pipeline route were approved, we could require the lessee to conduct additional surveys, per Lease Sale Stipulation No. 1, Protection of Biological Resources, as explained in Section B.1.a of Appendix B.

The Eastern Pipeline Route would be farther from the Boulder Patch than the proposed route, and the concentration of suspended-sediments that drift over the kelp would be lower than for Alternative I. However, we conclude that the effect on kelp would be about the same for this alternative and for Alternative I , as analyzed by Ban et al. (1999). Specifically, the reduction in kelp production would be similar for the eastern and proposed routes, because the sediment plume from the eastern route probably would drift over a denser portion of the Boulder Patch (Fig. IV.C-1). The figure was prepared with a drift rate and direction of the sediment plume that is similar to those that were used by Ban et al. (1999) for an assessment of Alternative I. The assessment is based on how far sediment particles are likely to drift; small particles, such as those in seafloor sediments, would drift much farther than coarse particles in island fill from an onshore mine. In other words, the assessment in Table IV.C-1 for fine particles would apply to all operations that would resuspend the seafloor sediments such as trenching, backfilling, hydraulic dredging, and storage of excess sediment in nearshore stockpiles. The sediment probably would not alter water temperature, salinity, or mixing zones but would reduce the amount of light that penetrated through the water column and stimulated kelp production. The assessment indicates that the sediment plume from the Southern Island and Eastern Pipeline Route would reduce kelp production by less than 5.10%, as opposed to a reduction from Alternative I by less than 6.33% (Table IV.C-1). The assessment indicates also that about two-thirds of the sediment effect would be due to disposal Zone 3 for excess soil; i.e., the projected effects are due primarily to the proposed location of the disposal site. The new slope-protection system on the island probably would be colonized by kelp, providing some mitigation to the project effects, as explained for Alternative I.

(5) Effects on Essential Fish Habitat

The general effects of a large spill and the effects of oil spill cleanup activities are analyzed in Section III.C.2.f.(2) and the general effects of disturbance are analyzed in Section III.C.3.f.(2).The potential adverse effects of this alternative on essential fish habitat could be reduced slightly, because the size of the island footprint and amount of offshore trenching would be reduced. Otherwise, the effects from possible oil spills or from other activities would be similar to the Proposal.

(6) Effects on Vegetation-Wetland Habitats

(a) Large Oil Spills

The general effects of a large spill and the effects of oil-spill-cleanup activities are analyzed in Section III.C.2.g(2)(a).

1) Summary and Conclusion for Effects of a Large Spill on Coastal and Onshore Vegetation-Wetland Habitats

Under this alternative, coastal vegetation and wetlands in the Foggy Island Bay area probably are more likely to be oiled by an assumed production-island spill with the island located closer to shore (4.1 miles [6.6 kilometers] compared to 6.1 miles [9.8 kilometers] under Alternative I). The main potential effects of a large offshore spill on vegetation and wetland include oil-fouling, smothering, asphyxiation, and poisoning of plants and associated insects and other small animals. In this case, complete recovery of moderately oiled wetlands of the Sagavanirktok River east to Mikkelsen Bay would take perhaps 10 years or longer. A second main effect is the disturbance of wetlands from cleanup activities. Complete recovery of heavily oiled coastal wetlands from these disturbances and oil could take several decades.

A large onshore spill would oil no more than 5 acres of vegetation along the pipeline landfall to the Badami tie-in would cause very minor ecological harm. Oiled vegetation should recover within a few years but may take more than 10 years to fully recover.

2) Details on How a Large Oil Spill May Affect Vegetation-Wetlands

Specific Effects: The spill assumed to occur at the south island location and enter offshore waters would contact coastal areas within 30 days from the Sagavanirktok River Delta and Endicott causeway east to Mikkelsen Bay, regardless of which spill scenario is assumed (Table A-1). These areas include wetlands and other vegetation cover (estimated 21-45 kilometers of coastline oiled from a crude oil spill Table A-7). We focus on effects expected should a spill contact vegetation and wetlands within 30 days during summer.

The Oil-Spill-Risk Assessment model estimates 12-30% chance of a spill starting at the south island location (AP1) and contacting land along the coast of Foggy Island Bay-Mikkelsen Bay within 30 days during the summer open-water season compared to an estimated 12-26% from the Liberty Island location (Tables A-23, and A-13 respectively Land Segments 25, 26, and 27). Overall, the Oil-Spill-Risk Assessment model estimates that there is an 88% chance that a spill starting at the south island location contacts the shoreline compared to 87% from the Liberty Island location (Tables A20, and A-12 respectively contact to Land within 30 days during the summer, Map A-1). The spill could oil an estimated 21-30 kilometers of shoreline (Table A-7) and extend inshore a few feet to several yards, depending on tides and storm surges. A 1,500-barrel diesel spill would dissipate quickly and would not be expected to persist beyond about 6 days. The amount of wetlands contacted by diesel fuel is expected to be less than that contacted by crude oil. The shoreline of the Liberty Project area contains habitats with fairly high values (1 being the lowest and 10 being the highest) for oil-spill retention (lagoonal beaches have a value of 5 and peat shores have a value of 6) along the eastern Sagavanirktok River Delta and near the mouth of the Kadleroshilik River (Nummedal, 1980). Stranded oil on sheltered intertidal areas, especially along peat shorelines, is likely to persist for many years (Nummedal, 1980; Owens et al., 1983). Complete recovery of moderately oiled wetland in the Sagavanirktok River, Foggy Island Bay, and Mikkelsen Bay shorelines would take up to perhaps 10 years for crude oil and probably less than 5 years for diesel fuel.

(b) Disturbances

The general effects of disturbances are analyzed in Section III.C.3.g.(2)(a). Effects of disturbances on vegetation-wetlands under Alternative IIIA are expected to be the same as for Alternative I (Sec. III.C.3.i). Moving the production-island a little closer to shore is not expected to increase the amount vegetation-wetlands altered under Alternative I.

(7) Effects on the Economy

The general effects of a large spill and the effects of oil-spill-cleanup activities are analyzed in Section III.C.2.k. The general effects of disturbances are evaluated in Section III.C.3.k.

Specific Effects: Alternative III.A generates fewer jobs, fewer wages, and less revenue to the Government than for the Proposal. This alternative would result in a decrease of approximately $1.7 million in wages for 12 months, 9 direct jobs in Alaska for 12 months, 14 indirect jobs in Alaska for 12 months, and $10 million in net present value to the company (Sec. II and Appendix D-1). Information in this analysis is interpreted in part from data by INTEC (1999). The net present value to the Government is estimated to be $107, or $7 million less than the Proposal (see Appendix D-1).

(8) Effects on Water Quality

(a) Large Oil Spills

The effects of an oil spill on water quality for this alternative are expected to be the same as analyzed for Alternative I in Section IV.C.1.c(8). The general effects of a large spill and the effects of oil-spill-cleanup activities are analyzed in Section III.C.2.l(2)(a).

(b) Disturbances

The general effects of disturbances are analyzed in Section III.C.3.l(2)(a).

1) Summary and Conclusions for Effects of Disturbances on Water Quality

The greatest effect on water quality from gravel island and pipeline construction would be additional turbidity caused by increases in suspended particles in the water column. Increases in turbidity generally are expected to be considerably less than the 7,500 parts per million suspended solids used in the analysis as an acute (toxic) criterion for water quality; exceptions may occur within the immediate vicinity of the construction activity. Turbidity increases from construction activities generally are temporary and expected to occur during the winter and end within a few days after construction stops. The duration of turbidity from Southern Island and eastern pipeline trenching is expected to be less by 3-5 and 15days, respectively, compared to Liberty Island (45-60 days) and pipeline (49 days). The overall effects of turbidity are expected to be about 14% less during the construction of the Southern Island and 32% less for the eastern pipeline compared to the construction of Liberty Island and pipeline, respectively. Material excavated from the pipeline trench but not used for backfill most likely would be left in an area where active erosion of sediment particles could occur during breakup and open water. This material would be similar in composition to seafloor sediments in the trenching and disposal areas, and its contribution to future turbidity from waves and currents is expected to be about the same as the sediments existing at the seafloor surface before pipeline construction. Construction activities are not expected to introduce or add any chemical pollutants.

2) Details on How Disturbances May Affect Water Quality

The following analysis of the effects constructing the Southern Island and eastern pipeline would have on water quality in Foggy Island Bay are based on a comparison of scenarios as summarized in Table II.A-1 and on the following analyses:

- general effects of construction activities on water quality in Section III.C.3.l(2)(a)
- specific effects of island and pipeline construction in Section IV.C.1.c(8).

a) Specific Effects of Constructing the Production Island

The types of effects on water quality from constructing the Southern Island part of this alternative would be the same as those analyzed for Liberty Island construction (Sec. IV.C.1.c(8)); see Table II.A-1 to compare the characteristics of Liberty and Southern Islands.

The Southern Island would be constructed in water about 18 feet deep using an estimated 661,000 cubic yards (Table II.C-1) of gravel mined from a permitted site on the Kadleroshilik River floodplain; the gravel is not expected to contain any contaminated material. The amount of gravel required to construct the Southern Island is about 14% less than the amount estimated for Liberty Island (773,000 cubic yards). The gravel would be trucked to the Southern Island site over ice roads and dumped into the water through openings cut in ice; this activity is estimated to take 40-57 days (Table II.A-1) compared to the 45-60 days estimated to construct Liberty Island.

Dumping river gravel would affect water quality by increasing the amount of suspended particulate matter in the water column in the area below the floating fast ice in several ways, including (1) suspension of sediments by currents generated from the gravel hitting the seafloor and (2) separation of fine-grained particles from the material falling through the water.

The effects of seafloor sediments suspended in the water column from dumping gravel and pipeline construction are assumed to be similar (Sec. IV.C.1.c(8)). Seafloor sediments in Foggy Island Bay consist mainly of fine sand-, silt-, and clay-size particles (Sec. VI.C.1.c(2)). The concentration of suspended sediments associated with trench excavation and backfilling are estimated to range from 500-1,000 milligrams per liter near the seafloor and 50-100 milligrams per liter near the surface (URS Corporation, 2000). Concentrations of suspended particles generally decrease as the distance from the disturbance increases. The larger and/or denser particles settle closer to the source while the smaller and/or less dense particles are carried farther. Suspended sediment concentrations at 1 and 10 kilometers are expected to be less than 20 and 10 milligrams per liter, respectively.

When the dumped gravel forms the base of Liberty Island and covers the seafloor, and as the height of the buildup increases, the effects of gravel dumping on suspended seafloor sediments will decrease.

As the dumped gravel falls through the water column, some of the fine-grained particles would separate from the mass and remain suspended. At the assumed maximum dumping rate of 20,000 cubic yards per day the suspended sediment concentration in the immediate vicinity of the dumping activity is estimated to be 250 milligrams per liter. If the current speed is 2 centimeters per second (0.04 knot), the concentration of suspended particles would be reduced to 50 milligrams per liter at a distance of 0.5 kilometer (0.3 mile) from the construction site, 20 milligrams per liter at 1.25 kilometers (0.78 mile) distance and 10 milligrams per liter at 1.5 kilometers (0.93 mile). The suspended-sediment plume width at the 10-milligram-per-liter concentration interval is estimated to be 400 meters. The suspended-sediment plume is a temporary feature and would disappear within a few days after island construction is complete. The thickness of the depositional layer decreases with distance from the island construction site. The total amount of suspended particles from the Southern Island construction is estimated to be about 14% less than the amount from Liberty Island construction.

Turbidity caused by summer island and slope maintenance activities is expected to be short term, lasting only as long as the activity, and greatest in the vicinity of the island. Turbidity increases are expected to be less than the turbidity caused by currents and waves resuspending sediment particles in shallow water areas.

b) Specific Effects of Constructing the Pipeline

The types of effects on water quality from constructing the eastern pipeline part of this alternative would be the same as those analyzed for Liberty pipeline construction (Sec. IV.C.1.c(8)); see Table II.A-1 to compare the characteristics of the Eastern and Liberty pipelines.

The eastern pipeline trench, about 4.2 miles long, would be dug with backhoes in the winter from the sea ice covering Foggy Island Bay. The average trench depth would be 10.5 feet; the range would be from 8-12 feet deep. An estimated 499,025 cubic yards of sediments would be excavated from the trench, and most of it would be used as backfill. The amount of sediments excavated for the eastern pipeline trench is about 32% less than the amount excavated from the Liberty pipeline trench (724,000 cubic yards). Pipeline trenching would take an estimated 34 days. Excavated material not used as backfill would be left on the ice to return to the seafloor by natural processes during spring breakup.

Pipeline construction would affect water quality by increasing suspended-particulate matter in the water column mainly in the area below the floating fast ice in the winter and in the vicinity of the area where excess trench material lies during the open-water period. Trenching would disturb and resuspend the seafloor sediments in those areas beneath the ice where the sea water has not frozen to the seafloor. Dumping excavated material into the water column to fill the trench also would cause some of the fine-grained particles to separate from the descending sediment mass and remain in suspension; however, exposure to subfreezing temperatures likely would freeze the particles together and reduce some particle separation.

For the eastern pipeline, less material is being exposed to the environment in terms of excavating, backfilling, and abandoning (excess material not used for backfill) than for the Liberty pipeline; excess backfill material would be left on the ice to return to the seafloor by natural processes during spring breakup. For one study, the initial suspended-sediment concentration in the water column during pipeline construction is estimated to be 1,000 milligrams per liter throughout the water column. The amount of suspended particles in the water column would decrease with distance from the construction area. If the current velocity is 0.02 meter per second (0.04 knot), suspended-sediment concentrations greater than 100, 20, and 10 milligrams per liter are estimated to occur within 0.75 kilometer (0.46 mile), about 1 kilometer (0.62 mile), and 10 kilometers (6.2 miles), respectively, from the trench.

In another study, URS Corporation (2000) estimates initial suspended sediment concentrations from pipeline construction could range from 500-1,000 milligrams per liter near the seafloor and 50-100 milligrams per liter at the surface. If the initial concentrations are less than 1,000 milligrams per liter, suspended sediment concentrations at 1 and 10 kilometers could be less that the 20 and 10 milligrams, respectively, estimated previously. Fine-grained particles (silt- and clay-size particles) are estimated to comprise about 65% of the material excavated from the trench.

The total amount of suspended particles from the eastern pipeline construction is estimated to be about 35% less than the amount from Liberty pipeline construction.

Also, the turbidity plume associated with the eastern pipeline would last less than a plume from the Liberty pipeline construction. The time the environment would be disturbed by excavating and backfilling activities is less for the eastern pipeline than for the Liberty pipeline; actual excavation time for the eastern pipeline is estimated to be 23 days compared to 30 days for the Liberty pipeline

Excavated trench material will be stored in two areas; a 230-acre site in waters southeast of the Southern Island site (Zone 3, Fig. II.C-1) and along the eastern pipeline route (Zone 4, Fig. II.C-1). The 230-acre storage site for the eastern pipeline, Zone 3, lies about 3.2 miles east of the comparable storage site, Zone 1, for the Liberty pipeline (Fig. II.A-18); the eastern pipeline lies between about 0.5 and 4.3 miles east of the Liberty pipeline.

Trench sediments would be stockpiled in different parts of the 230-acre site and graded to an average thickness of about 1 foot to minimize the potential for mounding on the seafloor.

After the pipeline has been buried, the amount of material stored on the ice is estimated to be less than the 100,000 cubic yards in the 230-acre site and 10,000 cubic yards along the northern part of the pipeline route amounts estimated for the Liberty pipeline trench.

These sediments could return to the water column in any number of ways described in Section III.C.3.l(2)(b)2).

When the material stockpiled on the ice returns to the seafloor, some of the fine-grained material would be suspended in the water column. The effects on water column turbidity are estimated to be about the same order of magnitude as were estimated for the Liberty Pipeline for 1 or 2 days. For the Liberty pipeline, the suspended-sediment concentration below the 230-acre site is estimated to be 1,168 milligrams per liter, and below the storage area adjacent to the northern part of the proposed pipeline it is estimated to be 14 milligrams per liter. The suspended-sediment concentrations decrease with distance from the storage sites. Concentrations of 200, 20, and 10 milligrams per liter are estimated to occur at about 0.5 kilometer (0.3 mile), 2.75 kilometers (1.70 miles) and 7 kilometers (4.3 miles), respectively, from the 230-acre site.

The thickness of the layer formed by excess trench material falling to the seafloor would be greatest in the vicinity of the storage area and would decrease with distance. The areal extent and thickness of this layer were calculated from a sediment deposition model (URS Greiner Woodward Clyde, 1998a). Within 400-530 meters of Zone 1, the layer formed by excess trench material falling to the seafloor would decrease to a thickness of 10 millimeters. The layer would have a thickness of 1 millimeter within 10-13 kilometers (6.2-8.1 miles) under easterly winds and with about 6.1 kilometers (3.8 miles) under westerly winds. Within 170-180 meters of Zone 3, the layer formed by excess trench material falling to the seafloor would decrease to a thickness of 1 millimeter.

The areal extent of the turbidity plume formed by the falling excess trench material could be approximated by considering where some of the smallest particles might be deposited. Particles 0.005 millimeter in diameter would be deposited at distances of about 13-18 kilometers (8-11 miles) from the Zone 1 site; the thickness of the deposits at these distances is calculated to be about 0.02 millimeter under easterly winds and 0.01 millimeter under westerly winds. Particles 0.005 millimeter in diameter would be deposited at distances of about 18-56.5 kilometers (11-35 miles) from the Zone 3 site; the thickness of the deposits at these distances is calculated to be about 0.001-0.002 millimeters under easterly winds and 0.001 millimeters under westerly winds.

Depending on wind and wave conditions, the fine-grained particles in the excess trench material on the seafloor could be resuspended. The contribution of the trench material to the background suspended-sediment concentration likely would be about the same as that of the area into which the sediments were dumped.

Pipeline trenching and backfilling are not likely to increase the amount of trace metals or hydrocarbons into the environment above the naturally occurring background concentrations.

c) Specific Effects of Repairing the Pipeline

Damage to the pipeline would require repairs, which would mean excavating the trench to expose the pipeline. Repair work most likely would be done in the winter, when the ice is stable enough so that it can be thickened to support the repair equipment, or during the open-water period (Table II.C-6). The pipeline repair techniques are described in Section II.A.1.b(3)(c)3) and summarized in Table II.C-7. Excavated trench material would be stored on the ice during a winter repair and on the seafloor alongside the trench during an open-water repair. The types of effects associated with excavating and backfilling would be the same as those analyzed for pipeline construction; the effects of pipeline repair on water quality are analyzed in Section III.C.3.1(2)(b)3), Effects of Repairing the Pipeline. Depending on the type of repair the amount of sediment excavated would be similar to the amounts estimated for the Proposal (Table II.C-7); these amounts could range from 1,150-6,490 cubic yards and are about 1% or less of the volume handled during construction.

e. Alternative III.B - Use the Tern Island Location and Tern Pipeline Route

Section IV.C.1.a describes the common elements shared by the alternatives in this component set. Those common elements, plus the components that follow, describe this Alternative.

Alternative III.B (see Map 1) assumes the location of the drilling island is moved about 1.5 miles east to the abandoned Tern exploration island. The Tern Island location is in about 23 feet of water on outer continental shelf Lease Y-01585. BPXA is a part owner of this lease. This location, about 2.5 miles southeast of the Boulder Patch, was used to drill the exploratory well from an ice cap on top of the remnants of the abandoned island. The Tern pipeline route would go directly south to shore. It would have the same shore-crossing location and onshore pipeline route to the Badami pipeline as the eastern pipeline route in Alternative III.A. About 230,000 cubic yards of gravel remain from the exploration island, which would reduce the gravel needs to construct the island to about 599,500 cubic yards.

In addition to the construction elements shared by all alternatives in this component set, as noted in Section II.A, construction of the Tern Island and pipeline would include the following:

- 574,500 cubic yards of gravel fill for the island.
- 18,000 interlinked concrete mats (4 feet x 4 feet x 9 inches) (Fig. II.A-5) placed from the base of the gravel bags to the seafloor and secured with anchors placed in the island gravel fill. About 8,000 cubic yards of gravel would be needed to make the concrete mats.
- 4,200 polyester gravel bags (4 cubic yards) placed on the upper slope of the island from 7-23 feet above sea level using an additional 17,000 cubic yards of gravel.
- Gravel bags would be filled from excess gravel at the island construction site.
- 599,500 cubic yards of gravel would be needed for constructing the island.
- Gravel would be hauled over the ice road for about 35-45 days but should be in place at the island construction site by the end of April of Year 2.
- A maximum footprint would be 850 feet by 1190 feet, which is about 23.3 acres. The perimeter berm rises to 23 feet above sea level, which is 8 feet above the working surface.

The overall pipeline length from the Liberty island to the Badami tie-in would be 8.6 miles (13.8 kilometers). Table II.A-2 shows the trenching, excavation, and backfill quantities for this alternative.

While the offshore pipeline routes differ this alternative shares the same shore crossing and onshore pipeline route as Alternative III.B. The rate of shore erosion for this alternative’s shore crossing is higher (2.7 feet per year) than the rate of erosion at the shore-crossing location for the Alternative I (2.0 feet per year.) (BPXA, 1998a) The onshore gravel pad has been moved farther inland and is located 205 feet from the shoreline. This would increase the length of the shore-crossing trench by 55 feet more than the Proposal, and it would increase by one-third the shoreline area disturbed.

In addition to the Zone 3 disposal site described in Section II.C.1.b, a second site would be needed along the west side of the Tern pipeline (Fig. II.C-2). Zone 5 (See Fig. II.C-2) is comparable in purpose to Zone 2 in Alternative I. Zone 5 is 5.5 miles long and 200 feet wide and extends from the island to shore. A 1.8-mile long portion of Zone 5 is seaward of the 3-mile boundary, and the remaining 3.7 miles are shoreward of the 3-mile.

As stated, Zone 5 is a temporary on-ice storage area. It is a contingent disposal location for excess trench materials, should weather or ice conditions cause operations to be abandoned before completion. The maximum quantity of excess trench materials stockpiled or left for disposal on this site at any one time would not exceed 10,000 cubic yards. Excess trench material in water depths greater than 16 feet would be stacked or groomed to maintain an approximate depth of less than 1 foot. Excess trench material placed where the water depths are less than 16 feet would be stacked or groomed to a height not to exceed 2 feet. During pipeline construction, the plan is to clear excess material stacked in Zone 5 of all excess dredged material/spoils by spring breakup. This would be done by scraping the ice with heavy equipment, leaving at most a veneer of dirty ice (a very small amount of sediment remaining in the frozen matrix).

A comparison of the key components for all of the alternative are shown in Table II.A-1. As noted in Section IV.C.1.b, the effects to the following resources are the same for any of the island locations or pipelines routes. The specific components of the Tern Island Location and Pipeline Route as described above would change the impacts to the following resources in the ways described in the analyses that follow:

- Eiders
- Marine and Coastal Birds
- Terrestrial Mammals
- Lower Trophic-Level Organisms
- Vegetation-Wetland Habitats
- Archaeological Resources
- Economy
- Water Quality

(1) Effects on Threatened and Endangered Species - Eiders

(a) Large Oil Spills

The general effects of a large spill and the effects of oil-spill-cleanup activities are analyzed in Section III.C.2.a.(2)(b)1).

1) Summary and Conclusion for Effects of a Large Oil Spill on Eiders

The chance of a spill from the Alternative III.B Tern Island location and offshore portion of the pipeline route contacting environmental resource areas or land segments is essentially the same as from the Alternative I (Sec. IV.C.1c) Liberty Island location. Alternative III.B would result in lower adverse effects because of a somewhat lower probability for contacts from a nearshore pipeline leak.

2) Details on How a Large Oil Spill May Affect Eiders

Specific Effects: The chance of an oil spill from the Alternative III.B Tern Island (T1; Map A-6) and corresponding offshore pipeline spill location (TP1) contacting any spectacled eiders in southern Foggy Island Bay (Environmental Resource Areas 34, 36, Land Segment 26; Map A-2) within 30 days during the summer season is similar (within 5 %) to that for the Alternative I location (L1, PP1). However, the probability of oil from a nearshore pipeline leak (TP2) contacting these environmental resource areas and land segments under Alternative III.B is 10-20% less than for Alternative I. The Alternative III.B Tern Island location/pipeline route is likely to result in lower adverse effects on spectacled eiders than the Alternative I location/route because of a somewhat lower potential for oil spill effects from a nearshore pipeline leak.

(b) Disturbances

The general effects of disturbances are analyzed in Section III.C.3.a.(2)(b)1).

1) Summary and Conclusion for Effects of Disturbances on Eiders

Disturbance under Alternative III.B is expected to be the same as for Alternative I (Sec. IV.C.1.c), with no significant adverse population effects likely to occur.

2) Details on How Disturbances May Affect Eiders

Specific Effects: Disturbance effects from the Alternative III.B and Alternative I island locations, inspections of associated marine and onshore pipeline routes which are of equal length, other helicopter and vessel traffic, and any spill cleanup activity, are expected to be essentially the same.

(2) Effects on Marine and Coastal Birds

(a) Large Oil Spills

The general effects of a large spill and the effects of oil-spill-cleanup activities are analyzed in Section III.C.2.c.(2)(a).

1) Summary and Conclusion for Effects of a Large Oil Spill on Marine and Coastal Birds

Although the chance of a spill from the Alternative III.B Tern Island location and offshore portion of the pipeline route contacting environmental resource areas or land segments is essentially the same as from the Alternative I (Sec. IV.C.1.c) Liberty Island location, Alternative III.B would result in lower adverse effects on waterbirds because of a somewhat lower probability for contacts from a nearshore pipeline leak.

2) Details on How a Large Oil Spill May Affect Marine and Coastal Birds

Specific Effects: The chance of an oil spill from the Alternative III.B Tern Island (T1; Map A-6) and corresponding offshore pipeline spill location (TP1)

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contacting any loons, waterfowl, shorebirds, or seabirds in southern Foggy Island Bay (Environmental Resource Areas 34, 36, Land Segment 26; Map A-2) within 30 days during the summer season is similar (within 5 %) to that for the Alternative I location (L1, PP1). However, the probability of oil from a nearshore pipeline leak (TP2) contacting these environmental resource areas and land segment under Alternative III.B is 10-20% less than for Alternative I. The Alternative III.B Tern Island location/pipeline route is likely to result in lower adverse effects on waterbirds than the Alternative I location/route because of a somewhat lower potential for oil spill effects from a nearshore pipeline leak.

(b) Disturbances

The general effects of disturbances are analyzed in Section III.C.3.c.(2)(a).

1) Summary and Conclusion for Effects of Disturbances on Marine and Coastal Birds

Disturbance of waterbirds under Alternative III.B is expected to be the same as for Alternative I (Sec. IV.C.1.c), with no significant adverse population effects likely to occur.

2) Details on How Disturbances May Affect Marine and Coastal Birds

Specific Effects: Disturbance effects on loons, waterfowl, shorebirds, or seabirds from the Alternative III.B and Alternative I island locations, inspections of associated marine and onshore pipeline routes which are of equal length, other helicopter and vessel traffic, and any spill cleanup activity, are expected to be essentially the same.

(3) Effects on Terrestrial Mammals

(a) Large Oil Spills

The general effects of a large spill and the effects of oil-spill-cleanup activities are analyzed in Section III.C.2.d(2)(a).

1) Summary and Conclusion for Effects of a Large Spill on Terrestrial Mammals

Under this alternative, caribou, muskoxen, grizzly bears, and arctic foxes as likely to encounter an oil spill from the Tern Island production island, should it occur, as from the Liberty Island location because the island is located about the same distance from shore. The effect of potential oil spills, is likely to be about the same as described under the Alternative I. Crude oil or diesel fuel is most likely to contact some coastal areas from the Sagavanirktok River Delta east to Mikkelsen Bay, regardless of which spill scenario is assumed (Table A-13; Land Segments 25, 26, and 27). Caribou may use some of these areas for relief from insects. The main potential effect on terrestrial mammals that contact spilled oil could be the loss of fewer than 100 caribou and a few muskoxen, grizzly bears, and arctic foxes. These losses are expected to be replaced by normal reproduction within about 1 year. A 1,500-barrel onshore pipeline spill could occur and oil less than 5 acres of vegetation along the pipeline landfall to the Badami tie in. Such a spill is not expected to directly affect caribou or other terrestrial mammals and would cause very minor ecological harm.

2) Details on How A Large Spill May Affect Terrestrial Mammals

Specific Effects: Caribou, muskoxen, grizzly bears, and arctic foxes may frequent coastlines near the Liberty Project. The Oil-Spill-Risk Assessment model estimates 11-22% chance of a spill starting at the Tern Island location (T1) and contacting land along the coast of Foggy Island Bay-Mikkelsen Bay within 30 days during the summer open-water season compared to 11-26% for the Liberty island location (Tables A-13 and A-14, Land Segments 25, 26, and 27). Overall, the Oil-Spill-Risk Assessment model estimates that there is an 86-87% chance that a spill starting at Tern Island or Liberty Island location contacts the shoreline (Tables A-12, and A-15 contact to Land within 30 days during the summer). Some Central Arctic Herd caribou could contact oil in coastal habitats from the Sagavanirktok River (east of Endicott causeway) east to about Mikkelsen Bay. Caribou move into these areas to escape insects. Even in a severe situation, however, fewer than 100 animals from the Central Arctic Herd (out of a population of 18,000) are likely to get the oil on their coats and die by inhaling and absorbing toxic hydrocarbons. We base this number on summer surveys of the caribou seen in marine waters (Pollard and Ballard, 1993). Normal reproduction is likely to replace this loss within about 1 year. Caribou could be scared away from the spill area by helicopters during cleanup; however, poor weather conditions may prevent helicopters from hazing caribou away from the spill.

A 1,500-barrel diesel spill would dissipate quickly and likely would not persist beyond about 6 days. The number of caribou and other terrestrial mammals affected is likely to be lower than that affected by a crude oil spill of the same size. The terrestrial mammal populations are expected to recover within 1 year.

(b) Disturbances

The general effects of disturbance on terrestrial mammals for this alternative are expected to be the same as analyzed for Alternative I (Sec.III.C.3.d (2) (a). Moving the production-island to the Tern Island location is not expected to increase the amount of disturbance of terrestrial mammals that they would be exposed to under Alternative I.

(4) Effects on Lower Trophic-Level Organisms

(a) Large Oil Spills

The general effects of a large spill and the effects of oil-spill-cleanup activities are analyzed in Section III.C.2.e(2)(a).

Diesel Fuel Spills: There might be specific differences in the effects of diesel fuel spills. The longer distance between the island and the Boulder Patch would allow greater dispersion of any spilled diesel fuel, reducing the toxicity to the kelp community.

(b) Disturbances

The general effects of disturbances are analyzed in Section III.C.3.e(2)(a).

1) Summary and Conclusion for Effects of Disturbances on Lower-trophic Level Organisms

There also would be specific differences in disturbance effects. The disturbance effects would be lower than for Alternative I but similar to the effects of the plan with a Southern Island and Eastern Pipeline Route (Alternative III.A). The differences in island footprints and pipeline lengths means that the Tern alternative would affect about 35 fewer acres of typical benthos than Alternative I.

2) Details On How Disturbances May Affect Lower Trophic-Level Organisms

Specific Effects: There would be specific differences in disturbance effects for three main reasons: (1) Tern pipeline trenching would encounter none of the kelp habitat that is in the pipeline route for Alternative 1, causing only minor, short-terms effects to typical organisms in silty/sandy sediments. (2) A Tern pipeline would be 0.6 mile shorter than the pipeline for Alternative 1 but about a mile longer than the pipeline for the Southern Island. (3) Tern Island would be in slightly deeper water than the island for Alternative I and much deeper than the Southern Island, which means that the overall size and footprint of Tern Island would be about 2% larger than for Alternative I. However, the Tern alternative would use an existing island berm (Tern), decreasing the amount of additional seafloor and benthos that would be covered to about 1 acre. Using an existing island also would reduce the amount of gravel that would he handled, decreasing the amount of suspended sediment that would result by about one-fourth. The differences in island footprints and pipeline lengths means that the Tern alternative would affect about 35 fewer acres of typical benthos than Alternative I but about 15 more acres than the Southern Island/Eastern Pipeline Route.

We assessed the effects of a Tern pipeline sediment plume in the same way that plumes from the proposed and eastern routes were assessed. Our assessment indicates that the sediment plume from the Tern Island route would reduce kelp production during the construction year by an estimated 7%, as opposed to 6% for Alternative I (Fig. IV.C-2 and Table IV.C-1). The assessment also indicates that the Tern Island pipeline trench and Disposal Zone 3 for excess sediment would be comparable sources of suspended sediment (Fig. IV.C-3 and Table IV.C-1). Overall, the disturbance effects on benthic, coastal and other lower trophic-level organisms for the alternative would be barely detectable against the background annual variations.

If Alternative III.B were approved, MMS could require the lessee to conduct additional surveys, per Lease Sale Stipulation No. 1 about Protection of Biological Resources, as explained in Section IV.A. Kelp would colonize the new slope-protection system on the island, providing some mitigation of the project effects, as discussed for Alternative I.

(5) Effects on Essential Fish Habitat

The general effects of a large spill and the effects of oil-spill-cleanup activities are analyzed in Section III.C.2.f(2) and the general effects of disturbances are analyzed in Section III.C.3.f(2). The potential adverse effects of this alternative on essential fish habitat could be slightly reduced primarily because of expected smaller effects on fish and algae at the Boulder Patch. The longer distance between Tern Island and the Boulder Patch would reduce the risk of diesel fuel spills to the kelp and associate fish communities. The disturbance effects would be slightly lower for the alternative, because pipeline trenching would not eliminate kelp. Less material would be used to construct Tern Island than would be used for Liberty, and the total amount of particulate matter suspended would be less. The turbidity plume would be expected to have a shorter duration than the plume associated with Liberty.

(6) Effects on Vegetation-Wetlands Habitats

(a) Large Oil Spills

The general effects of a large spill and the effects of oil-spill-cleanup activities are analyzed in Section III.C.2.g(2)(a).

1) Summary and Conclusion for Effects of a Large Spill on Coastal and Onshore Vegetation-Wetland Habitats

Under this alternative, coastal vegetation and wetlands in the Foggy Island Bay area probably are as likely to be oiled by an assumed production-island spill at Tern Island location as at the proposed Liberty location because both locations are about equal distance to shore. The main potential effects of a large offshore spill on vegetation and wetland include oil-fouling, smothering, asphyxiation, and poisoning of plants and associated insects and other small animals. In this case, complete recovery of moderately oiled wetlands of the Sagavanirktok River east to Mikkelsen Bay would take perhaps 10 years or longer.

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A large onshore spill would oil no more than 5 acres of vegetation along the pipeline landfall to the Badami tie in would cause very minor ecological harm. Oiled vegetation should recover within a few years but may take more than 10 years to fully recover.

2) Details on How a Large Oil Spill May Affect Vegetation-Wetlands

Specific Effects: The conditional probability of an oil spill starting at Tern Island or along the pipeline and contacting vegetation within 30 days during the summer-open-water season are highest with wetlands in the Foggy Island Bay area west to the Sagavanirktok River Delta. The Oil-Spill-Risk Assessment model estimates an 11-22% chance of a spill starting at Tern Island and entering offshore waters contacting Land Segments 27, 26, or 25 during the summer within 30 days compared to 11-26% for the Liberty Island location (Tables A-13 and A-14). Overall, the model estimates that there is an 86-87% conditional probability that a spill starting at Liberty Island (L1) or Tern Island location (T1) would contact land somewhere along the coast within 30 days during the summer (Tables A-12, and A-15 Land, Map A-1). The spill could oil an estimated 21-30 kilometers of shoreline (Table A-7) and extend inshore a few feet to several yards, depending on tides and storm surges. A 1,500-barrel diesel spill would dissipate quickly and would not be expected to persist beyond about 6 days. The amount of wetlands contacted by diesel fuel is expected to be less than that contacted by crude oil.

The shoreline of the Liberty Project area contains habitats with fairly high values (1 being the lowest and 10 being the highest) for oil-spill retention (lagoonal beaches have a value of 5 and peat shores have a value of 6) along the eastern Sagavanirktok River Delta and near the mouth of the Kadleroshilik River (Nummedal, 1980). Stranded oil on sheltered intertidal areas, especially along peat shorelines, is likely to persist for many years (Nummedal, 1980; Owens et al., 1983).

(b) Disturbances

The general effects of disturbances are analyzed in Section III.C.3.g.(2)(a). The effects of disturbance on vegetation and wetlands for this alternative are expected to be the same as analyzed for Alternative I (Sec IV.C.3.i). Moving the production-island to the Tern Island location is not expected to increase the amount vegetation-wetlands altered under Alternative I.

(7) Effects on the Economy

The general effects of a large spill and the effects of oil-spill-cleanup activities are analyzed in Section III.C.2.k. and the general effects of disturbances activities are analyzed in Section III.C.3.k.

Specific Effects: Alternative III generates fewer jobs, fewer wages, and less revenue to the Government than for the Proposal. This alternative would result in a decrease of approximately $1.7 million in wages for 12 months, 9 direct jobs in Alaska for 12 months. 14 indirect jobs in Alaska for 12 months, and $10 million in net present value to the company (Sec. II and Appendix D-1). Information in this analysis is interpreted in part from data in INTEC (1999a). The net present value to the government is estimated to be $107, or $7 million less than the Proposal (Appendix D-1).

(8) Effects on Water Quality

(a) Large Oil Spills

The effects of an oil spill on water quality for this alternative are expected to be the same as analyzed for Alternative I in Section IV.C.1.c(8). The general effects of a large oil spill and the effects of oil-spill-cleanup activities are analyzed in Section III.C.2.l (2)(a).

(b) Disturbances

The general effects of disturbances are analyzed in Section III.C.3.1(2)(a).

1) Summary and Conclusions for Effects of Disturbances on Water Quality

The greatest effect on water quality from gravel island and pipeline construction would be additional turbidity caused by increases in suspended particles in the water column. Increases in turbidity generally are expected to be considerably less than the 7,500 parts per million suspended solids used in the analysis as an acute (toxic) criterion for water quality; exceptions may occur within the immediate vicinity of the construction activity. Turbidity increases from construction activities generally are temporary and expected to occur during the winter and end within a few days after construction stops. The duration of turbidity from Tern Island is expected to be less by about 15 days compared to Liberty Island (45-60 days) and pipeline trenching is expected to be less by 5 days compared to Liberty pipeline (49 days). The overall effects of turbidity are expected to be about 25% less during the construction of the Southern Island and 10% less for the eastern pipeline compared to the construction of Liberty Island and pipeline, respectively. Material excavated from the pipeline trench but not used for backfill most likely would be left in an area where active erosion of sediment particles could occur during breakup and open water. This material would be similar in composition to seafloor sediments in the trenching and disposal areas, and its contribution to future turbidity from waves and currents is expected to be about the same as the sediments existing at the seafloor surface before pipeline construction. Construction activities are not expected to introduce or add any chemical pollutants.

2) Details on How Disturbances May Affect Water Quality

The following analysis of the effects constructing the Tern Island and Pipeline would have on water quality in Foggy

Island Bay are based on a comparison of scenarios as summarized in Table II.A-1 and the following analyses:

- general effects of construction activities on water quality in Section III.C.3.l(2)(a) and
- specific effects of island and pipeline construction in Section IV.C.1.c(8).

a) Specific Effects of Constructing the Production Island

The types of effects on water quality from constructing the Tern Island part of this alternative would be the same as those analyzed for Liberty Island construction (Sec. IV.C.1.c(8)); see Table II.A-1 to compare the characteristics of Liberty and Tern Islands.

Tern Island would be constructed in water about 23 feet deep using an estimated 574,500 cubic yards (Table II.C-1) of gravel mined from a permitted site on the Kadleroshilik River floodplain; the gravel is not expected to contain any contaminated material. The amount of gravel required to construct the Tern Island is about 25% less than the amount estimated for Liberty Island (773,000 cubic yards). The amount of gravel in place at the Tern Island site is estimated to be 230,000 cubic yards (Sec. II.C.1). The gravel would be trucked to the Tern Island site over ice roads and dumped into the water through openings cut in ice; this activity is estimated to take 30-45 days compared to the 45-60 days estimated to construct Liberty Island. Dumping river gravel would affect water quality by increasing the amount of suspended particulate matter in the water column in the area below the floating fast ice in several ways, including (1) suspension of sediments by currents generated from the gravel hitting the seafloor and (2) separation of fine-grained particles from the material falling through the water.

The effects of seafloor sediments suspended in the water column from dumping gravel and pipeline construction are assumed to be similar (Sec. IV.C.1.c(8)). Seafloor sediments in Foggy Island Bay consist mainly of fine sand-, silt-, and clay-size particles (Sec. VI.C.1.c(2)). The concentration of suspended sediments associated with trench excavation and backfilling are estimated to range from 500-1,000 milligrams per liter near the seafloor and 50-100 milligrams per liter near the surface (URS Corporation, 2000). Concentrations of suspended particles generally decrease as the distance from the disturbance increases. The larger and/or denser particles settle closer to the source while the smaller and/or less dense particles are carried farther. Suspended sediment concentrations at 1 and 10 kilometers are expected to be less than 20 and 10 milligrams per liter, respectively.

When the dumped gravel forms the base of Liberty Island and covers the seafloor, and as the height of the build up increases, the effects of gravel dumping on suspending seafloor sediments will decrease.

As the dumped gravel falls through the water column, some of the fine-grained particles would separate from the mass and remain suspended. At the assumed maximum dumping rate of 20,000 cubic yards per day the suspended sediment concentration in the immediate vicinity of the dumping activity is estimated to be 250 milligrams per liter. If the current speed is 2 centimeters per second (0.04 knot), the concentration of suspended particles would be reduced to 50 milligrams per liter at a distance of 0.5 kilometer (0.3 mile) from the construction site, 20 milligrams per liter at 1.25 kilometers (0.78 mile) distance and 10 milligrams per liter at 1.5 kilometers (0.93 mile). The suspended-sediment plume width at the 10-milligram-per-liter concentration interval is estimated to be 400 meters. The suspended-sediment plume is a temporary feature and would disappear within a few days after island construction is complete. The thickness of the depositional layer decreases with distance from the island construction site. The total amount of suspended particles from the Tern Island construction is estimated to be about 25% less than the amount from Liberty Island construction.

Turbidity caused by summer island and slope maintenance activities is expected to be short term, lasting only as long as the activity, and greatest in the vicinity of the island. Turbidity increases are expected to be less than the turbidity caused by currents and waves resuspending sediment particles in shallow water areas.

b) Specific Effects of Constructing the Pipeline

The types of effects on water quality from constructing the Tern pipeline part of this alternative would be the same as those analyzed for Liberty pipeline construction (Sec. IV.C.1.c(8)); see Table II.A-1 to compare the characteristics of the Tern and Liberty Pipelines.

The Tern pipeline trench, about 5.5 miles long, would be dug with backhoes in the winter from the sea ice covering Foggy Island Bay. The average trench depth would be 10.5 feet; the range would be from 8-12 feet deep. An estimated 652,800 cubic yards of sediments would be excavated from the trench, and most of it would be used as backfill. The amount of sediments excavated for the Tern pipeline trench is about 11% less than the amount excavated from the Liberty pipeline trench (724,000 cubic yards) Pipeline trenching would take an estimated 44 days. Excavated material not used as backfill would be left on the ice to return to the seafloor by natural processes during spring breakup.

Pipeline construction would affect water quality by increasing suspended-particulate matter in the water column mainly in the area below the floating fast ice in the winter and in the vicinity of the area where excess trench material lies during the open-water period. Trenching would disturb and resuspend the seafloor sediments in those areas beneath the ice where the sea water has not frozen to the seafloor. Dumping excavated material into the water column to fill the trench also would cause some of the fine-grained particles to separate from the descending sediment mass and remain in suspension; however, exposure to subfreezing temperatures likely would freeze the particles together and reduce some particle separation.

For the Tern pipeline, less material is being exposed to the environment in terms of excavating, backfilling, and abandoning (excess material not used for backfill) than for the Liberty pipeline; excess backfill material would be left on the ice to return to the seafloor by natural processes during spring breakup. For one study, the initial suspended-sediment concentration in the water column during pipeline construction is estimated to be 1,000 milligrams per liter throughout the water column. The amount of suspended particles in the water column would decrease with distance from the construction area. If the current velocity is 0.02 meter per second (0.04 knot), suspended sediment concentrations greater than 100, 20, and 10 milligrams per liter are estimated to occur within 0.75 kilometer (0.46 mile), about 1 kilometer (0.62 mile), and 10 kilometers (6.2 miles), respectively, from the trench.

In another study, URS Corporation (2000) estimates initial suspended sediment concentrations from pipeline construction could range from 500-1,000 milligrams per liter near the seafloor and 50-100 milligrams per liter at the surface. If the initial concentrations are less than 1,000 milligrams per liter, suspended sediment concentrations at 1 and 10 kilometers could be less that the 20 and 10 milligrams, respectively, estimated previously. Fine-grained particles (silt- and clay-size particles) are estimated to comprise about 65% of the material excavated from the trench.

The total amount of suspended particles from the Tern pipeline construction is estimated to be about 2% less than the amount from Liberty pipeline construction.

The turbidity plume associated with the eastern pipeline also would not last as long as a plume from the Liberty pipeline construction. The time the environment would be disturbed by excavating and backfilling activities is less for the Tern Pipeline than for the Liberty pipeline; actual excavation time for the Tern pipeline is estimated to be 27 days compared to 30 days for the Liberty pipeline.

Excavated trench material will be stored in two areas; a 230-acre site in waters south of Tern Island (Zone 3, Fig. II.C-2) and along the Tern pipeline route (Zone 5, Fig. II.C-2). The 230-acre storage site for the Tern pipeline, Zone 3, lies about 3.2 miles east of the comparable storage site, Zone 1, for the Liberty pipeline (Fig. II.A-18); the Tern pipeline lies about 1.4 and 4.3 miles east of the Liberty pipeline.

Trench sediments would be stockpiled in different parts of the 230-acre site and graded to an average thickness of about 1 foot to minimize the potential for mounding on the seafloor.

After the pipeline has been buried, the amount of material stored on the ice is estimated to be less than the 100,000 cubic yards in the 230-acre site and 10,000 cubic yards along the northern part of the pipeline route amounts estimated for the Liberty pipeline trench. These sediments could return to the water column in any number of ways described in Section III.C.3.l(2)(b)2)

When the material stockpiled on the ice returns to the seafloor, some of the fine-grained material would be suspended in the water column. The effects on water column turbidity are estimated to be about the same order of magnitude as were estimated for the Liberty pipeline for 1 or 2 days. For the Liberty pipeline, the suspended-sediment concentration below the 230-acre site is estimated to be 1,168 milligrams per liter, and below the storage area adjacent to the northern part of the proposed pipeline it is estimated to be 14 milligrams per liter. The suspended-sediment concentrations decrease with distance from the storage sites. Concentrations of 200, 20, and 10 milligrams per liter are estimated to occur at about 0.5 kilometer (0.3 miles), 2.75 kilometers (1.70 miles), and 7 kilometers (4.3 miles), respectively, from the 230-acre site.

The thickness of the layer formed by excess trench material falling to the seafloor would be greatest in the vicinity of the storage area and would decrease with distance. The areal extent and thickness of this layer were calculated from a sediment deposition model (URS Greiner Woodward Clyde, 1998a). Within 400-530 meters of Zone 1, the layer formed by excess trench material falling to the seafloor would decrease to a thickness of 10 millimeters. The layer would have a thickness of 1 millimeter within 10-13 kilometers (6.2-8.1 miles) under easterly winds and with about 6.1 kilometers (3.8 miles) under westerly winds. Within 170-180 meters of Zone 3, the layer formed by excess trench material falling to the seafloor would decrease to a thickness of 1 millimeter.

The areal extent of the turbidity plume formed by the falling excess trench material could be approximated by considering where some of the smallest particles might be deposited. Particles 0.005 millimeter in diameter would be deposited at distances of about 13-18 kilometers (8-11 miles) from the Zone 1site; the thickness of the deposits at these distances is calculated to be about 0.02 millimeter under easterly winds and 0.01 millimeter under westerly winds. Particles 0.005 millimeter in diameter would be deposited at distances of about 18 to 56.5 kilometers (11 to 35 miles) from the Zone 3site; the thickness of the deposits at these distances is calculated to be about 0.001-0.002 millimeter under easterly winds and 0.001 millimeter under westerly winds.

Depending on wind and wave conditions, the fine-grained particles in the excess trench material on the seafloor could be resuspended. The contribution of the trench material to the background suspended-sediment concentration likely would be about the same as that of the area into which the sediments were dumped.

Pipeline trenching and backfilling are not likely to increase the amount of trace metals or hydrocarbons into the environment above the naturally occurring background concentrations.

c) Specific Effects of Repairing the Pipeline

Damage to the pipeline would require repairs, and this means excavating the trench to expose the pipeline. Repair work most likely would be done in the winter, when the ice is stable enough so that it can be thickened to support the repair equipment, or during the open-water period (Table II.C-6). The pipeline repair techniques are described in Section II.A.1.b(3)(c)3) and summarized in Table II.C-7. Excavated trench material would be stored on the ice during a winter repair and on the seafloor alongside the trench during an open-water repair. The types of effects associated with excavating and backfilling would be the same as those analyzed for pipeline construction; the effects of pipeline repair on water quality are analyzed in Section III.C.3.1(2)(b)3), Effects of Repairing the Pipeline. Depending on the type of repair the amount of sediment excavated would be similar to the amounts estimated for the Proposal (Table II.C-7); these amounts could range from 1,150-6,490 cubic yards and are about 1% or less of the volume handled during construction.

2. Effects of Alternative Pipeline Designs

This set of component alternatives has four component alternatives:

Alternative I – Use Single Steel Wall Pipe System (proposed in Liberty Development and Production Plan)

Alternatives IV.A - Use Pipe-in-Pipe System

Alternative IV.B - Use Pipe-in-HDPE System

Alternative IV.C - Use Flexible Pipe System (Fig.II.C-3).

Alternatives IV.A, IV.B, and IV.C were identified during scoping by members of the Interagency Team. Some of the team members expressed concern about pipeline safety and wanted MMS to investigate further whether alternative pipeline designs could reduce the potential for oil spills to enter the marine environment. Each of the alternatives in this section evaluates the impacts of using different pipeline designs. Each of these design alternatives is based on a conceptual engineering report by INTEC (2000).

For the Liberty Project, the decisionmaker(s) may choose any of the four pipeline designs. The MMS has contracted several studies to look at pipeline designs. There are multiple designs of pipelines that appear to be feasible for the Liberty Project. Because absolute protection of the environment, from a pipeline containment failure, is not attainable, the MMS must exercise judgement in determining when the actions of the applicant are raising such a potential for harm that additional mitigation is necessary. During the Northstar pipeline permitting process, BPXA accepted additional mitigation to better protect the environment. One mitigation measure that was required on the Northstar project was the addition of a supplemental external leak-detection system. BPXA chose the LEOS system to meet this stipulation for Northstar and has included it as part of the proposal for the Liberty Project.

In the Executive Summary, we defined the terms functional failure and containment failure; this definition is repeated here. For the purpose of this draft EIS, we have categorized all pipeline failures as either functional or containment failures. A functional failure is one where the pipeline is no longer capable of operating as designed, such as excessive bending, ovalization, or in the case of a pipe-in-pipe system, a leak in one but not both pipes; however, the failure does not result in a leak to the environment. A containment failure is one that would allow oil to enter the environment; in the case of a pipe-in-pipe system this would require a leak in both pipelines. Both functional and containment failures would require the pipeline to be returned to within design basis parameters, or require the operator to prove to the proper regulatory agency(ies) that it is safe to continue operating the pipeline, before it can be returned to service.

The acceptable level of risk is the product of the probability of a spill and the associated consequences. Pipelines have a very low probability of failure when compared to other types of oil-transportation systems. This is attributed to their simplistic design and the fact that most are buried out of harm's way. Any pipeline can be designed to satisfy a target safety level. Double-wall pipelines provide secondary containment, which can reduce the probability of a containment failure; however, the added complexity of the system can increase the probability of a functional failure. Conversely, a single-wall pipeline is a simpler system that can reduce the probability of a functional failure. The lack of secondary containment in a single-wall pipeline can increase the probability of a containment failure.

The MMS concurs with C-CORE (2000) that "[i]n general terms, pipeline expenditure is best directed to reduction in hazard frequency rates (i.e., probability of an event occurrence) as opposed to mitigation of event consequences (i.e. severity of the event)." However, because no amount of effort could absolutely guarantee that a pipeline leak would not occur, the MMS participates in and supports oil-spill-cleanup research and testing, and insures operator compliance with the Oil Pollution Act of 1990 readiness requirements.

a. Evaluation of Leak Detection and Oil-Spill Sizes

The Proposal and the three pipeline design alternatives include the use of the LEOS or a LEOS-equivalent leak-detection system to identify small chronic leaks. (See Sec. II.A.1.b(3)(b)1)) (Fig. II-19) for a description of the LEOS

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system.) The LEOS system has been used successfully, primarily in Europe, for more than 20 years, but it has not yet been operated in offshore or arctic conditions. It was successfully installed as part of the Northstar pipeline system, and early testing has shown that the system appears to be working properly (Franklin, 2000, pers, commun.). Because the LEOS system's long-term performance in an offshore application, let alone in the Arctic, is unknown, this EIS evaluates what the MMS believes to be an unlikely condition that a LEOS or LEOS-equivalent leak-detection system does not function properly. This does not mean that we consider the system inadequate or unreliable. Rather, it provides additional information for readers and decisionmakers to consider. The following analyses comparing designs, assume that LEOS or the LEOS-equivalent leak-detection system either works or does not work.

Section III.C.1.e describes four different sizes of potential offshore oil spills. (125 barrels, 715 barrels, 1,580 barrels, and 2,956 barrels) that are evaluated in this section.

The amount of oil that could be contained in the annular space for the pipe-in-pipe system is estimated at 1,325 barrels; for the pipe-in-HDPE (high-density polyethylene) system, the annular capacity is estimated at 1,725 barrels. For purposes of analysis, the EIS assumes the oil in the pipe's annular space can be removed successfully. Detailed scenarios for annulus cleanup and double-wall pipeline repair would need to be developed, if a double wall pipeline system was chosen by the decisionmaker. The carrier pipe can be pigged and the oil in the carrier pipe removed, if the damage is not too extensive. However, the annular space cannot be pigged. Detergents and other fluids likely would be used to flush the oil out of the annulus. The oil and cleaning fluids would need to be pumped from the low point(s) in the pipeline, which would be near the gravel-drilling island. After the oil in the annulus has been cleaned out and all fluid removed, the repair to the pipeline could begin. The oil and detergents for the recovery and cleaning operation would be disposed of at an approved site. The different types of repairs are discussed in Section II.A1.b(c)(3). The costs and time required to clean the oil from the pipeline depends on the type and extent of damage and cannot be accurately estimated. Repair of the outer pipe most likely would require the use of a split-sleeve. If this were the case, the integrity of the outer pipe would be somewhat reduced from its original integrity due to the longitudinal welds.

Some members of the Interagency Team suggested that we perform an economic cost/benefit analysis to estimate the benefits, or costs savings, from cleaning up a leak that is contained in the annulus of either the pipe-in-pipe or pipe-in-HDPE systems. We calculated the expected "potential benefits" by estimating the costs that would have been expended to clean up a possible oil leak of the same size plus the environmental costs imposed by the leak. We found that this exercise was not very useful for two reasons: (1) the wide range of potential costs for cleanup and restoration and (2) the low rates of containment failures associated with the different pipeline designs. When we tried to subtract the representative containment benefits from the costs associated with construction, the results were nearly the same as the original construction costs. Therefore, the exercise became a comparison of construction costs and did not provide any useful comparison or information for the decisionmakers or readers.

b. Results of Pipeline Studies

As stated earlier, we contracted for several studies specific to pipeline designs being evaluated in this EIS. Before describing pipeline design alternatives, we feel it would be beneficial to describe the information and issues that have resulted from the ongoing studies.

In December 1999, we contracted with Stress Engineering Services, Inc. (Stress) to conduct a study titled *Independent Evaluation of Liberty Pipeline System Design Alternatives* (Stress, 2000). This study provides an independent review of the report *Pipeline System Alternatives – Liberty Development Project Conceptual Engineering* (INTEC, 1999a). The INTEC report contains conceptual engineering designs for the four pipeline designs that are described as the pipeline design alternatives in Section II: single-wall pipeline, a steel-in-steel pipe-in-pipe system, a steel pipe-in-HDPE system, and a flexible pipe system.

Stress defined the objective of the review was "…to ensure that all of the candidate designs were considered equally and that the conceptual designs, construction methods, inspection techniques, repair methods, loads, cost estimates, and operations/maintenance practices were reasonable" (Stress, 2000).

Stress concluded in the final report that: "We are confident that any of the four candidate concepts could be designed to fulfill the intended function of the pipeline. However, the concepts do have different levels of risk and different anticipated costs, both during installation and during the twenty year design life" (Stress, 2000).

The applicant was provided with a copy of the report prepared by Stress and comments from the MMS, Fish and Wildlife Service, and Corps of Engineers. With these comments, INTEC prepared a response to the comments and an addendum to the report that evaluated all four pipeline designs buried with a 7-foot burial depth. INTEC reissued their report in April 2000. This new version of the report (INTEC, 2000), with the response to comments and the addendum, was utilized in this report. It was decided that the original alternative designs would be the pipeline alternatives in this report and the 7-foot burial depth steel pipe-in-steel pipe design would be analyzed as part of Combination Alternative A.

Another contract was awarded to Fleet Technology Limited (Fleet) to conduct a study titled *Independent Risk Evaluation for the Liberty Pipeline* (Fleet, 2000). This study was awarded to get an independent assessment to the risks of spills from the original four pipeline designs generated by INTEC and the pipeline designs contained in the addendum to the Fleet report that modified the original designs for a 7-foot burial depth.

We also contracted with the Centre for Cold Oceans Resource Engineering (C-CORE) to conduct a study titled *An Engineering Assessment of Double Versus Single Wall Designs for Offshore Pipelines in an Arctic Environment* (C-CORE, 2000). This study compared the advantages and disadvantages of pipe-in-pipe and single-wall pipe designs in general and was not based on a specific project. The information contained in the C-CORE study is summarized in the following subsections.

The three reports are incorporated by reference into this EIS. The Executive Summary from each report is contained in Appendix D, and the full report is available for review at the MMS Office in Anchorage, Alaska, or can be downloaded from the MMS Alaska Region internet site www.mms.gov/alaska. A summary of the information contained in these reports appears in the following sections.

c. Pipe-in-Pipe Can Provide the Following Environmental Benefits

The outer pipe of a pipe-in-pipe system provides a secondary containment capability that is not available with a single-wall pipeline. This addition of secondary containment results in a pipe-in-pipe system having a reduced probability of a containment failure compared to a single-wall pipeline. The C-CORE (2000) study indicated that secondary containment was the primary benefit provided by a pipe-in-pipe system. While it is possible that some oil may spill from the annulus of a pipe-in-pipe system during repair operations, the volume would be small, less than 100 barrels, and spill-containment and cleanup equipment would be onsite to quickly respond to any such spill; therefore, the effects this would have on the environment would be minor. Containing a leak in the annulus of the pipeline also could provide some flexibility in scheduling the pipeline repair to minimize the impacts on the species that inhabit the area. For example, if a leak occurred during spring breakup, it might be possible to wait and repair the leak the following winter rather than in the summer, when waterfowl and bowhead whales are in the area. Another benefit of pipe-in-pipe is that the annulus surrounding the carrier pipeline provides an advantage for leak detection:

> The double wall pipe provides a potential leak detection advantage over a single walled pipeline. A pressure based annulus leak detection system does not fully realize this potential, but can provide continuous integrity monitoring of both the inner and outer pipes, and thus monitor effectiveness of both the primary or secondary containment (C-CORE, 2000).

The above-mentioned monitoring method would indicate that either the inner or the outer pipe has failed, but it would not be able to assess the integrity of either pipe before failure.

The C-CORE (2000) report states that: "The outside of the inner pipe and the inside of the outer pipe have low potential [for] corrosion because of the inert gas that would be used to fill the annulus."

The C-CORE (2000) report concluded that pipe-in-pipe would reduce the probability of a containment failure compared to a single-wall pipe. Although the report did not quantify the reduction in containment failure probability, it did indicate that probabilities of girth-weld failure and corrosion, what C-CORE believes to be the two major causes of containment failures, were substantially reduced for a pipe-in-pipe system. This reduction is due to the low probability of a simultaneous failure of both the inner and outer pipes.

The C-CORE (2000) report also concluded:

> Selection of the Most appropriate pipeline, whether I be single wall or double wala, would be influenced by several factors. There is no basis for a simple conclusion that one is better than the other, as each has advantages and disadvantages. The only basis would be a project specific risk assessment that concluded that the risk of oil getting into the environment was lower for double wall pipe. Both robust single wall pipe and double wall pipe meet or exceed specified code requirements; for example, DNV (1006).
>
> The most compelling reason for a double wall pipe, instead of a robust single wall pipeline, is the containment of a product leak. The annulus can also be monitored for evidence of a leak (or even pipe degradation). In these respects it has advantages over a single wall pipe. However, a leak in a robust single wall pipe has a very low probability. The thicker wall than normally used provides greater strength to resist environmental loads and greater resistance to erosion and corrosion than is the case for most of the offshore pipes (if not all) that have experienced leaks or failures. The major advantages of a single wall pipe are simpler construction, lower construction costs, lower life cycle costs and greater inspection reliability. The major disadvantages are that any size leak would release product into the environment. The major advantage of the double wall pipe is that the probability of a failure or leak in both pipes at the same time is very low. It has a

lower risk of product release to the environment than a single wall pipe. The disadvantages of the double wall pipe include its relative complexity and potential difficulties with integrity monitoring of the outer pipe.

The Fleet (2000) report concluded that the “expected” volume of oil spilled from a pipe-in-pipe system over the project’s life would be about a third of what it would be for a single-wall pipeline, 8 and 28 barrels, respectively. The Fleet report also concluded that the probability of a large spill (greater than 1,000 barrels) is 0.00158 for the pipe-in-pipe system, and 0.0138 for the single-wall system.

This information can be interpreted in two ways. The probability of a large spill from a single-wall pipeline system is approximately nine times greater than for the pipe-in-pipe system. Alternatively, the chances of not having a large spill from the single-wall pipeline system, or the pipe-in-pipe system, over the project’s life are 98.6% and 99.8%, respectively.

Pipe-in-pipe would provide for better leak-detection capability within the annular space with LEOS or another annular monitoring system, if such a system could be installed and operate effectively within the annular space. Pressure monitoring of the annular space could determine if either the carrier pipe or casing has failed. The LEOS or equivalent system may be able to detect a small, chronic leak in an annulus sooner than it could in the soil surrounding a single-wall pipeline. This earlier detection could reduce the total amount of oil released from a pipeline.

d. Pipe-in-Pipe Monitoring, Operation, and Maintenance Concerns

A pipe-in-pipe design reduces the ability to monitor the integrity of the outer pipe for problems associated with corrosion or external forces. The outer pipe would be coated and a cathodic protection system installed, but the effectiveness of this system cannot be monitored as thoroughly as a single-wall pipe. The pipe-to-soil potential, an indicator of the effectiveness of the cathodic protection system, can be monitored at the island and shore crossing, but it would be impractical to obtain these readings along the remainder of the subsea pipeline. A wall-thickness pig can determine if corrosion is occurring along the entire length of a single-wall pipeline. However, since a wall-thickness pig cannot monitor the outer pipe of a pipe-in-pipe system, this represents a reduction in the cathodic protection monitoring capabilities of a pipe-in-pipe system relative to a single-wall pipeline system. Smart-pigging tools would not be able to determine the condition of the outer pipe of a pipe-in-pipe system, unless then damage was so extensive that it was also affecting the inner pipe. This also represents a reduction in the defect monitoring capabilities of a pipe-in-pipe system relative to a single-wall system. These limitations apply to the monitoring capabilities of the outer pipe. The monitoring capabilities of the inner pipe should be comparable to what is achievable for a single-wall pipeline, except that it would not be able to measure the corrosion potential if seawater entered the annulus.

The C-CORE (2000) report indicates that the potential for annular corrosion is low, because the annulus will be kept dry and an inert material, presumably nitrogen or another inert gas, will fill the annulus. The Stress (2000) report was not as optimistic about the ability to keep the annulus dry. Even though the inner pipe would have a protective coating applied, Stress indicated that it would be possible for this coating to be damaged and suggested it maybe possible to add a cathodic protection system to the inner pipe. The cathodic protection system would then be in place waiting to protect the inner pipe should the annulus become contaminated with a corrosive material, such as seawater. They indicated that either attaching anodes two the inner pipe during pipeline construction or spraying an aluminum coating on the inner pipe could provide a cathodic protection system that should work if the annulus were flooded with seawater. Stress also notes that the use of aluminum coatings is technically feasible, but some development work is required before it can be used routinely, and it may be cost prohibitive. Smart pigging could be used to determine if the inner pipe has corroded, but it would not be able to measure the inner pipes potential for corrosion, which would indicate the effectiveness of the cathodic protection system.

The increased number of welded joints in the pipe-in-pipe system, twice as many as for the single-wall pipeline, makes quality control and quality assurance during pipeline construction more difficult. All welds on the inner pipe and most welds on the outer pipe would be tested with both ultrasonic and radiographic (x-ray) testing. Interference from the inner pipe would prevent the use of x-ray testing on the tie-in welds of the outer pipe. While either ultrasonic or x-ray testing alone should be able to determine if a weld defect exists they look at the weld in different ways and it may be possible for a defect to go undetected in one test but show up in the other. It is our opinion that redundancy afforded by performing both tests provides a higher level of confidence that the weld is adequate. To repair the outer pipe of a pipe-in-pipe system, it most likely would be necessary to use a split section of pipe for part of the repair. The presence of longitudinal welds on this split section of pipe would reduce the integrity of the outer pipe in comparison to its original integrity. The Stress (2000) report indicates that it will be difficult to dry the annulus after a repair, and the drying operation would likely take a month or more. Stress estimates that if the outer wall leaked and allowed water to enter the annulus. there would be moisture in the annulus for at least 4 months from the time the leak is detected until the pipeline can be repaired and the annulus has been dried. They indicate that this is more than enough time for corrosion to begin.

C-CORE stated several disadvantages centered on issues of operations and maintenance. These include reduced outer pipe defect-monitoring capability, reduced outer pipe defect-assessment capability, and more complicated commissioning requirements. Repair procedures would be more complicated, and the increased complexity of the double-wall system would increase the probability of a functional failure (C-CORE, 2000).

When considering defect monitoring and assessment during pipeline operations, C-CORE concluded:

> The majority of existing defect inspection, monitoring, and associated assessment methods and technologies cannot be applied to the outer pipe wall of PIP configurations. This limitation means the condition of the outer pipe cannot be readily inspected and evaluated for 'fitness of service'. As a result this represents a significant maintenance difference between PIP and single configurations (C-CORE, 2000).

and that:

> …in the event of an integrity failure of the outer pipe, a potential for local accelerated corrosion within the annulus will develop. Due to PIP configuration geometry, even with the assumption of 'best practices' repair and commissioning, a completely clean, vacuum dried and chemically inhibited and 'oxygen scavenged' annulus will be difficult to ensure (C-CORE, 2000).

One way to improve the outer wall defect monitoring capability would be to permanently install monitoring devices on the outer pipe during installation. However, these devices would be located at discreet points along the pipeline and may miss areas of damage to the outer pipeline.

The C-CORE report goes on to say that: "except for extreme defects that affect both the inner and outer pipes, the following monitoring methods [for assessment of the outer pipe] do not apply: caliper pig, inertial mapping pigging, and strain gauge" (C-CORE, 2000).

The C-CORE report also makes the following statement regarding repairing a pipe-in-pipe system:

> The two pipe walls, with or without Bulkheads, shear rings, guides and inert gas annulus 'packs', are physically more difficult to repair relative to a single wall pipeline. Commissioning PIP configurations for return to service will also be more difficult potentially requiring an annulus flush, vacuum drying and the application of chemical inhibitors and oxygen 'scavenger'. As a result this represents a moderate maintenance difference between PIP and single wall configuration (C-CORE, 2000).

There are numerous technical aspects to the operations and maintenance of all of the alternative pipelines. The concerns with the pipe-in-pipe system largely deal with the complexities of monitoring and maintaining the annulus and outer pipe of the system. C-CORE summarizes their findings relative to the operations and maintenance of the inner and outer pipes of the pipe-in-pipe system in their Executive Summary:

> The main operating and maintenance disadvantages of a double wall pipeline relative to single wall pipelines are the limited capability to inspect and monitor the condition of the outer pipe.
>
> Double wall and single wall pipeline configurations have similar operating and maintenance requirements on the product (inner) pipe for operational condition monitoring, leak detection, chemical inhibition application, pipe cleaning, defect monitoring and evaluation, and cathodic protection testing, monitoring and maintenance (C-CORE, 2000).

C-CORE reports that the complexity inherent in the addition of the outer pipe increases the probability of functional failure in the pipe-in-pipe system relative to the single-wall system. Although a functional failure would not release oil to the environment, it would require the pipeline to be repaired, or require the operator to prove to the proper regulatory agency(ies) that it is safe to continue operating the pipeline before the pipeline can be returned to service.

The Fleet (2000) report and the C-CORE (2000) report differ on the probability of a functional failure of a pipe-in-pipe system as a result of a corrosion-related failure of the inner pipe. Fleet indicates that the inner pipe of a pipe-in-pipe system is more likely to develop a leak from corrosion than a single-wall pipeline. C-CORE indicates that the low potential for corrosion in the annulus of a pipe-in-pipe system reduces the probability of a corrosion-related leak of the inner pipe compared to a single wall pipeline.

e. Other Pipe-in-Pipe Issues from the Third-Party Evaluation of Pipeline Alternatives by Stress Engineering Services, Inc. and Fleet Technology Limited

(1) Issues Related to Environmental Impacts

Stress (2000) identified four issues that have direct implications to potential environmental impacts between the various designs. These are discussed in the following sections.

(a) Burial Depth

Stress noted the following:

> While the chosen depths appear appropriate for each design concept, we would adopt a different approach. The depth of cover for the single wall

> pipe is 7 feet. We would prefer to keep this depth constant for all of the concepts. If this were done, questions would be answered as to how much benefit do you get when an outer pipe is added to a single wall pipe (i.e., If the only change is adding the outer pipe, what is the benefit?).
>
> We are concerned that the INTEC report has chosen to minimize the burial depth of each concept. This choice prejudices the equal comparison of the different concepts. By assigning different burial depths to the different concepts, the benefit of using an alternative design (as opposed to a single wall pipe) can be lost. The single wall pipe is picked as the best pipeline system candidate. However, the risk of an oil leak is primarily a function of the burial depth and the single wall pipe is buried the deepest (Stress, 2000).

Ice scour was the controlling factor used by INTEC for the burial depth for the steel pipe-in-pipe design alternative. The deeper burial depth for the single-wall pipeline alternative was required to prevent upheaval buckling. INTEC (2000) estimated the risk of the various pipeline systems by calculating the containment failure probability and multiplying this by the potential spill volume. They estimated the risk of a spill for the pipe-in-pipe system installed as designed is 0.028 (2.8×10^{2}) barrels, and the risk for the single-wall pipeline was 0.0016 (1.6×10^{3}) barrels. The INTEC (2000) report states:

> The shallower depth of cover for the pipe-in-pipe system is the main factor increasing the risk of oil spilled into the environment. In order to bring the pipe-in-pipe system alternative to about the same level of risk as the single wall, depth of cover needs to be increased to 7 feet. This would have the effect of lowering the damage frequency for Category 3 (small or medium leak) to 10^{6} occurrences per project lifetime, and the damage frequency of Category 4 (large leak or rupture) to 10^{7}. Therefore, a pipe-in-pipe system with a 7-foot depth of cover would have a risk of 2.8×10^{4} barrels of oil spilling into the environment, which is about 6 times less risk as the currently evaluated single wall pipeline system.
>
> Increasing the pipe-in-pipe depth of cover from 5 to 7 feet has an increased cost that can be estimated with the information given in this report at about $10 million. It is estimated that the risk posed to the currently proposed single wall pipeline system can be further lowered with less expenditure,

The Stress (2000) report determined that INTEC's estimate of the cost to increase the burial depth of the pipe-in-pipe system from 5 to 7 feet was too high and calculated the increase at $1.6 million. In Addendum A of the INTEC (2000) report there is a table that shows the costs for constructing all pipelines at their proposed burial depth and at a 7-foot burial depth. This table indicates that it will cost $4million more to install a pipe-in-pipe system with a 7-foot burial depth than with a 5-foot burial depth. This same table also indicates that a pipe-in-pipe system would cost $24 to $28 million more than a single wall pipeline system depending on what burial depth was selected. Assuming the pipelines are installed at the same burial depth, the increased cost for the pipe-in-pipe system is approximately 90% that of the single-wall pipe. The C-CORE (2000) report indicated that a pipe-in-pipe system would cost about 27% (plus or minus 25%) more to install than a single-wall pipeline. When reviewing the INTEC (1999) cost estimates, Stress Engineering Services concluded that "[t]he overall trends in the cost numbers appear reasonable."

Two relatively inexpensive methods that can be used to reduce the containment failure probability of a single wall pipeline system are increasing the wall thickness or increasing its burial depth. Increasing wall thickness and/or burial depth can be used to decrease the probability of a containment failure for any pipeline design alternative. In general if the objective is to reduce containment failure probability this may be done more economically by modifying a single wall pipeline design than by switching from a single wall to a double wall pipeline system. However, if the objective is to provide secondary containment, this can only be achieved by using a double wall pipeline system.

The effects of deeper burial on oil-spill probabilities are described in Section II of the EIS for the steel in steel pipeline design alternative. The effects of deeper burial on sediment volumes and other associated environmental impacts are fully described under Alternative VII in Section IV.C.5.

Fleet's report concludes that: "environmentally-induced risks (i.e., ice gouging, strudel scour, permafrost thaw subsidence, and thermal loads) are a minor component of the total risk for these designs…" and that operational failures are the most significant concern for any of the pipeline designs. In response to comments from Federal Agencies and the Stress (2000) report, INTEC modified their pipe-in-pipe design essentially to take their single-wall design and add an outer pipe to provide secondary containment, which resulted in an increased inner wall thickness and a decreased outer wall thickness, and used this as their pipe-in-pipe with 7-foot burial depth alternative. All other pipelines remained as originally designed and simply had their burial depth increased to equal the single-wall pipeline at 7 feet. Because the pipe design itself changed for the pipe-in-pipe system, it is the only system that shows a substantial change in containment failure probability when comparing its original burial depth to a 7-foot burial depth. The probability of containment failure, as determined by Fleet, for the pipe-in-pipe system actually increased more than 50% from 0.00158 to 0.00234 occurrences over the life of the project when the burial depth was increased from 5 to 7 feet.

(b) Leak Containment

It is assumed that a pipe-in-pipe system would provide secondary containment in the event that the inner pipe has failed. However, none of the offshore double-wall pipelines that have been installed to date have been designed to provide secondary containment. The Fleet (2000) report relied heavily on the assumption that a pipe-in-pipe system would provide secondary containment and indicated that "the assumptions necessary to evaluate the secondary containment provided by the steel pipe-in-pipe and the pipe-in-HDPE designs" was one of the most important uncertainties in their study (Fleet, 2000).

Stress Engineering Services, Inc. noted the following:

> The INTEC report states that pipe-in-pipe designs are used for insulation or installation reasons. While this is true, this past practice should not exclude the potential for using a pipe-in-pipe system for leak containment or other legitimate reasons. It seems that the main advantage of the pipe-in-pipe and pipe-in-HDPE systems, the ability to contain small leaks, has been discounted.
>
> Since the outer steel pipe can withstand the operating pressure of the pipeline, it is feasible that the pipeline could remain in operation even if there was a leak in the inner pipe. At a minimum this would mean that if the inner pipe develops a leak, the oil could be pumped from the pipeline before repairs are made. Unless both the inner and outer pipes were leaking simultaneously, this would prevent oil from entering the environment.

The benefits of a pipe-in-pipe design to provide product containment are recognized and described in this section (Sec. IV.C.2).

(c) Leak detection

The Stress report indicated that the use of inert gas in the annulus would prohibit the use of the method of supplemental leak-detection described in the INTEC (2000) report where the entire annulus is sampled to detect the presence of hydrocarbons and essentially act as a large LEOS tube. However, if the LEOS system were installed in the annulus, a low-pressure inert gas could be used in the annulus without significantly affecting the leak-detection capabilities of the LEOS system. Care would have to be taken that the pressure in the annulus was not high enough to collapse the LEOS tube.

Stress made the following comments:

> The leak detection threshold of 0.3 BOPD by Siemens is stated, in the LEOS reports, to have been based on experience. The accuracy of this estimate is difficult to assess because it depends on a variety of factors such as the permeability of the soil if the tube is buried beside a pipeline, the size of the annulus if the tube is in the annulus, the permeability of the sensor tube, the location of the tube in relation to the leak, and the hold time between sampling runs (Stress, 2000).
>
> One would think that if the tube were in an annulus that a smaller leak could be detected since the oil would be confined to the annulus rather than being able to soak into the soil. In the event of a small leak in the inner pipe, the oil would spray from the hole and impinge the inner wall of the outer pipe. This would create a mist of oil that should surround the inner pipe in a short time. Therefore, we would expect that leaks on the side of the pipe opposite the LEOS tube would be detected sooner if confined in an annulus than if the tube were buried in soil. By confining the oil in the annulus, the concentration of oil around the sampling tube would be higher and as a result more hydrocarbons would permeate the tube wall and the probability of detecting a leak would increase (Stress, 2000).
>
> Although we can not comment on the reasonableness of the 0.3 BOPD threshold as it relates to the Liberty pipeline, it should be noted that such a low threshold indicates a high degree of confidence on the part of Siemens. In addition, a 0.3 BOPD leak rate is well below a reasonable leak rate. We would expect that any leak in the pipeline would be at a minimum on the order of a 29 BOPD leak. We estimate that a 1 inch long crack 0.001 inches wide would leak approximately 29 bbls/day at 1100 psi. This is equivalent to a 0.036 inch (0.9 mm) diameter hole (which is about the size of a pencil lead). It is difficult to imagine a case for this pipeline where a leak would be smaller than this 29 BOPD figure. This is almost 100 times the threshold cited by Siemens (Stress, 2000).

Section III.C.1 in the EIS describes the possible oil-spill volumes and takes into consideration different spill rates depending on different leak-detection systems. For purposes of analysis, the EIS assumes a minimum leak rate of 97.5 barrels of oil per day, which is the maximum leak rate achievable below the detection level of the inline leak-detection systems (pressure-point analysis and mass-balance line-pack compensation). We recognize that leak rates can be smaller, but for consistency within the EIS, we assume the higher. Both the C-CORE and Stress reports indicate the LEOS leak-detection system may have improved detection levels if used within the annulus of a double-wall pipeline system (C-CORE, 2000; Stress, 2000). Because this improvement was not quantified in either report, nor anywhere else that we are aware of, we assume that the LEOS system would have the same leak-detection threshold within the annulus as it does in the soil outside the pipeline.

We realize that this is probably not accurate, but this assumption is conservative in nature. The EIS evaluates the effects of small spills, less than 500 barrels of oil; we are unable to differentiate between effects for spill volumes less than 500 barrels of oil (see Sec. III.D.3). The size of leak that can be detected by the LEOS system is under the detection threshold of the other leak-detection systems—pressure-point analysis and mass-balance line-pack compensation—and would result in a total spill volume of less than 500 barrels of oil. Therefore, the potential improvement in leak-detection threshold that may be gained by placing the LEOS system within the annulus of a double-wall pipeline system would not result in a change in the level of effects to the environment associated with a small spill.

(d) Construction Season

Stress made the following comments:

> We agree that both the steel pipe-in-pipe and pipe-in-HDPE alternatives would be more difficult to construct than either the single wall steel pipe or the flexible pipe. However, there are some refinements to the construction process that could reduce the time required to install the steel pipe-in-pipe and pipe-in-HDPE alternative (Stress, 2000).
>
> With any of the alternatives, the possibility of construction requiring a second season is present and should be considered when the construction is planned. However, we feel that if a single wall pipe can be constructed in one season, then the other alternatives could also be completed in one season. It would be the factors that are unpredictable, such as an unusually short winter, which one would expect to result in a second construction season and these unpredictable would affect any of the designs (Stress, 2000).

For purposes of analysis, we assume that all of the pipelines can be constructed in a single season.

(2) Issues Related to Construction, Operation, Maintenance, and Repair

Stress identified a number of issues, that relate to the construction, operation, maintenance, and repair of pipe-in-pipe versus single-wall pipeline designs. These types of issues have implications to the final design of a pipeline system, and they are summarized here to help the reader understand the implications of the various design options to the long-term integrity of the various pipeline options. However, the resolution of these concerns in the final pipeline design would not significantly change the environmental effects from those stated in this EIS. In the unlikely event that a pipeline feature changed so significantly in the final engineering design that the pipeline system would no longer be within the scope of this EIS, a supplemental National Environmental Policy Act document would be prepared.

(a) Operation and Maintenance

A concern related to operation and maintenance of the pipelines dealt with the ability to run smart pigs through a pipeline that had been bent from an external load. Stress states that:

> In the event the pipe curvature is changed by loads, such as ice keel gouging or upheaval buckling, there is a possibility the instrumented pig may not be able to go through the pipe The point is that the ability of the pig to pass through the line may be more limiting than the allowable strain in the pipe (Stress, 2000).

(b) Repair of a Pipe-in-Pipe System

Stress indicated several concerns relating to difficulties repairing a pipe-in-pipe system. One concern was with drying the annulus. The Stress report states that:

> For cases where there is an annulus, in order to prevent corrosion, all moisture would need to be removed from the annulus after a repair. This could be a difficult operation. As a result, a significant amount of moisture could be present for a long period of time (i.e., the 2.5-3 month period when repairs could not be made during a freeze-up or break-up plus the drying time). We would expect that drying the annulus could take a month or more. This means that moisture would be present on the order of 4 months. This would be more than enough time for corrosion to begin in the annulus (Stress, 2000).

As a method of dealing with this problem, Stress proposes:

> …installing a cathodic protection system on the inner pipe should be considered. Such a system could consist of a sprayed aluminum or other cathodic coating applied to the inner pipe to provide in-situ cathodic protection. Another method would be to attach anodes to the inner pipe. Either of these methods should supply adequate cathodic protection for the inner pipe (Stress, 2000).

Stress noted that this solution had its own concerns "The drawback to this is that the cathodic protection of the inner pipe could not be monitored." The inner pipe could be pigged to detect metal loss that would indicate corrosion was occurring, but the cathodic protection system itself could not be monitored.

Another concern regarding pipe-in-pipe repair that Stress raised dealt with quality assurance. The report states that:

> We agree that the repair of the pipe-in-pipe design would be much more involved and that the

> restoration of the outer pipe to original integrity is doubtful given the type of repairs described… However, if the repair pipe has the same diameter, wall thickness, and material properties as the original pipe and is installed using butt welds that are inspected by UT [ultrasonic testing] examination, it should be possible to restore the pipe to near its original integrity… When designing the pipeline, the designers should consider the capacity of a repaired pipe when establishing the design allowables. If the repaired pipeline would not be as sound as the new line, the design allowables should be based on the repaired pipe strength (Stress, 2000).

(3) Issues Related to Testing

Stress questions the concerns that INTEC has related to not being able to use radiographic testing and only having ultrasonic testing available to inspect the welds on the outer pipe of a repaired pipe-in-pipe section. Stress states that:

> …we would point out that although the INTEC report states that only UT will be conducted on the outer pipe tie-in welds [and outer pipe welds for a repaired section] for the pipe-in-pipe alternative (page 5-18 of the INTEC report) this is not a reason for concern. A well designed UT [ultrasonic] procedure executed by a qualified technician should be able to detect any linear or cracklike defects in the welds as well or better than a RT inspection. This is especially true if an automated UT method, such as time of flight diffraction (TOFD), is used (Stress, 2000).

(4) Issues Related to Installation and Corrosion Protection

Stress also raised the issue of damage to the inner pipe during installation and its effects on corrosion protection for the pipe-in-pipe system. The report states that:

> For the concepts involving inserting the inner pipe into an outer pipe or sleeve, there is a possibility of damage to the corrosion protection coating during this operations. Emphasis is placed on keeping the annulus dry to prevent corrosion and that the inner pipe would not be cathodically protected. It would seem prudent to include some cathodic protection of the inner pipe… The drawback here is that the cathodic protection in the annulus could not be monitored. However, the system would be in place and could provide some benefit (Stress, Ltd., 2000).

These comments were made on conceptual engineering designs that likely would change somewhat during the preliminary and detailed engineering design phases. The concerns raised by Stress have been sent to BPXA for their comments. Relevant information from the responses will be included in the EIS when they become available.

The information provided above is applicable to both the pipe-in-pipe and pipe-in-HDPE designs.

The following subsections describe the basic characteristics of each proposed pipeline design as presented in a conceptual design study for the four alternative pipelines (INTEC, 2000).

f. Common Elements Shared by All Pipeline Design Alternatives

Section II.C.2.a describes the common elements shared by all alternatives in the set of component alternatives. That information is being repeated here for the convenience of the reader.

(1) General Pipeline Design, Construction, and Operational Information

The pipeline systems in this alternative are expected to withstand the environmental conditions that can be expected to occur along the Liberty, Eastern, or Tern pipeline routes. All designs can be constructed and operated safely.

It is expected that all of these designs would be constructed in a single construction season. It is possible that a second construction season may be needed if there are problems with construction or weather for any of the designs. The more complex the construction processes, the higher the potential for multiple year construction. All offshore pipeline systems evaluated in this Section of the EIS would be constructed the third year of the project and the second winter construction season. This pipeline would be constructed using conventional construction equipment, like the process used for the Northstar Project. Construction and fabrication of the pipeline would occur on the surface of the ice. The LEOS, or an equivalent, leak-detection system would be installed with all pipelines. In addition to the LEOS system, a pressure-point analysis and mass-balance line-pack compensation leak-detection systems would be installed for leak detection. Excess trenching material would be disposed at approved ocean dumping sites.

Higher pipeline construction costs result in higher pipeline tariffs. Higher pipeline tariffs reduce royalty revenue to the Federal Government from the project and likewise reduce Section 8(g) payments to the State.

(2) Pipeline Construction

A pipeline makeup site needs to be prepared on the ice surface, in the bottomfast-ice zone. This site would be used to assemble the pipeline strings before transporting them to the side of the ice slotted trench for final tie-in welds and lowering into the trench. The size of the site required depends on the amount of materials necessary for pipeline

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makeup. The size of the makeup site and number of days required to construct those sites are shown in Table II.C-2. Table II.C-2 also provides information about the number of days required to makeup the pipeline strings, transports the strings to the trench, install the pipeline in the trench, and to backfill the trench. Table II.C-3 provides a comparison of the trench excavation and backfill quantities for the four alternatives in this component set.

Upheaval bucking is a concern for some of the pipeline designs. Select gravel can be used to prevent pipeline instability that could be caused by pipeline flotation during backfilling. The pipe-in-pipe system would require only native backfill to prevent upheaval buckling. The pipe-in-HDPE and flexible pipe systems would need approximately 10,000 cubic yards of gravel placed in 30-cubic-yard mounds every 100 feet along the pipeline in addition to the native backfill. The single-wall steel system (Alternative I) would require approximately 16,000 cubic yards of gravel placed in 4-cubic-yard bags covering approximately 50% of the pipeline route in addition to the native backfill. All of the pipeline systems would use a pull-tube installed during construction of the island, to transition the pipeline from subsea to above ground at the island.

The pipeline designs were optimized by INTEC to provide the best overall design in terms of safety, ease of construction, operation and maintenance, leak detection, and costs. All four pipeline systems evaluated in this section are designed for a maximum allowable operating pressure of 1,415 pounds per square inch gauge. After installation the pipelines would be hydrostatically tested at 1,775 pounds per square inch gauge for a minimum of 8 hours.

For comparative purposes in this EIS, the same pipeline route (Liberty pipeline route/Alternative I) was assumed for each of the pipeline systems evaluated in this alternative, with a length of 6.1 miles (32,314 feet). The length of the pipeline in water 0-8 feet deep is 14,877 feet, in water 8-18 feet deep is 12,473 feet, and in water 18-22 feet deep is 4,964 feet.

All of the pipeline systems would be constructed in winter of Year 3, starting in January and finishing by May. The pipeline system would be constructed within a temporary right-of-way (250 feet wide onshore, 1,500 feet wide offshore). For welding strings of offshore pipeline, workers would need a site close to shore on grounded sea ice artificially thickened, as needed, and usually in water less than 5.5 feet deep.

All of the pipelines would use through-ice winter construction and use techniques that are similar to those used onshore and at Northstar project. Trenching would use conventional excavation equipment, such as backhoes. Hydraulic dredging may be used for final smoothing of the trench bottom. (See Sec. I.H.5.b(11) for additional information and discussion about hydraulic dredging).

Construction activities include (See Sec. II.A.1(3)(a) for a more detailed description of each activity):

- mobilizing equipment, material, and workforce
- constructing the Ice road and thickening the ice
- slotting the ice
- trenching (including temporary storage and disposal of excess material)
- preparing the pipeline makeup site
- welding pipe strings
- attaching anodes
- attaching LEOS
- transporting pipe string and welding tie in
- island transition
- shoreline transition
- installing pipeline
- backfilling the trench
- hydrostatic testing
- demobilizing equipment

All of the pipelines systems evaluated in this section would use three leak-detection systems

- Pressure-Point Analysis
- Mass-Balance Line-Pack Compensation
- Leak-Detection and Location System (LEOS) or an equivalent system

Pressure-point analysis is the continuous monitoring of the pipeline to alert the operator to any pressure variances that leaks would induce and variances in measured volumes of oil at the inlet and outlet of the Liberty oil pipeline. Mass-balance line-pack compensation measures the volumetric throughput at both the island and the Badami tie-in. The accuracy of the meters would be such that the threshold for the leak-detection system would be 0.15% of flow. Operating procedures require periodic calibration of the meters. If the crude oil meters are above or below 100 barrels or more per day for 2 days, the meters would be checked and calibrated. If there are volume discrepancies after the meters have been checked and there is no apparent operational reason, the pipelines would be shut in. Combined, these systems have been used extensively on the North Slope and are considered as part of the best available and safest technology.

The LEOS system is described in greater detail in Section II.A.1.b(3)(b)2). The LEOS system can detect a leak within 24 hours when the total volume of the leak reaches 0.3 barrels. Because the tube is sampled at a specific rate, it can accurately determine within meters the location of a pipeline leak. Should a leak be detected, it sets off an alarm. The system automatically stores more than 100 days' worth of data on a personal computer.

(3) Pipeline Oil-Spill Information

The EIS evaluates four offshore pipeline oil-spill sizes—less than 125 barrels, 715 barrels, 1,580 barrels, and 2,956 barrels. These are described in Section III.c.1(e) in more detail. For a description of the different sizes of oil spills evaluated in this section, please see Section III.C.1(g). Because all of the carrier pipelines in the alternatives have the same diameter and transport the same volumes of oil, these spill sizes are evaluated for all pipeline alternatives.

All pipeline systems would have a monitoring program that includes both pre- and post installation monitoring, aimed at reducing the risk of a pipeline failure. Visual surveillance flights to search for oil sheens on the water would occur weekly during open-water and broken-ice conditions. Aerial surveys for river overflooding would be conducted during the initial years of operation. The shoreline would be inspected annually for erosion. A check of the pipeline integrity would occur every 5 years. Visual inspection of the overland pipe and valves would occur monthly. Process operators would continuously monitor the automated control systems for pipeline leaks. Monthly on ice inspections would monitor for possible oil leaks during the winter period if the LEOS leak-detection system is not operating properly.

All pipeline systems would periodically monitor the status of the pipelines using smart pig tools. Smart pigging of the pipeline at startup would be used to determine the initial condition of the pipeline and establish a baseline against which future pigging results can be compared. Smart pigging would involve three different types of pigs:

- A caliper pig would measure any internal deformation of the pipeline, such as dents and buckling. It would always be run before running either of the other two pigs to ensure that there are no internal blockages that would prevent the other pigs from passing through the pipeline.
- A geometry pig would record the configuration of the offshore pipeline system. It can be used to determine the amount of displacement in the pipeline due to thaw settlement, upheaval buckling, strudel scour, or ice gouging. This information can be evaluated to determine if the pipeline's. allowable strains have been exceeded, or if the amount of displacement exceeds the design parameters. This pig would be run after the pipeline has been constructed to measure its baseline condition, then once a year for the first 5 years, and then once every 2 years for the life of the pipeline. It also would be run after extreme ice gouging or strudel scouring is observed or suspected to have occurred.
- A wall-thickness pig would measure the thickness of the pipeline wall to determine the amount of corrosion that has occurred and to determine if the pipeline has been gouged. This pig can provide an early warning of potential pipeline failures that would allow them to be repaired before a leak could occur. This pig would be run at startup and then every 2 years. The pig would be run in early winter, so that any needed repairs can be carried out that same winter after the ice has thickened sufficiently to be safe to work on.

The pipe-in-pipe and pipe-in-HDPE systems are subject to a type of functional failure that likely would require immediate attention and repair, although it would not result in a containment failure. Conditions relating to this type of damage are discussed in Table II.C-4. The outer pipe could be damaged or corroded, which would allow seawater to enter the annular space. The pipeline may continue operating for a limited time until it could be repaired, if pigging and other tests show the integrity of the carrier pipeline has not been adversely affected.

The currently proposed supplemental leak-detection system is intended to sample the entire annulus, as if it were a large LEOS tube, and analyze the air for the presence of hydrocarbon vapors. This system would have to be modified or a different system installed that is capable of detecting water in the annulus. If there is seawater in the annulus that is an indication that the outer pipe has leaked and is no longer capable of providing secondary containment. Seawater in the annulus also increases corrosion concerns for the carrier pipeline.

If the annulus of a double-wall system is sealed so that it is pressure tight, the annulus could be monitored for significant pressure changes that would indicate that one of the pipes has leaked. If the annulus is pressurized with an inert gas so that pressure inside the annulus was greater than the pressure in the seawater outside the casing, it would be possible for a pressure monitor on the annulus to determine which wall of the pipeline was leaking. A leak in the outer wall would cause the pressure in the annulus to drop. A leak from the inner pipe would cause annular pressure to increase. This type of a system would not be very effective for determining the location of a leak. The carrier pipeline could be pigged to determine a leak location, but pigging would not be able to determine the location of a leak in outer pipeline.

(4) Pipeline Damage Probability Assessment

INTEC defined four damage categories for each pipeline system:

- category 1 is a displacement of the pipeline with no leak;
- category 2 is a buckle of the pipeline with no leak;
- category 3 is a 125-barrel leak; and
- category 4 is 1,580-barrel leak or rupture (INTEC, 2000).

Fleet used somewhat different failure categories than did INTEC. Fleet's three categories are:

- Minor incident (less than 100 barrels released to the environment);
- Major Incident (more than 100 barrels released to the environment); and
- Spills greater than 1,000 barrels released to the environment (Fleet, 2000).

Based on the method of analysis used by Fleet, there essentially is no difference in the probability of a spill greater than 100 barrels and a spill greater than 1,000 barrels. Therefore, for simplicity when discussing the results of the Fleet study, only two cases will be considered. The first case is the “expected” volume of oil spilled from the pipeline during the life of the project. The other case is the probability of a spill greater than 1,000 barrels occurring. Table II.C-5 contains a summary of the probability data from the INTEC and Fleet reports. The first set of numbers is from the INTEC report. (INTEC, 2000). The second set of numbers is from the Independent Risk Evaluation for the Liberty Pipeline, as prepared by Fleet Technology Limited (Comfort, 2000). The executive summaries of both reports are provided in Appendix D, and the full report is incorporated by reference in this EIS. The full texts of both reports are available for review at the MMS office in Anchorage, Alaska or for download on the MMS Alaska Web Page http://www.mms.gov/alaska.

The containment failure rates from the Fleet report (Fleet Technology Ltd., 2000) are much higher than those from the INTEC report (INTEC, 2000). This is primarily due to the fact that Fleet included the probability of operator error being the cause of the leak, whereas INTEC just considered the physical hazards from the environment and third parties. If the individual failure mechanisms (ice gouging, strudel scour, corrosion, etc.) are compared Fleet and INTEC arrived at numbers that are comparable.

The Fleet report indicates that the category operational failure and third-party activity is the most likely failure mode for the Liberty pipeline, regardless of which design is chosen. This information was based on a review of the pipeline failures that have occurred for the Trans Alaska Pipeline System and the Norman Wells pipeline in Canada. The Fleet report concluded that using the Trans-Alaska Pipeline System and the Norman Wells pipeline failure statistics for the Liberty pipeline would cause the failure probability to be overestimated. The overestimation is a result of the Liberty pipeline having a much lower diameter-to-thickness ratio, a thicker pipeline in relation to its size, than either the Trans-Alaska Pipeline System or the Norman Wells pipeline. The overestimation of risk is considered acceptable in this analysis because it provides a conservative result, there are other similarities between the three pipeline systems, and because the other data available is much less applicable than using the Trans-Alaska Pipeline System and Norman Wells pipeline data to estimate failure rates from operational or third party activities. (Fleet, 2000)

Fleet’s review of the statistical data indicated that all of the failures in the operational and third party activity category were operational failures. The most common types of operational failures are pumping against a closed valve and failures due to Supervisory Control And Data Acquisition (SCADA) system failures.

Pumping against a closed valve would cause the pipeline system to go over the design pressure, if this were to happen the pipeline could burst. Due to the thick walls of the subsea portion of the pipeline it is more likely that the pipeline system would fail at either a valve or the onshore portion of the pipeline than the subsea portion. In either case the spill would occur on land and would probably not reach the marine environment.

A SCADA system failure would provide the pipeline operator with inaccurate information about the operation of the pipeline. It could tell the operator that the pipeline is leaking when in actuality it is operating well. Or it could tell the operator that the pipeline is operating normally when in fact it is leaking. The most useful tool for combating a SCADA system failure is a well-trained and experienced operator who does not have to rely solely on the SCADA system to determine the actual condition of the pipeline system.

Despite the discrepancies in failure probabilities between the two studies, three if the non-site specific C-CORE study is included, one conclusion can be made. The probability of a large leak from any of the pipeline systems is low, less than a 1.5% chance of a large leak, greater than 1,000 barrels, over the life of the project using the most conservative study.

(5) Pipeline Operations, Maintenance, and Repair

Pipeline operations and maintenance essentially are the same for all pipeline systems, except as noted in the following. See Section II.A.1.b(3)(c) for a complete description of pipeline monitoring, including pigging.

For the pipe-in-pipe system, interference from the inner pipe would prevent a x-ray test of the tie-in weld of the outer pipe. The caliper pig would not be able to determine if the outer pipe has buckled or is dented for the pipe-in-pipe and pipe-in HDPE systems, unless the damage to the outer pipe was so extensive that it affected the inner pipe. The geometry pig cannot directly measure the outer pipe of the pipe-in-pipe and pipe-in HDPE systems, but inferences from the shape of the inner pipe could be applied to the outer pipe. The wall-thickness pig cannot investigate either the outer pipe of the pipe-in-pipe and pipe-in HDPE systems or the outer layer of the flexible pipeline system, so it would be impossible to determine if the outer pipe or layer has been damaged.

Several types of pipeline repairs are available, based on the nature of the damage that has occurred. These include welded repair with cofferdam, hyperbaric weld repair, surface tie-in repair, tow-out of replacement string, rigid spool piece with mechanical connectors, and split sleeve repair. A matrix for evaluating the appropriateness of the various repair techniques is given in Table II.C-6. Details on each repair method (INTEC, 2000:Appendix E) are provided in Section II.A.1.b(3)(c)3) and summarized in Table II.C-7.

The exact type of repair would depend upon the type of leak, the season of year, weather conditions, and many other variables. Any analysis of the environmental assessment associated with the repair of the pipeline would be driven by the assumptions and may not reflect the actual environmental conditions. A small area of the pipeline trench surface area would need to be excavated and backfilled after the repair work was completed. Those effects would be considerably smaller than the construction of the pipeline and would be short-term in nature. The repair area would be contained with oil boom and oil response equipment would be stationed on site to remove any oil that may be released, although the goal of pipeline repair would be zero release. The effects of any oil spill would be similar to those evaluated in Section III.C.2 and III.D.3.

Automated pipeline isolation valves for the sales oil pipeline would be located at the landfall and the Badami pipeline tie-in point and on the island. BPXA currently is considering using a vertical loop in lieu of the landfall isolation valve; if implemented this option probably would reduce the size of the landfall pad.

g. Resource Effects that are the Same for All Pipeline Design Alternatives

All of the pipeline design alternatives share the common elements noted in Section IV.C.2.f, similar types of activities, and about the same time and locations for all pipeline design alternatives. For purposes of analysis, this EIS assumes an oil spill occurs and the effects of an oil spill to the following resources are essentially the same. Many resources evaluated migrate annually and would not be present during construction; therefore, the effects to bowhead whales, eiders, and marine and coastal birds are essentially the same. Other resources, such as vegetation-wetland habitats and terrestrial mammals occur onshore, and offshore construction effects would not differ between pipeline design alternatives. For other resources, such as seals and polar bears, subsistence-harvest patterns, and sociocultural systems, the timing and disturbance effects from construction activities for all pipeline designs do not result in measurable differences.. The differences in quantities of offshore trench and backfill material do not result in measurable differences in results or differences in effects on fishes. Effects of surface disturbance on archaeological resources would be the same as those discussed in Sections III.C.2.j and III.C.3.j for all alternatives. All known onshore and offshore archaeological sites are outside of the proposed onshore pipeline routes. All alternatives would have essentially the same effect on archaeological sites. The air-quality effects occur at the same locations for all alternatives. Overall, the effects to air quality essentially would be the same for all alternatives. For the reasons stated, the pipeline design alternatives analysis that follow will not include effects to these resources.

The different pipeline designs for Alternatives I, IV.A, IV.B, and IV.C provide measurable differences to the following resources:

- Essential Fish Habitat
- Lower Trophic-Level Organisms
- Archaeological Resources
- Air Quality

h. Alternative I – Use Single-Wall Pipe System (Liberty Development and Production Plan)

Sections II.C.1.a and IV.C.2.f describe the common elements shared by all alternatives in the set of component alternatives. Those common elements, plus the following alternative components specific to this particular pipeline design, complete the description of this alternative. Note that this description of Alternative I was given in Sections II.A.1 and II.C.2.e and is being repeated here for the convenience of the reader.

For the offshore single-wall steel pipeline (Fig. II.C-3), BPXA proposes a single-wall steel pipeline system that would be constructed with a 12.75-inch outside diameter pipe with a 0.688-inch wall thickness. The system would be protected from corrosion by a dual-layer fusion-bonded epoxy coating and sacrificial anodes. The system would be buried with a minimum burial depth of 7 feet (Fig. II.A-12).

A detailed description of the activities involved in constructing a pipeline is found in Section II.A.1.b(3)(a). Table IV.C-2 provides information about the number of days required to construct the pipeline. All of the pipeline welds would undergo x-ray and ultrasonic tests to ensure that they are sound. Any weld that has a defect larger than the maximum acceptable level would be cut out and replaced.

The amount of excavation in the various water depths for this system is shown in Table II.A-2. The size of the pipeline makeup site required would be 416,500 square yards, about 86 acres. An estimated 17,000 cubic yards of gravel fill material would be required as pipeline-bedding material in various locations within the trench between the gravel island and the 3-mile limit. Approximately 50,000 cubic yards of gravel fill would be required as pipeline-bedding material in various locations within the Territorial Seas (shoreward of the 3-mile limit). These estimates include the gravel material contained within the 4-cubic-yard bags (about 4,000 bags) that periodically would be placed over the entire pipeline before placing the backfill material. The bags would cover approximately 50% of the pipeline route. Backfill material would consist of material dredged from the trench. Between the Liberty Island and the 3-mile limit, approximately 162,000 cubic yards of

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trench-dredged material would be used as backfill. Between the 3-mile limit and the shoreline, about 495,000 cubic yards of trench-dredged material would be used as backfill. A minimum of 7 feet of fill material would cover the pipeline. In water up to 8 feet deep, the cap of the backfill would be close to the original seafloor, not to exceed 1 foot higher than the surrounding seafloor. In water deeper than 8 feet, the trench cap would not exceed 2 feet higher than the surrounding seafloor. The affected footprint would be 18.2 acres beyond the 3-mile limit and 55.4 acres within the 3-mile limit. This includes the trench cap, which could overstep the limits of the trench excavation.

Any dredged/excavated material that could not be placed back into the trench would require disposal into ocean water. See Section II.A.1.b(3)(a)12)c) for more a detailed description of disposal Zones 1 and 2 (Fig. II.A-18).

Table II.C-5 provides information about the failure rates for this pipeline. Table IV.C-5 provides information about the different sizes of oil spills that may occur.

This pipeline system does not offer any secondary containment should a leak occur to the carrier pipeline.

As noted above in Section IV.C.2.g, the effects to many resources are the same for all pipelines design alternatives

The specific components of the single-wall pipe system (Liberty Development and Production Plan) as described would change the impacts to the following resources in the ways described in the analyses that follow:

- Lower Trophic-Level Organisms
- Essential Fish Habitat
- Economy
- Water Quality

(1) Effects on Lower Trophic-Level Organisms

(a) Large Oil Spills

The general effects of a large spill and the effects of oil-spill-cleanup activities are analyzed in Section III.C.2.e(2)(a). Lower trophic-level organisms would be affected by a large oil spill. It would have only short-term effects on plankton, including phytoplankton, zooplankton, and epontic species on the bottom of the ice cover, but longer term effects on the fouled coastlines. As documented in Section III.C.2.e(2)(c) and Appendix A, up to 15% of the sound's coastline would be affected by a large spill. While the ice-gouged coastline is inhabited by mobile, seasonal invertebrate species that would recover within a year, fractions of the oil would persist in the sediments for about 5 years in most areas, and could persist up to 10 years in areas where water circulation is reduced. Very little of Liberty crude, which is highly viscous and particularly resistant to natural dispersion, would be dispersed down in the Stefansson Sound water column and affect deep benthic communities such as the Boulder Patch kelp habitat. However, diesel oil, which would be used on the island for startup and emergency fuel, could be dispersed down to the seafloor. If 1,500 barrels of diesel were spilled from a fuel-delivery barge at the island during the open-water season, the concentration would be toxic within an area of about 18 square kilometers (7 square miles), as noted in the water quality section (III.A.2(l)). Such toxicity would probably stunt the seasonal growth of kelp plants and reduce the population size of associated invertebrates for several years. Oil-spill responses in general would have both beneficial effects of some and adverse effects on other lower trophic-level organisms.

(b) Disturbances

The general effects of disturbances are analyzed in Section III.C.3.e(2)(a).

1) Summary and Conclusions for Effects of Disturbances on Lower Trophic-Level Organisms

Alternative I would disturb lower trophic-level organisms in two primary ways: (1) pipeline trenching would bury up to 14 acres with very low (1%) coverage of kelp, boulders, and suitable substrate; and (2) sediment plumes would reduce Boulder Patch kelp production by up to 6% during 1 year. The buried 14 acres would equal less than 0.1% of the Boulder Patch kelp habitat. The density of the kelp, boulders, and suitable substrate in the pipeline corridor is very low, averaging about 1% coverage, and the lost kelp biomass and production probably would be less than .01% of the Boulder Patch totals, but the effect (substrate burial) would last forever.

Some of the suspended sediment from pipeline trenching and island construction would drift over other parts of the Boulder Patch, reducing light penetration and kelp production during 1 year. This reduction is estimated to be less than 6%, about one-third of which would be due to the proximity between the Boulder Patch to the Zone 1 disposal area for excess sediments. However, in relation to the large range of natural variability, all of these suspended sediment effects would be barely detectable.

From 6 feet deep to the seafloor, the island's concrete slope would temporarily benefit kelp and other organisms that need a hard substrate for settlement. This portion of the concrete slope would be a temporary home for colonies of species similar to those of the Boulder Patch area. Upon abandonment, the concrete mats would probably be removed or would become buried naturally, eliminating the additional kelp habitat.

2) Details on How Disturbances May Affect Lower Trophic-Level Organisms

a) Specific Effects from Island Construction

Construction of Liberty Island would alter the seafloor habitat permanently and would kill the benthic animals living there. Underwater surveys show the seafloor at the

Alternative I site is silty mud and contains less than 10% rock cover, similar to most of the Beaufort Sea's floor (Fig. III.C-1). Placing gravel to construct Liberty Island would kill the benthic invertebrates occupying about 28 acres of this habitat. Similar amounts of benthos were buried during construction of several exploration islands in Stefansson Sound during the past two decades, including Tern, Duck, Endeavor, BF-37, Niakuk, Goose, and Sag islands. The 28 acres would be relatively small compared to the area that was affected by the Endicott causeway and Northstar pipeline that were constructed within this same region and depth range. Liberty effects should be similar to the concluding statements in the Northstar EIS about the project effect on benthic infaunal and epifaunal invertebrates aside from those in the Boulder Patch kelp community(U.S. Army Corps of Engineers, 1999:6-29):

> The trenching for the pipeline will impact both infauna and epifauna through direct physical disturbance, burial with sediment, or from increased turbidity in the surrounding water. Trenching the shallow waters of the lagoon would have a negligible effect on benthic invertebrates. Impact to marine invertebrates in deeper waters would be considered minor because of the rapid recolonization and geographic range of these species.

However, the level of effect for Liberty would be alternative-specific because the use of the existing Tern Island would affect less benthos.

Island construction also would increase the amount of under-ice suspended sediment in the water column. Because of the prevailing under-ice currents in this area, a sediment plume from island construction would drift east or west in line with the isobaths. If the plume drifted west, it would drift over the kelp in the Boulder Patch, depositing a thin blanket of sediment over the kelp and reducing the amount of light for growth (Fig. III.C-2). An under-ice plume from construction that drifted west toward the Boulder Patch probably would affect up to 105 acres (BPXA, 1998a:5-8). Because the more productive rocky areas are widely scattered, the plume is likely to affect less than 105 acres of productive Boulder Patch habitat. The heavier sediments should settle out within one-half mile of the island and are not expected to reach the Boulder Patch. Sediments larger than clay-sized particles are likely to settle out within 3-7 miles of the construction area (USDOI, MMS, Alaska OCS Region, 1998a:8). Sediments that reach the Boulder Patch are likely to reduce the amount of light for marine kelp living in rocky bottom areas. This was the primary concern regarding the health and growth of Boulder Patch kelp communities during winter (USDOI, MMS, Alaska OCS Region, 1998a).

Storms and river discharges place a lot of sediment into the waters of the Boulder Patch area. These discharges, plus variations in snow cover, annually make up to two-thirds of the winter ice in this area uninhabitable for ice algae (there is not enough light). This results in naturally fluctuating growth rates for Boulder Patch kelp communities. The plume from construction could reduce kelp growth in some rocky bottom areas where clear-ice conditions exist. This possibility was considered in a recent analysis by Gallaway, Martin, and Dunton (1999:16-18), which is based partly on field observations during construction of the BF-37 gravel island. They concluded that under worst-case conditions:

- Island construction may reduce kelp production in the Boulder Patch by 2%.
- No changes are expected in the health or distribution of Boulder Patch communities.
- The effects of island construction would be limited to 1 year and would constitute short-term impacts.

We believe that the above conclusions are conservative, and that they were based on the appropriate model methods, calculations, and assumptions. Hence, any effects due to island construction are expected to fall within the range of natural variation for Boulder Patch kelp communities. Any reduction in the amount of light due to island construction is expected to be very small and is not expected to have a measurable effect on kelp communities in the Boulder Patch. Any sediment accumulating on kelp from construction would probably be washed away by currents, as observed natural sediment accumulations.

b) Specific Effects from Pipeline Construction

Pipeline construction would involve about 6 miles of trenching and backfilling in marine waters along the pipeline corridor. There would be alternative-specific effects from both suspended sediments and trenching.

Suspended Sediments: Pipeline construction also would increase the amount of suspended sediment in the water column during winter trenching and backfilling (Fig. III.C-3) and during the natural dispersal at breakup of any excess sediment that is stored on the ice (Fig. III.C-4 and -5). The dense part of the plume is predicted to move less than 1,000 feet along-shore to the west or east, as indicated partly by BPXA measurements during preparation of the Northstar test trench. The plume from pipeline construction could reduce kelp growth in some rocky bottom areas where clear-ice conditions exist. This scenario was considered also by Gallaway, Martin, and Dunton (1999) and Ban et al. (1999). They concluded that under worst-case conditions:

- Suspended sediments from pipeline trenching may reduce kelp production in the Boulder Patch by 4% (Fig. III.C-1), and the excess-sediment stockpiled on the ice cover (Fig. III.C-5) may reduce it by another 2%. In other words, about one-third of the effect would be due to the proximity between the Boulder Patch and disposal zone.
- No changes are expected in the health or distribution of Boulder Patch communities.
- The effects from construction would be limited to 1 year and would constitute short-term impacts.

- The effects of pipeline repair, if necessary, probably would be site specific and less than the construction effects.

The effects would probably be less than these worst-case predictions, as indicated by some recent field measurements during construction of Northstar pipeline in late April 2000 (Trefry, 2000, pers. commun.). The measurements were made at six sites in the Northstar area, two of which were within a couple hundred meters east and west of the pipeline corridor while the trench was being backfilled. The measurements included three water samples and a turbidity profile at each site. In spite of the backfilling, the sampled water appeared to be low with less than 0.5 milligrams per liter of sediment (Trefry, 2000, pers. commun.).

One reason that the measurements were lower than the predictions is that some of the dredged sediment probably froze before it was used as backfill over the pipeline. Hence, any effects due to suspended sediments from pipeline construction are expected to fall within the range of natural variation for Boulder Patch kelp communities.

Trenching: Some benthic plants and animals would be disturbed by pipeline trenching (Sec. II.A.1.b(3)(a)(4)). Most of the seafloor in the project area is covered with sandy/silty sediments that are disrupted naturally by the ice cover and strudel scour (BPXA, 1998a:Sec. 4.6). The resident organisms in the silty/sandy sediments generally are small and short-lived. Liberty effects should be similar to the conclusion in the Northstar Final EIS that "natural re-population of the trench area by infaunal invertebrates is expected within a few years" (U.S. Army Corps of Engineers, 1999:6-26).

The BPXA Environmental Report also describes the Boulder Patch and the diverse community of organisms associated with the kelp and solid substrate. The report notes that there is diffuse kelp and solid substrate in the outer section of the pipeline corridor (BPXA, 1998b:Secs. 4.6.3 and 5.2.5). The kelp and solid substrate occurs in a 4,700-foot section that is diagramed in Figures III.C-1and 5, Surveys for Boulders and Kelp. A similar map was prepared for a BPXA report on construction effects on Boulder Patch kelp production (Ban et al., 1999); the map clarifies the location and distribution of dense kelp near the Alternative I island site. The band's location and distribution indicate that the light kelp that is illustrated in Figure III.C-1 probably is the shoreward, marginal end of the dense band that is illustrated in the report by Ban et al. (1999). The map that was prepared by Ban et al. is redrawn as Figures III.C-2 through 4 and is used as the base map for our assessment of alternatives.

After the Environmental Report was prepared (BPXA, 1998a), additional side-scan and video surveys were conducted along the 4,700-foot section. The investigators summarized the preliminary results during the MMS Arctic Kelp Workshop in May 1998 (USDOI, MMS, Alaska OCS Region, 1998a), and the final results were summarized in a July 1998 report to BPXA (Coastal Frontiers Corp., 1998). The report explains that the video detected scattered bivalve shells, pebbles, and rocks, some of which were found to have small pieces of kelp attached. It also explains that the "concentrations of these objects appeared to represent less than 1% of the sea bottom in most instances, and in no case greater than 2%" (Coastal Frontiers Corp., 1998:16). Figure III-C.2 shows that the distance to a portion of the Boulder Patch with a concentration over 10% is at least 1,600 feet (500 meters). Therefore, the average density of kelp and solid substrate in the 4,700-foot long section was assumed to be 1% for the following assessment of trenching effects.

The width of the area that would be disturbed by trenching would be related mainly to the amount of slumping on the sides of the trench. The Development and Production Plan explains that the slump or slope angle would be 3:1 typically (extending three times the trench depth to each side) but that the excavation limits could be up to 5:1 in unconsolidated sediments (Fig. II.A-6 and BPXA, 2000a:Fig. 8-4 and p. 71). The 5:1 ratio means that the overall disturbed area could be up to 10 times the trench depth plus the bottom width of the trench. Therefore, the bottom of the trench for Alternative I would be up to 12 feet deep and 12 feet wide (Fig. II.A-12 and Table II.A-1), and the overall width at the top would be up to 132 feet.

The boulders with kelp near the center of the Boulder Patch lie at the sediment surface in a layer that is very thin, "no more than one boulder thick" (Dunton, Reimnitz, and Schonberg, 1982). We assume that the solid substrate with kelp that lies in the pipeline corridor is no different, that it also lies at the sediment surface in a layer that is very thin. After trenching, if the solid substrate could be returned to the sediment surface, it probably would be recolonized by kelp in a decade (Martin and Gallaway, 1994). However, the operation probably could not return the kelp and solid substrate to the sediment surface, and the only natural process that might return it to the surface would be gradual erosion over geological time scales.

In summary, trenching would bury up to 611,000 square feet or 14 acres of kelp and solid substrate at very light densities. The 14 acres can be compared with the total area of the adjacent Boulder Patch. The area in which kelp and solid substrate exceed 10% coverage recently was estimated as 64 square kilometers, or 15,871 acres (Ban et al., 1999). Therefore, the buried 14 acres would equal less than 0.1% of the Boulder Patch area. Furthermore, the concentration of kelp in the Boulder Patch is more than 10 times that in the pipeline corridor, so the lost kelp biomass and production probably would be less than 0.01% of the total.

The burial of kelp and solid substrate in the pipeline corridor would be mitigated partly by a countervailing effect—the creation of a new kelp habitat on the concrete blocks in the island's slope-protection system (Secs. III.C.1.b(5) and III.D.3.e(2)(a)). The concrete blocks below the ice-scour depth (6 feet) would add about 3 acres of kelp habitat. However, this new kelp habitat might be temporary, because the slope-protection materials might be removed during the abandonment phase in 15-20 years, as noted in Section III.D.6.c(2)(b) of this EIS and Section 15 of the Development and Production Plan (BPXA, 2000a). BPXA could also mitigate some trenching effects if excess quarry boulders were placed on the backfill in the outer portion of the trench. The quarry boulders would probably reduce the longevity of trenching effects from permanent ones to decade-long ones because a Boulder Patch study showed that bare rocks were colonized by kelp within a decade. Future unanticipated effects on kelp could be moderated by Lease Sale Stipulation No. 1, Protection of Biological Resources. The stipulation explains that MMS may require additional biological surveys and, based on the surveys, may require the lessee to “modify operations to ensure that significant biological populations or habitats deserving protection are not adversely affected.”

(2) Effects on Essential Fish Habitat

The general effects of a large spill and the effects of oil-spill-cleanup activities are analyzed in Section III.C.2.f(2) and the general effects of disturbances are analyzed in Section III.C.2.f(2). The effects of Alternative IV.A are expected to be essentially the same on potential salmon prey and associated vegetation for all Alternatives. As a result of disturbances caused by Liberty Island construction and operation, fish and zooplankton might experience short-term, localized but unmeasurable effects.

(3) Effects on the Economy

The general effects of a large spill and the effects of oil-spill-cleanup activities are analyzed in Section III.C.2.k and the general effects of disturbances are analyzed in Section III.C.3.k. The Liberty Project would generate approximately the following economic benefits related to Alternative IV:

- $100 million in wages and 870 full-time equivalent construction jobs for 1 year in Alaska during 14-18 months of construction
- 1,248 indirect full-time equivalent jobs during the 14-18 months of construction
- $480 million capital expenditure

(4) Effects on Water Quality

(a) Large Oil Spills

The general effects of a large spill and the effects of oil-spill-cleanup activities are analyzed in Section III.C.2.l(2)(a). During open water, hydrocarbons dispersed in the water from a large (greater than 500 barrels) crude oil spill could exceed the 0.015-parts per million chronic criterion for 10-30 days in an area that ranges from 30-45 square kilometers (11.6-17.4 square miles) to 51-186 square kilometers (19.7-71.8 square miles). Hydrocarbons in the water could exceed the 1.5-parts per million acute (toxic) criterion during the first day in the immediate vicinity of the spill. A large crude oil spill in broken sea ice or when the sea ice melts could exceed the chronic criterion for several days in an area of about 7.6 square kilometers (2.9 square miles). Hydrocarbons from a large diesel spill during open water could exceed the acute (toxic) criterion for about 7 days in an area of about 18 square kilometers (7 square miles). During broken sea ice or melting ice conditions, a large diesel spill could exceed the acute (toxic) criterion for about 1 day in an area of about 1 square kilometers (0.4 square miles) and the chronic criterion for more than 30 days in an area of about 103 square kilometers (39.8 square miles). The effects from a spill occurring under the ice would be similar to those described for broken ice or melting conditions; the oil would be trapped and essentially remain unchanged until breakup occurred and the ice began to melt.

A large crude or refined oil spill (greater than or equal to 500 barrels) would significantly affect water quality by increasing the concentration of hydrocarbons in the water column to levels that greatly exceed background concentrations; however, the chance of a large spill occurring and oil entering the offshore waters is estimated to be about 1%. Also, regional (more than 1,000 square kilometers [386 square miles]), long-term (more than 1 year) degradation of water quality to levels above State and Federal criteria because of hydrocarbon contamination is very unlikely.

(b) Disturbances

The general effects of disturbances are analyzed in Section III.C.3.l(2)(a).

1) Summary and Conclusions for Effects of Disturbances on Water Quality

The greatest effect on water quality from gravel island and pipeline construction would be additional turbidity caused by increases in suspended particles in the water column. Increases in turbidity generally are expected to be considerably less than the 7,500 parts per million suspended solids used in the analysis as an acute (toxic) criterion for water quality; exceptions may occur within the immediate vicinity of the construction activity. Turbidity increases from construction activities generally are temporary and expected to occur during the winter and end within a few days after construction stops. Material excavated from the pipeline trench but not used for backfill most likely would be left in an area where active erosion of sediment particles could occur during breakup and open water. This material would be similar in composition to seafloor sediments in the trenching and disposal areas, and its contribution to future turbidity from waves and currents is expected to be about the same as the sediments existing at the seafloor surface before pipeline construction. Construction activities are not expected to introduce or add any chemical pollutants.

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2) Details on How Disturbance May Affect Water Quality

The following analysis is a summary of the effects Liberty Island and Pipeline construction would have on water quality in Foggy Island Bay and is based on the following information and analysis:

- scenario assumptions in Table II.A-1
- general effects of disturbances on water quality in Section III.C.3.l(2)(a)
- specific effects of disturbances on water quality in Section III.C.3.l(2)(b).

a) Specific Effects of Constructing the Production Island

The Liberty Island would be constructed in water about 21 feet deep using an estimated 773,000 cubic yards of gravel mined from a permitted site on the Kadleroshilik River floodplain; the gravel is not expected to contain any contaminated material. The gravel would be trucked to the Liberty site over ice roads and dumped into the water through openings cut in ice; this activity is estimated to take from 45-60 days. Dumping river gravel would affect water quality by increasing the amount of suspended-particulate matter in the water column in the area below the floating fast ice in several ways, including (1) suspension of sediments by currents generated from the gravel hitting the seafloor and (2) separation of fine-grained particles from the material falling through the water.

The effects of seafloor sediments suspended in the water column from dumping gravel and pipeline construction are assumed to be similar. The effects of suspending the seafloor sediments during pipeline construction are analyzed in Section III.C.3.l(2)(b)2. Seafloor sediments in Foggy Island Bay consist mainly of fine sand-, silt-, and clay-size particles (Sec. VI.C.1.c(2)). The concentration of suspended sediments associated with trench excavation and backfilling are estimated to range from 500-1,000 milligrams per liter near the seafloor and 50-100 milligrams per liter near the surface (URS Corporation, 2000). Concentrations of suspended particles generally decrease as the distance from the disturbance increases. The larger and/or denser particles settle closer to the source while the smaller and/or less dense particles are carried farther. Suspended sediment concentrations at 1 and 10 kilometers are expected to be less than 20 and 10 milligrams per liter, respectively. See Section III.C.3.l(2)(b)2) for a more complete analysis of the effects of suspending the seafloor sediments in Foggy Island Bay during pipeline construction.

When the dumped gravel forms the base of Liberty Island and covers the seafloor, and as height of the build up increases, the effects of gravel dumping on suspending seafloor sediments will decrease.

As the dumped gravel falls through the water column, some of the fine-grained particles would separate from the mass and remain suspended: this amount is estimated to range from 10-12%. Ice-bonding of particles will likely reduce the amount of fine-grained particles that actually separates from the dumped mass.

At the assumed maximum dumping rate of 20,000 cubic yards per day the suspended sediment concentration in the immediate vicinity of the dumping activity is estimated to be 250 milligrams per liter. The concentration of particles suspended in the water decreases with distance from the source. If the current speed is 2 centimeters per second (0.04 knot), the concentration of suspended particles would be reduced to 50 milligrams per liter at a distance of 0.5 kilometer (0.3 miles from the construction site, 20 milligrams per liter at 1.25 kilometers (0.78 mile) distance, and 10 milligrams per liter at 1.5 kilometers (0.93 mile). The suspended-sediment plume width at the 10-milligram-per-liter concentration interval is estimated to be 400 meters. The suspended-sediment plume is a temporary feature and would disappear within a few days after island construction is complete. The thickness of the depositional layer decreases with distance from the island construction site.

The increase in turbidity as a result of summer grading and shaping the island's surface and subsurface slope, placement of the slope-protection systems and maintenance of the slope-protection systems during the life of the island is expected to be short term, lasting only as long as the activity, and greatest in the vicinity of the island. Turbidity increases are not expected to be greater than the turbidity cased by currents and waves resuspending sediment particles in shallow water areas.

b) Specific Effects of Constructing the Pipeline

The pipeline trench, about 6.1 miles long, would be dug with backhoes in the winter from the sea ice covering Foggy Island Bay. The average trench depth would be 10.5 feet; the range would be from 8 to 12 feet. An estimated 724,000 cubic yards of sediments would be excavated from the trench, and most of it would be used as backfill. Pipeline trenching would take an estimated 49 days. Excavated material not used as backfill would be left on the ice to return to the seafloor by natural processes during spring breakup. Seafloor sediments in Foggy Island Bay consist mainly of fine sand-, silt-, and clay-size particles.

Pipeline construction would affect water quality by increasing suspended-particulate matter in the water column mainly in the area below the floating fast ice in the winter and in the vicinity of the area where excess trench material lies during the open-water period. Trenching would disturb and resuspend the seafloor sediments in those areas beneath the ice where the sea water has not frozen to the seafloor. Dumping excavated material into the water column to fill the trench also would cause some of the fine-grained particles to separate from the descending sediment mass and remain in suspension.

Both trenching and backfilling operations are likely to be performed at the same time along the pipeline route. In the floating fast-ice zone, suspended sediments generated from these operations could form a turbidity plume in the presence of currents in the water column between the bottom of the floating ice and the seafloor surface.

For one study, the initial suspended-sediment concentration in the water column during pipeline construction is estimated to be 1,000 milligrams per liter. The amount of suspended particles in the water column would decrease with distance from the construction area. If the current velocity is 0.02 meter per second (0.04 knot), suspended sediment concentrations greater than 100 milligrams per liter are estimated to occur within 0.75 kilometer (0.46 mile) of the trench. Concentrations of 20 and 10 milligrams per liter are estimated to be reached at distances of about 1 kilometer (0.62 mile) and 10 kilometers (6.2 miles), respectively, from the trench.

In another study, URS Corporation (2000) estimates initial suspended sediment concentrations from pipeline construction could range from 500-1,000 milligrams per liter near the seafloor and 50-100 milligrams per liter at the surface. (This study was done to improve the capability to predict the effects of Liberty development construction on the Boulder Patch community. The previous analysis assumed an initial suspended sediment concentration of 1,000 milligrams per liter was uniform throughout the water column.) If the initial concentrations are less than 1,000 milligrams per liter, suspended sediment concentrations at 1 and 10 kilometers could be less that the 20 and 10 milligrams, respectively, estimated previously. Fine-grained particles (silt- and clay-size particles) are estimated to comprise about 65% of the material excavated from the trench.

Excavated trench material will be stored in two areas; a 230-acre site in waters 5-10 feet deep about 4 miles southwest of the Liberty site (Zone 1, Fig. II.A-18) and along the proposed pipeline route (Zone 2, Fig. II.A-18). Trench sediments would be stockpiled in different parts of the 230-acre site and graded to an average thickness of about 1 foot to minimize the potential for mounding on the seafloor.

After the pipeline has been buried, the amount of material stored on the ice is estimated to be about 100,000 cubic yards in the 230-acre site and 10,000 cubic yards along the northern part of the proposed pipeline route.

These sediments could return to the water column in any number of ways that might include:

- sinking to the seafloor directly beneath the ice pad as the ice melts in place;
- dumping into the water when the melting ice becomes unstable and overturns;
- eroding of particles by waves in open-water areas;
- melting and transporting of particles by meltwater in the frozen material; or
- melting, eroding, and transporting of particles during river flooding of the fast ice.

Depending on weather, ice conditions and breakup, and river flood stage, natural removal of the stockpiled sediments could take up to several weeks.

When the material stockpiled on the ice returns to the seafloor, some of the fine-grained material would be suspended in the water column. The effects on water column turbidity are estimated by assuming all stockpiled material falls from the ice in 24 hours, 10% of the material would be suspended in the water column, and a current of 0.05 meters per second (0.1 knots) transports the water in a northerly direction. Based on these assumptions, the suspended-sediment concentration below the 230-acre site is estimated to be 1,168 milligrams per liter, and below the storage area adjacent to the northern part of the proposed pipeline it is estimated to be 14 milligrams per liter. The suspended-sediment concentrations decrease with distance from the storage sites. Concentrations of 200, 20, and 10 milligrams per liter are estimated to occur at about 0.5 kilometer (0.3 mile), 2.75 kilometers (1.70 miles), and 7 kilometers (4.3 miles), respectively, from the 230-acre site. These estimates probably represent maximum suspended-sediment concentrations over 1 or 2 days. If the return of the stockpiled material takes more than a day, suspended-sediment concentrations could be reduced and/or last for a longer period. Also exposure to subfreezing temperatures would freeze the particles together and reduce some particle separation when the stockpiled material returns to the seafloor. The suspended concentration estimates are based on no ice bonding of particles and, thus, estimate possible maximum concentrations.

During broken-ice conditions or open water, winds from the east force the nearshore waters to move in a westerly direction parallel to the bathymetry; the characteristics of Beaufort Sea coastal winds are summarized in Section III.C.2.l(2)(a). Under these conditions, particles in the turbidity plume from the Zone 1 spoils area would be deposited in an area that extends in a northerly direction from the spoils site (Fig. III.C-5). Westerly winds force the nearshore waters to move in an easterly direction parallel to the bathymetry. Under these conditions, particles in the turbidity plume from the Zone 1 spoils area would be deposited in an area that extends in an easterly direction from the site of the excess trench material (Fig. III.C-5).

The thickness of the layer formed by excess trench material falling to the seafloor would be greatest in the vicinity of the storage area and would decrease with distance. The areal extent and thickness of this layer were calculated from a sediment deposition model (URS Greiner Woodward Clyde, 1998a). Within 400-530 meters of Zone 1, the layer formed by excess trench material falling to the seafloor would decrease to a thickness of 10 millimeters. The layer would have a thickness of 1 millimeter within 10-13 kilometers (6.2-8.1 miles) under easterly winds and within about 6.1 kilometers (3.8 miles) under westerly winds. Within 170-180 meters of Zone 3, the layer formed by excess trench

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material falling to the seafloor would decrease to a thickness of 1 millimeter.

The areal extent of the turbidity plume formed by the falling excess trench material could be approximated by considering where some of the smallest particles might be deposited. Particles 0.005 millimeter in diameter would be deposited at distances of about 13-18 kilometers (8-11 miles) from the Zone 1 site; the thickness of the deposits at these distances is calculated to be about 0.02 millimeter under easterly winds and 0.01 millimeter under westerly winds. Particles 0.005 millimeter in diameter would be deposited at distances of about 18-56.5 kilometers (11-35 miles) from the Zone 3 site; the thickness of the deposits at these distances is calculated to be about 0.001-0.002 millimeter under easterly winds and 0.001 millimeter under westerly winds.

Depending on wind and wave conditions, the fine-grained particles in the excess trench material on the seafloor could be resuspended. Foggy Island Bay is a dynamic environment where a number of phenomena interact to produce changes in the seafloor. These phenomena include winds and storms, sea ice, and river flooding of the nearshore ice. If all or most of the excess trench material returns to the seafloor in the vicinity of the storage site a layer, or scattered layers, or variable thickness could form. The layer(s) would consist of a heterogeneous mixture of clay, silt, sand and gravel-size particles similar to the grains-size composition of present-day surface sediments. Multiyear satellite images suggest the turbidity in coastal waters in mid- and late summer are, for the most part, associated with wave-induced resuspension of cohesionless muddy sediments from shallow-water regions. The contribution of the trench material to the background suspended-sediment concentration likely would be about the same as that of the area into which the sediments were dumped.

Pipeline trenching and backfilling are not likely to increase the amount of trace metals or hydrocarbons into the environment above the naturally occurring background concentrations.

c) Specific Effects of Repairing the Pipeline

Damage to the pipeline would require repairs, which would mean excavating the trench to expose the pipeline. Repair work most likely would be done in the winter when the ice is stable enough so that it can be thickened to support the repair equipment or during the open-water period (Table II.C-6).

The types of effects associated with excavating and backfilling would be the same as those analyzed for pipeline construction. These activities would affect water quality by increasing suspended-particulate matter in the water column in the area of the activity. In the winter, if the repair work takes place in the bottomfast-ice zone, there would be very little, if any, effects in the water column. If the repair work takes place in the floating fast-ice zone, the effects would be in the water column mainly in the area below the floating ice.

Depending on the type of repair, the amount of sediment excavated could range from 1,150-6,490 cubic yards. The rate at which the trench backfill material would be removed is likely to be less than the rate at which sediment was excavated to form the trench. An estimated 10-15 days would be required to excavate 6,490 cubic yards (Table II.C-7). Repair excavation would take place in a small area, and the size of the associated turbidity plume is expected to be smaller than the one formed during the initial trench excavation. In the winter, the excavated material would be stored on the ice and used as backfill when the pipeline repair is finished. During the open-water period, the excavated material would be placed on the seafloor alongside the trench and used as backfill when the pipeline repair is completed.

i. Alternative IV.A – Use Pipe-in-Pipe System

A discussion of the benefits and disadvantages of this alternative can be in Section IV.C.2.e. The primary benefit provided by this pipeline design is it reduces the probability of a containment failure. Most of the information from the C-CORE and Stress Engineering Services, Inc. studies in Sections IV.C.2.b through f are applicable to this alternative.

The pipe-in-pipe system (Fig. II.C-3) would be constructed with a steel inner pipe with an outside diameter of 12.75 inches and a wall thickness of 0.500 inch. The inner pipe would be placed in a steel outer pipe with an outside diameter of 16.00 inches and a wall thickness of 0.844 inch. The inner pipe would be supported in the outer pipe with annular spacers or centralizers. The outer pipe would be protected from external corrosion by a dual-layer fusion-bonded epoxy and sacrificial anodes. The inner pipe would be protected from corrosion by a dual-layer fusion-bonded epoxy. For the EIS analysis, we assume the double-wall pipeline design can be built in a single winter construction season, although its complexity increases the risk that it may require a 2-season (2 winters) construction. The system would be buried with a minimum burial depth of 5 feet. Table II.A-1 provides a comparison of key components for the different alternatives being analyzed.

A detailed description of the activities involved in constructing a pipeline are in Section II.A.1.b(3)(a). Table IV.C-2 provides information about the number of days required to construct the pipeline. All of the pipeline welds on the carrier pipe would undergo x-ray and ultrasonic tests to ensure that they are sound. Most welds on the outer pipe would also be undergo x-ray and ultrasonic tests, so some welds (primarily tie-in welds) can only be tested by ultrasonically because of the pipe-in-pipe configuration.

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Any weld that has a defect larger than the maximum acceptable level would be cut out and replaced.

This alternative is described I detail in Section II.C.2.b. The amount of excavation in the various water depths for this system is shown in Table II.A-2. The size of the pipeline makeup site required would be 533,000 square yards, about 110 acres. No select backfill material would be needed. Between the Liberty Island and the 3-mile limit, approximately 137,000 cubic yards of trench-dredged material would be used as backfill. Between the 3-mile limit and the shoreline, about 419,700 cubic yards of trench-dredged material would be used as backfill. A pipeline will buried at a minimum burial depth of 5 feet of fill material would cover the pipeline. In water up to 8 feet deep, the cap of the backfill would be close to the original seafloor, not to exceed 1 foot higher than the surrounding seafloor. In water deeper than 8 feet, the trench cap would not exceed 2 feet higher than the surrounding seafloor. The affected footprint would be 15.4 acres beyond the 3-mile limit and 47.1 acres within the 3-mile limit. This includes the trench cap, which could overstep the limits of the trench excavation.

Any dredged/excavated material that could not be placed back into the trench would require disposal into ocean water. See Sections IV.C.1.b. and II.A.1.b(3)(a)12)a) for more a detailed description of disposal zones 3 and 4 (See Fig. II.A-18).

This alternative provides secondary containment in the unlikely event that a functional failure occurs that causes the inner pipe to leak. The outer pipe in the pipe-in-pipe system can handle the pressure that could occur if the inner pipe leaked, but the outer pipe did not.

For the Liberty pipeline route, MMS calculated that 1,325 barrels would be the maximum volume that may be contained in the annulus (the space between the two pipes) for the pipe-in-pipe design system. A process would have to be developed to remove the oil from and clean out the annulus and repair the pipeline before it could be returned to service.

As noted above in Section IV.C.2.g, the effects to many resources are the same for all pipeline design alternatives. The specific components of the single-wall pipe system (Liberty Development and Production Plan) as described above would change the impacts to the following resources in the ways described in the analyses that follow:

- Lower Trophic-Level Organisms
- Essential Fish Habitat
- Economy
- Water Quality

(1) Effects on Lower Trophic-Level Organisms

(a) Large Oil Spills

The general effects of a large spill and the effects of oil-spill-cleanup activities are analyzed in Section III.C.2.e(2)(a). The general oil-spill risk to these organisms would be about the same for Alternative 1 and pipe-in-pipe because the main risk in both cases would come from spills of diesel rather than Liberty crude. Further, the risk with pipe-in-pipe in the Eastern or Tern pipeline routes would be the same as with the Alternative I.

(b) Disturbances

The general effects of disturbances are analyzed in Section III.C.3.e(2)(a).

1) Summary and Conclusions for Effects of Disturbances on Lower Trophic-Level Organisms

There would be specific differences in the disturbance effects. The pipe-in-pipe design would require less burial depth, causing fewer effects than Alternative I in two important ways: (1) shallower burial in the Alternative I pipeline route would permanently eliminate 2 acres or fewer of very diffuse kelp, boulder, and suitable substrate than would the Alternative I burial depth; and (2) the amount of turbidity generated by shallower burial would be only two-thirds of that for Alternative I, probably causing less reduction in annual kelp production during the construction phase. There is no kelp or solid substrate in the eastern or Tern pipeline corridors, so shallower burial there would not save any kelp habitat, however, the reduced suspended sediments probably would cause less reduction in annual kelp production during the construction phase.

2) Details on How Disturbances May Affect Lower Trophic-Level Organisms

Specific Effects: Burial of pipe-in-pipe would not require as deep a trench as the pipeline in Alternative I. Pipe-in-pipe would require a maximum depth of only 10.5 feet rather than 12 feet (Table II.A-1 and Fig. II.A-12). The shallower trench would remove the scattered kelp and solid substrate from the sediment surface in an area up to 112 feet wide rather than 132 feet. In other words, the pipe-in-pipe in the Alternative I pipeline route would eliminate 15% less kelp and solid substrate than with the Alternative I pipeline design. The effect would be the same, regardless of the island design (steel sheetpile). However, there is no kelp or solid substrate in the eastern or Tern Island pipeline routes, so shallower pipeline burial there would not save kelp habitat.

The shallower trench would cause only two-third as much suspended sediments as the Alternative I design. The effects of suspended sediment on kelp production in the Boulder Patch were analyzed by Ban et al. (1999). They concluded that suspended sediments from the Alternative 1 pipeline route would drift northwest over the Boulder Patch and would reduce annual kelp production by about 6% for 1 year. Therefore, the pipe-in-pipe design would probably reduce annual kelp production by only 4% for 1 year. As explained for Alternative I, kelp would colonize the new slope-protection system on the island, providing some mitigation of the project effects. BPXA could also mitigate some trenching effects if excess quarry boulders were placed on the backfill in the outer portion of the trench. Any unanticipated effects on kelp could be mitigated by Lease Sale Stipulation No. 1, Protection of Biological Resources.

(2) Effects on Essential Fish Habitat

The general effects of a large spill and the effects of oil-spill-cleanup activities are analyzed in Section III.C.2.f(2), and the general effects of disturbances are evaluated in Section III.C.3.f(2). The effects of Alternative IV.A are expected to be essentially the same on potential salmon prey and associated vegetation for all alternatives. Water quality is expected to be improved, because the total amount of suspended-particulate matter would be less than under the Alternative I (Liberty Development and Production Plan).

(3) Effects on the Economy

The general effects of a large spill and the effects of oil-spill-cleanup activities are analyzed in Section III.C.2.k, and the general effects of disturbances are evaluated in Section III.C.3.k.

Specific Effects: Alternative IV.A generates more jobs, more wages, and greater capital expenditure than for the Alternative I. This alternative would result in an increase of $4 million in wages for 7 months; 34 direct jobs in pipeline construction in Alaska for 7 months; 50 indirect jobs in Alaska for 7 months; and $20 million in capital expenditures. The increased cost of this alternative is based primarily on additional labor, welding, and material cost. Information for this analysis is interpreted from data in INTEC (1999a).

(4) Effects on Water Quality

(a) Large Oil Spills

The effects of an oil spill on water quality for this alternative are expected to be the same as analyzed for Alternative I in Section IV.C.2.h(4). The general effects of a large spill and the effects of oil-spill-cleanup activities are analyzed in Section III.C.2.l(2)(a).

(b) Disturbances

The general effects of disturbances are analyzed in Section III.C.3.l(2)(a).

1) Summary and Conclusions for Effects of Disturbances on Water Quality

The greatest effect on water quality from gravel island and pipeline construction would be additional turbidity caused by increases in suspended particles in the water column. Increases in turbidity generally are expected to be considerably less than the 7,500 parts per million suspended solids used in the analysis as an acute (toxic) criterion for water quality; exceptions may occur within the immediate vicinity of the construction activity. Turbidity increases from construction activities generally are temporary and expected to occur during the winter and end within a few days after construction stops. The duration of turbidity from pipe-in-pipe pipeline trenching is expected to be 11 days less compared to Liberty Pipeline (49 days). The overall effects of turbidity are expected to be about 23% less for the pipe-in-pipe pipeline construction compared to the Liberty pipeline construction. Material excavated from the pipeline trench but not used for backfill most likely would be left in an area where active erosion of sediment particles could occur during breakup and open water. This material would be similar in composition to seafloor sediments in the trenching and disposal areas, and its contribution to the future turbidity from waves and currents is expected to be about the same as the sediments existing at the seafloor surface prior to pipeline construction. Construction activities are not expected to introduce or add any chemical pollutants.

2) Details on How Disturbances May Affect Water Quality

The following is a summary of the effects constructing Liberty Island and pipeline would have on water quality in Foggy Island Bay. The general effects of construction activities on water quality are analyzed in Section III.C.3.l(2)(a) and the specific effects of island and pipeline construction are analyzed in Section IV.C.2.h(4(b)).

a) Specific Effects of Constructing the Production Island

The effects on water quality during the construction of the production island for this alternative are expected to be the same as analyzed for Alternative I in Section IV.C.2.h(4)(b)2)a).

b) Specific Effects of Constructing the Pipeline

The types of effects on water quality from constructing the pipeline part of this alternative would be the same as those analyzed for Liberty Pipeline construction (Sec. IV.C.2.h(4)(b)2)b)); see Table II.A-1 to compare the characteristics of the pipelines.

The pipeline trench, about 6.1 miles long, would be dug with backhoes in the winter from the sea ice covering Foggy Island Bay. The average trench depth would be 9 feet; the range would be from 6.5-10.5 feet deep. An estimated 557,300 cubic yards (Table IV.C-2) of sediments would be excavated from the trench, and most of it would be used as backfill. The amount of sediments excavated for the pipe-in-pipe trench is about 23% less than the amount excavated from the single-wall pipe trench (724,000 cubic yards). Pipeline trenching would take an estimated 38 days. Excavated material not used as backfill would be left on the ice to return to the seafloor by natural processes during spring breakup. Seafloor sediments in Foggy Island Bay consist mainly of fine sand-, silt-, and clay-size particles.

Pipeline construction would affect water quality by increasing suspended-particulate matter in the water column mainly in the area below the floating fast ice in the winter and in the vicinity of the area where excess trench material lies during the open-water period. Trenching would disturb and resuspend the seafloor sediments in those areas beneath the ice where the sea water has not frozen to the seafloor. Dumping excavated material into the water column to fill the trench also would cause some of the fine-grained particles to separate from the descending sediment mass and remain in suspension; however, exposure to subfreezing temperatures likely would freeze the particles together and reduce some particle separation.

Both trenching and backfilling operations are likely to be performed at the same time along the pipeline route. In the floating fast-ice zone, suspended sediments generated from these operations could form a turbidity plume in the presence of currents in the water column between the bottom of the floating ice and the seafloor surface.

For the pipe-in-pipe pipeline, less material is being exposed to the environment in terms of excavating, backfilling, and abandoning (excess material not used for backfill) than for the Liberty pipeline; excess backfill material would be left on the ice to return to the seafloor by natural processes during spring breakup.

For one study, the initial suspended-sediment concentration in the water column during pipeline construction is estimated to be 1,000 milligrams per liter throughout the water column. The amount of suspended particles in the water column would decrease with distance from the construction area. If the current velocity is 0.02 meter per second (0.04 knot) suspended sediment concentrations greater than 100 and 20 and 10 milligrams per liter are estimated to occur within 0.75 kilometer (0.46 mile) and about 1 kilometer (0.62 mile) and 10 kilometers (6.2 miles), respectively, from the trench.

In another study, URS Corporation (2000) estimates initial suspended sediment concentrations from pipeline construction could range from 500-1,000 milligrams per liter near the seafloor and 50-100 milligrams per liter at the surface. If the initial concentrations are less than 1,000 milligrams per liter, suspended sediment concentrations at 1 and 10 kilometers could be less that the 20 and 10 milligrams, respectively, estimated previously. Fine-grained particles (silt- and clay-size particles) are estimated to comprise about 65 percent of the material excavated from the trench.

The total amount of suspended particles from the pipe-in-pipe pipeline construction is estimated to be about 23% less than the amount from single-wall pipeline construction.

The turbidity plume associated with the pipe-in-pipe trenching also would not last as long as a plume from the single-wall pipeline trenching. The time the environment would be disturbed by excavating and backfilling activities is less for the pipe-in-pipe trenching than for the Liberty pipeline; actual excavation time for the pipe-in-pipe pipeline is estimated to be 38 days compared to 49 days for the single-wall pipeline trenching. Excavated trench material will be stored in two areas; a 230-acre site in waters 5-10 feet deep about 4 miles southwest of the Liberty site (Zone 1, Fig. II.A-18) and along the proposed pipeline route (Zone 2, Fig. II.A-18). Trench sediments would be stockpiled in different parts of the 230-acre site and graded to an average thickness of about 1 foot to minimize the potential for mounding on the seafloor.

After the pipeline has been buried, the amount of material stored on the ice is estimated to be less than the 100,000 cubic yards in the 230-acre site and 10,000 cubic yards along the northern part of the pipeline route amounts estimated for the Liberty pipeline trench.

These sediments could return to the water column in any number of ways described in Section III.C.3.l(2)(b)1.

When the material stockpiled on the ice returns to the seafloor, some of the fine-grained material would be suspended in the water column. The effects on water column turbidity are estimated to be about the same order of magnitude as were estimated for the Liberty Pipeline for 1 or 2 days. For the Liberty pipeline, the suspended-sediment concentration below the 230-acre site is estimated to be 1,168 milligrams per liter, and below the storage area adjacent to the northern part of the proposed pipeline it is estimated to be 14 milligrams per liter. The suspended-sediment concentrations decrease with distance from the storage sites. Concentrations of 200, 20, and 10 milligrams per liter are estimated to occur at about 0.5 kilometer (0.3 miles), 2.75 kilometers (1.70 miles) and 7 kilometers (4.3 miles), respectively, from the 230-acre site.

The thickness of the layer formed by excess trench material falling to the seafloor would be greatest in the vicinity of the storage area and would decrease with distance. The areal extent and thickness of this layer were calculated from a sediment deposition model (URS Greiner Woodward Clyde, 1998a). Within 400-530 meters of Zone 1, the layer formed by excess trench material falling to the seafloor would decrease to a thickness of 10 millimeters. The layer would have a thickness of 1 millimeter within 10-13 kilometers (6.2-8.1 miles) under easterly winds and with about 6.1 kilometers (3.8 miles) under westerly winds. Within 170-180 meters of Zone 3, the layer formed by excess trench material falling to the seafloor would decrease to a thickness of 1 millimeter.

The areal extent of the turbidity plume formed by the falling excess trench material could be approximated by considering where some of the smallest particles might be deposited. Particles 0.005 millimeter in diameter would be deposited at distances of about 13-18 kilometers (8-11 miles) from the Zone 1 site; the thickness of the deposits at these distances is calculated to be about 0.02 millimeter under easterly winds and 0.01 millimeter under westerly

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winds. Particles 0.005 millimeter in diameter would be deposited at distances of about 18-56.5 kilometers (11-35 miles) from the Zone 3 site; the thickness of the deposits at these distances is calculated to be about 0.001-0.002 millimeters under easterly winds and 0.001 millimeter under westerly winds.

Depending on wind and wave conditions, the fine-grained particles in the excess trench material on the seafloor could be resuspended. The contribution of the trench material to the background suspended-sediment concentration likely would be about the same as that of the area into which the sediments were dumped.

Pipeline trenching and backfilling are not likely to increase the amount of trace metals or hydrocarbons into the environment above the naturally occurring background concentrations.

3) Specific Effects of Repairing the Pipeline

Damage to the pipeline would require repairs, and this means excavating the trench to expose the pipeline. Repair work most likely would be done in the winter, when the ice is stable enough so that it can be thickened to support the repair equipment, or during the open-water period (Table II.C-6). The pipeline repair techniques are described in Section II.B.2.c and summarized in Table II.C-7. Excavated trench material would be stored on the ice during a winter repair and on the seafloor alongside the trench during an open-water repair. The types of effects associated with excavating and backfilling would be the same as those analyzed for pipeline construction; the effects of pipeline repair on water quality are analyzed in Section III.C.3.1(2)(b)3), Effects of Repairing the Pipeline. Depending on the type of repair the amount of sediment excavated would be similar to the amounts estimated for the Proposal (Table II.C-7); these amounts could range from 1,034-8,500 cubic yards and are about 2% or less of the volume handled during construction.

j. Alternative IV.B – Use Pipe-in-HDPE System

The information in section (IV.C.2) provide a discussion of the advantages and disadvantages that apply to pipe-in-pipe and pipe-in-HDPE pipeline systems. The primary benefit of a pipe-in-HDPE system is the ability of the HDPE sleeve to contain a leak from the inner pipe. The issues and narrative from both the C-CORE and Stress Engineering Services, Inc. studies discussed in Section IV.C.2.f also are applicable to this alternative.

(1) Pipe-in-HDPE Can Provide Environmental Benefits

The environmental benefits noted in Section IV.C.2.f. generally are applicable to this alternative pipeline design. INTEC (2000) and Fleet (2000) estimate that the pipe-in-HDPE has a higher probability of a containment failure than a steel-in-steel pipe-in-pipe configuration and no better than a single-wall pipeline. INTEC (2000) predicts that increasing the burial depth of a pipe-in-HDPE will significantly reduce the containment failure probability, but Fleet (2000) predicts that increasing burial depth will have no affect on this probability. The HDPE (high-density polyethylene) cannot accommodate the full operating pressure of the carrier pipe. Stress noted that there should be time to detect the presence of oil in the annulus from a small leak before the burst pressure of the HDPE sleeve is reached, and the system could be connected to a reservoir at the ends of the pipeline to contain any oil that leaks (Stress, 2000).

(2) Pipe-in-HDPE Installation, Operation, and Maintenance Considerations

In addition to the items noted in Section IV.C.2.b concerning the pipe-in-pipe systems, the following additional considerations would apply to the pipe-in-HDPE alternative.

The functional failure probability of the pipe-in-HDPE system is greater than the functional failure probability of the single-wall pipeline. INTEC estimated the containment failure probability of the pipe-in-HDPE system and the single-wall pipeline at 0.0001 ($1x10^{4}$) and 0.00001 ($1x10^{5}$), respectively, which corresponds to a recurrence rate of 10,000 years and 100,000 years, respectively (INTEC, 2000). Fleet's analysis indicated that the pipe-in-HDPE alternative has essentially the same probability of a containment failure as the single-wall pipeline and a higher probability than the pipe-in-pipe alternative. The "expected" volume of oil released over the life of the pipeline is estimated at 24 barrels, and the probability of a large spill greater than 1,000 barrels occurring is 0.0138 (Fleet, 2000).

Due to its material properties HDPE not as robust as steel and therefore is more susceptible to damage during installation than a steel casing.

(3) Other Comments Specific to High-Density Polyethylene

The Stress report (2000) identified four issues that have direct implications to potential environmental impacts between the various designs. Two of them—pipeline burial depth and leak-containment capabilities—have comments specific to pipe-in-HDPE. For the other two issues—leak-detection capability, and constructability—the discussion in Section IV.C.2.e is applicable.

(a) Pipeline Burial Depth

Upheaval buckling is the controlling factor for design burial depth of the pipe-in-HDPE system. The INTEC (2000) report indicates that the containment failure probability would be reduced to 2.22 x 10^{7} if the burial depth were increased to 7 feet. The Fleet (2000) report indicates that there will be no change in the containment failure probability if the burial depth were increased.

(b) Leak-Containment Capability

Stress had the following comments related to leak-containment capability:

> It is our opinion that the HDPE sleeve used in the pipe-in-HDPE concept could contain small leaks, but could not contain the operating pressure of the pipeline. However, it should be noted that a small leak in the inner pipe would not result in the HDPE sleeve being immediately subjected to the operating pressure of the pipeline. Therefore, we expect that there would be time to detect the presence of oil in the annulus with either the LEOS system or by pressure fluctuations in the annulus before the burst pressure of the HDPE sleeve was reached (Stress, 2000).

(4) Other Design Considerations

The Stress report also identified several other considerations specific to the pipe-in-HDPE design:

The Stress report states:

> For the pipe-in-HDPE concept, it is stated that only visual inspection of the fusion welds is possible. We agree with this and that the best avenue for assuring the quality of the fusion welds is to qualify the procedure using test samples fusion welded by the same machine and operators as would be used during installation (Stress, Inc., 2000).

Stress is concerned that the amount of the contingency for a second season of construction is too low. The report states:

> The 5 million dollar contingency for a second construction season for the pipe-in-HDPE candidate appears low. We understand that Intec based this on the perceived likelihood of a second season being required to complete construction. However, the costs for mobilization, ice thickening/road construction, and demobilization for the pipe-in-HDPE concept total 9.7 million dollars. There are also no costs included for the abandonment of the line at the end of the first construction season and the retrieval of the partially completed pipeline so that construction can be resumed. Therefore, the 5 million dollar contingency for the second season work seems low (Stress, 2000).

Stress raised concerns about transporting the pipe-in-HDPE segments. The report states:

> For the pipe-in-HDPE concept, the pipe transport method mentioned is the same as for the pipe-in-pipe technique. The spacers between the inner pipe and the HDPE outer sleeve are not described in any detail. However, the spacers must be designed so that the weight of the inner pipe is distributed along the length of the HDPE sleeve. The inner pipe is so heavy that the ability of the HDPE sleeve to carry this load, unless it is well distributed, is doubtful (Stress, 2000).

Stress suggested a solution to this concern:

> An alternative would be to use a thicker walled HDPE sleeve and a smaller annulus size and omit the centralizers. This would distribute the weight of the inner pipe over a larger area than if centralizers were present (Stress, 2000).

Finally, Stress identified a number of design approaches for the pipe-in-HDPE alternative. These designs are described in the Stress report and would be further evaluated during the preliminary design stage, if the pipe-in-HDPE alternative were adopted.

(5) Analysis of Pipe-in-HDPE Design

This alternative uses a steel carrier pipe, which is identical to the Proposal. That carrier pipe is placed inside an (HDPE) sleeve with a diameter of 16.25 inches and a wall thickness of 0.75 inch. The outer pipe cannot corrode. This alternative is described in detail in Section II.C.2.c.

Section IV.C.2.f describes the common elements shared by all alternatives in the set of component alternatives. Those common elements, plus the following alternative components specific to this particular pipeline design complete the description of this alternative. Note that this description of Alternative IV.B was previously given in Sections II.C.2.c and is being repeated here for the convenience of the reader. Table II.A-1 provides a comparison of key components for the different alternatives being analyzed.

The pipe-in-HDPE system (Fig. II.C-3) would be constructed with a steel inner pipe with an outer diameter of 12.75 inches and a wall thickness of 0.688 inch. The inner pipe would be placed in a high-density polyethylene outer pipe with an outer diameter of 16.25 inches and a wall thickness of 0.75 inch. The inner pipe would be placed in the high-density polyethylene outer pipe without the use of spacers or centralizers. Because the outer pipe is made of HDPE, it would not require any corrosion protection. The inner pipe would be protected from corrosion by a dual-layer fusion-bonded epoxy. The EIS assumes this pipeline could be constructed in a single winter construction, although the complexity would increase the possibility that the construction could take 2 years. The system would be buried with a minimum burial depth of 6 feet. Table II.A-1 provides a comparison of key components for the different alternatives being analyzed.

The amount of excavation in the various water depths for this system is shown in Table II.A-2. The size of the pipeline makeup site required would be 416,500 square yards, about 86 acres. An estimated 17,000 cubic yards of gravel fill material would be required as pipeline-bedding material in various locations within the trench between the gravel island and the 3-mile limit. Approximately 50,000 cubic yards of gravel fill would be required as pipeline-bedding material in various locations within the Territorial Seas (shoreward of the 3-mile limit). These estimates include the gravel material contained within the 4-cubic-yard bags (about 4,000 bags) that periodically would be placed over the entire pipeline before placing the backfill material. The bags would cover approximately 50% of the pipeline route. Backfill material would consist of material dredged from the trench. Between the Liberty Island and the 3-mile limit, approximately 162,000 cubic yards of trench-dredged material would be used as backfill. Between the 3-mile limit and the shoreline, about 495,000 cubic yards of trench-dredged material would be used as backfill. A minimum of 7 feet of fill material would cover the pipeline. In water up to 8 feet deep, the cap of the backfill would be close to the original seafloor, not to exceed 1 foot higher than the surrounding seafloor. In water deeper than 8 feet, the trench cap would not exceed 2 feet higher than the surrounding seafloor. The affected footprint would be 18.2 acres beyond the 3-mile limit and 55.4 acres within the 3-mile limit. This includes the trench cap, which could overstep the limits of the trench excavation.

This alternative could provide secondary containment of small spills in the unlikely event of an oil leak occurring only to the carrier pipeline. The transition pad would need to be designed to contain a possible oil spill of up to 2,000 barrels.

For the Liberty pipeline route, MMS calculated that 1,725 barrels would be the maximum volume that could be contained in the annulus (the space between the two pipes) for the pipe-in HDPE system. Those volumes would be reduced to about 1,550 barrels for the Tern Island route and 1,190 barrels for the eastern pipeline route. If this pipeline design is selected, additional work and testing would be needed to develop a procedure from cleaning the annular space of any oil, should a leak occur.

As noted in Section IV.C.2.g, the effects to many resources are the same for all of pipelines design alternatives. The differences would change the impacts to the following resources in the ways described in the analyses that follow:

- Lower Trophic-Level Organisms
- Essential Fish Habitat
- Economics
- Water Quality

(6) Effects on Lower Trophic-Level Organisms

(a) Large Oil Spills

The general effects of a large spill and the effects of oil-spill-cleanup activities are analyzed in Section III.C.2.e(2)(a). The general oil-spill risk to these organisms would be about the same for Alternative I and pipe-in-HDPE, because the main risk in both cases would come from spills of diesel rather than Liberty crude. Further, the risk with pipe-in-HDPE in the eastern or Tern pipeline routes would be the same as with the Alternative I.

(b) Disturbances

The general effects of disturbances are analyzed in Section III.C.3.e(2)(a).

1) Summary and Conclusions for Effects of Disturbances on Lower Trophic-Level Organisms

There would be specific differences in the disturbance effects. The pipe-in-HDPE would require less burial depth, causing fewer effects than Alternative I in two important ways. (1) Shallower burial in the Alternative I pipeline route would permanently eliminate 2 less acres of very diffuse kelp, boulder and suitable substrate than would the Alternative I burial depth. (2) The amount of turbidity generated by shallower burial would be only two-thirds of that for Alternative I, probably causing less reduction in annual kelp production during the construction phase. There is no kelp or solid substrate in the Eastern or Tern pipeline corridors, so shallower burial there would not save any kelp habitat, however, the reduced suspended sediments probably would cause less reduction in annual kelp production during the construction phase.

2) Details on How Disturbances May Affect Lower Trophic-Level Organisms

Specific Effects: Burial of pipe-in-HDPE would not require as deep a trench as the pipeline in Alternative I. Pipe-in-HDPE would require a maximum depth of only 10.5 feet rather than 12 feet (Table II.A-1 and Fig. II.A-12). The shallower trench would remove the scattered kelp and solid substrate from the sediment surface in an area up to 112 feet wide rather than 132 feet. In other words, the pipe-in-HDPE in the Alternative I pipeline route would eliminate 15% less kelp and solid substrate than with the Alternative I pipeline design. The effect would be the same, regardless of the island design (steel sheetpile). However, there is no kelp or solid substrate in the eastern or Tern Island pipeline routes, so shallower pipeline burial there would not save kelp habitat.

The shallower trench would cause only two-third as much suspended sediments as the Alternative I design. The effects of suspended sediment on kelp production in the Boulder Patch were analyzed by Ban et al. (1999). They concluded that suspended sediments from the Alternative I

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pipeline route would drift northwest over the Boulder Patch and would reduce annual kelp production by about 6% for 1 year. So, the pipe-in-HDPE design would probably reduce annual kelp production by only 4% for 1 year. As explained for Alternative I, kelp would colonize the new slope-protection system on the island, providing some mitigation of the project effects. BPXA could also mitigate some trenching effects if excess quarry boulders were placed on the backfill in the outer portion of the trench. Any unanticipated effects on kelp could be mitigated by Lease Sale Stipulation No. 1, Protection of Biological Resources.

(7) Effects on Essential Fish Habitat

The general effects of a large spill and the effects of oil-spill-cleanup activities are analyzed in Section III.C.2.f(2) and the general effects of disturbances are analyzed in Section III.C.2.f(2). The effects of Alternative IV.B are expected to be essentially the same on potential salmon prey and associated vegetation as Alternative I. Water quality is expected to be improved slightly, because the total amount of suspended-particulate matter would be slightly less than under the Alternative I.

(8) Effects on the Economy

The general effects of a large spill and the effects of oil-spill-cleanup activities are analyzed in Section III.C.2.k and the general effects of disturbances are evaluated in Section III.C.3.k.

Specific Effects: Alternative IV.B (pipe-in-HDPE) generates more jobs, greater wages, and greater capital expenditures than for the Proposal. This alternative would result in an increase of $2.4 million in wages for 7 months; 22 direct jobs in pipeline construction in Alaska for 7 months; 33 indirect jobs in Alaska for 7 months; and $12.6 million in capital expenditures. The increased cost of this alternative is based primarily on additional labor and material costs. Information for this analysis is interpreted from data in INTEC (1999a).

(9) Effects on Water Quality

(a) Large Oil Spills

The effects of an oil spill on water quality for this alternative are expected to be the same as analyzed for Alternative I in Section IV.C.2.h(4). The general effects of a large spill and the effects of oil-spill-cleanup activities are analyzed in Section III.C.2.l(2).

(b) Disturbances

1) Summary and Conclusions for Effects of Disturbances on Water Quality

The greatest effect on water quality from gravel island and pipeline construction would be additional turbidity caused by increases in suspended particles in the water column. Increases in turbidity generally are expected to be considerably less than the 7,500 parts per million suspended solids used in the analysis as an acute (toxic) criterion for water quality; exceptions may occur within the immediate vicinity of the construction activity. Turbidity increases from construction activities generally are temporary and expected to occur during the winter and end within a few days after construction stops. The duration of turbidity from pipe-in-HDPE pipeline trenching is expected to be 4 days less compared to Liberty Pipeline (49 days). The overall effects of turbidity are expected to be about 7% less for the pipe-in-pipe pipeline construction compared to the Liberty Pipeline construction. Material excavated from the pipeline trench but not used for backfill most likely would be left in an area where active erosion of sediment particles could occur during breakup and open water. This material would be similar in composition to seafloor sediments in the trenching and disposal areas, and its contribution to future turbidity from waves and currents is expected to be about the same as the sediments existing at the seafloor surface before pipeline construction. Construction activities are not expected to introduce or add any chemical pollutants.

2) Details on How Disturbance May Affect Water Quality

The following is a summary of the effects constructing Liberty Island and pipeline would have on water quality in Foggy Island Bay. The general effects of construction activities on water quality are analyzed in Section III.C.3.l(2)(a) and the specific effects of island and pipeline construction are analyzed in Section IVC.2.h(4)(b).

a) Specific Effects of Constructing the Production Island

The effects on water quality during the construction of the production island for this alternative are expected to be the same as analyzed for Alternative I in Section IV.C.2.h(4)(b)2)a).

b) Specific Effects of Constructing the Pipeline

The types of effects on water quality from constructing the pipeline part of this alternative would be the same as those analyzed for Liberty Pipeline construction (Sec. IV.C.2.h(4)(b)2)b)); see Table II.A-1 to compare the characteristics of the pipelines.

The pipeline trench, about 6.1 miles long, would be dug with backhoes in the winter from the sea ice covering Foggy Island Bay. The average trench depth would be 10 feet; the range would be from 7.5-11.5 feet deep. An estimated 673,920 cubic yards of sediments would be excavated from the trench, and most of it would be used as backfill. The amount of sediments excavated for the pipe-in-HDPE trench is about 7% less than the amount excavated from the single-wall pipe trench (724,000 cubic yards). Pipeline trenching would take an estimated 45 days. Excavated material not used as backfill would be left on the ice to return to the seafloor by natural processes during spring breakup.

Seafloor sediments in Foggy Island Bay consist mainly of fine sand-, silt-, and clay-size particles.

Pipeline construction would affect water quality by increasing suspended-particulate matter in the water column mainly in the area below the floating fast ice in the winter and in the vicinity of the area where excess trench material lies during the open-water period. Trenching would disturb and resuspend the seafloor sediments in those areas beneath the ice where the sea water has not frozen to the seafloor. Dumping excavated material into the water column to fill the trench also would cause some of the fine-grained particles to separate from the descending sediment mass and remain in suspension; however, exposure to subfreezing temperatures likely would freeze the particles together and reduce some particle separation.

Both trenching and backfilling operations are likely to be performed at the same time along the pipeline route. In the floating fast-ice zone, suspended sediments generated from these operations could form a turbidity plume in the presence of currents in the water column between the bottom of the floating ice and the seafloor surface.

For the pipe-in-HDPE pipeline, less material is being exposed to the environment in terms of excavating, backfilling, and abandoning (excess material not used for backfill) than for the Liberty pipeline; excess backfill material would be left on the ice to return to the seafloor by natural processes during spring breakup.

For one study, the initial suspended-sediment concentration in the water column during pipeline construction is estimated to be 1,000 milligrams per liter throughout the water column. The amount of suspended particles in the water column would decrease with distance from the construction area. If the current velocity is 0.02 meter per second (0.04 knot), suspended sediment concentrations greater than 100 and 20 and 10 milligrams per liter are estimated to occur within 0.75 kilometer (0.46 mile) and about 1 kilometer (0.62 mile) and 10 kilometers (6.2 miles), respectively, from the trench.

In another study, URS Corporation (2000) estimates initial suspended sediment concentrations from pipeline construction could range from 500-1,000 milligrams per liter near the seafloor and 50-100 milligrams per liter at the surface. If the initial concentrations are less than 1,000 milligrams per liter, suspended sediment concentrations at 1 and 10 kilometers could be less that the 20 and 10 milligrams, respectively, estimated previously. Fine-grained particles (silt- and clay-size particles) are estimated to comprise about 65% of the material excavated from the trench.

The total amount of suspended particles from the pipe-in-HDPE pipeline construction is estimated to be about 8percent less than the amount from single-wall pipeline construction.

The turbidity plume that might be associated with the pipe-in-HPDE trenching would not last as long as a plume from the Liberty pipeline construction. The time the environment would be disturbed by excavating and backfilling activities is less for the pipe-in-HDPE pipeline trenching than for the single-wall pipeline trenching; actual excavation time for the pipe-in-HDPE pipeline is estimated to be 45 days compared to 45 days for the single-wall pipeline.

Excavated trench material will be stored in two areas; a 230-acre site in waters 5-10 feet deep about 4 miles southwest of the Liberty site (Zone 1, Fig. II.A-18) and along the proposed pipeline route (Zone 2, Fig. II.A-18). Trench sediments would be stockpiled in different parts of the 230-acre site and graded to an average thickness of about 1 foot to minimize the potential for mounding on the seafloor.

After the pipeline has been buried, the amount of material stored on the ice is estimated to be less than the 100,000 cubic yards in the 230-acre site and 10,000 cubic yards along the northern part of the pipeline route amounts estimated for the Liberty pipeline trench.

These sediments could return to the water column in any number of ways described in Section III.C.3.l(2)(b)1)

When the material stockpiled on the ice returns to the seafloor, some of the fine-grained material would be suspended in the water column. The effects on water column turbidity are estimated to be about the same order of magnitude as were estimated for the Liberty Pipeline for 1 or 2 days. For the Liberty Pipeline the suspended-sediment concentration below the 230-acre site is estimated to be 1,168 milligrams per liter, and below the storage area adjacent to the northern part of the proposed pipeline it is estimated to be 14 milligrams per liter. The suspended-sediment concentrations decrease with distance from the storage sites. Concentrations of 200, 20, and 10 milligrams per liter are estimated to occur at about 0.5 kilometer (0.3 mile), 2.75 kilometers (1.70 miles), and 7 kilometers (4.3 miles), respectively, from the 230-acre site.

The thickness of the layer formed by excess trench material falling to the seafloor would be greatest in the vicinity of the storage area and would decrease with distance. The areal extent and thickness of this layer were calculated from a sediment deposition model (URS Greiner Woodward Clyde, 1998a). Within 400-530 meters of Zone 1, the layer formed by excess trench material falling to the seafloor would decrease to a thickness of 10 millimeters. The layer would have a thickness of 1 millimeter within 10-13 kilometers (6.2-8.1 miles) under easterly winds and with about 6.1 kilometers (3.8 miles) under westerly winds. Within 170-180 meters of Zone 3, the layer formed by excess trench material falling to the seafloor would decrease to a thickness of 1 millimeter.

The areal extent of the turbidity plume formed by the falling excess trench material could be approximated by considering where some of the smallest particles might be deposited. Particles 0.005 millimeter in diameter would be deposited at distances of about 13-18 kilometers (8-11 miles) from the Zone 1 site; the thickness of the deposits at these distances is calculated to be about 0.02 millimeter under easterly winds and 0.01 millimeter under westerly winds. Particles 0.005 millimeter in diameter would be deposited at distances of about 18-56.5 kilometers (11-35 miles) from the Zone 3 site; the thickness of the deposits at these distances is calculated to be about 0.001-0.002 millimeter under easterly winds and 0.001 millimeter under westerly winds.

Depending on wind and wave conditions, the fine-grained particles in the excess trench material on the seafloor could be resuspended. The contribution of the trench material to the background suspended-sediment concentration likely would be about the same as that of the area into which the sediments were dumped.

Pipeline trenching and backfilling are not likely to increase the amount of trace metals or hydrocarbons into the environment above the naturally occurring background concentrations.

c) Specific Effects of Repairing the Pipeline

Damage to the pipeline would require repairs, and this means excavating the trench to expose the pipeline. Repair work most likely would be done in the winter, when the ice is stable enough so that it can be thickened to support the repair equipment, or during the open-water period (Table II.C-6). The pipeline repair techniques are described in Section II.A.1.b(3)(c)3) and summarized in Table II.C-7. Excavated trench material would be stored on the ice during a winter repair and on the seafloor alongside the trench during an open-water repair. The types of effects associated with excavating and backfilling would be the same as those analyzed for pipeline construction; the effects of pipeline repair on water quality are analyzed in Section III.C.3.1(2)(c), Effects of Repairing the Pipeline. Depending on the type of repair the amount of sediment excavated would be similar to the amounts estimated for the Proposal (Table II.C-7); these amounts could range from 1,150-6,490 cubic yards and are about 1% or less of the volume handled during construction.

k. Alternative IV.C – Use Flexible Pipe System

The initial pages of this section describe in detail some of the advantages and disadvantages associated with alternative pipeline designs. Many of them are applicable primarily to Alternatives IV.A and IV.B.

The following discussion of the issues is from the MMS studies for pipeline design by C-CORE and Stress. Most of the information is from the Stress study, because the C-CORE study focused primarily on pipe-in-pipe and single-wall designs. Although the flexible pipe has many different layers that make up the pipeline system (which in theory gives it an annulus), that space is very different from the previous pipe-in-pipe and pipe-in-HDPE systems. For analysis purposes in the EIS, we do not consider the annulus of the flexible pipe to have any containment capabilities, even though the flexible pipe has many different layers in its design.

(1) Flexible Pipe has Environmental Benefits

Flexible pipe has a shallower trench depth than any of the other pipeline designs evaluated in this EIS. Less trenching and dredge and fill materials are needed than for any other alternative. There also is a greater probability of completing installation in a single season, compared to Alternatives IV.A, IV.B, or I (The Proposal).

(2) Flexible Pipe Installation, Operation, and Maintenance Considerations

Flexible pipe is more complex to construct and has a higher probability of a functional failure than the other pipeline alternatives. It also has the highest estimated risk (containment failure probability times the volume of a spill) of oil entering the environment of any of the alternatives: $1.4x10^{1}$ barrels (INTEC, 2000). The Fleet report indicates that the flexible pipe system has essentially the same failure probability as the single wall pipeline design. The "expected" volume of oil released over the life of the pipeline is 28 barrels, and the probability of a large spill greater than 1,000 barrels is 0.0138 (Fleet, 2000). The replacement of large sections (2,800 feet) may be required to effect repairs, even for localized damage. Flexible pipe has a limited capability to monitor the integrity of the outer wrapping, which provides a barrier against corrosion.

(3) Third-Party Peer Review

The Stress (2000) report indicated that the flexible pipe would have a disadvantage when it came to leak detection. The mass-balance line-pack compensation leak-detection method would be more complicated on a flexible system than any of the other systems. The report states:

> For the flexible pipe system, a disadvantage that is not mentioned in the INTEC report is that the flow balance calculations become more complex. The flexible line can be expected to expand under pressure more than a steel pipe would. This would mean that the variation in the internal volume of the line due to internal pressure would be greater than for a steel pipe and may affect the flow balance calculations (Stress, 2000).

Stress also expressed concern about the annular leak-detection capability of the flexible pipe. The report stated:

> For the flexible pipe system, there is not a true annulus. The INTEC report states that the

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> sampling for leak detection would occur in the annulus, but this annulus is filled with steel strips. One would be counting on being able to pump clean air through an annulus that contains steel wraps. This seems unlikely to work. It also seems unlikely that oil could be extracted from this annulus. The ability of the system to sample from this annulus, with internal pressure applied to the pipe, needs to be confirmed (Stress, 2000).

Stress raised many concerns related to the repair of flexible pipe systems stating:

> We have a few questions concerning the repair of the flexible pipe alternative. Why is a flanged connection considered temporary? Is there standard repair equipment for flexible pipe? What do the repair connections look like? How could/would end fittings be installed in the field? It appears that any permanent repair to the flexible pipe system would consist of replacing an entire 2800 ft section. This significant effort may increase the repair costs of the line enough to offset any initial savings of using the flexible pipe system. Replacement sections would have to be kept on site, or production could be halted for months waiting for a replacement section (Stress, 2000).

Fleet's analysis shows that the flexible pipeline system has essentially the same probability of failure as the single wall and Pipe-in-HDPE alternatives, but a higher risk than the pipe-in-pipe system. Their analysis also indicated that the probability of a spill did not change as a result of burial depth since the operational failures are by far the most significant failure mode for this, and all other pipeline alternatives.

(4) Analysis of the Flexible Pipe System Design

Sections II.C.2.a and IV.C.2.f describe the common elements shared by all alternatives in the set of component alternatives. Those common elements, plus the following alternative components specific to this particular pipeline design complete the description of this alternative. Note that this description was previously given in Section II.C.2.d and is being repeated here for the convenience of the reader. Table II.A-1 provides a comparison of key components for the different alternatives being analyzed.

The flexible pipe system (Fig. II.C-3) would be constructed with an internal diameter of 12 inches of flexible pipe with a wall thickness of 1.47 inches. The flexible pipe is a nonbonded pipe made of thermoplastic layers and steel strips. The plastic layers provide very limited containment, and they transfer the pressure loads to the steel strips. The pipe has eight layers: an inner interlocked steel carcass; a pressure thermoplastic sheath; two layers of armor wires; fabric tape; and a polyethylene external sheath (INTEC, 2000). The pipe is typically supplied on a reel, and each reel holds about 0.75 miles of flexible pipe. Each of the sections terminates with a fitting that can be welded to the next section. The flexible pipe itself does not require cathodic protection, but the butt-weld connectors joining the segments would have anticorrosion coating and possibly sacrificial anodes. This system could be constructed in a single season, and construction would start in Year 3, which is the second winter construction season. The system would be buried with a minimum burial depth of 5 feet. Monitoring of the system's integrity would be done by periodic smart pigging.

A detailed description of the activities involved in constructing a pipeline are in Section II.A.1.b(3)(a). Table IV.C-2 provides information about the number of days required to construct the pipeline. All of the pipeline welds would undergo x-ray and ultrasonic tests to ensure that they are sound. Any weld that has a defect larger than the maximum acceptable level would be cut out and replaced.

The amount of excavation in the various water depths for this system is shown in Table II.C-3. The size of the pipeline makeup site required would be 533,000 square yards, about 110 acres. An estimated 17,000 cubic yards of gravel fill material would be required as pipeline-bedding material in various locations within the trench between the gravel island and the 3-mile limit. Approximately 50,000 cubic yards of gravel fill would be required as pipeline-bedding material in various locations within the Territorial Seas (shoreward of the 3-mile limit). Backfill material would consist of material dredged from the trench. Between the Liberty Island and the 3-mile limit, approximately 123,200 cubic yards of trench-dredged material would be used as backfill. Between the 3-mile limit and the shoreline, about 375,760 cubic yards of trench-dredged material would be used as backfill. A minimum of 5 feet of fill material would cover the pipeline. In water up to 8 feet deep, the cap of the backfill would be close to the original seafloor, not to exceed 1 foot higher than the surrounding seafloor. In water deeper than 8 feet, the trench cap would not exceed 2 feet higher than the surrounding seafloor. The affected footprint would be 14.7 acres beyond the 3-mile limit and 44.9 acres within the 3-mile limit. This includes the trench cap, which could overstep the limits of the trench excavation.

Any dredged/excavated material that could not be placed back into the trench would require disposal into ocean water. See Section II.A.1.b(3)(a)12)c) for more a detailed description of disposal zones 1 and 2 (see Fig. II.A-18). Leaks would be detected by a combination of the pressure-point analysis, mass-balance line-pack compensation, and LEOS systems, or a LEOS-equivalent system. The containment offered by the flexible pipe system is much different than that offered by either of the other two pipe systems (Alternatives IV.A and IV.B).

Technically, flexible pipe offers secondary containment, but the volume is very small, and the annular space is very different from the Alternatives IV.A and IV.B. This space

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cannot be monitored or cleaned effectively. For analysis purposes in this EIS we assume any leak in the flexible pipe system would result in a leak to the environment. For the most part, it does not offer secondary containment, because the space available between the layers is extremely small.

Flexible pipe systems have been used offshore in applications where strength and flexibility are needed.

As noted in Section IV.C.2.g, the effects to many resources are the same for all pipeline design alternatives. The differences noted would change the impacts to the following resources in the ways described in the analyses that follow:

- Lower Trophic-Level Organisms
- Essential Fish Habitat
- Economy
- Water Quality

(5) Effects on Lower Trophic-Level Organisms

(a) Large Oil Spills

The general effects of a large spill and the effects of oil-spill-cleanup activities are analyzed in Section III.C.2.e(2)(a). The general oil-spill risk to these organisms would be about the same for Alternative I and flexible pipe because the main risk in both cases would come from spills of diesel rather than Liberty crude. Further, the risk with flexible pipe in the Eastern or Tern pipeline routes would be the same as with the Alternative I.

(b) Disturbances

The general effects of disturbances are analyzed in Section III.C.3.e(2)(a).

1) Summary and Conclusions for Effects of Disturbances on Lower Trophic-Level Organisms

There would be specific differences in the disturbance effects. The flexible pipe would require less burial depth, causing fewer effects than Alternative I in two important ways: (1) shallower burial in the Alternative I pipeline route would permanently eliminate 2 fewer acres of very diffuse kelp, boulder and suitable substrate than would the Alternative I pipeline design; and (2) the amount of turbidity generated by shallower burial would be only two-thirds of that for Alternative I, probably causing less reduction in annual kelp production during the construction phase. These effects of shallower burial would be the same for the alternate island design (steel sheetpile). There is no kelp or solid substrate in the Eastern or Tern pipeline corridors, so shallower burial there would not save any kelp habitat, however, the reduced suspended sediments probably would cause less reduction in annual kelp production during the construction phase.

2) Details on How Disturbances May Affect Lower Trophic-Level Organisms

Specific Effects: Burial of flexible pipe would not require as deep a trench as the pipeline in Alternative I. It would require a maximum depth of only 10.5 feet rather than 12 feet (Table II.A-1 and Fig. II.A-12). The shallower trench would remove the scattered kelp and solid substrate from the sediment surface in an area up to 112 feet wide rather than 132 feet. In other words, the flexible pipe in the Alternative I pipeline route would eliminate 15% less kelp and solid substrate than with the Alternative I pipeline design. The effect would be the same, regardless of the island design (steel sheetpile). However, there is no kelp or solid substrate in the eastern or Tern Island pipeline routes, so shallower pipeline burial there would not save kelp habitat.

The shallower trench would cause only two-third as much suspended sediments as the Alternative I design. The effects of suspended sediment on kelp production in the Boulder Patch were analyzed by Ban et al. (1999). They concluded that suspended sediments from the Alternative I pipeline route would drift northwest over the Boulder Patch, reducing annual kelp production by about 6% for 1 year. Therefore, the flexible pipe design would probably reduce annual kelp production by only 4% for 1 year. As explained for Alternative I, kelp would colonize the new slope-protection system on the island, providing some mitigation of the project effects. BPXA could also mitigate some trenching effects if excess quarry boulders were placed on the backfill in the outer portion of the trench. Any unanticipated effects on kelp could be mitigated by Lease Sale Stipulation No. 1, Protection of Biological Resources.

(6) Effects on Essential Fish Habitat

The general effects of a large spill and the effects of oil-spill-cleanup activities are analyzed in Section III.C.2.f(2), and the general effects of disturbances are analyzed in Section III.C.3.f(2). The effects of Alternative IV.C are expected to be essentially the same on potential salmon prey and associated vegetation for all alternatives. Water quality is expected to be improved, because the total amount of suspended-particulate matter would be less than under Alternative I.

(7) Effects on the Economy

The general effects of a large spill and the effects of oil-spill-cleanup activities are analyzed in Section III.C.2.k and the general effects of disturbances are analyzed in Section III.C.3.k.

Specific Effects: Alternative IV.C generates more jobs, greater wages, and greater capital expenditures than for the Proposal. This alternative would result in increases of $0.9 million in wages for 7 months; 8 direct jobs in pipeline construction in Alaska for 7 months; 12 indirect jobs in Alaska for 7 months; and $5.1 million in capital expenditures. The increased cost of this alternative is based primarily on increased material cost. Information for this analysis is interpreted from data in INTEC (1999a). Due to the increased cost of the pipeline, the pipeline tariff would be higher. Higher pipeline tariffs mean higher allowable transportation costs and reduced royalty revenue to the government from the project and reduced Section 8(g) payments to the State.

(8) Effects on Water Quality

(a) Large Oil Spills

The effects of an oil spill on water quality for this alternative are expected to be the same as analyzed for Alternative I in Section IV.C.2.h(4). The general effects of a large spill and the effects of oil-spill-cleanup activities are analyzed in Section III.C.2.l.(2).

(b) Disturbances

The general effects of disturbances are analyzed in Section III.C.3.l.(2)(a).

1) Summary and Conclusions for Effects of Disturbances on Water Quality

The greatest effect on water quality from gravel island and pipeline construction would be additional turbidity caused by increases in suspended particles in the water column. Increases in turbidity generally are expected to be considerably less than the 7,500 parts per million suspended solids used in the analysis as an acute (toxic) criterion for water quality; exceptions may occur within the immediate vicinity of the construction activity. Turbidity increases from construction activities generally are temporary and expected to occur during the winter and end within a few days after construction stops. The duration of turbidity from trenching of the flexible pipeline is expected to be about 15 days less compared to the Liberty pipeline (49 days). The overall effects of turbidity are expected to be about 31% less for the pipe-in-pipe pipeline construction compared to the Liberty pipeline construction. Material excavated from the pipeline trench but not used for backfill most likely would be left in an area where active erosion of sediment particles could occur during breakup and open water. This material would be similar in composition to seafloor sediments in the trenching and disposal areas, and its contribution to the future turbidity from waves and currents is expected to be about the same as the sediments existing at the seafloor surface before pipeline construction. Construction activities are not expected to introduce or add any chemical pollutants.

2) Details on How Disturbance May Affect Water Quality

The following is a summary of the effects constructing Liberty Island and pipeline would have on water quality in Foggy Island Bay. The general effects of construction activities on water quality are analyzed in Section III.C.3.l(2)(a) and the specific effects of island and pipeline construction are analyzed in Section IV.C.2.h(4)(b)).

a) Specific Effects of Constructing the Production Island

The effects on water quality during the construction of the production island for this alternative are expected to be the same as analyzed for Alternative I in Section IV.D.6C.2.h(4)(b)2)a.

b) Specific Effects of Constructing the Pipeline

The types of effects on water quality from constructing the pipeline part of this alternative would be the same as those analyzed for Liberty Pipeline construction (Sec. IV.C.2.h(4)(b)2)b)); see Table II.A-1 to compare the characteristics of the pipelines.

The pipeline trench, about 6.1 miles long, would be dug with backhoes in the winter from the sea ice covering Foggy Island Bay. The average trench depth would be 8.5 feet; the range would be from 6-10 feet deep. An estimated 498,960 cubic yards of sediments would be excavated from the trench, and most of it would be used as backfill. The amount of sediments excavated for the flexible pipeline trench is about 31% less than the amount excavated from the single-wall pipe trench (724,000 cubic yards). Pipeline trenching would take an estimated 34 days. Excavated material not used as backfill would be left on the ice to return to the seafloor by natural processes during spring breakup. Seafloor sediments in Foggy Island Bay consist mainly of fine sand-, silt-, and clay-size particles.

Pipeline construction would affect water quality by increasing suspended-particulate matter in the water column mainly in the area below the floating fast ice in the winter and in the vicinity of the area where excess trench material lies during the open-water period. Trenching would disturb and resuspend the seafloor sediments in those areas beneath the ice where the sea water has not frozen to the seafloor. Dumping excavated material into the water column to fill the trench also would cause some of the fine-grained particles to separate from the descending sediment mass and remain in suspension; however, exposure to subfreezing temperatures likely would freeze the particles together and reduce some particle separation.

Both trenching and backfilling operations are likely to be performed at the same time along the pipeline route. In the floating fast-ice zone, suspended sediments generated from these operations could form a turbidity plume in the presence of currents in the water column between the bottom of the floating ice and the seafloor surface.

For the flexible pipeline, less material is being exposed to the environment in terms of excavating, backfilling, and abandoning (excess material not used for backfill) than for the Liberty pipeline; excess backfill material would be left on the ice to return to the seafloor by natural processes during spring breakup.

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For one study, the initial suspended-sediment concentration in the water column during pipeline construction is estimated to be 1,000 milligrams per liter throughout the water column. The amount of suspended particles in the water column would decrease with distance from the construction area. If the current velocity is 0.02 meter per second (0.04 knot), suspended sediment concentrations greater than 100 and 20 and 10 milligrams per liter are estimated to occur within 0.75 kilometer (0.46 mile) and about 1 kilometer (0.62 mile) and 10 kilometers (6.2 miles), respectively, from the trench.

In another study, URS Corporation (2000) estimates initial suspended sediment concentrations from pipeline construction could range from 500-1,000 milligrams per liter near the seafloor and 50-100 milligrams per liter at the surface. If the initial concentrations are less than 1,000 milligrams per liter, suspended sediment concentrations at 1 and 10 kilometers could be less that the 20 and 10 milligrams, respectively, estimated previously. Fine-grained particles (silt- and clay-size particles) are estimated to comprise about 65% of the material excavated from the trench.

The total amount of suspended particles from the flexible pipeline construction is estimated to be about 30% less than the amount from single-wall pipeline construction.

The turbidity plume associated with the flexible pipeline trenching also would not last as long as a plume from the single-wall pipeline trenching. The time the environment would be disturbed by excavating and backfilling activities is less for the flexible pipeline than for the Liberty pipeline; actual excavation time for the flexible pipeline is estimated to be 34days compared to 49 days for the single-wall pipeline.

Excavated trench material will be stored in two areas; a 230-acre site in waters 5-10 feet deep about 4 miles southwest of the Liberty site (Zone 1, Fig. II.A-18) and along the proposed pipeline route (Zone 2, Fig. II.A-18). Trench sediments would be stockpiled in different parts of the 230-acre site and graded to an average thickness of about 1 foot to minimize the potential for mounding on the seafloor.

After the pipeline has been buried, the amount of material stored on the ice is estimated to be less than the 100,000 cubic yards in the 230-acre site and 10,000 cubic yards along the northern part of the pipeline route amounts estimated for the Liberty pipeline trench.

These sediments could return to the water column in any number of ways described in Section III.C.3.l(2)(b)1).

When the material stockpiled on the ice returns to the seafloor, some of the fine-grained material would be suspended in the water column. The effects on water column turbidity are estimated to be about the same order of magnitude as were estimated for the Liberty Pipeline for 1 or 2 days. For the Liberty pipeline, the suspended-sediment concentration below the 230-acre site is estimated to be 1,168 milligrams per liter, and below the storage area adjacent to the northern part of the proposed pipeline it is estimated to be 14 milligrams per liter. The suspended-sediment concentrations decrease with distance from the storage sites. Concentrations of 200, 20, and 10 milligrams per liter are estimated to occur at about 0.5 kilometer (0.3 mile), 2.75 kilometers (1.70 miles), and 7 kilometers (4.3 miles), respectively, from the 230-acre site.

The thickness of the layer formed by excess trench material falling to the seafloor would be greatest in the vicinity of the storage area and would decrease with distance. The areal extent and thickness of this layer were calculated from a sediment deposition model (URS Greiner Woodward Clyde, 1998a). Within 400-530 meters of Zone 1, the layer formed by excess trench material falling to the seafloor would decrease to a thickness of 10 millimeters. The layer would have a thickness of 1 millimeter within 10-13 kilometers (6.2-8.1 miles) under easterly winds and with about 6.1 kilometers (3.8 miles) under westerly winds. Within 170-180 meters of Zone 3, the layer formed by excess trench material falling to the seafloor would decrease to a thickness of 1 millimeter.

The areal extent of the turbidity plume formed by the falling excess trench material could be approximated by considering where some of the smallest particles might be deposited. Particles 0.005 millimeter in diameter would be deposited at distances of about 13-18 kilometers (8-11 miles) from the Zone 1 site; the thickness of the deposits at these distances is calculated to be about 0.02 millimeter under easterly winds and 0.01 millimeter under westerly winds. Particles 0.005 millimeter in diameter would be deposited at distances of about 18-56.5 kilometers (11-35 miles) from the Zone 3 site; the thickness of the deposits at these distances is calculated to be about 0.001-0.002 millimeter under easterly winds and 0.001 millimeter under westerly winds.

Depending on wind and wave conditions, the fine-grained particles in the excess trench material on the seafloor could be resuspended. The contribution of the trench material to the background suspended-sediment concentration likely would be about the same as that of the area into which the sediments were dumped.

Pipeline trenching and backfilling are not likely to increase the amount of trace metals or hydrocarbons into the environment above the naturally occurring background concentrations.

3) Specific Effects of Repairing the Pipeline

Damage to the pipeline would require repairs, which would mean excavating the trench to expose the pipeline. Repair work most likely would be done in the winter, when the ice is stable enough so that it can be thickened to support the repair equipment, or during the open-water period (Table II.C-6). The pipeline repair techniques are described in Section II.B.2.c and summarized in Table II.C-7. Excavated

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trench material would be stored on the ice during a winter repair and on the seafloor alongside the trench during an open-water repair. The types of effects associated with excavating and backfilling would be the same as those analyzed for pipeline construction; the effects of pipeline repair on water quality are analyzed in Section III.C.3.1(2)(b)3, Effects of Repairing the Pipeline. Depending on the type of repair the amount of sediment excavated would be similar to the amounts estimated for the Proposal (Table II.C-7); these amounts could range from 1,150-6,580 cubic yards and are about 2% or less of the volume handled during construction.

3. Effects of Alternative Upper Island Slope-Protection Systems

This component set of alternatives evaluates the effects for two options that provide upper slope protection to the gravel island:

Alternative I – use gravel bags would use gravel bags like those used at the Endicott island.

Alternative V – use steel sheetpile would use steel sheetpile similar to the system installed at the Northstar Project.

The following elements are common or shared by both of the above alternatives:

- A proposed working surface elevation of island alternatives at 15 feet above sea level to ensure the gravel island is adequate to handle the potential 100-year-wave height (12.2 feet) and the 100-year ice-rideup event (49 feet). The total mass of the island (gravel fill and production facilities) is intended to provide sufficient resistance to lateral movement under maximum ice loads.
- Interlinking concrete mats would be placed on the lower slope of the island from the base of the upper slope protection system (steel sheetpile or gravel bags) down to the seafloor to provide stability and protection against erosion. Filter-cloth material placed the concrete matting and would prevent the gravel fill material from washing out but would not itself, be susceptible to washing away.
- The working surface area would be 345 feet by 680 feet. The oblong shape of the island is oriented so that the narrower end of the island would be facing north to lessen exposure to potential ice and wave forces. Production modules and wells would be positioned away from the north face of the island and towards the center of the island to further lessen potential exposure to ice override onto the working surface of the island. The surface of the island would be contoured, so that runoff flows into sumps away from production facilities.

Both upper slope-protection system alternatives share the common elements noted above. Although Alternative V, use steel sheetpile, uses more gravel, the difference in gravel mining, hauling, and constructing the island would not result in any meaningful differences to many resources. Although there would be an increase in the noise level after breakup when the steel sheetpile would be installed, that noise would occur after the seals and polar bears have left the area and would be completed before the bowhead whale migration would start. It would not affect any onshore resources, offshore archaeology, water quality, or air quality. Any noise effects to birds, fish, and subsistence-harvest patterns would be limited to small, local areas around the island. It would be short-term in duration, and the effects essentially would be the same. In the unlikely event the gravel bags in Alternative I were to enter the marine environment, they would not float; therefore, the effects to subsistence activities would be the same for both alternatives. Impacts to the following resources would be the same for both alternatives, because they are not impacted differently by the unique aspects of this Proposal:

- Bowhead Whales
- Eiders
- Seals and Polar Bears
- Marine and Coastal Birds
- Terrestrial Mammals
- Lower Trophic-Level Organisms
- Fishes and Essential Fish Habitat
- Vegetation-Wetland Habitat
- Subsistence-Harvest Pattern
- Archaeological Resources
- Economy
- Water Quality
- Air Quality

For the reasons stated, the upper island slope protection system alternative analysis that follows will not include effects to these resources.

a. Alternative I - Use Gravel Bags (Liberty Development and Production Plan)

(1) Description of the Alternative

Sections II.C.3.a and IV.C.3 describe the common elements shared by all alternatives in the set of component alternatives. Those common elements, plus the following alternative components specific to this particular pipeline design complete the description of this alternative. Note that this description was previously given in Sections I.A and II.C.3.c and is being repeated here for the convenience of the reader. Table II.A-1 provides a comparison of key components for the different alternatives being analyzed.

Gravel bags would be used in the upper portion of the island slope (Fig. II.A-3) starting at 7-8 feet above sea level and continuing to the top of the berm, which is 23 feet above sea level and 8 feet above the working surface of the island.. This alternative would use 4,200 polyester gravel bags (4 cubic yards) placed on the upper slope of the island from 7-23 feet above sea level using an additional 17,000 cubic yards of gravel. The gravel would be hauled to the island location during construction of the island. The bags would be placed in an overlapping pattern. A gravel bench covered with concrete mats extending more than 40 feet from the base of the gravel bags to the sea surface would dampen wave energy approaching the island and induce natural formation of ice rubble. The bags provide additional frictional resistance in the unlikely event of ice rideup past the 40-foot bench. The gravel bags would be used only in the upper portion of the island to avoid direct forces from ice or wave action, to lessen potential damage and dislocation, and to protect the surface of the island from the unlikely event of further ice rideup.

BPXA's proposed use of gravel bags for this project is quite different from previous exploration island construction. The bags proposed for use in the Liberty Island construction are made from a polyester material, which does not float. The gravel bags for the proposed Liberty slope-protection system would be used only on the upper slope (above the concrete lined bench, approximately 7 feet above the water line), which makes them less likely to be torn by an ice event. BPXA would monitor ice events at or near the island and repair or replace any torn or ripped bags as part of their ongoing maintenance program. Major ice events usually happen during freezeup and in winter, and major wave events occur during the open-water season. With the proposed BPXA maintenance, it is highly unlikely that a gravel bag would be ripped or torn during an ice event and not be repaired before a wave event that could wash the bag into the ocean. In the unlikely event a bag or part of a bag is washed into the marine environment, the bag would not float but sink to the bottom. BPXA would remove all of the gravel bags used in the upper slope-protection system at project abandonment.

The effects to many resources are the same for both slope protection systems. The specific components of the Alternative V, use steel sheetpile, as described above would change the impacts to Sociocultural Systems in the ways described in the analyses that follow.

(2) Effects on Sociocultural Systems

(a) Large Oil Spills

The general effects of a large spill and the effects of oil-spill-cleanup activities on Sociocultural Systems are analyzed in Section III. C.2.i(2).

1) Summary and Conclusion for Effects of A Large Oil Spill on Sociocultural Systems

Effects on the sociocultural systems of the communities of Nuiqsut and Kaktovik could come from disturbance from small changes in population and employment and periodic interference with subsistence-harvest patterns from oil spills and oil-spill cleanup. Effects from these sources are not expected to displace ongoing sociocultural systems, but community activities and traditional practices for harvesting, sharing, and processing subsistence resources could be seriously curtailed in the short term, if there are concerns over the tainting of bowhead whales from an oil spill.

2) Details on How A Large Oil Spill May Affect Sociocultural Systems

Specific Effects: Effects on the sociocultural systems of the communities of Nuiqsut and Kaktovik could come from disturbance from small changes in population and employment and periodic interference with subsistence-harvest patterns from oil spills and oil-spill cleanup. Effects from these sources are not expected to displace ongoing sociocultural systems, but community activities, and traditional practices for harvesting, sharing, and processing subsistence resources could be seriously curtailed in the short term, if there are concerns over the tainting of bowhead whales from an oil spill.

Because Liberty development is enclave based, stresses to the local village infrastructure, health care, and emergency response systems are expected to be minimal. Demands on local village infrastructures from construction, operation, maintenance, and abandonment from the Liberty Project would not be expected, because all these activities would be staged out of Prudhoe Bay or the Liberty production island itself.

(b) Disturbances

The general effects of disturbances are analyzed in Section III.C.3.i(2)(a).

1) Summary and Conclusion for Effects of Disturbances on Sociocultural Systems

Effects on the sociocultural systems of communities near the Liberty Project area could occur as a result of disturbance from industrial activities; changes in population and employment; and effects on subsistence-harvest patterns. These effects could affect the social organization, cultural values, and social health of the communities. Together, effects may periodically disrupt but not displace ongoing social systems, community activities, and traditional practices for harvesting, sharing, and processing subsistence resources.

2) Details on How Disturbances May Affect Sociocultural Systems

Specific Effects: Because staging would be from Deadhorse, social systems in the communities of Nuiqsut and Kaktovik would experience little direct disturbance from the staging of people and air freight expected from the development and production of Liberty oil. These activities would have little effect on sociocultural systems.

Oil workers from the Liberty Project likely would not interact with Nuiqsut or Kaktovik residents, and there would be no expected displacement of social systems. Changes in population and employment likely would not disrupt sociocultural systems.

Stress would occur if a village was not successful in the bowhead whale harvest, with possible disruption of the sharing networks and task groups. This stress also could disrupt the community's social organization but likely would not displace the social processes of whaling and sharing. Other more successful villages will share with a village having an unsuccessful whaling season and recently, there have been no unsuccessful whaling seasons by Nuiqsut since 1994 and Kaktovik since 1991 (Braund, Marquette, and Bockstoce, 1988; Alaska Eskimo Whaling Commission, 1987-1995). Recently, negotiated conflict resolution agreements between the Alaska Eskimo Whaling Commission, subsistence whaling communities, and the oil industry have successfully served as a means to coordinate whaling activities and potential disturbance to whaling from industry activities.

Any effects on social health would have ramifications in the social organization, but North Slope Borough Native communities have, in fact, proven quite resilient to such effects with the Borough's continued support of Inupiat cultural values and its strong commitment to health, social service, and other assistance programs. Health and social-service programs have attempted to meet the needs of alcohol and drug-related problems with treatment programs and shelters for wives and families of abusive spouses and with greater emphasis on recreational programs and services. However, in comments before the Department of the Interior's Outer Continental Shelf Policy Committee, May 2000 meeting, the North Slope Borough May, George Ahmaogak, stated resident are extremely concerned that a lack of adequate financing for individual North Slope Borough city governments has hampered the development of these programs, and declining revenues from the State of Alaska have seriously impaired the overall function of North Slope Borough city governments. Partnering together, Tribal governments, city governments, and the North Slope Borough government may be able to provide programs, services, and benefits to residents. For several years, all communities in the Borough have banned the sale of alcohol, although alcohol possession is not banned in Barrow, and many communities are continually under pressure to bring the issue up for a local referendum vote (North Slope Borough, 1998).

Effects on social health in Nuiqsut could have direct consequences on the sociocultural system but would not have a tendency toward displacement of existing systems above the displacement that has already occurred with the current level of development. Effects in Kaktovik would be periodic and would not displace existing sociocultural systems.

b. Alternative V - Use Steel Sheetpile

Sections II.C.3.a and IV.C.3 describe the common elements shared by all alternatives in the set of component alternatives. Those common elements, plus the following alternative components specific to this particular pipeline design complete the description of this alternative. Note that this description was previously given in Section II.E and is being repeated here for the convenience of the reader. Table II.A-1 provides a comparison of key components for the different alternatives being analyzed.

Under this alternative, steel sheetpile would protect the upper part of Liberty Island; no gravel-filled bags would be on the island (see Fig. II.C-4). The sheetpile would be similar to that proposed for Seal Island in the Northstar Development Project (U.S. Army Corps of Engineers, 1999:Fig. 4-17). This alternative would eliminate the need for gravel bags as upper slope protection, which would eliminate the possibility of damaged bags entering the environment as a result of a storm or ice event. It would be designed to carry the surface loads. The sheetpile would protect the island above the concrete blocks used for slope protection and would weather to a natural rust color.

The seafloor footprint would be 905 feet by 1,240 feet, which is about 25.8 acres. This footprint is about 15% larger than Alternative I, 18% larger than Alternative III.A, and 11% larger than Alternative III.B. On the lower slope of the island, 22,500 concrete mats (see Table II.C-1) and filter fabric still would protect the slope up to 5-feet above the seawater level. The concrete block would be placed on filter fabric, which is put in place prior to laying the concrete blocks, to help keep the gravel from washing away.

On the sides of the island where a storm's effects would be most intense, the wall would rise to at least 27 feet (8.8 meters) above sea level (mean lower low-water level). On the other sides, the wall would rise to an elevation of at least 21 feet (6.4 meters) above sea level. Open-cell sheetpile would be used on the south side of the island and for the dock area. The top portion of the sheetpile along a section of the dock face would be 7 feet (2 meters) above sea level. The sheetpile would extend about twice the height of the gravel bag armor in Alternative I to accommodate direct wave action (gravel bags dissipate wave energy where vertical steel walls do not). A gravel bench covered with concrete mats extending more than 75 feet from the base of the gravel bags to the sea surface would dampen wave energy approaching the island and induce natural formation of ice rubble. The wider bench would be required for the large cranes needed to install the concrete mat that would protect the side slope. This alternative would use approximately 1,900 linear feet of sheetpile for the four sides, excluding the dock. The dock would use about 470 linear feet of sheetpile.

The sheetpile would be shipped by ice road or barge. The sheetpile around the dock would be installed before the open-water period. The installation of the remainder of the sheetpile would take place during open water and would be installed before the start of the fall bowhead whale migration.

Under this alternative, steel sheetpile would be installed using vibrator equipment, which reduces noise to the marine environment. The installation of the steel sheetwall around the perimeter of the whole island probably would continue into August. During abandonment, BPXA would be required to remove the sheetpile wall with all other steel and hardware.

As noted in Section IV.C.3, the effects to most resources are the same for both slope protection systems. The specific components of the Alternative V – use steel sheetpile as described above would change the impacts to Sociocultural Systems in the ways described in the analyses that follow.

(1) General Effects on Sociocultural Systems

The general effects of a large spill and the effects of oil-spill-cleanup activities are analyzed in Section III.C.2.i (2), and the general effects of disturbances are analyzed in Section III.C.3.i(2)(a).

(2) Specific Effects on Sociocultural Systems

Using steel sheetpile in island construction would relieve ongoing concerns of local subsistence hunters about gravel bags based on past gravel island developments contaminating the environment and creating navigation hazards for whaling boats. Using steel sheetpile would serve to reduce overall stress in the local Inupiat population, particularly Nuiqsut, over the development of Liberty Island in the Beaufort Sea offshore environment. This reduction in stress of local Inupiat could be considered a slight reduction in effect to sociocultural systems and also could be construed as taking into account local knowledge and concern for the offshore environment and its resources. General oil-spill effects on sociocultural systems would be the same as for Alternative I.

4. Effects of Alternative Gravel Mine Sites

This set of component alternative evaluates two different gravel mine sites (see Map 1).

Alternative I – Use the Kadleroshilik River Mine Site evaluates the effects of creating a new mine site at the Kadleroshilik River.

Alternative VI – Use Duck Island Mine site evaluates the existing Duck Island mine site, which was used as a gravel source for the Endicott and other projects.

Key components of these alternatives are summarized in Table II.A-1. Both of the alternatives in this set of component alternatives share the following elements:

Ice roads to support gravel-extraction activities and gravel island construction would start in December of Year 1, so that they can access the mine site, haul gravel, and construct the island. The gravel-extraction process would start in January of Year 2. Similar activities would be needed in Year 3 to support construction of the pipeline. Gravel hauling would be completed by the end of April both years. Gravel would be excavated by blasting, ripping, and removing materials in 20-foot lifts. Gravel would be hauled from the mine site to the gravel island location or pipeline site over ice road or existing gravel road.

Both mine sites share the common elements noted above. Because both sites are onshore and activities would occur during the winter, they would have essentially the same effects on bowhead whales, subsistence activities, and sociocultural resources. Effects of surface disturbance on archaeological resources would be the same as those discussed in Sections III.C.2.j and III.C.3.j for all alternatives. No known onshore archaeological sites would be affected at either site. For the reasons stated, the upper island slope-protection alternatives analysis that follow will not include effects to these resources:

- Bowhead Whales
- Subsistence-Harvest Patterns
- Sociocultural Systems
- Archaeological Resources

For the reasons stated, the gravel mine site alternative analysis that follows will not include effects to these resources.

a. Alternative I – Use Kadleroshilik River Mine (Liberty Development and Production Plan)

Sections II.C.4.a and IV.C.4 describe the common elements shared by both alternatives in the set of component alternatives. Those common elements plus the following alternative components specific to this gravel mine site complete the description of this alternative. Note that this description was previously given in Section I.A.1.b(1)(b) and Section II.C.4.c and is being repeated here for the convenience of the reader. Table II.A-1 provides a comparison of key components for the different alternatives being analyzed.

The Kadleroshilik River mine site (Map 1) is approximately 1.4 miles south of Foggy Island Bay, with a ground surface elevation of 6-10 feet above mean sea level. (BPXA, 2000a). The mine site is in a region of riverine barrens and alluvial floodplain. BPXA has estimated the proposed site is about 40% dry dwarf shrub /lichen tundra, 10% dry barren/dwarf shrub, forb grass complex, and 50% river gravel (Noel and McKendrick, 2000).

The development mine site (Figs. II.A-7a, 8, and 9) is approximately 31 acres, with the primary excavation area developed in two cells (BPXA, 2000b). The first cell would be approximately 19 acres and developed in Year 2; it would support construction of the gravel island.(Noel and McKendrick, 2000) The second cell is approximately 12 acres and would support pipeline construction activities in Year 3. In preparation for mining, snow, ice, and unusable overburden (organic and inorganic materials) would be removed from the mine site. For Cell 1, up to 100,000 cubic yards of overburden would be stockpiled temporarily on a 5-acre portion of the Cell 2 mine area just south of Cell 1. Cell 2 overburden (up to 13,000 cubic yards) plus about 2,500 cubic yards of excess spoil from the onshore pipeline transition trench would be placed either directly into the Cell 1 pit or on an ice pad in a temporary stockpile area (about 0.5 acres) located just south of the Cell 2 pit.

Mining would not extend into the active river channel; a dike approximately 50 feet wide would be left in place between the mine site and the river channel while mining operations are under way. Gravel would be excavated by blasting, ripping, and removing materials in two 20-foot lifts to a total depth of 40 plus feet below the ground surface. Some portion of the lower 20-foot lift may be left in place, if all gravel available from the site is not needed to meet island requirements.

The activities listed above would take place in both Years 2 and 3. (See Sec. III.D.2 of this EIS and Sec. 5.1.10 of the Liberty Environmental Report [BPXA, 1998a] for more detailed information about the proposed gravel mine site.) The mining plan also includes a reserve area of approximately 22 acres. Approximately 31 acres of the total 53 acres of the planned mine site would be disturbed. (BPXA, 2000d). Of the 31 acres, approximately 24 acres are considered wetland habitat. About 17 acres of the reserve area is considered wetland habitat (see Table IV.D-6). Therefore, this alternative would result in the lose of about 24 acres of wetland, and if the reserve area should be needed, then the wetland loss would be 41 acres.

For information about possible effects to the natural processes and functions of Kadleroshilik River system, such as sediment transport and stream channel meandering, groundwater-surface water interactions, and nutrient cycling, see Section III.D.2. The effects of gravel mining in the natural process and functions of the Kadleroshilik River would be short term and relatively low.

After useable gravel has been removed from the mine, materials unsuitable for construction (for example, unusable materials stockpiled during mining) would be placed back into the mine excavation. Stockpiled snow and ice also would be pushed back into the pit to minimize effects on natural drainage patterns during spring breakup. These backfilled materials would be used to create a shelf (approximately mean water level) along one side of the mine to improve future habitat potential. The access ramp down into the mine would form the foundation of the constructed shelf, maximizing new surface area created. To complete construction, the adjacent edge of the pit would be beveled back a distance of 10-20 feet, creating a gradual slope to the shelf. The backfilled area would provide substrate and nutrients to support revegetation and improve future habitat potential of the constructed shelf along the mine wall.

After Phase I mining is complete and the pit edge contoured, the dike between the mined site and the active channel of the Kadleroshilik River would be breached to approximately 6 inches below mean low water in the channel. During spring breakup, the mine site would flood with freshwater, forming a deep lake adjacent to the river. To avoid stranding fish in the lake during periods of low water, a short section of the breach would be lowered to match the river's bottom level.

Development of the Phase 2 cell is expected to begin in Year 3 to support construction of the offshore pipeline, the shoreline transition, and pipeline valve pads. The Phase 2 mining (Fig. II.A-9) would disturb approximately 12 acres, to provide the estimated volume of gravel needed for pipeline and pad construction. An approximately 15-foot wide dike would be left between the two cells until mining has been completed.

Mining and rehabilitation plans for Phase 2 (Figs. II.A-10 and 11) are similar to those described for Phase 1. After Phase 2 mining is completed, the dike separating the two mine cells would be breached, expanding the original flooded site to create a larger lake. Some portion of the breach would be at least as low as the river's bottom to avoid stranding fish during periods of low water. Backfill (materials stockpiled during Phase 2 mining and excess material from onshore pipeline construction) would be used to enhance the shallow area created during Phase 1 to improve the future habitat potential of that site.

Remnants of the dike between Phase I and Phase II cells would form islands (0.4 plus acres) in the deep lake, diversifying the aquatic habitat. The shelves constructed along the side of the mine (estimated to be 0.5-2.0 acres) should evolve into shallow water habitat over time in conjunction with flooding the mine site. After a thaw season, it is expected that irregular settlement of the material comprising the shelf would create a surface mosaic of small, shallow ponds, humps, and flats.

During fall Year 3 or spring-summer Year 4, the plan would be implemented to encourage revegetation of the shelf areas. Depending on the extent and pattern of thaw settlement, the areas would be seeded, likely with a combination of salt-tolerant (and disturbance-tolerant) seed stock, as well as other seed stock, as conditions dictate. Depending on access to appropriate sites, ambient moisture, and salinity (both current and predicted), some plugging and/or sprigging also may be done.

After rehabilitation, the flooded mine site would provide several benefits. Deepwater sources connected to streams and rivers are uncommon in this area. The excavation would create potential overwintering habitat for fish in an area where this type of habitat is limited. It also is possible that the lake could be a source of water for future ice-road construction, although over time, coastal storm surges could make the lake water too brackish for this purpose.

As noted in Section IV.C.4, the effects to some resources are the same for both gravel mine sites. The specific components of the Alternative I, use the Kadleroshilik River mine site as described above would change the impacts to the following resources in the ways described in the analyses that follow:

- Eiders
- Seals and Polar Bears
- Marine and Coastal Birds
- Lower Level-Trophic Organisms
- Terrestrial Mammals
- Fishes and Essential Fish Habitat
- Vegetation-Wetland Habitats
- Economy
- Water Quality
- Air Quality

(1) Effects on Threatened and Endangered Species - Eiders

(a) Large Oil Spills

The general effects of a large spill and the effects of oil-spill-cleanup activities are analyzed in Section III.C.2.a(2)(b)1). Effects of an oil spill on spectacled eiders under Alternative VI is expected to be essentially the same as for Alternative I.

(b) Disturbances

The general effects of disturbances are analyzed in Section III.C.3.a(2)(b)1).

1) Summary and Conclusion for Effects of Disturbances on Eiders

The potential for occurrence of resting, foraging, or nesting eiders is likely to be lower at the Duck Island quarry site than at the proposed Kadleroshilik site due to the undisturbed character and vegetative cover of the latter. Although this represents a substantial difference in habitat availability between the two sites, spectacled eiders are not actually expected to be nesting at either site, so no significant difference in effect on the spectacled eider is expected between this alternative and Alternative I.

2) Details on How Disturbances May Affect Eiders

Specific Effects: Obtaining gravel from the proposed mine site on the Kadleroshilik River instead on the Duck Island quarry site on the Sagavanirktok River Delta could disturb potential resting, foraging, or marginal nesting habitat at the former site. Thus, any eiders that might nest or stop in that area in summer could be displaced by the disturbed nature of the habitat following quarrying. However, although the Duck Island site has been disturbed for some years, and presumably any nesting eiders potentially displaced are no longer present, the potential for eider use of the Kadleroshilik site probably is not high given the substantial proportion of the island covered by vegetation not typically associated with eider nest sites or foraging (Noel and McKendrick, 2000). Considering factors that might suggest potential use of these areas by any eiders occupying the surrounding tundra areas, the nesting density and average density of eiders in the general vicinity of the two sites were similar (0.3-0.5 nests per square kilometer and 0.4 birds per square kilometer) in 1994 (TERA, 1995b). Thus, the numbers of resting or nesting eiders displaced from either the Kadleroshilik area (Alternative I) or the Duck Island site (Alternative VI) as a result of habitat disturbance are expected to range from zero to very low. Because eiders are not present in winter, activity associated with quarrying and vehicle traffic would not disturb this species at either site. No significant population effects for this species are expected to occur as a result of using either of these sites.

(2) Effects on Seals and Polar Bears

(a) Large Oil Spills

The general effects of a large spill and the effects of oil-spill-cleanup activities are analyzed in Section III.C.2.b(2)(a). Seals and polar bears most likely would contact the spill in the Foggy Island Bay, and Mikkelsen Bay areas regardless of which spill scenario is assumed (Table A-1). An estimated 60-150 ringed seals (out of a resident population of 40,000) and fewer than 50 bearded seals (based on their sparse distribution in the project area) out of a population of several thousand) could be affected by the large spill. An estimated 5-30 bears could be lost if the spill contacted Cross Island when and where that many polar bears may be concentrated during the whale harvest. This represents a severe event. The more likely loss from Liberty development would be no more than three to six bears. The seal and polar bear populations are expected to recover individuals killed by the spill within 1 year, and there would be no effect on the population.

Amstrup, Durner, and McDonald (2000) estimated that a 5,912 barrel spill could contact 0-25 polar bears in open water conditions and 0-61 polar bears in autumn mixed ice conditions. The oil spill trajectories contacted small numbers of bears far more often than they contacted large numbers of bears. In October, 75% of the trajectories oiled 12 or fewer bears while in September, 75% of the trajectories oiled 7 or fewer polar bears (Amstrup , Durner, and McDonald, 2000). The median number of polar bears that could be affected by a 5,912 barrel spill in October was 4.2. These results are comparable to the estimate of 5-30 bears. A spill from Liberty is likely to affect 12 or fewer polar bears. The polar bear population is expected to recover this likely loss within 1 year (see Sec. III.C.2.b for specific effects of a large spill).

Secondary effects could come from oil contaminating food sources. A spill might affect the abundance of some prey species in local, coastal areas of Foggy Island Bay where epibenthic food such as amphipods (small shrimp) concentrate, but a spill should not greatly decrease abundant food, such as arctic cod. Local changes in the abundance of some food sources would not affect the seal populations or, in turn, affect the polar bear population in the Beaufort Sea (see Sec. III. C.f(1)(a) effects of a large oil spill on fishes and essential fish habitat).

(b) Disturbances

The general effects of disturbances are analyzed in Section III.C.3.b(2)(a).

1) Summary and Conclusion for Effects of Disturbances on Seals and Polar Bears

Vehicle traffic on the ice roads from the Endicott causeway directly to the production island and along the coast to Foggy Island Bay/Kadleroshilik River could disturb and displace a few denning polar bears and a small number of denning ringed seals (see Map 2B). The number of bears and seals potentially displaced is expected to be low and would not affect the populations of ringed seals and polar bears.

2) Details on How Disturbances May Affect Seals and Polar Bears - Specific Effects

Ice Roads: A few adult ringed seals and pups would be displaced by ice roads where the roads pass over floating fast ice to the Liberty Island and from the island to the Kadleroshilik River gravel mine site and from Endicott-Duck Island to the Liberty Island (see Map 2B). Ice roads that are routed over grounded fast ice near the shore would not pass over ringed seal pupping habitat. The number of seals displaced is expected to be very low, perhaps 1-2 seals per kilometer of ice road (about 20 miles of ice road would pass over floating fast ice; see Map 2B). This seasonal effect is expected to occur over the 15-year life of Liberty along the route between Liberty and the Endicott causeway, when this ice road is constructed and used. This displacement is not expected to affect the seal population or greatly affect their distribution in Foggy Island Bay. Construction of ice roads for the Northstar Project affected the behavior of a few seals within 0.64 kilometer of the ice roads but had no effect on ringed seal distribution and abundance (Richardson and Williams, 1999).

Ice roads for winter development may disturb a few polar bear maternity dens during the 2 years of construction activities (Blix and Lentfer, 1991; Amstrup, 1993; USDOI, Fish and Wildlife Service, 1995b). However, denning polar bears have tolerated high levels of seismic activity and ice-road traffic (the latter only 400 meters from the den) (Amstrup, 1993). The proposed ice road and noise from vehicle traffic on the road from the Endicott causeway along the coast of Foggy Island Bay and near the Kadleroshilik River could disturb and displace a few denning polar bears. However, the number of bears potentially displaced is likely to be low and would not affect the population (see Map 2B). As recommended by the Fish and Wildlife Service, BPXA plans to obtain a Letter of Authorization for unintentional take of polar bear, especially during winter months, in accordance with existing regulations. We expect the monitoring program and mitigation required under the authorization to prevent significant disturbance of denning polar bears.

(3) Effects on Marine and Coastal Birds

(a) Large Oil Spills

The general effects of a large spill and the effects of oil-spill-cleanup activities are analyzed in Section III.C.2.c.(2)(a). Effects of an oil spill on marine and coastal birds under Alternative VI is expected to be essentially the same as for Alternative I.

(b) Disturbances

The general effects of disturbances are analyzed in Section III.C.3.c(2)(a).

1) Summary and Conclusion for Effects of Disturbances on Marine and Coastal Bird

The potential for occurrence of resting, foraging, or nesting birds and probably ptarmigan in winter, is likely to be considerably lower at the Duck Island quarry site than at the proposed Kadleroshilik site due to the undisturbed character and vegetative cover of the latter. Thus, a potentially significant difference in effect on marine and coastal bird species is expected between this alternative and Alternative I.

2) Details on How Disturbances May Affect Marine and Coastal Birds

Specific Effects: Obtaining gravel from the proposed mine site on the Kadleroshilik River instead of the Duck Island quarry site on the Sagavanirktok River Delta could disturb potential nesting habitat at the former, which is undisturbed and has substantial vegetative cover. Thus, any of several shorebird and passerine species and associated predatory species that may nest in that area could be displaced from disturbed habitat following quarrying. Although the nesting density and average density of 14 species (Lapland longspur not included) on tundra in the general vicinity of the two

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sites were similar (Kadleroshilik = 44.3 nests per square kilometer and 108.2 birds per square kilometer) in 1994 (TERA, 1995b), the Duck Island site has been disturbed for some years, and presumably any species potentially displaced are no longer present. The potential for bird use of the Kadleroshilik site is expected to be considerably greater due to the presence of a variety of vegetation types potentially used by various shorebirds and passerines for nesting, foraging, and rearing young. Because most species are not present in winter, activity associated with quarrying and vehicle traffic would not disturb these species at either site. Small numbers of rock ptarmigan could be disturbed at either site. No substantial population effects for any species are expected to occur as a result of using either of these sites. The effect of Alternative I on marine and coastal birds potentially could be significantly higher than Alternative VI.

(4) Effects on Terrestrial Mammals

(a) Large Oil Spills

The general effects of a large spill and the effects of oil-spill-cleanup activities are analyzed in Section III.C.2.d.(2)(a). Crude oil or diesel fuel is most likely to contact some coastal areas from the Sagavanirktok River Delta east to Mikkelsen Bay, regardless of which spill scenario is assumed (Table A-13; Land Segments 25, 26, and 27). Caribou may use some of these areas for relief from insects. The main potential effect on terrestrial mammals that contact spilled oil could be the loss of fewer than 100 caribou and a few muskoxen, grizzly bears, and arctic foxes. These losses are expected to be replaced by normal reproduction within about 1 year. A 1,500-barrel onshore pipeline spill could occur and oil less than 5 acres of vegetation along the pipeline landfall to the Badami tie in. Such a spill is not expected to directly affect caribou or other terrestrial mammals and would cause very minor ecological harm.

Secondary effects could come from disturbance associated with spill-cleanup activities and temporary local displacement of some caribou, muskoxen, grizzly bears, and foxes. These activities, however, would not affect the terrestrial mammals' movements or overall use of habitat.

(b) Disturbances

The general effects of disturbances are analyzed in Section III.C.3.d(2)(a).

1) Summary and Conclusion for Effects of Disturbances on Terrestrial Mammals

Traffic for constructing the ice roads, production island, pipeline, and gravel pads and to haul gravel and supplies could disturb some caribou and muskoxen along the ice roads during the 2 years of development and during other winters, when further work on the project is needed. This traffic would occur during December though early May, with more ice-road construction and traffic occurring during the 2 years of development. Some continued ice-road activity would occur during the 15 years of production to support project operations. These disturbances would have short-term effects on individual animals and would not affect populations.

2) Details on How Disturbance Affect Terrestrial Mammals-Specific Effects

a) Effects of Ice Roads

BPXA would not build permanent access roads along the Badami pipeline or next to the onshore pipeline that ties into it. Most of the length of ice roads would be located offshore and routed from the Endicott causeway to the production-island. The short ice roads would connect the island with the gravel mine on the Kadleroshilik River (see Map 2A). Traffic for constructing the ice roads, production island, pipeline, and gravel pads and to haul gravel and supplies could disturb some caribou and muskoxen along the ice roads during the 2 years of development and during other winters, when further work on the project is needed. This traffic would occur during December though early May, with more ice-road construction and traffic occurring during the 2 years of development. Some continued ice-road activity would occur during the 15 years of production to support project operations. These disturbances would have short-term effects on individual animals and would not affect populations.

b) Effects of Gravel Mining

Gravel mining would alter a small area of river habitat along the Kadleroshilik River (about 38 acres of sparsely vegetated river-barrens land cover and about 7 acres of reserve area at the gravel mining site, for a total disturbed area of about 45.1 acres. This alteration would not disturb many terrestrial mammals. Most caribou migrate south to the Brooks Range during the winter months, when gravel will be mined, but small bands may be present.

Muskoxen recently have been sighted along the Kadleroshilik River, but few were sighted during the winter (LGL Alaska Research Assocs., Inc., Woodward-Clyde Consultants, and Applied Sociocultural Research, 1998). There are no known grizzly bear dens near the preferred gravel mining site on the Kadleroshilik River (see Map 2A). Grizzly bears would be denning during the winter and would not encounter mining and ice-road activities.

(5) Effects on Lower Trophic-Level Organisms

(a) Large Oil Spills

The general effects of a large spill and the effects of oil-spill-cleanup activities are analyzed in Section III.C.2.e(2)(a). Lower trophic-level organisms would be affected by a large oil spill. It would have only short-term effects on plankton, including phytoplankton, zooplankton, and epontic species on the bottom of the ice cover, but longer term effects on the fouled coastlines. As documented in Section III.C.2.e(2)(c) and Appendix A, up to 15% of the sound's coastline would be affected by a large spill. While the ice-gouged coastline is inhabited by mobile, seasonal invertebrate species that would recover within a year, fractions of the oil would persist in the sediments for about 5 years in most areas, and could persist up to 10 years in areas where water circulation is reduced. Very little of Liberty crude, which is highly viscous and particularly resistant to natural dispersion, would be dispersed down in the Stefansson Sound water column and affect deep benthic communities such as the Boulder Patch kelp habitat. However, diesel oil, which would be used on the island for startup and emergency fuel, could be dispersed down to the seafloor. If 1,500 barrels of diesel were spilled from a fuel-delivery barge at the island during the open-water season, the concentration would be toxic within an area of about 18 square kilometers (7 square miles), as noted in the water quality section (III.A.2 (l)). Such toxicity would probably stunt the seasonal growth of kelp plants and reduce the population size of associated invertebrates for several years. Oil-spill responses in general would have both beneficial effects of some and adverse effects on other lower trophic-level organisms.

(b) Disturbances

The general effects of a large spill and the effects of oil spill cleanup activities are analyzed in Section III.C.3.e(2)(a).

1) Summary and Conclusions for Effects of Disturbances on Lower Trophic-Level Organisms

Alternative I would disturb lower trophic-level organisms in two primary ways: (1) pipeline trenching would bury up to 14 acres with very low (1%) coverage of kelp, boulders and suitable substrate; and (2) sediment plumes would reduce Boulder Patch kelp production by up to 6% during one year. The buried 14 acres would equal less than 0.1% of the Boulder Patch kelp habitat. The density of the kelp, boulders and suitable substrate in the pipeline corridor is very low, averaging about 1% coverage, and the lost kelp biomass and production probably would be less than .01% of the Boulder Patch totals, but the effect (substrate burial) would last forever.

Some of the suspended sediment from pipeline trenching and island construction would drift over other parts of the Boulder Patch, reducing light penetration and kelp production during 1 year. This reduction is estimated to be less than 6%, about one-third of which would be due to the proximity between the Boulder Patch to the Zone 1 disposal area for excess sediments. However, in relation to the large range of natural variability, all of these suspended sediment effects would be barely detectable.

From 6 feet deep to the seafloor, the island's concrete slope would temporarily benefit kelp and other organisms that need a hard substrate for settlement. This portion of the concrete slope would be a temporary home for colonies of species similar to those of the Boulder Patch area. Upon abandonment, the concrete mats would probably be removed or would become buried naturally, eliminating the additional kelp habitat.

2) Details on How Disturbances May Affect Lower Trophic-Level Organisms

a) Specific Effects from Island Construction

Construction of Liberty Island would alter the seafloor habitat permanently and would kill the benthic animals living there. Underwater surveys show the seafloor at the Alternative 1 site is silty mud and contains less than 10% rock cover, similar to most of the Beaufort Sea's floor (Fig. III.C-1). Placing gravel to construct Liberty Island would kill the benthic invertebrates occupying about 28 acres of this habitat. Similar amounts of benthos were buried during construction of several exploration islands in Stefansson Sound during the past two decades, including Tern, Duck, Endeavor, BF-37, Niakuk, Goose, and Sag islands. The 28 acres would be relatively small compared to the area that was affected by the Endicott causeway and Northstar pipeline that were constructed within this same region and depth range. We agree with the concluding statements in the Northstar EIS about the project effect on benthic infaunal and epifaunal invertebrates aside from those in the Boulder Patch kelp community (U.S. Army Corps of Engineers, 1999:6-29):

> The trenching for the pipeline will impact both infauna and epifauna through direct physical disturbance, burial with sediment, or from increased turbidity in the surrounding water. Trenching the shallow waters of the lagoon would have a negligible effect on benthic invertebrates. Impact to marine invertebrates in deeper waters would be considered minor because of the rapid recolonization and geographic range of these species.

However, the level of effect for Liberty would be alternative-specific, because the use of the existing Tern Island would affect less benthos.

Island construction also would increase the amount of under-ice suspended sediment in the water column. Because of the prevailing under-ice currents in this area, a sediment plume from island construction would drift east or west in line with the isobaths. If the plume drifted west, it would drift over the kelp in the Boulder Patch, depositing a thin blanket of sediment over the kelp and reducing the amount of light for growth (Fig. III.C-2). An under-ice plume from construction that drifted west toward the Boulder Patch probably would affect up to 105 acres (BPXA, 1998a:5-8). Because the more productive rocky areas are widely scattered, the plume is likely to affect less than 105 acres of productive Boulder Patch habitat. The heavier sediments should settle out within one-half mile of the island and are not expected to reach the Boulder Patch.

Sediments larger than clay-sized particles are likely to settle out within 3-7 miles of the construction area (USDOI, MMS, Alaska OCS Region, 1998a:8). Sediments that reach the Boulder Patch are likely to reduce the amount of light for marine kelp living in rocky bottom areas. This was the primary concern regarding the health and growth of Boulder Patch kelp communities during winter (USDOI, MMS, Alaska OCS Region, 1998a).

Storms and river discharges place a lot of sediment into the waters of the Boulder Patch area. These discharges, plus variations in snow cover, annually make up to two-thirds of the winter ice in this area uninhabitable for ice algae (there is not enough light). This results in naturally fluctuating growth rates for Boulder Patch kelp communities. The plume from construction could reduce kelp growth in some rocky bottom areas where clear-ice conditions exist. This possibility was considered in a recent analysis by Gallaway, Martin, and Dunton (1999:16-18), which is based partly on field observations during construction of the BF-37 gravel island. They concluded that under worst-case conditions:

- Island construction may reduce kelp production in the Boulder Patch by 2%.
- No changes are expected in the health or distribution of Boulder Patch communities.
- The effects of island construction would be limited to 1 year and would constitute short-term impacts.

We believe that the above conclusions are conservative, and that they were based on the appropriate model methods, calculations, and assumptions. Hence, any effects due to island construction are expected to fall within the range of natural variation for Boulder Patch kelp communities. Any reduction in the amount of light due to island construction is expected to be very small and is not expected to have a measurable effect on kelp communities in the Boulder Patch. Any sediment accumulating on kelp from construction would probably be washed away by currents, as observed natural sediment accumulations.

b) Specific Effects from Pipeline Construction

Pipeline construction would involve about 6 miles of trenching and backfilling in marine waters along the pipeline corridor. There would be alternative-specific effects from both suspended sediments and trenching.

Suspended Sediments: Pipeline construction also would increase the amount of suspended sediment in the water column during winter trenching and backfilling (Fig. III.C-3) and during the natural dispersal at breakup of any excess sediment that is stored on the ice (Fig. III.C-4 and -5). The dense part of the plume is predicted to move less than 1,000 feet along-shore to the west or east, as indicated partly by BPXA measurements during preparation of the Northstar test trench. The plume from pipeline construction could reduce kelp growth in some rocky bottom areas where clear-ice conditions exist. This scenario was considered also by Gallaway, Martin, and Dunton (1999) and Ban et al. (1999). They concluded that under worst-case conditions:

- Suspended sediments from pipeline trenching may reduce kelp production in the Boulder Patch by 4% (Fig. III.C-1), and the excess-sediment stockpiled on the ice cover (Fig. III.C-5) may reduce it by another 2%. In other words, about one-third of the effect would be due to the proximity between the Boulder Patch and disposal zone.
- No changes are expected in the health or distribution of Boulder Patch communities.
- The effects from construction would be limited to 1 year and would constitute short-term impacts.
- The effects of pipeline repair, if necessary, probably would be site specific and less than the construction effects.

The effects would probably be less than these worst-case predictions, as indicated by some recent field measurements during construction of Northstar pipeline in late April 2000 (Trefry, 2000, pers. commun.). The measurements were made at six sites in the Northstar area, two of which were within a couple hundred meters east and west of the pipeline corridor while the trench was being backfilled. The measurements included three water samples and a turbidity profile at each site. In spite of the backfilling, the sampled water appeared to be low with less than 0.5 milligrams per liter of sediment (Trefry, 2000, pers. commun.).

One reason that the measurements were lower than the predictions is that some of the dredged sediment probably froze before it was used as backfill over the pipeline Hence, any effects due to suspended sediments from pipeline construction are expected to fall within the range of natural variation for Boulder Patch kelp communities.

Trenching: Some benthic plants and animals would be disturbed by pipeline trenching (Sec. II.A.1.b(3)(a)(4)). Most of the seafloor in the project area is covered with sandy/silty sediments that are disrupted naturally by the ice cover and strudel scour (BPXA, 1998a:Sec. 4.6). The resident organisms in the silty/sandy sediments generally are small and short-lived, and we agree with the conclusion in the Northstar Final EIS that "natural re-population of the trench area by infaunal invertebrates is expected within a few years" (U.S. Army Corps of Engineers, 1999:6-26).

The BPXA Environmental Report also describes the Boulder Patch and the diverse community of organisms associated with the kelp and solid substrate. The report notes that there is diffuse kelp and solid substrate in the outer section of the pipeline corridor (BPXA, 1998a:Secs. 4.6.3 and 5.2.5). The kelp and solid substrate occurs in a 4,700-foot section that is diagramed in Figures III.C-1and 5, Surveys for Boulders and Kelp. A similar map was prepared for a BPXA report on construction effects on Boulder Patch kelp production (Ban et al., 1999); the map clarifies the location and distribution of dense kelp near the Alternative 1 island site. The band's location and distribution indicate that the light kelp that is illustrated in Figure III.C-1 probably is the shoreward, marginal end of the dense band that is illustrated in the report by Ban et al. (1999). The map that was prepared by Ban et al. is redrawn as Figures III.C-2 through 4 and is used as the base map for our assessment of alternatives.

After the Environmental Report was prepared (BPXA, 1998a), additional side-scan and video surveys were conducted along the 4,700-foot section. The investigators summarized the preliminary results during the MMS Arctic Kelp Workshop in May 1998 (USDOI, MMS, Alaska OCS Region, 1998), and the final results were summarized in a July 1998 report to BPXA (Coastal Frontiers Corp., 1998). The report explains that the video detected scattered bivalve shells, pebbles, and rocks, some of which were found to have small pieces of kelp attached. It also explains that the "concentrations of these objects appeared to represent less than 1% of the sea bottom in most instances, and in no case greater than 2%" (Coastal Frontiers Corp., 1998:16). Figure III-C.2 shows that the distance to a portion of the Boulder Patch with a concentration over 10% is at least 1,600 feet (500 meters). So, the average density of kelp and solid substrate in the 4,700-foot long section was assumed to be 1% for the following assessment of trenching effects.

The width of the area that would be disturbed by trenching would be related mainly to the amount of slumping on the sides of the trench. The Plan explains that the slump or slope angle would be 3:1 typically (extending three times the trench depth to each side) but that the excavation limits could be up to 5:1 in unconsolidated sediments (Fig. II.A-12 and BPXA, 2000a:Fig. 8-4 and p. 71). The 5:1 ratio means that the overall disturbed area could be up to 10 times the trench depth plus the bottom width of the trench. Therefore, the bottom of the trench for Alternative 1 would be up to 12 feet deep and 12 feet wide (Fig. II.A-12 and Table II.A-1), and the overall width at the top would be up to 132 feet.

The boulders with kelp near the center of the Boulder Patch lie at the sediment surface in a layer that is very thin, "no more than one boulder thick" (Dunton, Reimnitz, and Schonberg, 1982). We assume that the solid substrate with kelp that lies in the pipeline corridor is no different, that it also lies at the sediment surface in a layer that is very thin. After trenching, if the solid substrate could be returned to the sediment surface, it probably would be recolonized by kelp in a decade (Martin and Gallaway, 1994). However, the operation probably could not return the kelp and solid substrate to the sediment surface, and the only natural process that might return it to the surface would be gradual erosion over geological time scales.

In summary, trenching would bury up to 611,000 square feet or 14 acres of kelp and solid substrate at very light densities. The 14 acres can be compared with the total area of the adjacent Boulder Patch. The area in which kelp and solid substrate exceed 10% coverage recently was estimated as 64 square kilometers, or 15,871 acres (Ban et al., 1999). Therefore, the buried 14 acres would equal less than 0.1% of the Boulder Patch area. Furthermore, the concentration of kelp in the Boulder Patch is more than 10 times that in the pipeline corridor, so the lost kelp biomass and production probably would be less than 0.01% of the total.

The burial of kelp and solid substrate in the pipeline corridor would be mitigated partly by a countervailing effect—the creation of a new kelp habitat on the concrete blocks in the island's slope-protection system (Secs. III.C.1.b(5) and III.D.3.e(2)(a)). The concrete blocks below the ice-scour depth (6 feet) would add about 3 acres of kelp habitat. However, this new kelp habitat might be temporary because the slope-protection materials might be removed during the abandonment phase in 15-20 years, as noted in Section III.D.6.e (2)(b) of this EIS and Section 15 of the Plan (BPXA, 2000a). BPXA could also mitigate some trenching effects if excess quarry boulders were placed on the backfill in the outer portion of the trench. The quarry boulders would probably reduce the longevity of trenching effects from permanent ones to decade-long ones because a Boulder Patch study showed that bare rocks were colonized by kelp within a decade. Future unanticipated effects on kelp could be moderated by Lease Sale Stipulation No. 1, Protection of Biological Resources. The stipulation explains that MMS may require additional biological surveys and, based on the surveys, may require the lessee to "modify operations to ensure that significant biological populations or habitats deserving protection are not adversely affected."

(6) Effects on Fishes and Essential Fish Habitat

The general effects of a large spill and the effects of oil-spill-cleanup activities are analyzed in Section III.C.2.f(2)(a) and (b). The general effects of disturbances are analyzed in Section III.C.3.f(2)(a) and (b).

(a) Fishes

Noise and discharges from dredging, gravel mining, island construction, island reshaping, and pipeline trenching associated with Liberty are expected to have no measurable effect on fish populations. While a few fish could be harmed or killed, most in the immediate area would avoid these activities and would be otherwise unaffected. Discussions with Al Ott of the Alaska Department of Fish and Game confirm the findings of Hemming (1996) that the Kadleroshilik River supports only small numbers of ninespine stickleback, Dolly Varden, and arctic grayling. Also, while it is possible that some ninespine stickleback could overwinter there, neither spawning nor overwintering are known to occur anywhere on the Kadleroshilik River for any fish species. However, if the Kadleroshilik River did support overwintering fish, the effects on most would be expected to be short term and sublethal, with no measurable effect on overwintering fish populations. After the mine site becomes accessible to fishes, it may benefit them by providing the first viable overwintering habitat in this region of the Kadleroshilik River. This assumes that the mine site depth is adequate (i.e., 20 feet or more), and that oxygen levels remain sufficient during winter to support the number of fishes under the ice. Placement of the concrete mat would create additional food resources for fishes and, thereby, would have a beneficial effect on nearshore fish populations in the Beaufort Sea.

(b) Essential Fish Habitat

The use of the Kadleroshilik River Mine Site would create potential overwintering habitat on the Kadleroshilik River for fish that would potentially serve as prey for salmon. Increased turbidity and sedimentation down stream of the mine site could disturb fish or algae.

(7) Effects on Vegetation-Wetland Habitats

(a) Large Oil Spills

The general effects of a large spill and the effects of oil-spill-cleanup activities are analyzed in Section III.C.2.g(2)(a). The main potential effects of a large offshore spill on vegetation and wetland include oil-fouling, smothering, asphyxiation, and poisoning of plants and associated insects and other small animals. In this case, complete recovery of moderately oiled wetlands of the Sagavanirktok River east to Mikkelsen Bay would take perhaps 10 years or longer. A second main effect is the disturbance of wetlands from cleanup activities. Complete recovery of heavily oiled coastal wetlands from these disturbances and oil could take several decades.

A large onshore spill would oil no more than 5 acres of vegetation along the pipeline landfall to the Badami tie-in would cause very minor ecological harm. Oiled vegetation should recover within a few years but may take more than 10 years to fully recover.

(b) Disturbances

The general effects disturbance are analyzed in Section III.C.3.g(2)(a).

1) Summary and Conclusion of Effects of Disturbances on Vegetation-Wetland Habitats

Disturbances mainly come from constructing gravel pads and ice roads and installing the onshore pipeline and tie in with the Badami pipeline. Gravel pads, pipeline trench, and the 1.4-mile-long onshore pipeline would destroy only 0.8 acres of vegetation and affect a few acres of nearby vegetation and have only local effects on the tundra ecosystem. Ice roads would have local effects (compression of tundra under the ice roads) on vegetation, with recovery expected within a few years, and no vegetation would be killed. The construction and installation of the onshore pipeline and gravel pad on State land will be required to have a Section 404/10 permit and approval by the Corps of Engineers, as stated in the Liberty Development Project Development and Production Plan (BPXA, 2000a). The permit and approval process is expected to minimize adverse effects on wetlands.

2) Details on How Disturbances May Affect Vegetation-Wetland Habitats - Specific Effects

a) Gravel Pads

Liberty's gravel pads and pipeline trench development would cover only 0.8 acre, they are likely to have very little effect on nearby tundra, because permits (State and Federal) require that natural drainage be maintained.

b) Ice Roads

BPXA would not build permanent access roads along the Badami pipeline or next to the onshore pipeline that ties into it. Most of the length of ice roads would be located offshore and routed from the Endicott causeway to the production island. The short ice roads would connect the island with the gravel mine on the Kadleroshilik River, with two coastal lakes used as water sources for the ice roads (see Maps 2A and 2B). Ice roads tend to compress and flatten the vegetation under them, and compressed vegetation would be common along onshore ice roads to the gravel mine and to the freshwater lakes. Ice roads probably would melt later in spring than nearby tundra and green up later because of the ice cover, resulting in "green trails" along the ice roads. Compression would not kill the vegetation, and we expect it to recover within a few years. We assume currently implemented stipulations on ice roads would be followed for the Liberty Project.

(8) Effects on the Economy

The general effects of a large spill and the effects of oil-spill-cleanup activities and disturbances are analyzed in Sections III.C.2.k and III.C.3.k.

The Liberty Project would generate approximately the following economic benefits related to Alternative I:

- $100 million in wages and 870 full-time equivalent construction jobs for 1 year in Alaska during 14-18 months of construction
- 1,248 indirect full-time equivalent jobs during the 14-18 months of construction
- $480 million capital expenditure.

(9) Effects on Water Quality

(a) Specific Effects of an Oil Spill on Water Quality

The general effects of a large spill and the effects of oil-spill-cleanup activities are analyzed in Section III.C.2.l(2)(a). During open water, hydrocarbons dispersed in the water column from a large (greater than 500 barrels) crude oil spill could exceed the 0.015-parts per million chronic criterion for 10-30 days in an area that ranges from 30-45 square kilometers (11.6-17.4 square miles) to 51-186 square kilometers (19.7-71.8 square miles). Hydrocarbons in the water could exceed the 1.5-parts per million acute (toxic) criterion during the first day in the immediate vicinity of the spill. A large crude oil spill in broken sea ice or when the sea ice melts could exceed the chronic criterion for several days in an area of about 7.6 square kilometers (2.9 square miles). Hydrocarbons from a 1,283-barrel diesel oil spill during open water could exceed the acute (toxic) criterion for about 7 days in an area of about 18 square kilometers (7 square miles). During broken sea ice or melting ice conditions, a 1,283-barrel diesel spill could exceed the acute (toxic) criterion for about 1 day in an area of about 1 square kilometer (0.4 square mile) and the chronic criterion for more than 30 days in an area of about 103 square kilometers (39.8 square miles). The effects from a spill occurring under the ice would be similar to those described for broken ice or melting conditions; the oil would be trapped and essentially remain unchanged until breakup occurred and the ice began to melt.

A large crude or refined oil spill (greater than or equal to 500 barrels) would have a significant effect on water quality by increasing the concentration of hydrocarbons in the water column to levels that greatly exceed background concentrations; however, the chance of a large spill occurring and oil entering the offshore waters is estimated to be about 1%. Also, regional (more than 1,000 square kilometers [386 square miles]), long-term (more than 1 year) degradation of water quality to levels above State and Federal criteria because of hydrocarbon contamination is very unlikely.

(b) Specific Effects of Disturbances on Water Quality

The general effects of disturbances are analyzed in Section III.C.3.l(2)(a). The greatest effect on water quality from gravel island and pipeline construction would be additional turbidity caused by increases in suspended particles in the water column. Increases in turbidity generally are expected to be considerably less than the 7,500 parts per million suspended solids used in the analysis as an acute (toxic) criterion for water quality (Sec. III.C.3.l(2)); exceptions may occur within the immediate vicinity of the construction activity. Turbidity increases from construction activities generally are temporary and expected to occur during the winter and end within a few days after construction stops. Material excavated from the pipeline trench but not used for backfill most likely would be left in an area where active erosion of sediment particles could occur during breakup and open water. This material would be similar in composition to seafloor sediments in the trenching and disposal areas, and its contribution to the future turbidity from waves and currents is expected to be about the same as the sediments existing at the seafloor surface before pipeline construction. Construction activities are not expected to introduce or add any chemical pollutants.

(10) Effects on Air Quality

The general effects of a large spill and the effects of oil-spill-cleanup activities are analyzed in Section III.C.2.m(2). The proposed Liberty Project would affect air quality in several ways, but the overall effects would be very low. An oil spill could cause an increase in hydrocarbon air pollutants, as discussed in Section III.C.2.m and summarized in Section III.A.1.a(13). The overall effects on air quality would be minimal.

The most noticeable effects on air quality are caused by emissions from equipment. This is discussed in detail in Section III.D.1.m. That section concludes that the Liberty Proposal would cause a small, local increase in the concentrations of criteria pollutants. Concentrations would be within the Prevention of Significant Deterioration Class II limits and National Ambient Air Quality Standards. Therefore, the effects would be low.

b. Alternative VI - Use the Duck Island Gravel Mine

Sections II.C.4.a and IV.C.4 describe the common elements shared by both alternatives in the set of component alternatives. Those common elements, plus the following alternative components specific to this gravel mine site to complete the description of this alternative. Note that this description was previously given in Section II.C.4.b and is being repeated here for the convenience of the reader. Table II.A-1 provides a comparison of key components for the different alternatives being analyzed.

Under Alternative VI, the existing Duck Island gravel mine (Figs. II.C-6 and II.C-7) would be mined to provide gravel for the project (see Map 1). To get the required gravel for the project from the Duck Island mine site, BPXA would need to deepen a portion of the gravel pit by 20-40 feet (6-12 meters). This site does not require the removal of any overburden, and it would reduce by about half the cost of snow and ice removal at the mine site. Eventually, BPXA would need to rehabilitate the site (Figs. II.C-7, II.C-8, II.C-9), but the Liberty Project would share a portion of the total costs.

Under this alternative, BPXA also would need to remove water from the mine before extracting the gravel. At the current permitted rate, it would take more than 400 days to remove the estimated 600 million gallons of water from the mine site. This water could go to adjacent tundra or creeks under the current General National Pollutant Discharge Elimination System Permit. However, BPXA’s preferred construction method would be to obtain a modified General National Pollutant Discharge Elimination System Permit to increase appreciably the discharge rate (5-6 million gallons per day) to avoid a delay in the construction schedule. If permitted, this dewatering activity would need to start in the summer of Year 1, before the decisions are made for many of the other permits. At a pump rate of 5 million gallons per day, it would take at least 120 days to remove the water from the site. The removal of the water from the gravel mine also would temporarily preclude BPXA and other companies in the area from using the pit as a source of freshwater for the construction of ice roads supporting this and other projects. If the National Pollutant Discharge Elimination System permit is not approved, dewatering the pit at the current approved rate of 1.5 million gallons a day would delay the project a year. (**Note:** BPXA has not consulted with the regulatory and permitting and resource agencies regarding the feasibility of mining from this location. It is unknown at this time, whether the permitting agencies would require additional mitigation or if they would even permit the higher dewatering rate.)

The Duck Island mine site is about 17.4 miles (28 kilometers), or about 2.7 times farther from the Liberty Island construction sites than the proposed Kadleroshilik mine. For purposes of analysis, the EIS assumes the use of two different sizes of vehicles and the use of a temporary dumping site. The larger of the vehicles (B70's) would haul the gravel from the mine site to a temporary site near the base of the Endicott Causeway. The gravel would be reloaded at the temporary site into smaller trucks (Maxhauls), which would haul the gravel to the island location. This is similar to the process used to construction the Northstar gravel island. A 7.9-mile (12.7-kilometer) long ice road from the base of Endicott to the gravel island would need to be constructed and maintained. From there, the distance to any of the three island locations (Liberty, Southern, and Tern) is approximately the same.

This alternative could delay the planned rehabilitation of the Duck Island mine site by a year or more.

As noted in Section IV.C.4. the effects to some resources are the same for both mine sites. The specific components of the Alternative VI – Use Duck Island mine site as described above would change the impacts to the following resources in the ways described in the analyses that follow:

- Eiders
- Seals and Polar Bears
- Marine and Coastal Birds
- Lower Level-Trophic Organisms
- Terrestrial Mammals
- Fishes and Essential Fish Habitat
- Vegetation-Wetland Habitats
- Economy
- Water Quality
- Air Quality

(1) Effects on Threatened and Endangered Species - Eiders

(a) Large Oil Spills

The general effects of a large spill and the effects of oil-spill-cleanup activities are analyzed in Section III.C.2.a(2)(b)1). Effects of an oil spill on spectacled eiders under Alternative VI are expected to be essentially the same as for Alternative I.

(b) Disturbances

The general effects of disturbances are analyzed in Section III.C.3.a(2)(b)1).

1) Summary and Conclusion for Effects of Disturbances on Eiders

The potential for occurrence of resting, foraging, or nesting eiders is likely to be lower at the Duck Island quarry site than at the proposed Kadleroshilik site due to the undisturbed character and vegetative cover of the latter. Although this represents a substantial difference in habitat availability between the two sites, spectacled eiders are not actually expected to be nesting at either site, so no significant difference in effects of habitat disturbance on the spectacled eider is expected between this Alternative and Alternative I.

2) Details on How Disturbances May Affect Eiders

Specific Effects: Obtaining gravel from the Duck Island gravel mine site on the Sagavanirktok River Delta instead of the proposed Kadleroshilik River site would avoid disturbing any potential resting, foraging, or marginal nesting habitat at the latter site. Thus, any eiders that might nest or stop in the currently undisturbed Kadleroshilik area in the summer would not be displaced from habitats disturbed by quarrying. However, although the Duck Island site has been disturbed for some years, and presumably any nesting eiders potentially displaced are no longer present, it is likely the potential for eider use of the Kadleroshilik site probably is not high in spite of its undisturbed character and vegetative cover given the substantial proportion of the island covered with vegetation not typically associated with eider nest sites or foraging (Noel and McKendrick, 2000). Considering factors that might suggest potential use of these areas by any eiders occupying the surrounding tundra areas, the nesting density and average density of eiders in the general vicinity of the two sites were similar (0.3-0.5 nests per square kilometer and 0.4 birds per square kilometer) in 1994 (TERA, 1995b). Thus, the numbers of resting or nesting eiders displaced from either the Kadleroshilik area (Alternative I) or the Duck Island site (Alternative VI) as a result of habitat disturbance are expected to range from zero to very low. Because eiders are not present in winter, activity associated with quarrying and vehicle traffic would not disturb this species at either site. No significant population effects for this species are expected to occur as a result of using either of these sites.

Contents

(2) Effects on Seals and Polar Bears

(a) Large Oil Spills

The general effects of a large spill and the effects of oil-spill-cleanup activities are analyzed in Section III.C.2.b(2)(a). Effects of a large oil spill on seals and polar bears under Alternative VI are expected to be the same as under Alternative I Section IV.C.4.b.

(b) Disturbances

The general effects of disturbances are analyzed in Section III.C.3.b(2)(a).

1)Summary and Conclusion for Effects of Disturbances on Seals and Polar Bears

Using the Duck Island gravel mine rather than the Kadleroshilik River mine site would avoid potential noise and disturbance of denning polar bears in the Kadleroshilik River area during winter. Using this gravel mine site probably would involve an increase in ice-road traffic to and from the Sagavanirktok River to Liberty Island, which could present a potential increase in disturbance of polar bears and seals in this area. The potential effect on polar bears from mining and other development activities could be reduced along the coast of the Kadleroshilik River.

2) Details on How Disturbances May Affect Seals and Polar Bears- Specific Effects

Ice Roads: A few adult ringed seals and pups would be displaced by ice roads where the roads pass over floating fast ice to the Liberty Island and from the Duck Island mine site-Endicott road to the Liberty Island (see Map 2B). Ice roads that are routed over grounded fast ice near the shore would not pass over ringed seal pupping habitat. The number of seals displaced is expected to be very low, perhaps 1-2 seals per kilometer of ice road (about 20 miles of ice road would pass over floating fast ice; see Map 2B). This seasonal effect is expected to occur over the 15-year life of Liberty along the route between Liberty and the Endicott causeway, when this ice road is constructed and used. This displacement is not expected to affect the seal population or greatly affect their distribution in Foggy Island Bay. Construction of ice roads for the Northstar Project affected the behavior of a few seals within 0.64 kilometer of the ice roads but had no effect on ringed seal distribution and abundance (Richardson and Williams, 1999).

Ice roads for winter development may disturb a few polar bear maternity dens during the 2 years of construction activities (Blix and Lentfer, 1991; Amstrup, 1993; USDOI, Fish and Wildlife Service, 1995b). However, denning polar bears have tolerated high levels of seismic activity and ice-road traffic (the latter only 400 meters from the den) (Amstrup, 1993). The proposed ice road and noise from vehicle traffic on the road from the Endicott causeway along the coast of Foggy Island Bay and near the Kadleroshilik River could disturb and displace a few denning polar bears. However, the number of bears potentially displaced is likely to be low and would not affect the population (see Map 2B). As recommended by the Fish and Wildlife Service, BPXA plans to obtain a Letter of Authorization for unintentional take of polar bear, especially during winter months, in accordance with existing regulations. We expect the monitoring program and mitigation required under the authorization to prevent significant disturbance of denning polar bears.

(3) Effects on Marine and Coastal Birds

(a) Large Oil Spills

The general effects of a large spill and the effects of oil-spill-cleanup activities are analyzed in Section III.C.2.c(2)(a). Effects of an oil spill on marine and coastal birds under Alternative VI is expected to be essentially the same as for Alternative I.

(b) Disturbances

The general effects of disturbances are analyzed in Section III.C.3.c(2)(a).

1) Summary and Conclusion for Effects of Disturbances on Marine and Coastal Birds

The potential for occurrence of resting, foraging, or nesting birds, and probably ptarmigan in winter, is likely to be considerably lower at the Duck Island quarry site than at the proposed Kadleroshilik site due to the undisturbed character and vegetative cover of the latter. Thus a potentially significant difference in effect of habitat disturbance on marine and coastal bird species is expected between this Alternative and Alternative I.

2) Details on How Disturbances May Affect Marine and Coastal Birds

Specific Effects: Obtaining gravel from the Duck Island gravel mine site on the Sagavanirktok River Delta instead of the proposed Kadleroshilik River site would avoid disturbing any potential resting, foraging, or nesting habitat at the latter site, which is undisturbed and has substantial vegetative cover. Thus any of several shorebird and passerine species and associated predatory species that may nest in the Kadleroshilik area would not be displaced from disturbed habitat following quarrying. Although the total nest density and total average bird density for 14 species (Lapland longspur not included) on tundra in the general vicinity of the two sites were similar (Kadleroshilik = 44.3 nests per square kilometer and 108.2 birds per square kilometer, and Duck Island (Prudhoe) = 46.8 nests per square kilometer and 134.9 birds per square kilometer) in 1994 (TERA, 1995b), the Duck Island site has been disturbed for some years, and presumably any species potentially displaced are no longer present. The potential for bird use of the Kadleroshilik site is expected to be considerably greater due to the presence of a variety of vegetative types potentially used by various shorebirds and passerines for nesting, foraging, and rearing young (Noel and McKendrick, 2000). Because most species are not present in winter, activity associated with quarrying and vehicle traffic would not disturb these species at either site. Small numbers of rock ptarmigan could be disturbed at either site. No substantial population effects for any species are expected to occur as a result of using either of these sites. The effect of Alternative VI on marine and coastal birds potentially would be significantly lower than Alternative I.

(4) Effects on Terrestrial Mammals

(a) Large Oil Spills

The general effects of a large spill and the effects of oil-spill-cleanup activities are analyzed in Section III.C.2.d(2)(a). Effects of a large oil spill on terrestrial mammals under Alternative VI are expected to be the same as under Alternative I Section IV.C.4.a. (4)

(b) Disturbances

The general effects of disturbances are analyzed in Section III.C.3.d(2)(a).

1) Summary and Conclusion for Effects of Disturbances on Terrestrial Mammals

Using the Duck Island gravel mine site rather than the Kadleroshilik River mine site would avoid potential noise and disturbance to muskoxen from ice-road traffic and mining activities in the Kadleroshilik River area during winter.

2) Details on How Disturbances May Affect Terrestrial Mammals

a) Specific Effects of Ice Roads

BPXA would not build permanent access roads along the Badami pipeline or next to the onshore pipeline that ties into it. Most of the length of ice roads would be located offshore and routed from the Duck Island mine site and the Endicott causeway to the Liberty production island. Traffic for constructing the ice roads, production island, pipeline, and gravel pads and to haul gravel and supplies could disturb some caribou and muskoxen along the ice roads during the 2 years of development and during other winters, when further work on the project is needed. This traffic would occur during December though early May, with more ice-road construction and traffic occurring during the 2 years of development. Some continued ice-road activity would occur during the 15 years of production to support project operations. These disturbances would have short-term effects on individual animals and would not affect populations.

b) Specific Effects of Gravel Mining

Using the Duck Island gravel mine site rather than the Kadleroshilik River mine site would avoid potential noise and disturbance to muskoxen from ice-road traffic and mining activities in the Kadleroshilik River area during winter. Using the duck island gravel mine site would involve a general increase in ice-road traffic to and from this mine site to Liberty Island, which may disturb some overwintering caribou in the area. The potential disturbance effect on muskoxen from mining and other development activities would be avoided.

(5) Effects on Lower Trophic-Level Organisms

(a) Large Oil Spills

The general effects of a large spill and the effects of oil-spill-cleanup activities are analyzed in Section III.C.2.e(2)(a). The general oil-spill risk to these organisms would be the same for the project with the Duck Island mine and for the Alternative I mine site.

(b) Disturbances

The general effects of disturbance, which are analyzed in Section III.C.3.e(2)(a), would be similar to those for Alternative 1 (use Kadleroshilik River Mine).

1) Summary and Conclusions for Effects of Disturbances on Lower Trophic-Level Organisms

There would be specific differences in the disturbance effects, because gravel from the Duck Island mine might be hauled along an ice road over the Boulder Patch.

2) Details of How Disturbances May Affect Lower Trophic-Level Organisms

Gravel probably would be hauled out the Endicott access road and across an ice road to the Liberty island site (Map 1). A direct ice road would pass over 5 miles of Boulder Patch kelp habitat. The roadway might reduce light transmission and growth of kelp during the spring. Assuming that the roadbed would be 50 feet wide, kelp growth would be reduced in about 30 acres during 1 year.

(6) Effects on Fishes and Essential Fish Habitat

(a) Fishes

The general effects of a large spill and the effects of oil-spill-cleanup activities are analyzed in Section III.C.2.f(2)(a) and the general effects of disturbances are evaluated in Section III.C.3.f(2)(a).

Alternative VI is expected to have similar effects on fishes as Alternative I. While the Duck Island mine site would eliminate any possibility of disturbing fish dredging, gravel mining, island construction, island reshaping, and pipeline trenching, it also would eliminate the possibility of creating overwintering habitat on the Kadleroshilik River, as discussed for Alternative I. Otherwise, Alternative VI is not expected to result in measurable differences in effects on fishes. Oil-spill-related effects would remain unchanged from that of Alternative I.

(b) Essential Fish Habitat

The general effects of a large spill and the effects of oil-spill-cleanup activities are analyzed in Section III.C.2.f(2)(b) and the general effects of disturbances are analyzed in Section III.C.f(2)(b).

The potential net effect of this alternative on essential fish habitat is expected to be similar to Alternative I. However, using the Duck Island mine site as a source for gravel would eliminate any possibility of disturbance of fish or algae from increased turbidity and sedimentation downstream of the mine site. It also would eliminate the potential countervailing effect of creating overwintering habitat on the Kadleroshilik River for fish that potentially would serve as prey for salmon.

(7) Effects on Vegetation-Wetlands Habitats

(a) Large Oil Spills

The general effects of a large spill and the effects of oil-spill-cleanup activities are analyzed in Section III.C.2.g(2)(a). The effects of a large spill on vegetation-wetlands for this alternative are expected to be the same as analyzed for Alternative I.

(b) Disturbances

The general effects of disturbances are analyzed in Section III.C.3.g(2)(a).

1) Summary and Conclusion of Effects of Disturbances on Vegetation-Wetland Habitats

Using Duck Island-Sagavanirktok River gravel mines rather than the Kadleroshilik River mine site would avoid disturbance of the sparsely vegetated gravel bar on the Kadleroshilik River. Consequently, the disturbance effect on vegetation and wetlands from mining activities would be avoided. Disturbance of vegetation and wetlands from the Liberty Project would still occur at the pipeline land-fall site and along the on shore pipeline route. Effects would be local and have very little effect on overall the vegetation and wetlands habitats.

2) Details on How Disturbances May Affect Vegetation-Wetland Habitats-Specific Effects

Ice Roads: BPXA would not build permanent access roads along the Badami pipeline or next to the onshore pipeline that ties into it. Most of the length of ice roads would be located offshore and routed from the Duck Island mine site and the Endicott causeway to the Liberty production island. The short ice roads would connect the island with the gravel mine on the Kadleroshilik River, with two coastal lakes used as water sources for the ice roads (see Maps 2A and 2B). Ice roads tend to compress and flatten the vegetation under them, and compressed vegetation would be common along onshore ice roads to the gravel mine and to the freshwater lakes. Ice roads probably would melt later in spring than nearby tundra and green up later because of the ice cover, resulting in “green trails” along the ice roads. Compression would not kill the vegetation, and we expect it to recover within a few years. We assume currently implemented stipulations on ice roads would be followed for all alternatives.

(8) Effects on the Economy

The general effects of a large spill and the effects of oil-spill-cleanup activities are analyzed in Section III.C.2.k and the general effects of disturbances are analyzed in Section III.C.3.k.

Specific Effects: Alternative VI generates more jobs, greater wages, and greater costs than Alternative I. This alternative would result in an increase of approximately $4.4 million in wages for 14 months; 20 direct jobs in Alaska for 14 months; 30 indirect jobs in Alaska for 14 months; approximately $15 million in cost for gravel island construction; and additional costs associated for gravel mining and hauling for pipeline construction (BPXA, 2000a). The increased costs are based on three factors. Dewatering the Duck Island site would cost about $2.4 million. The distance from the Duck Island mine to the island is about 17.3 miles or about 2.7 times farther from the Kadleroshilik mine, causing increased costs of hauling. The Duck Island haul route would include preparation of a longer floating ice segment than the route to the island in Alternative 1. Information in this analysis is interpreted in part from data in BPXA (2000a) and Appendix D-1.

(9) Effects on Water Quality

(a) Summary of Effects on Water Quality

The effects of a large oil spill and disturbances on marine water quality are expected to be the same as analyzed for Alternative I in Section IV.C.4.a(9). The general effects of a large spill and disturbances and the effects of oil-spill-cleanup activities are analyzed in Sections III.C.2.l(2)(a) and III.C.3.l(2)(a), respectively.

If the Duck Island gravel mine is used as a source of gravel for Liberty Island 600 million gallons of water would have to be pumped from the site before mining could be done. The potential effects of increasing the water removal rate from 1.5-5 million gallons per day are analyzed in this section.

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(b) Details on How Removing Water from the Mine Site May Affect Freshwater Quality

Specific Effects: Presently, gravel pit dewatering is authorized in accordance with the Environmental Protection Agency's General National Pollution Discharge Elimination System Permit AKG-31-0000 covering Alaska's North Slope Borough. Effluent limitations are as follows:

- a maximum flow of 1.5 million gallons per day
- no increase in settleable solids above natural conditions
- pH with a range of 6.5-8.5
- no discharge of floating solids, visible foam, or oily wastes

As indicated in Section II.C.4.b, water from the mine site is used to construct ice roads. Permit AKG-31-0000 covering this use requires a Best Management Practices Plan to prevent or minimize the release of pollutants to the waters of the United States.

Removal of 600 million gallons of water at a rate of 1.5 million gallons per day would require about 400 days. If the rate were increased to 5 million gallons per day, about 120 days would be needed to remove the water from the mine site. This increase may require a modification to the permit and/or Best Management Practices Plan.

Water for ice-road construction probably would be withdrawn from near the surface of the flooded site. If there is concern that the waters in the deeper part of the mine site may be anoxic (oxygen deficient), they can be tested. If the oxygen level in the deeper part of the mine site is low, the water can be aerated to increase oxygen levels so the discharge will not degrade the quality of the receiving waters.

Increasing the mine dewatering rate from 1.5-5 million gallons per day most likely would have little, if any, measurable effect on the quality of the receiving waters.

The effect on marine water quality from using gravel from the Duck Island mine site most likely would be the same as for Alternative I, using gravel from the Kadleroshilik River mine site.

(10) Effects on Air Quality

(a) Summary of Effects on Air Quality

The general effects of a large spill and the effects of oil-spill-cleanup activities are analyzed in Section III.C.2.m(2). The proposed Liberty Project would affect air quality in several ways, but the overall effects would be very low. An oil spill could cause an increase in hydrocarbon air pollutants, as discussed in Section III.C.2.m and summarized in Section III.A.1.a(13). The overall effects on air quality would be minimal.

The most noticeable effects on air quality are caused by emissions from equipment. This is discussed in detail in Section III.D.1.m. That section concludes that the Liberty Proposal would cause a small, local increase in the concentrations of criteria pollutants. Concentrations would be within the Prevention of Significant Deterioration Class II limits and National Ambient Air Quality Standards. Therefore, the effects would be low.

The general effects of this alternative gravel mine site on air quality are expected to be the same as analyzed for Alternative I in Section IV.C.4.a(10).

If the Duck Island gravel mine is used as a source of gravel for Liberty Island, the gravel would need to be hauled about 17.4 miles (28 kilometers), or about 2.7 times farther from the Liberty Island construction sites than the proposed Kadleroshilik mine. The potential effects of increasing this gravel-hauling distance are analyzed in this section.

(b) Details on How Increasing the Gravel-Hauling Distance from the Mine Site May Affect Air Quality

Specific Effects: The Duck Island mine site is about 17.4 miles (28 kilometers), or about 2.7 times farther from the Liberty Island construction sites than the proposed Kadleroshilik mine. For purposes of analysis, the EIS assumes the use of two different sizes of vehicles and the use of a temporary dumping site. The larger of the vehicles (B70's) would haul the gravel from the mine site to a temporary site near the base of the Endicott Causeway. The gravel would be reloaded at the temporary site into smaller trucks (Maxhauls), which would haul the gravel to the island location. A 7.9-mile (12.7-kilometer) long ice road from the base of Endicott to the gravel island would need to be constructed and maintained. From there, the distance to any of the three island locations (Liberty, Southern, and Tern) is approximately the same.

Ice roads to support gravel mines extraction activities and gravel island construction would start in December of Year 1, so they can access the mine site, haul gravel, and construct the island. The gravel extraction process would start in January of Year 2. Similar activities would be needed in Year 3 to support construction of the pipeline. Gravel hauling will be completed by the end of April both years. Gravel will be excavated by blasting, ripping, and removing materials in 20-foot lifts. Gravel will be hauled from the mine site to the gravel island location or pipeline site via ice road or existing gravel road.

The effect on air quality at the Liberty Island site from using gravel from the Duck Island mine site should be the same as for Alternative I, using gravel from the Kadleroshilik River mine site.

The differences in air-quality effects from hauling the gravel from the Duck Island mine site a greater distance than from BPXA's proposed Kadleroshilik mine site would be a slight increase in the fugitive dust from trucks traveling a greater distance and in the air emissions from truck engines operating for a longer period of time. These air emissions would remain at negligible levels and should have no significant effect on regional air quality.

5. Effects of Alternative Pipeline Burial Depths

This set of component alternative evaluates two different pipeline burial depths:

Alternative I, use a 7-foot burial depth, evaluates digging a trench 8-12 feet in depth (10.5 foot average depth) and burying the pipeline an average depth of 7-feet.

Alternative VII, use a 15-foot pipeline trench depth, evaluates the excavating a trench to a 15-foot depth, which would result in a minimum 11-foot burial depth. Key components of these alternatives are summarized in Table II.A-1.

Both of the alternatives in this set of component alternatives share the following elements.

- The pipeline system would be constructed on thickened ice during the winter within a temporary right-of-way (250 feet wide onshore, 1,500 feet wide offshore). For welding strings of offshore pipeline, workers would need a site close to shore on grounded sea ice artificially thickened, as needed, and usually in water less than 5.5 feet deep. The site would be east of the right-of-way and would hold a welding pad 6,000 feet long by 750 feet wide.
- All of the pipelines would use through-ice winter construction and use techniques that are similar to those used onshore and at Northstar Project. Trenching would use conventional excavation equipment, such as backhoes. Hydraulic dredging may be used for final smoothing of the trench bottom. (See Sec. I.H.5.b(11) for additional information and discussion about hydraulic dredging.)

Construction activities include the following (see Sec. II.A.1.(3)(a) for a more detailed description of each activity):

- mobilizing equipment, material, and workforce
- constructing the Ice road and thickening the ice
- slotting the ice
- trenching (including temporary storage and disposal of excess material)
- preparing the pipeline makeup site
- welding pipe strings
- attaching anodes
- attaching LEOS
- transporting pipe string and welding tie in
- island transition, shoreline transition
- installing pipeline
- backfilling the trench
- hydrostatic testing
- demobilizing equipment

Given that Alternative VII is essentially the same as Alternative I , except for the trench depth of 15 feet and minimum burial depth of 11 feet, the effects associated with construction of the pipeline would occur during the winter and would be short term. The impacts to the following resources essentially would be the same for both alternatives. Bowheads are not present in the area during the pipeline construction period. Terrestrial mammals and vegetation are onshore. The increased trenching activities would not alter the impacts to subsistence or to the sociocultural system, and effects are essentially the same. Air emissions associated with digging the trench deeper may be greater or last longer, but they are similar for both alternatives. Based on the conclusions of the INTEC (2000) report, this alternative would lower the failure rate for any pipeline design. However, conclusions drawn from the Fleet (2000) report indicate that failure rates will not change because operational failures are the dominant factor that effects pipeline safety. Increasing the pipeline burial depth, as well as any of the other pipeline-related alternatives, cannot eliminate the possibility of a pipeline containment failure. Neither would it change the risk of other leaks from either the facility or from the onshore pipeline. The very small reduction in the pipeline failure rates from burying the pipeline deeper does not translate into different levels of oil-spill impacts to resources evaluated in this EIS.

Both pipeline burial depth alternatives share the common elements noted above in this section. Similar types of activities will occur at about the same time and locations for both alternatives. Many resources evaluated migrate annually and would not be present during most of the island construction; therefore, the effects to bowhead whales, eiders, and marine and coastal birds are essentially the same. Other resources such as vegetation-wetland habitats and terrestrial mammals occur onshore and offshore construction effects would not differ between pipeline design alternatives. For other resources, such as seals and polar bears, subsistence-harvest patterns, and sociocultural systems, the timing and disturbance effects from construction activities for all pipeline burial depths do not result in measurable differences. The differences in quantities of sediment from trenching and backfilling do not result in measurable differences in effects on fishes. Effects of surface disturbance on archaeological resources would be the same as those discussed in Sections III.C.2.j and III.C.3.j for all alternatives. The air-quality effects occur at the same locations for both alternatives. Overall, the effects to air quality essentially would be the same for both alternatives.

- Bowhead Whales
- Eiders
- Marine and Coastal Birds
- Terrestrial Mammals
- Vegetation-Wetlands Habitat
- Subsistence-Harvest Patterns
- Sociocultural Systems

- Archaeological Resources
- Air Quality

For the reasons stated, the pipeline burial depth alternatives analysis that follows will not include effects to these resources.

a. Alternative I – Use a 7-Foot Burial Depth (Liberty Development and Production Plan)

Sections II.C.5.b and IV.C.5 describe the common elements shared by all alternatives in the set of component alternatives. Those common elements, plus the following alternative components specific to this particular pipeline design complete the description of this alternative. Note that this description was given in Sections II.C.5 and I.H.3.e. and is being repeated here for the convenience of the reader. Table II.A-1 provides a comparison of key components for the different alternatives being analyzed.

For this alternative, the pipeline trench would be 10.5 feet (3.2 meters) (BPXA, 2000a). The trench depth may vary between 8 and 12 feet (2.4 and 3.7 meters). The trench would be dug using the conventional trenching equipment and constructed on the ice surface. The minimum burial depth, assuming a single wall steel pipe is 7 feet. The trench at the seafloor would be 61-132 feet (18.5-40 meters) under for this alternative. This alternative would require excavating and backfilling approximately 724,000 cubic yards of soil (See Table II.A-2). Trenching is estimated to take about 58 days.

Any excess trenched material likely would be placed in a 5,000-foot by 2,000-foot disposal site (Zone 1). This site would be along the construction right-of-way, outside the 5-foot isobath (see Figs. II.A-18 and II.A-12).

Key components of this alternative are summarized in Table II.A-1.

As noted in Section IV.C.5, the effects to many resources are the same for both alternatives

The differences would change some of the impacts to the following resources in the ways described in the analyses that follow:

- Seals and Polar Bears
- Lower Trophic-Level Organisms
- Fishes and Essential Fish Habitat
- Economy
- Water Quality

(1) Effects on Seals and Polar Bears

(a) Large Oil Spills

The general effects of a large spill and the effects of oil-spill-cleanup activities are analyzed in Section III.C.2.b(2)(a). Seals and polar bears most likely would contact the spill in the Foggy Island Bay, and Mikkelsen Bay areas regardless of which spill scenario is assumed (Table A-1). An estimated 60-150 ringed seals (out of a resident population of 40,000) and fewer than 50 bearded seals (based on their sparse distribution in the project area) out of a population of several thousand) could be affected by the large spill. An estimated 5 to 30 bears could be lost if the spill contacted Cross Island when and where that many polar bears may be concentrated during the whale harvest. This represents a severe event. The more likely loss from Liberty development would be no more than one or two bears. The seal and polar bear populations are expected to recover individuals killed by the spill within 1 year, and there would be no effect on the population.

Amstrup, Durner, and McDonald (2000) estimated that a 5,912 barrel spill could contact 0 to 25 polar bears in open water conditions and 0-61 polar bears in autumn mixed ice conditions. The oil spill trajectories contacted small numbers of bears far more often than they contacted large numbers of bears. In October, 75% of the trajectories oiled 12 or fewer bears while in September, 75% of the trajectories oiled 7 or fewer polar bears (Amstrup , Durner, and McDonald, 2000). The median of polar bears that could be affected by a 5,912-barrel spill in October was 4.2. These results are comparable to the estimate of 5-30 bears given above. A spill from Liberty is likely to affect 12 or fewer polar bears. The polar bear population is expected to recover this likely loss within one year. Secondary effects could come from oil contaminating food sources. A spill might affect the abundance of some prey species in local, coastal areas of Foggy Island Bay where epibenthic food such as amphipods (small shrimp) concentrate, but a spill should not greatly decrease abundant food, such as the arctic cod. Local changes in the abundance of some food sources would not affect the seal populations or, in turn, affect the polar bear population in the Beaufort Sea (see Sec. III.C.f.(1)(a), effects of a large oil spill on fishes and essential fish habitat).

(b) Disturbances

The general effects of disturbances are analyzed in Section III.C.3.b(2)(a).

1) Summary and Conclusion for Effects of Disturbance on Seals and Polar Bears

Construction activity would displace some ringed seals within perhaps 1 kilometer of the production-island and along the pipeline route in Foggy Island Bay. This disturbance of seals and polar bears would be local, within about 1 mile along the pipeline route, and would persist for one season.

2) Details on How Disturbances May Affect Seals and Polar Bears- Specific Effects

Effects of Pipeline Burial: Pipeline burial would alter benthic habitat along the pipeline installation route. Seals and polar bears would be exposed to noise and disturbance from pipeline dredging and burial activities in Foggy Island Bay. This disturbance of seals and polar bears would be local, within about 1 mile along the pipeline route, and would persist for one season. Pipeline construction involves trenching, hydraulic dredging, backfilling material into the trench, and storing excess trenching material on the ice. These activities are likely to temporarily displace some seal prey organisms from the immediate area of the activities, and a few individual prey organisms could be harmed or killed. However, these effects are not expected to continue after construction is completed or to have a measurable effect on prey populations.

(2) Effects On Lower Trophic-Level Organisms

(a) Large Oil Spills

The general effects of a large spill and the effects of oil-spill-cleanup activities are analyzed in Section III.C.2.e(2)(a). Lower trophic-level organisms would be affected by a large oil spill. It would have only short-term effects on plankton, including phytoplankton, zooplankton, and epontic species on the bottom of the ice cover, but longer term effects on the fouled coastlines. As documented in Section III.C.2.e(2)(c) and Appendix A, up to 15% of the sound's coastline would be affected by a large spill. While the ice-gouged coastline is inhabited by mobile, seasonal invertebrate species that would recover within a year, fractions of the oil would persist in the sediments for about 5 years in most areas, and could persist up to 10 years in areas where water circulation is reduced. Very little of Liberty crude, which is highly viscous and particularly resistant to natural dispersion, would be dispersed down in the Stefansson Sound water column and affect deep benthic communities such as the Boulder Patch kelp habitat. However, diesel oil, which would be used on the island for startup and emergency fuel, could be dispersed down to the seafloor. If 1,500 barrels of diesel were spilled from a fuel-delivery barge at the island during the open-water season, the concentration would be toxic within an area of about 18 square kilometers (7 square miles), as noted in the water quality section (III.A.2 (l)). Such toxicity would probably stunt the seasonal growth of kelp plants and reduce the population size of associated invertebrates for several years. Oil-spill responses in general would have both beneficial effects of some and adverse effects on other lower trophic-level organisms.

(b) Disturbances

The general effects of disturbances are analyzed in Section III.C.3.e(2)(a).

1) Summary and Conclusions for Effects of Disturbances on Lower Trophic-Level Organisms

Alternative I would disturb lower trophic-level organisms in two primary ways: (1) pipeline trenching would bury up to 14 acres with very low (1%) coverage of kelp, boulders, and suitable substrate; and (2) sediment plumes would reduce Boulder Patch kelp production by up to 6% during 1 year. The buried 14 acres would equal less than 0.1% of the Boulder Patch kelp habitat. The density of the kelp, boulders, and suitable substrate in the pipeline corridor is very low, averaging about 1% coverage, and the lost kelp biomass and production probably would be less than .01% of the Boulder Patch totals, but the effect (substrate burial) would last forever.

Some of the suspended sediment from pipeline trenching and island construction would drift over other parts of the Boulder Patch, reducing light penetration and kelp production during 1 year. This reduction is estimated to be less than 6%, about one-third of which would be due to the proximity between the Boulder Patch to the Zone 1 disposal area for excess sediments. However, in relation to the large range of natural variability, all of these suspended sediment effects would be barely detectable.

From 6 feet deep to the seafloor, the island's concrete slope would temporarily benefit kelp and other organisms that need a hard substrate for settlement. This portion of the concrete slope would be a temporary home for colonies of species similar to those of the Boulder Patch area. Upon abandonment, the concrete mats would probably be removed or would become buried naturally, eliminating the additional kelp habitat.

2) Details on How Disturbances May Affect Lower Trophic-Level Organisms

a) Specific Effects from Island Construction

Construction of Liberty Island would alter the seafloor habitat permanently and would kill the benthic animals living there. Underwater surveys show the seafloor at the Alternative I site is silty mud and contains less than 10% rock cover, similar to most of the Beaufort Sea's floor (Fig. III.C-1). Placing gravel to construct Liberty Island would kill the benthic invertebrates occupying about 28 acres of this habitat. Similar amounts of benthos were buried during construction of several exploration islands in Stefansson Sound during the past two decades, including Tern, Duck, Endeavor, BF-37, Niakuk, Goose, and Sag islands. The 28 acres would be relatively small compared to the area that was affected by the Endicott causeway and Northstar pipeline that were constructed within this same region and depth range. We agree with the concluding statements in the Northstar EIS about the project effect on benthic infaunal and epifaunal invertebrates aside from those in the Boulder Patch kelp community:

> The trenching for the pipeline will impact both infauna and epifauna through direct physical disturbance, burial with sediment, or from increased turbidity in the surrounding water. Trenching the shallow waters of the lagoon would have a negligible effect on benthic invertebrates.

> Impact to marine invertebrates in deeper waters would be considered minor because of the rapid recolonization and geographic range of these species (U.S. Army Corps of Engineers, 1999:6-29).

However, the level of effect for Liberty would be alternative-specific because the use of the existing Tern Island would affect less benthos.

Island construction also would increase the amount of under-ice suspended sediment in the water column. Because of the prevailing under-ice currents in this area, a sediment plume from island construction would drift east or west in line with the isobaths. If the plume drifted west, it would drift over the kelp in the Boulder Patch, depositing a thin blanket of sediment over the kelp and reducing the amount of light for growth (Fig. III.C-2). An under-ice plume from construction that drifted west toward the Boulder Patch probably would affect up to 105 acres (BPXA, 1998a:5-8). Because the more productive rocky areas are widely scattered, the plume is likely to affect less than 105 acres of productive Boulder Patch habitat. The heavier sediments should settle out within one-half mile of the island and are not expected to reach the Boulder Patch. Sediments larger than clay-sized particles are likely to settle out within 3-7 miles of the construction area (USDOI, MMS, Alaska OCS Region, 1998a:8). Sediments that reach the Boulder Patch are likely to reduce the amount of light for marine kelp living in rocky bottom areas. This was the primary concern regarding the health and growth of Boulder Patch kelp communities during winter (USDOI, MMS, Alaska OCS Region, 1998a).

Storms and river discharges place a lot of sediment into the waters of the Boulder Patch area. These discharges, plus variations in snow cover, annually make up to two-thirds of the winter ice in this area uninhabitable for ice algae (there is not enough light). This results in naturally fluctuating growth rates for Boulder Patch kelp communities. The plume from construction could reduce kelp growth in some rocky bottom areas where clear-ice conditions exist. This possibility was considered in a recent analysis by Gallaway, Martin, and Dunton (1999:16-18), which is based partly on field observations during construction of the BF-37 gravel island. They concluded that under worst-case conditions:

- Island construction may reduce kelp production in the Boulder Patch by 2%.
- No changes are expected in the health or distribution of Boulder Patch communities.
- The effects of island construction would be limited to 1 year and would constitute short-term impacts.

We believe that the above conclusions are conservative, and that they were based on the appropriate model methods, calculations, and assumptions. Hence, any effects due to island construction are expected to fall within the range of natural variation for Boulder Patch kelp communities. Any reduction in the amount of light due to island construction is expected to be very small and is not expected to have a measurable effect on kelp communities in the Boulder Patch. Any sediment accumulating on kelp from construction would probably be washed away by currents, as observed natural sediment accumulations.

b) Specific Effects from Pipeline Construction

Pipeline construction would involve about 6 miles of trenching and backfilling in marine waters along the pipeline corridor. There would be alternative-specific effects from both suspended sediments and trenching.

Suspended Sediments: Pipeline construction also would increase the amount of suspended sediment in the water column during winter trenching and backfilling (Fig. III.C-3) and during the natural dispersal at breakup of any excess sediment that is stored on the ice (Fig. III.C-4 and -5). The dense part of the plume is predicted to move less than 1,000 feet along-shore to the west or east, as indicated partly by BPXA measurements during preparation of the Northstar test trench. The plume from pipeline construction could reduce kelp growth in some rocky bottom areas where clear-ice conditions exist. This scenario was considered also by Gallaway, Martin, and Dunton (1999) and Ban et al. (1999). They concluded that under worst-case conditions:

- Suspended sediments from pipeline trenching may reduce kelp production in the Boulder Patch by 4% (Fig. III.C-1), and the excess-sediment stockpiled on the ice cover (Fig. III.C-5) may reduce it by another 2%. In other words, about one-third of the effect would be due to the proximity between the Boulder Patch and disposal zone.
- No changes are expected in the health or distribution of Boulder Patch communities.
- The effects from construction would be limited to 1 year and would constitute short-term impacts.
- The effects of pipeline repair, if necessary, probably would be site specific and less than the construction effects.

The effects would probably be less than these worst-case predictions, as indicated by some recent field measurements during construction of Northstar pipeline in late April 2000 (Trefry, 2000, pers. commun.). The measurements were made at six sites in the Northstar area, two of which were within a couple hundred meters east and west of the pipeline corridor while the trench was being backfilled. The measurements included three water samples and a turbidity profile at each site. In spite of the backfilling, the sampled water appeared to be low with less than 0.5 milligrams per liter of sediment (Trefry, 2000, pers. commun.).

One reason that the measurements were lower than the predictions is that some of the dredged sediment probably froze before it was used as backfill over the pipeline. Hence, any effects due to suspended sediments from pipeline construction are expected to fall within the range of natural variation for Boulder Patch kelp communities.

Trenching: Some benthic plants and animals would be disturbed by pipeline trenching (Sec. II.A.1.b(3)(a)(4)). Most of the seafloor in the project area is covered with sandy/silty sediments that are disrupted naturally by the ice cover and strudel scour (BPXA, 1998a:Sec. 4.6). The resident organisms in the silty/sandy sediments generally are small and short-lived, and we agree with the conclusion in the Northstar Final EIS that "natural re-population of the trench area by infaunal invertebrates is expected within a few years" (U.S. Army Corps of Engineers, 1999:6-26).

The BPXA Environmental Report also describes the Boulder Patch and the diverse community of organisms associated with the kelp and solid substrate. The report notes that there is diffuse kelp and solid substrate in the outer section of the pipeline corridor (BPXA, 1998a:Secs. 4.6.3 and 5.2.5). The kelp and solid substrate occurs in a 4,700-foot section that is diagramed in Figures III.C-1and 5, Surveys for Boulders and Kelp. A similar map was prepared for a BPXA report on construction effects on Boulder Patch kelp production (Ban et al., 1999); the map clarifies the location and distribution of dense kelp near the Alternative I island site. The band's location and distribution indicate that the light kelp that is illustrated in Figure III.C-1 probably is the shoreward, marginal end of the dense band that is illustrated in the report by Ban et al. (1999). The map that was prepared by Ban et al. is redrawn as Figures III.C-2 through 4 and is used as the base map for our assessment of alternatives.

After the Environmental Report was prepared (BPXA, 1998a), additional side-scan and video surveys were conducted along the 4,700-foot section. The investigators summarized the preliminary results during the MMS Arctic Kelp Workshop in May 1998 (USDOI, MMS, Alaska OCS Region, 1998), and the final results were summarized in a July 1998 report to BPXA (Coastal Frontiers Corp., 1998). The report explains that the video detected scattered bivalve shells, pebbles, and rocks, some of which were found to have small pieces of kelp attached. It also explains that the "concentrations of these objects appeared to represent less than 1% of the sea bottom in most instances, and in no case greater than 2%" (Coastal Frontiers Corp., 1998:16). Figure III-C.2 shows that the distance to a portion of the Boulder Patch with a concentration over 10% is at least 1,600 feet (500 meters). So, the average density of kelp and solid substrate in the 4,700-foot long section was assumed to be 1% for the following assessment of trenching effects.

The width of the area that would be disturbed by trenching would be related mainly to the amount of slumping on the sides of the trench. The Plan explains that the slump or slope angle would be 3:1 typically (extending three times the trench depth to each side) but that the excavation limits could be up to 5:1 in unconsolidated sediments (Fig. II.A-12 and BPXA,2000a:Fig. 8-4 and p. 71). The 5:1 ratio means that the overall disturbed area could be up to 10 times the trench depth plus the bottom width of the trench. Therefore, the bottom of the trench for Alternative I would be up to 12 feet deep and 12 feet wide (Fig. II.A-12 and Table II.A-1), and the overall width at the top would be up to 132 feet.

The boulders with kelp near the center of the Boulder Patch lie at the sediment surface in a layer that is very thin, "no more than one boulder thick" (Dunton, Reimnitz, and Schonberg, 1982). We assume that the solid substrate with kelp that lies in the pipeline corridor is no different, that it also lies at the sediment surface in a layer that is very thin. After trenching, if the solid substrate could be returned to the sediment surface, it probably would be recolonized by kelp in a decade (Martin and Gallaway, 1994). However, the operation probably could not return the kelp and solid substrate to the sediment surface, and the only natural process that might return it to the surface would be gradual erosion over geological time scales.

In summary, trenching would bury up to 611,000 square feet or 14 acres of kelp and solid substrate at very light densities. The 14 acres can be compared with the total area of the adjacent Boulder Patch. The area in which kelp and solid substrate exceed 10% coverage recently was estimated as 64 square kilometers, or 15,871 acres (Ban et al., 1999). Therefore, the buried 14 acres would equal less than 0.1% of the Boulder Patch area. Furthermore, the concentration of kelp in the Boulder Patch is more than 10 times that in the pipeline corridor, so the lost kelp biomass and production probably would be less than 0.01% of the total.

The burial of kelp and solid substrate in the pipeline corridor would be mitigated partly by a countervailing effect—the creation of a new kelp habitat on the concrete blocks in the island's slope-protection system (Sections III.C.1.b(5) and III.D.3.e(2)(a)). The concrete blocks below the ice-scour depth (6 feet) would add about 3 acres of kelp habitat. However, this new kelp habitat might be temporary because the slope-protection materials might be removed during the abandonment phase in 15-20 years, as noted in Section III.D.6e(2)(b) of this EIS and Section 15 of the Plan (BPXA, 2000a). BPXA could also mitigate some trenching effects if excess quarry boulders were placed on the backfill in the outer portion of the trench. The quarry boulders would probably reduce the longevity of trenching effects from permanent ones to decade-long ones because a Boulder Patch study showed that bare rocks were colonized by kelp within a decade. Future unanticipated effects on kelp could be moderated by Lease Sale Stipulation No. 1, Protection of Biological Resources. The stipulation explains that MMS may require additional biological surveys and, based on the surveys, may require the lessee to "modify operations to ensure that significant biological populations or habitats deserving protection are not adversely affected."

(3) Effects on Fishes and Essential Fish Habitat

The general effects of a large spill and the effects of oil-spill-cleanup activities are analyzed in Section III.C.2.f.

The general effects of disturbances are analyzed in Section III.C.3.f.

(a) Fishes

Noise and discharges from dredging, gravel mining, island construction, island reshaping, and pipeline trenching associated with Liberty are expected to have no measurable effect on fish populations. While a few fish could be harmed or killed, most in the immediate area would avoid these activities and would be otherwise unaffected. Effects on most overwintering fish are expected to be short term and sublethal, with no measurable effect on overwintering fish populations. Placement of the concrete mat would create additional food resources for fishes and, thereby, would have a beneficial effect on nearshore fish populations in the Beaufort Sea.

(b) Essential Fish Habitat

As a result of disturbances caused by Liberty Island construction and operation, fish and zooplankton might experience short-term, localized but unmeasurable effects. This would include potential adverse effects from noise during construction and operations and from increased turbidity and sedimentation as a result of dredging, gravel mining, island construction, and pipeline trenching (Secs. III.C.3.e and III.C.3.f). Marine plants could be subjected to short-term, localized, negative effects due to mechanical removals of individuals and from sedimentation resulting from pipeline trenching and island construction (Sec. III.C.3.e). Pipeline construction is expected to bury up to 14 acres of kelp and solid substrate, and sediment plumes are expected to reduce kelp production by 6% during 1 year (Sec. III.C.3.e). The effect of disturbance on water quality is discussed in Section III.C.3.l. Water quality would be primarily affected by increased turbidity that would result from gravel island and pipeline construction, Liberty Island abandonment, and gravel mine reclamation. Turbidity and salinity of seawater discharged from the Liberty Island production facility are expected to be slightly higher than water in surrounding Foggy Island Bay (Sec. III.C.3.l). All of these disturbances are expected to be fairly localized and short term.

(4) Effects on the Economy

The general effects of a large spill, oil-spill-cleanup activities, and disturbances are analyzed in Sections III.C.2.k and III.C.3.k.

The Liberty Project would generate approximately the following economic benefits related to Alternative I:

- $100 million in wages and 870 full-time equivalent construction jobs for 1 year in Alaska during 14-18 months of construction
- 1,248 indirect full-time equivalent jobs during the 14-18 months of construction.

(5) Effects on Water Quality

(a) Large Oil Spills

The general effects of a large spill and the effects of oil-spill-cleanup activities are analyzed in Section III.C.2.l(2)(a). During open water, hydrocarbons dispersed in the water from a large (greater than 500 barrels) crude oil spill could exceed the 0.015-parts per million chronic criterion for 10-30 days in an area that ranges from 30-45 square kilometers (11.6-17.4 square miles) to 51-186 square kilometers (19.7-71.8 square miles). Hydrocarbons in the water could exceed the 1.5-parts per million acute (toxic) criterion during the first day in the immediate vicinity of the spill. A large crude oil spill in broken sea ice or when the sea ice melts could exceed the chronic criterion for several days in an area of about 7.6 square kilometers (2.9 square miles). Hydrocarbons from a large diesel spill during open water could exceed the acute (toxic) criterion for about 7 days in an area of about 18 square kilometers (7 square miles). During broken sea ice or melting ice conditions, a large diesel spill could exceed the acute (toxic) criterion for about 1 day in an area of about 1 square kilometers (0.4 square mile) and the chronic criterion for more than 30 days in an area of about 103 square kilometers (39.8 square miles). The effects from a spill occurring under the ice would be similar to those described for broken ice or melting conditions; the oil would be trapped and essentially remain unchanged until breakup occurred and the ice began to melt.

A large crude or refined oil spill (greater than or equal to 500 barrels) would significantly affect water quality by increasing the concentration of hydrocarbons in the water column to levels that greatly exceed background concentrations; however, the chance of a large spill occurring and oil entering the offshore waters is estimated to be about 1%. Also, regional (more than 1,000 square kilometers [386 square miles]), long-term (more than 1 year) degradation of water quality to levels above State and Federal criteria because of hydrocarbon contamination is very unlikely.

(b) Disturbances

The general effects of disturbances are analyzed in Section III.C.3.l(2)(a).

1) Summary and Conclusions for Effects of Disturbances on Water Quality

The greatest effect on water quality from gravel island and pipeline construction would be additional turbidity caused by increases in suspended particles in the water column. Increases in turbidity generally are expected to be considerably less than the 7,500 parts per million suspended solids used in the analysis as an acute (toxic) criterion for water quality; exceptions may occur within the immediate vicinity of the construction activity. Turbidity increases from construction activities generally are temporary and

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expected to occur during the winter and end within a few days after construction stops. Material excavated from the pipeline trench but not used for backfill most likely would be left in an area where active erosion of sediment particles could occur during breakup and open water. This material would be similar in composition to seafloor sediments in the trenching and disposal areas, and its contribution to future turbidity from waves and currents is expected to be about the same as the sediments existing at the seafloor surface before pipeline construction. Construction activities are not expected to introduce or add any chemical pollutants.

2) Details on How Disturbance May Affect Water Quality

The following analysis is a summary of the effects Liberty Island and Pipeline construction would have on water quality in Foggy Island Bay and is based on the following information and analysis:

- scenario assumptions in Table II.A-1
- general effects of disturbances on water quality in Section III.C.3.l(2)(a)
- specific effects of disturbances on water quality in Section III.C.3.l2(b).

a) Specific Effects of Constructing the Production Island

The Liberty Island would be constructed in water about 21 feet deep using an estimated 773,000 cubic yards of gravel mined from a permitted site on the Kadleroshilik River floodplain; the gravel is not expected to contain any contaminated material. The gravel would be trucked to the Liberty site over ice roads and dumped into the water through openings cut in ice; this activity is estimated to take from 45-60 days. Dumping river gravel would affect water quality by increasing the amount of suspended-particulate matter in the water column in the area below the floating fast ice in several ways, including (1) suspension of sediments by currents generated from the gravel hitting the seafloor and (2) separation of fine-grained particles from the material falling through the water.

The effects of seafloor sediments suspended in the water column from dumping gravel and pipeline construction are assumed to be similar. The effects of suspending the seafloor sediments during pipeline construction are analyzed in Section III.C.3.l(2)(b)2). Seafloor sediments in Foggy Island Bay consist mainly of fine sand-, silt-, and clay-size particles (Sec. VI.C.1.c(2)). The concentration of suspended sediments associated with trench excavation and backfilling are estimated to range from 500-1,000 milligrams per liter near the seafloor and 50-100 milligrams per liter near the surface (URS Corporation, 2000). Concentrations of suspended particles generally decrease as the distance from the disturbance increases. The larger and/or denser particles settle closer to the source, while the smaller and/or less dense particles are carried farther. Suspended sediment concentrations at 1 and 10 kilometers are expected to be less than 20 and 10 milligrams per liter, respectively. See Section III.C.3.l(2)(b)2) for a more complete analysis of the effects of suspending the seafloor sediments in Foggy Island Bay during pipeline construction.

When the dumped gravel forms the base of Liberty Island and covers the seafloor and as height of the build up increases the effects of gravel dumping on suspending seafloor sediments will decrease.

As the dumped gravel falls through the water column, some of the fine-grained particles would separate from the mass and remain suspended: this amount is estimated to range from 10-12%. Ice-bonding of particles will likely reduce the amount of fine-grained particles that actually separates from the dumped mass.

At the assumed maximum dumping rate of 20,000 cubic yards per day the suspended sediment concentration in the immediate vicinity of the dumping activity is estimated to be 250 milligrams per liter. The concentration of particles suspended in the water decreases with distance from the source. If the current speed is 2 centimeters per second (0.04 knot), the concentration of suspended particles would be reduced to 50 milligrams per liter at a distance of 0.5 kilometer (0.3 mile) from the construction site, 20 milligrams per liter at 1.25 kilometers (0.78 mile) distance, and 10 milligrams per liter at 1.5 kilometers (0.93 mile). The suspended-sediment plume width at the 10-milligram-per-liter concentration interval is estimated to be 400 meters. The suspended-sediment plume is a temporary feature and would disappear within a few days after island construction is complete. The thickness of the depositional layer decreases with distance from the island construction site.

The increase in turbidity as a result of summer grading and shaping the island’s surface and subsurface slope, placement of the slope-protection systems and maintenance of the slope-protection systems during the life of the island is expected to be short term, lasting only as long as the activity, and greatest in the vicinity of the island. Turbidity increases are not expected to be greater than the turbidity cased by currents and waves resuspending sediment particles in shallow water areas.

b) Specific Effects of Constructing the Pipeline

The pipeline trench, about 6.1 miles long, would be dug with backhoes in the winter from the sea ice covering Foggy Island Bay. The average trench depth would be 10.5 feet; the range would be from 8-12 feet. An estimated 724,000 cubic yards of sediments would be excavated from the trench, and most of it would be used as backfill. Pipeline backfilling would take an estimated 37 days. Excavated material not used as backfill would be left on the ice to return to the seafloor by natural processes during spring breakup. Seafloor sediments in Foggy Island Bay consist mainly of fine sand-, silt-, and clay-size particles.

Pipeline construction would affect water quality by increasing suspended-particulate matter in the water column mainly in the area below the floating fast ice in the winter and in the vicinity of the area where excess trench material lies during the open-water period. Trenching would disturb and resuspend the seafloor sediments in those areas beneath the ice where the sea water has not frozen to the seafloor. Dumping excavated material into the water column to fill the trench also would cause some of the fine-grained particles to separate from the descending sediment mass and remain in suspension.

Both trenching and backfilling operations are likely to be performed at the same time along the pipeline route. In the floating fast-ice zone, suspended sediments generated from these operations could form a turbidity plume in the presence of currents in the water column between the bottom of the floating ice and the seafloor surface.

For one study, the initial suspended-sediment concentration in the water column during pipeline construction is estimated to be 1,000 milligrams per liter. The amount of suspended particles in the water column would decrease with distance from the construction area. If the current velocity is 0.02 meter per second (0.04 knot), suspended-sediment concentrations greater than 100 milligrams per liter are estimated to occur within 0.75 kilometer (0.46 mile) of the trench. Concentrations of 20 and 10 milligrams per liter are estimated to be reached at distances of about 1 kilometer (0.62 mile) and 10 kilometers (6.2 miles), respectively, from the trench.

In another study, URS Corporation (2000) estimates initial suspended sediment concentrations from pipeline construction could range from 500-1,000 milligrams per liter near the seafloor and 50-100 milligrams per liter at the surface. (This study was done to improve the capability to predict the effects of Liberty development construction on the Boulder Patch Community. The previous analysis assumed an initial suspended sediment concentration of 1,000 milligrams per liter was uniform throughout the water column.) If the initial concentrations are less than 1,000 milligrams per liter, suspended sediment concentrations at 1 and 10 kilometers could be less that the 20 and 10 milligrams, respectively, estimated previously. Fine-grained particles (silt- and clay-size particles) are estimated to comprise about 65% of the material excavated from the trench.

Excavated trench material will be stored in two areas; a 230-acre site in waters 5-10 feet deep about 4 miles southwest of the Liberty site (Zone 1, Fig. II.A-18) and along the proposed pipeline route (Zone 2, Fig. II.A-18). Trench sediments would be stockpiled in different parts of the 230-acre site and graded to an average thickness of about 1 foot to minimize the potential for mounding on the seafloor.

After the pipeline has been buried, the amount of material stored on the ice is estimated to be about 100,000 cubic yards in the 230-acre site and 10,000 cubic yards along the northern part of the proposed pipeline route.

These sediments could return to the water column in any number of ways that might include:

- sinking to the seafloor directly beneath the ice pad as the ice melts in place;
- dumping into the water when the melting ice becomes unstable and overturns;
- eroding of particles by waves in open-water areas;
- melting and transporting of particles by meltwater in the frozen material; or
- melting, eroding, and transporting of particles during river flooding of the fast ice.

Depending on weather, ice conditions and breakup, and river flood stage, natural removal of the stockpiled sediments could take up to several weeks.

When the material stockpiled on the ice returns to the seafloor, some of the fine-grained material would be suspended in the water column. The effects on water column turbidity are estimated by assuming all stockpiled material falls from the ice in 24 hours, 10% of the material would be suspended in the water column, and a current of 0.05 meter per second (0.1 knot) transports the water in a northerly direction. Based on these assumptions, the suspended-sediment concentration below the 230-acre site is estimated to be 1,168 milligrams per liter, and below the storage area adjacent to the northern part of the proposed pipeline it is estimated to be 14 milligrams per liter. The suspended-sediment concentrations decrease with distance from the storage sites. Concentrations of 200, 20, and 10 milligrams per liter are estimated to occur at about 0.5 kilometer (0.3 mile), 2.75 kilometers (1.70 miles), and 7 kilometers (4.3 miles), respectively, from the 230-acre site. These estimates probably represent maximum suspended-sediment concentrations over 1 or 2 days. If the return of the stockpiled material takes more than a day, suspended-sediment concentrations could be reduced and/or last for a longer period. In addition, exposure to subfreezing temperatures would freeze the particles together and reduce some particle separation when the stockpiled material returns to the seafloor. The suspended concentration estimates are based on no ice bonding of particles and, thus, estimate possible maximum concentrations.

During broken-ice conditions or open water, winds from the east force the nearshore waters to move in a westerly direction parallel to the bathymetry; the characteristics of Beaufort Sea coastal winds are summarized in Section III.C.2.l(2)(a). Under these conditions, particles in the turbidity plume from the Zone 1 spoils area would be deposited in an area that extends in a northerly direction from the spoils site (Fig. III.C-5). Westerly winds force the nearshore waters to move in an easterly direction parallel to the bathymetry. Under these conditions, particles in the turbidity plume from the Zone 1 spoils area would be deposited in an area that extends in an easterly direction from the site of the excess trench material (Fig. III.C-5).

The thickness of the layer formed by excess trench material falling to the seafloor would be greatest in the vicinity of the storage area and would decrease with distance. The areal extent and thickness of this layer were calculated from a sediment deposition model (URS Greiner Woodward Clyde, 1998a). Within 400-530 meters of Zone 1, the layer formed by excess trench material falling to the seafloor would decrease to a thickness of 10 millimeters. The layer would have a thickness of 1 millimeter within 10-13 kilometers (6.2-8.1 miles) under easterly winds and within about 6.1 kilometers (3.8 miles) under westerly winds. Within 170-180 meters of Zone 3, the layer formed by excess trench material falling to the seafloor would decrease to a thickness of 1 millimeter.

The areal extent of the turbidity plume formed by the falling excess trench material could be approximated by considering where some of the smallest particles might be deposited. Particles 0.005 millimeter in diameter would be deposited at distances of about 13-18 kilometers (8-11 miles) from the Zone 1 site; the thickness of the deposits at these distances is calculated to be about 0.02 millimeter under easterly winds and 0.01 millimeter under westerly winds. Particles 0.005 millimeter in diameter would be deposited at distances of about 18-56.5 kilometers (11-35 miles) from the Zone 3 site; the thickness of the deposits at these distances is calculated to be about 0.001-0.002 millimeter under easterly winds and 0.001 millimeter under westerly winds.

Depending on wind and wave conditions, the fine-grained particles in the excess trench material on the seafloor could be resuspended. Foggy Island Bay is a dynamic environment where a number of phenomena interact to produce changes in the seafloor. These phenomena include winds and storms, sea ice, and river flooding of the nearshore ice. If all or most of the excess trench material returns to the seafloor in the vicinity of the storage site a layer, or scattered layers, or variable thickness could form. The layer(s) would consist of a heterogeneous mixture of clay, silt, sand and gravel-size particles similar to the grains-size composition of present-day surface sediments. Multiyear satellite images suggest the turbidity in coastal waters in mid- and late summer are, for the most part, associated with wave-induced resuspension of cohesionless muddy sediments from shallow-water regions. The contribution of the trench material to the background suspended-sediment concentration likely would be about the same as that of the area into which the sediments were dumped.

Pipeline trenching and backfilling are not likely to increase the amount of trace metals or hydrocarbons into the environment above the naturally occurring background concentrations.

c) Specific Effects of Repairing the Pipeline

Damage to the pipeline would require repairs, which would mean excavating the trench to expose the pipeline. Repair work most likely would be done in the winter when the ice is stable enough so that it can be thickened to support the repair equipment or during the open-water period (Table II.C-6).

The types of effects associated with excavating and backfilling would be the same as those analyzed for pipeline construction. These activities would affect water quality by increasing suspended-particulate matter in the water column in the area of the activity. In the winter, if the repair work takes place in the bottomfast-ice zone, there would be very little, if any, effects in the water column. If the repair work takes place in the floating fast-ice zone, the effects would be in the water column mainly in the area below the floating ice.

Depending on the type of repair, the amount of sediment excavated could range from 1,150-6,490 cubic yards. The rate at which the trench backfill material would be removed is likely to be less than the rate at which sediment was excavated to form the trench. An estimated 10-15 days would be required to excavate 6,490 cubic yards (Table II.C-7). Repair excavation would take place in a small area, and the size of the associated turbidity plume is expected to be smaller than the one formed during the initial trench excavation. In the winter, the excavated material would be stored on the ice and used as backfill when the pipeline repair is finished. During the open-water period, the excavated material would be placed on the seafloor alongside the trench and used as backfill when the pipeline repair is completed.

b. Alternative VII – Use a 15-Foot Trench Depth

Sections II.C.5.b and IV.C.5 describe the common elements shared by all alternatives in the set of component alternatives. Those common elements, plus the following alternative components specific to this particular pipeline design complete the description of this alternative. Note that this description was given in Section II.E and is being repeated here for the convenience of the reader. Table II.A-1 provides a comparison of key components for the different alternatives being analyzed.

For this alternative, the pipeline trench (Fig. II.C-10) would be 15 feet (4.6 meters) deep rather than the proposed 10.5 feet (3.2 meters) (BPXA, 2000a:Sec. 8.3 and BPXA, 1998b:Sec. 3.9.3). This alternative assumes the trench would be dug using the same equipment and constructed on the ice surface, the same as for the other alternatives. For purposes of analysis, we assume an 11-foot minimum burial depth, regardless of the pipeline route or pipeline design. The trench at the seafloor would be 120-200 feet (36.5-61 meters) wide. This greater width would be needed for the 6.1 miles (9.8 kilometers) of offshore pipe. Table II.C-3 provides information about the trench excavation and backfill quantities for this alternative in combination with the three pipeline routes evaluated in this EIS.

This alternative would require excavating approximately 1,438,560 cubic yards of soil, which almost doubles (98%) the quantity the amount of soil excavated in Alternative I. For the three alternative pipeline designs, the increases in quantity of trench material excavated would be 158% for Alternative IV.A, 113% for Alternative IV.B, and 188% for Alternative IV.C. The additional excavation work would add trenching time of about 30 days. Increasing the number of days needed for trenching also increases the number of days required for ice maintenance. This alternative would add to the risk of not completing the installation of the pipeline in a single winter construction season because of increased excavation and backfill handling.

Excavating and backfilling the deeper trench would produce a larger amount of excess trenched material. This trenched material likely would be placed in a 5,000-foot by 2,000-foot disposal site (Zone 1). This site would be along the construction right-of-way, outside the 5-foot isobath. A wider trench could mean a slightly larger disposal site. Zone 1 is large enough disposal sites to handle the additional volume of trench material (see Fig. II.A-18).

Using the techniques for excavating the trench described in Section II.A.1.b.(3)(a)4), this alternative might require more use of a hydraulic dredge to clean out the trench. See Section I.H.5.b.(a)) for additional information about hydraulic dredging.

Table II.C-3 provides information about the different excavation volumes for each of the different pipelines. The table also provides information about the excavation volume and area of surface disturbance for each of the different pipeline designs.

Fleet's analysis (Fleet, 2000) of failure probabilities indicates that operational failures are by far the most significant concern to pipeline risk. Because the probability of operational failure is not affected by burial depth, Fleet's analysis also indicates that increasing burial depth from 5 to 7 feet does not reduce the probability of failure. It can be inferred that because the probability of a containment failure does not decrease when burial depth is increased from 5 to 7 feet, it also would not decrease appreciably when burial depth is increased from 7 to 11 feet. This is because operational failure is the most significant hazard for any of the pipeline alternatives and the significance of all other hazards, except for thaw subsidence, decrease as burial depth increases.

As noted in Section IV.C.5, the effects to many resources are the same for both alternatives.

The differences would change some of the impacts to the following resources in the ways described in the analyses that follow:

- Seals and Polar Bears
- Lower Trophic-Level Organisms
- Fishes and Essential Fish Habitat
- Economy
- Water Quality

(1) Effects on Seals and Polar Bears

(a) Large Oil Spills

The general effects of a large spill and the effects of oil-spill-cleanup activities are analyzed in Section III.C.2.b(2)(a). The effects of a large spill on seals and polar bears for this alternative are expected to be the same as under Alternative I in Section IV.C.5.b.

(b) Disturbances

The general effects of disturbance are analyzed in Section III.C.3.b(2)(a).

1) Summary and Conclusions for Effects of Disturbances on Seals and Polar Bears

Burying the offshore pipeline deeper would double the amount of benthic habitat altered by pipeline installation. This alternative would increase the amount of time that seals and polar bears would be exposed to noise and disturbance from pipeline dredging and burial activities in Foggy Island Bay. The disturbance of seals and polar bears would be local, within about 1 mile along the pipeline route, and would persist for one season.

2) Details on How Disturbances May Affect Seals and Polar Bears- Specific Effects

Pipeline Burial: Under this alternative, burying the offshore pipeline deeper would double the amount of benthic habitat altered by pipeline installation. This alternative would increase the amount of time that seals and polar bears would be exposed to noise and disturbance from pipeline dredging and burial activities in Foggy Island Bay, because a deeper trench would take longer to dredge and backfill over the pipeline. The general disturbance of seals and polar bears would be local, within about 1 mile along the pipeline route, and would persist for one season. The general effects of oil spills are expected to be the same as under Alternative I. The overall effect of this alternative would be about the same as for Alternative I.

(2) Effects on Lower Trophic-Level Organisms

(a) Large Oil Spills

The general effects of a large spill and the effects of oil-spill-cleanup activities are analyzed in Section III.C.2.e(2)(a). The general oil-spill risk to these organisms

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would be about the same with deeper pipeline burial and with the Alternative I pipeline-burial depth, because the main risk in both cases would come from spills of diesel fuel rather than Liberty crude.

(b) Disturbances

The general effects of a disturbances are analyzed in Section III.C.3.e(2)(a).

1) Summary and Conclusion for Effects of Disturbances on Lower Trophic-Level Organisms

There would be specific differences in the disturbance effects. The disturbance effects of deeper pipeline burial would be greater than the effects of Alternative I in two important ways: (1) deeper burial in the Alternative I pipeline route would permanently eliminate 3 additional acres of very diffuse kelp, boulder, and suitable substrate; and (2) the amount of turbidity generated by deeper burial would be about two times greater than for Alternative I, possibly causing additional reduction in annual kelp production during the construction phase. These effects of deeper burial would be the same for the alternate island design (steel sheetpile). There is no kelp or solid substrate in the eastern or Tern pipeline corridors, so deeper burial there would not eliminate additional kelp habitat, however, the additional suspended sediments possibly would cause additional reduction in annual kelp production during the construction phase.

2) Details on How Disturbances May Affect Lower-Trophic-Level Organisms

Burial of the pipeline deeper would require a substantially deeper trench than Alternative I—an average depth of 15 feet rather than about 8 feet (Table II.A-1). The deeper trenching would remove the scattered kelp and solid substrate from the sediment surface in an area up to 160 feet wide, or from 17 acres. In other words, burying the pipeline deeper in the Alternative I pipeline route would eliminate 3 additional acres of very diffuse kelp and solid substrate than with the Alternative I pipeline. The effect would be the same with alternate island designs (steel sheetpile). However, there is no kelp or solid substrate in the eastern or Tern Island pipeline routes, and burying the pipeline deeper with either of those island/route alternatives would not affect kelp habitat.

The deeper trench would cause about two times as much suspended sediment during construction. The effects of suspended sediment on kelp production in the Boulder Patch were analyzed by Ban et al. (1999). They concluded that suspended sediments from the Alternative I pipeline route would drift northwest over the Boulder Patch, reducing annual kelp production by about 6% for 1 year; therefore, deeper burial potentially would reduce it further. As explained for Alternative I, kelp would colonize the new slope-protection system on the island, providing some mitigation of the project effects. BPXA also could mitigate some trenching effects, if excess quarry boulders were placed on the backfill in the outer portion of the trench. Any unanticipated effects on kelp could be mitigated by Lease Sale Stipulation No. 1, Protection of Biological Resources.

(3) Effects on Fishes and Essential Fish Habitat

The general effects of a large spill, oil-spill-cleanup activities, and disturbances are analyzed in Sections III.C.2.f and III.C.3.f.

(a) Fishes

Alternative VII would be expected to have a slightly greater effect on fishes than Alternative I, due to more trenching and disturbance. Overall, this would not be expected to result in measurable differences in effects on fishes over that of Alternative I. Oil-spill effects would remain unchanged from those of Alternative I.

(b) Essential Fish Habitat

The potential adverse effects of this alternative on essential fish habitat could be slightly increased compared to Alternative I. The risk of oil spills to essential fish habitat would be unchanged. However, deeper burial in the proposed pipeline route would permanently eliminate about 3 more acres of diffuse kelp and solid substrate. Moreover, the amount of suspended sediments from deeper burial would be about two times greater than for Alternative I, possibly causing additional reduction in annual kelp production during the construction phase.

(4) Effects on the Economy

The general effects of a large spill, of oil-spill-cleanup activities, and disturbances are analyzed in Sections III.C.2.k and III.C.3.k.

Specific Effects: Alternative VII generate more jobs and greater wages than for the Proposal. Assuming labor costs for construction of the deeper pipeline would increase by as much as two times over those of the Proposal, this alternative would result in increases of $10.8 million in wages; 100 direct jobs in pipeline construction for 7 months in Alaska; and 150 indirect jobs in Alaska. This twofold factor is about in proportion to the volume of additional material to be handled in this alternative as compared to the Proposal (Sec. III.D.5). Higher pipeline construction costs result in higher pipeline tariffs. Higher pipeline tariffs reduce royalty revenue to the Federal Government from the project and likewise reduce Section 8(g) payments to the State.

(5) Effects on Water Quality

(a) Large Oil Spills

The effects of an oil spill on water quality for this alternative are expected to be the same as analyzed for Alternative I in Section IV.C.5.a(5). The general effects of a large spill and the effects of oil-spill-cleanup activities are analyzed in Section III.C.2.l(2)(a).

(b) Disturbances

The general effects of disturbances are analyzed in Section III.C.3.l(2)(a).

1) Summary and Conclusions for Effects of Disturbances on Water Quality

The greatest effect on water quality from gravel island and pipeline construction would be additional turbidity caused by increases in suspended particles in the water column. Increases in turbidity generally are expected to be considerably less than the 7,500 parts per million suspended solids used in the analysis as an acute (toxic) criterion for water quality; exceptions may occur within the immediate vicinity of the construction activity. Turbidity increases from construction activities generally are temporary and expected to occur during the winter and end within a few days after construction stops. Pipeline trenching and backfilling would take longer and/or use more equipment than estimated for the Liberty Pipeline buried at a minimum depth of 7 feet. The overall effects of turbidity are expected to be about 98% greater for the 15-foot trench compared to the 10-foot trench. Material excavated from the pipeline trench but not used for backfill most likely would be left in an area where active erosion of sediment particles could occur during breakup and open water. This material would be similar in composition to seafloor sediments in the trenching and disposal areas, and its contribution to the future turbidity from waves and currents is expected to be about the same as the sediments existing at the seafloor surface before pipeline construction. Construction activities are not expected to introduce or add any chemical pollutants.

2) Details on How Disturbance May Affect Water Quality

The following is a summary of the effects Liberty Island and pipeline construction would have on water quality in Foggy Island Bay. The general effects of construction activities on water quality are analyzed in Section III.C.2.l(2)(a), and the specific effects of island and pipeline construction are analyzed in Section IV.C.5.a(5)). Levels of activities associated with scenario assumptions are show in Table II.A-1.

a) Specific Effects of Constructing the Production Island

The effects on water quality during the construction of the production island for this alternative are expected to be the same as analyzed for Alternative I in Section IV.C.5.a(5).

b) Specific Effects of Constructing the Pipeline

The pipeline trench, about 6.1 miles long, would be dug with backhoes in the winter from the sea ice covering Foggy Island Bay. The average trench depth would be 15 feet. An estimated 1,438,560 cubic of sediments would be excavated from the trench, and most of it would be used as backfill. Pipeline trenching and backfilling would take longer and/or use more equipment than estimated for the Liberty pipeline buried at a minimum depth of 7 feet. Excavated material not used as backfill would be left on the ice to return to the seafloor by natural processes during spring breakup. Seafloor sediments in Foggy Island Bay consist mainly of fine sand-, silt-, and clay-size particles.

Pipeline construction would affect water quality by increasing suspended-particulate matter in the water column mainly in the area below the floating fast ice in the winter and in the vicinity of the area where excess trench material lies during the open-water period. Trenching would disturb and resuspend the seafloor sediments in those areas beneath the ice where the sea water has not frozen to the seafloor. Dumping excavated material into the water column to fill the trench also would cause some of the fine-grained particles to separate from the descending sediment mass and remain in suspension; however, exposure to subfreezing temperatures likely would freeze the particles together and reduce some particle separation.

Both trenching and backfilling operations are likely to be performed at the same time along the pipeline route. In the floating fast-ice zone, suspended sediments generated from these operations could form a turbidity plume in the presence of currents in the water column between the bottom of the floating ice and the seafloor surface.

For one study, the initial suspended-sediment concentration in the water column during pipeline construction is estimated to be 1,000 milligrams per liter throughout the water column. The amount of suspended particles in the water column would decrease with distance from the construction area. If the current velocity is 0.02 meter per second (0.04 knot), suspended-sediment concentrations greater than 100, 20, and 10 milligrams per liter are estimated to occur within 0.75 kilometer (0.46 mile), about 1 kilometer (0.62 mile), and 10 kilometers (6.2 miles), respectively, from the trench.

In another study, URS Corporation (2000) estimates initial suspended sediment concentrations from pipeline construction could range from 500-1,000 milligrams per liter near the seafloor and 50-100 milligrams per liter at the surface. If the initial concentrations are less than 1,000 milligrams per liter, suspended sediment concentrations at 1 and 10 kilometers could be less that the 20 and 10 milligrams, respectively, estimated previously. Fine-grained particles (silt- and clay-size particles) are estimated to comprise about 65% of the material excavated from the trench.

Excavated trench material will be stored in two areas; a 230-acre site in waters 5-10 feet deep about 4 miles southwest of the Liberty site (Zone 1, Fig. II.A-18) and along the proposed pipeline route (Zone 2, Fig. II.A-18). Trench sediments would be stockpiled in different parts of the 230-acre site and graded to an average thickness of about 1 foot to minimize the potential for mounding on the seafloor.

After the pipeline has been buried, the amount of material stored on the ice is estimated to be about 100,000 cubic yards in the 230-acre site and 10,000 cubic yards along the northern part of the proposed pipeline route.

These sediments could return to the water column in any number of ways that might include:

- sinking to the seafloor directly beneath the ice pad as the ice melts in place;
- dumping into the water when the melting ice becomes unstable and overturns;
- eroding of particles by waves in open-water areas;
- melting and transporting of particles by meltwater in the frozen material; or
- melting, eroding, and transporting of particles during river flooding of the fast ice.

Depending on weather, ice conditions and breakup, and river flood stage, natural removal of the stockpiled sediments could take up to several weeks.

When the material stockpiled on the ice returns to the seafloor, some of the fine-grained material would be suspended in the water column. The effects on water column turbidity are estimated by assuming all stockpiled material falls from the ice in 24 hours, 10% of the material would be suspended in the water column, and a current of 0.05 meter per second (0.1 knot) transports the water in a northerly direction. Based on these assumptions, the suspended-sediment concentration below the 230-acre site is estimated to be 1,168 milligrams per liter, and below the storage area adjacent to the northern part of the proposed pipeline it is estimated to be 14 milligrams per liter. The suspended-sediment concentrations decrease with distance from the storage sites. Concentrations of 200, 20, and 10 milligrams per liter are estimated to occur at about 0.5 kilometer (0.3 mile), 2.75 kilometers (1.70 miles), and 7 kilometers (4.3 miles), respectively, from the 230-acre site. These estimates probably represent maximum suspended-sediment concentrations over 1 or 2 days. If the return of the stockpiled material takes more than a day, suspended-sediment concentrations could be reduced and/or last for a longer period. Also exposure to subfreezing temperatures would freeze the particles together and reduce some particle separation when the stockpiled material returns to the seafloor. The suspended concentration estimates are based on no ice bonding of particles and, thus, estimate possible maximum concentrations.

During broken-ice conditions or open water, winds from the east force the nearshore waters to move in a westerly direction parallel to the bathymetry; the characteristics of Beaufort Sea coastal winds are summarized in Section III.C.2.l(2)(a). Under these conditions, particles in the turbidity plume from the Zone 1 spoils area would be deposited in an area that extends in a northerly direction from the spoils site (Fig. III.C-5). Westerly winds force the nearshore waters to move in an easterly direction parallel to the bathymetry. Under these conditions, particles in the turbidity plume from the Zone 1 spoils area would be deposited in an area that extends in an easterly direction from the site of the excess trench material (Fig. III.C-5).

The thickness of the layer formed by excess trench material falling to the seafloor would be greatest in the vicinity of the storage area and would decrease with distance. The areal extent and thickness of this layer were calculated from a sediment deposition model (URS Greiner Woodward Clyde, 1998a). Within 400-530 meters of Zone 1, the layer formed by excess trench material falling to the seafloor would decrease to a thickness of 10 millimeters. The layer would have a thickness of 1 millimeter within 10-13 kilometers (6.2-8.1 miles) under easterly winds, and within about 6.1 kilometers (3.8 miles) under westerly winds. Within 170-180 meters of Zone 3, the layer formed by excess trench material falling to the seafloor would decrease to a thickness of 1 millimeter.

The areal extent of the turbidity plume formed by the falling excess trench material could be approximated by considering where some of the smallest particles might be deposited. Particles 0.005 millimeter in diameter would be deposited at distances of about 13-18 kilometers (8-11 miles) from the Zone 1 site; the thickness of the deposits at these distances is calculated to be about 0.02 millimeter under easterly winds and 0.01 millimeter under westerly winds. Particles 0.005 millimeter in diameter would be deposited at distances of about 18-56.5 kilometers (11-35 miles) from the Zone 3 site; the thickness of the deposits at these distances is calculated to be about 0.001-0.002 millimeter under easterly winds and 0.001 millimeter under westerly winds.

Depending on wind and wave conditions, the fine-grained particles in the excess trench material on the seafloor could be resuspended. Foggy Island Bay is a dynamic environment where a number of phenomena interact to produce changes in the seafloor. These phenomena include winds and storms, sea ice, and river flooding of the nearshore ice. If all or most of the excess trench material returns to the seafloor in the vicinity of the storage site a layer, or scattered layers, or variable thickness could form. The layer(s) would consist of a heterogeneous mixture of clay, silt, sand and gravel-size particles similar to the grains-size composition of present-day surface sediments. Multiyear satellite images suggest the turbidity in coastal waters in mid- and late summer are, for the most part, associated with wave-induced resuspension of cohesionless muddy sediments from shallow-water regions. The contribution of the trench material to the background suspended-sediment concentration likely would be about the same as that of the area into which the sediments were dumped.

Pipeline trenching and backfilling are not likely to increase the amount of trace metals or hydrocarbons into the environment above the naturally occurring background concentrations.

c) Specific Effects of Repairing the Pipeline

Damage to the pipeline would require repairs, which would mean excavating the trench to expose the pipeline. Repair work most likely would be done in the winter when the ice is stable enough so that it can be thickened to support the repair equipment or during the open-water period (Table II.C-6).

The types of effects associated with excavating and backfilling would be the same as those analyzed for pipeline construction. These activities would affect water quality by increasing suspended-particulate matter in the water column in the area of the activity. In the winter, if the repair work takes place in the bottomfast-ice zone, there would be very little, if any, effects in the water column. If the repair work takes place in the floating fast-ice zone, the effects would be in the water column mainly in the area below the floating ice.

Depending on the type of repair, the amount of sediment excavated could range from 1,150-6,490 cubic yards. The rate at which the trench backfill material would be removed is likely to be less than the rate at which sediment was excavated to form the trench. An estimated 10-15 days would be required to excavate 6,490 cubic yards (Table II.C-7). Repair excavation would take place in a small area, and the size of the associated turbidity plume is expected to be smaller than the one formed during the initial trench excavation. In the winter, the excavated material would be stored on the ice and used as backfill when the pipeline repair is finished. During the open-water period, the excavated material would be placed on the seafloor alongside the trench and used as backfill when the pipeline repair is completed.

D. COMBINATION ALTERNATIVES

The three component alternatives and the BPXA Proposal are made up of the following components:

Combination Alternative A

- The Liberty Island and Liberty Pipeline Route (Alternative I)
- Steel Pipe in Steel Pipe Pipeline Design (Alternative IV.A)
- Steel Sheetpile for Upper Slope Protection (Alternative V)
- The Duck Island Mine Site (Alternative VI)
- A 7-Foot Burial Depth (Alternative I)

Combination Alternative B

- Gravel Bag for Upper Slope Protection (Alternative I)
- The Kadleroshilik River Mine Site (Alternative I)
- The Southern Island and Eastern Pipeline Route (Alternative III.A)
- Steel Pipe in HDPE Pipeline Design (Alternative IV.B)
- The 6-Foot Burial Depth (Alternative IV.B) as designed by for the Steel Pipe in HDPE pipeline design

Combination Alternative C

- The Tern Island and Tern Pipeline Route (Alternative III.B)
- Steel Pipe in Steel Pipe Pipeline Design (Alternative IV.A)
- Steel Sheetpile for Upper Slope Protection (Alternative V)
- The Duck Island Mine Site (Alternative VI
- A 15-foot Trench Depth (Alternative VII)

BPXA Proposal (Liberty Development and Production Plan)

- The Liberty Island and Liberty Pipeline Route
- Single-Wall Pipeline Design
- Gravel Bags for Upper Slope Protection
- The Kadleroshilik River Mine Site
- A 7-Foot Burial Depth

The rationale for the development of the combination alternatives was provided in Section I.H.4. Table IV.D-1 provides a summary of key project elements for the three combination alternatives and the BPXA Proposal. These combination alternatives, as well as the component alternatives analyzed in Section IV.C, address the following concerns raised during the scoping process:

1. Effects of oil in the environment, especially to bowhead whales and other subsistence activities.
2. Effects from disturbances, including noise and sediment, especially to the Boulder Patch area.
3. Effects on other physical and biological resources.
4. Effects on social and economic systems.

Scoping also identified cumulative impacts as an important issue. Section V of this EIS evaluates the cumulative impacts of developing the Liberty Prospect. Any of the combination alternatives and the BPXA Proposal would add to the cumulative impacts of oil and gas development to the local geographical area, including offshore (about 4-6 miles) and onshore (1-3 miles) pipelines. However, the contribution to cumulative effects from all Beaufort Sea and North Slope oil and gas activities relative to the

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development of the Liberty Prospect is small. The cumulative contribution of the Liberty Prospect to potential oil spills is about 1% (total) and about 6% of the potential cumulative offshore oil-spill risk. Developing the Liberty Prospect would add an additional manmade island with additional noise and disturbance as well as gravel mining and the transportation impacts. Note, however, that Combination C uses the existing gravel at the Tern Island exploration location and enlarges the island.

The MMS is required to conserve oil and gas resources. This mandate was considered in the development of alternatives. Combination A and the BPXA Proposal are located near the center of the Liberty Prospect. Combination B and C are located farther from the center of the prospect. They would require additional drilling to produce the Liberty Prospect, which increases the risk of completing the wells and achieving maximum production; however, those risks are considered low.

Table IV.D-2 compares selected features of the three combination alternatives and the BPXA Proposal. It also provides some information about potential impacts to key resources, such as the bowhead whale and the Boulder Patch. It provides comparison in such terms as “least to most” and “closest to farthest.” For example, the “likelihood of disturbance of bowhead whales and subsistence fishing” is rated “low” for Combination A, C, and the BPXA Proposal, and “lowest” for combination B. This means that we estimate the impacts to be low for all the alternatives, but B has the lowest impact.

All of the proposed pipeline burial depths are more than twice the greatest observed ice-gouge depths in the Foggy Island Bay area.

Some people feel that the probability of a pipeline leak increases, to some extent, with the length of pipeline. However, for pipeline ranges evaluated in this EIS (offshore between 4.2 and 6.1 miles and onshore between 1.4 and 3.1 miles), MMS estimates that the risks are essentially the same.

1. Combination A

Combination A, along with BPXA’s Proposal, uses the Liberty Island and, therefore, has the longest offshore pipeline. Combination A uses a steel pipe within steel pipe design. This pipeline design provides some additional protection of the inner pipe from ice gouging and, should a leak to the carrier (inner) pipe occur from flaws in construction or corrosion, it would provide secondary containment of any oil leaked.

Noise disturbance of bowhead whales during migration and the consequent impact on subsistence hunting of the whales was a concern voiced during scoping. The bowhead whale migration route is greater than 10 kilometers from the Liberty Island location; therefore, operational noises from the island would not adversely impact the whale migration. Construction noises could carry into the migration route, but most construction activities would occur during the winter when the whales are not present. Combination A and the BPXA Proposal use the Liberty Island location, which is about the same distance from the whale migration route as Combination C, Tern Island location. Combination B, Southern Island Location, is farther away from the bowhead whale migration route.

Regarding other effects on physical and biological resources, Combination A poses a number of advantages and disadvantages. Combination A would use the most gravel of all the alternatives. It would use steel sheetpile for slope protection on the island. This would prevent gravel bags from entering the environment, which is a problem that occurred from some exploration islands that used gravel bags at and below the water line for slope protection. Combination A uses of the existing Duck Island gravel mine. Using an existing mine would prevent the surface disturbance to 24-41 acres of wetland habitat in the Kadleroshilik River floodplain. The resulting pit would be connected to the main channel and could disrupt natural function of the floodplain/river system. Such functions as sediment transport and stream-channel mobility could be altered. Under Combination A, gravel would be hauled 20 miles from the mine to the construction site. This would increase air emissions and require the use of more fuel over Combination B and the BPXA Proposal that uses the Kadleroshilik River mine. Using Duck Island would eliminate the potential development of any fish overwintering habitat at the Kadleroshilik River mine site.

Combination A would result in the loss of 25.8 acres of ocean bottom from construction of the island. It would also cause the temporary disturbance of 59 acres of ocean floor habitat due to pipeline trenching and burying. Also, the Liberty Island location (Combination A and BPXA Proposal) is the closest to the Boulder Patch, somewhat increasing the potential for impacts to that sensitive biological community.

Combination A could reduce the cumulative impacts associated with new gravel mines by using the existing gravel mine; however, the cumulative benefits of potential new fish overwintering habitat also would be lost.

Combination A’s costs are second highest at $415.5 million: $51.5 million, or about 14% more. Combination A is in the optimal location for recovering oil from the reservoir.

2. Combination B

Combination B uses the Southern Island location, which is closest to shore and the farthest from the bowhead whale migration route and the Boulder Patch of all the island locations. Combination B would provide some additional protection of the bowhead whale migration and subsistence hunting, because the island is nearly 2 miles closer to shore than the other alternative island locations. The effects of sediments from construction of the gravel island and pipeline construction on the Boulder Patch, a sensitive biological area, would be somewhat reduced.

Combination B's use of steel pipe within a plastic pipe could provide secondary containment of a oil leak to the carrier pipe, if the outer pipe remains structurally sound.

Regarding other effects on physical and biological resources, Combination B poses a number of advantages and disadvantages. Combination B would use gravel bags for upper slope protection on the island and could result in broken bags entering the environment. However, the gravel island design uses interlocking cement blocks at the water/ice edge, which is different from the previous exploration island designs that used gravel bags for slope protection from the seafloor up. Also, the proposed polyester gravel bags are the same as those used at the Endicott Island, and they do not float in the marine environment. Combination B uses the Kadleroshilik River Gravel Mine and creates a new pit; thus, it will destroy 24-41 acres of wetland habitat in the Kadleroshilik River floodplain. However, after rehabilitation, the mine site could provide fish overwintering habitat. Under Combination B, gravel will be hauled 5 miles from the mine to the construction site. This is the shortest haul distance and would result in less air emission and require the use of less fuel over alternatives using the Duck Island mine. Combination B would cover about 21.9 acres of the ocean floor from the construction of the gravel island. It also would cause the temporary disturbance of 49 acres of ocean floor habitat due to trenching the pipeline, which is the least amount of pipeline area disturbed.

Combination B would increase the number of gravel pits by one, but it also would create potential fish overwintering habitat on the Kadleroshilik River.

Combination B does cost more, $388.5 million, than the BPXA Proposal: $24.5 million, or about 7% more. Combination B requires additional directional drilling for oil, which may influence the ability to recover all of the producible oil from the reservoir.

3. Combination C

Combination C builds onto the existing Tern Island and is about the same distance from shore as Combination A and the BPXA Proposal but further from shore than Combination B. Combination C uses a steel pipe within steel pipe design. This pipeline design provides some additional protection of the inner pipe from ice gouging and, should a leak to the carrier (inner) pipe occur from flaws in construction or corrosion, it would provide secondary containment of any oil leaked. Combination C's 11-foot burial depth for the pipeline is more than five times the deepest observed ice-gouging depth in Foggy Island Bay.

Regarding other effects on physical and biological resources, Combination C poses a number of advantages. Combination C would use the most gravel of all the alternatives. It would use steel sheetpile for slope protection on the island. This would prevent gravel bags from entering the environment, which was a problem that occurred from some exploration islands that used gravel bags at and below the water line for slope protection. Combination C would use the Duck Island gravel mine. Using an existing mine would prevent the surface disturbance to 24-41 acres of wetland habitat in the Kadleroshilik River floodplain. Under Combination C, gravel would be hauled 21 miles from the mine to the construction site. This would increase air emissions from the longer truck route and require the use of more fuel over Combination B and the BPXA Proposal that uses the Kadleroshilik River mine. Using Duck Island would eliminate the potential development of any fish overwintering habitat at the Kadleroshilik River mine site. Although Combination C's Tern Island would cover about 26.8 acres ocean floor, which is the largest area, it uses the gravel from the existing Tern exploration island; therefore, the amount of new area covered would be the smallest. It would cause the temporary disturbance of 91 acres of ocean floor habitat due to trenching the pipeline. Finally, the Tern Island site is the second farthest from the Boulder Patch, somewhat decreasing the potential for impacts to that sensitive biological community.

Combination C causes the least cumulative impact on gravel resources of the combination alternatives. It uses an existing mine for gravel and an existing island and requires the least amount of gravel.

Combination C costs the most of any of the combinations, $423 million: $59 million or 16% more than the BPXA Proposal (see Table IV.D-3).

4. BPXA Proposal

The BPXA Proposal, along with Combination A, uses Liberty Island and has the longest offshore pipeline. It is farther offshore than Combination B, but about the same distance from shore as Combination C. The single steel-wall pipeline design does not provide secondary containment but has a lower functional failure rate than the other pipeline designs.

The BPXA Proposal would use gravel bags for upper slope protection on the island and could result in broken bags entering the environment. However, the gravel island design uses interlocking cement blocks at the water/ice edge, which is different from the previous exploration island designs that used gravel bags for the entire slope protection system from the sea floor up. Also, the proposed polyester gravel bags are the same as those used at the Endicott

Island, and they do not float in the marine environment. The BPXA Proposal uses the Kadleroshilik River Gravel Mine and would create a new gravel pit that would destroy 24-41 acres of wetland habitat in the Kadleroshilik River floodplain. After rehabilitation, the mine site could provide fish overwintering habitat. As with Combination B, the BPXA Proposal would haul gravel 6 miles from the mine to the construction site. This distance is shorter than all the other two combinations and would result in less air emission and require the use of less fuel over alternatives using the Duck Island mine. The BPXA Proposal would occupy 22.4 acres of the ocean floor for construction of the island. It also would cause the temporary disturbance of 59 acres of ocean floor habitat due to trenching the pipeline. As with combination A, the BPXA proposed island is the closest to the Boulder Patch, somewhat increasing the potential for impacts to that sensitive biological community.

The BPXA Proposal would increase cumulative impacts of oil and gas development to the local geographic area by increasing the number of gravel pits by one, but it also would create potential fish overwintering habitat on the Kadleroshilik River.

The BPXA Proposal costs the least of all the combinations and is in the optimal location for recovering oil from the reservoir. For the comparison costs between combination alternatives, the BPXA Proposal is considered the base.

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SECTION V

CUMULATIVE
EFFECTS

CONTENTS FOR SECTION V

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V. Cumulative Effects

A. INTRODUCTION AND GENERAL CONCLUSIONS

1. Introduction

To help determine the structure and scope of our cumulative-effects analysis, we were guided by our past experience in preparing cumulative effects analyses and by the National Environmental Policy Act (40 CFR 1508.7) and 1508.25(a)(2):

> ‘Cumulative impact’ is the impact on the environment which results from the incremental impact of the action when added to the other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time.
>
> To determine the scope of environmental impact statements, agencies shall consider…Cumulative actions, which when viewed with other proposed actions have cumulatively significant impacts and should therefore be discussed in the same impact statement.

A handbook issued by the Council on Environmental Quality, *Considering Cumulative Effects Under the National Environmental Policy Act, January 1997*, suggests, among other things, that the analyses: “determine the magnitude and significance of the environmental consequences of the proposed action in the context of the cumulative effects of other past, present, and future actions…identify significant cumulative effects…” and “…focus on truly meaningful effects.” As suggested by this handbook, we consider the following basic types of effects that might occur:

- “additive” (the total loss of animals from more than one incident),
- “countervailing” (adverse effects that are compensated for by beneficial effects), and
- “synergistic” (when the total effect is greater than the sum of the effects taken independently).

The publication *Guidelines for Environmental Impact Assessment in the Arctic* (Finnish Ministry of the Environment, 1997) indicates that a “cumulative impact assessment should be kept at reasonable and manageable levels” and, thus, need not be voluminous and exhaustive.

2. Structure of the Analysis

Based on a consideration of our past experience and these references, we designed our cumulative-effects analysis for this EIS as a five-step process:

1. We identify the potential effects of the Liberty Development and Production Plan on the natural resources and human environment that may occur
   - in the Beaufort Sea,
   - on the North Slope, and
   - along the oil transportation route.

2. We analyze other past, present, and reasonably foreseeable future oil-development activity on the North Slope/Beaufort Sea for effects on the natural resources and human environment that we found were potentially affected by the Liberty Plan.

3. We consider effects from other actions (sport harvest, commercial fishing, subsistence hunting, and loss of overwintering range, etc.) on these same natural resources and human environments.

4. We attempt to quantify effects by estimating the extent of the effects (number of animals and habitat affected) and how long the effects would last (population recovery time).

5. To keep the cumulative-effects analysis useful, manageable, and concentrated on the effects that are meaningful, we weigh more heavily other activities that are more certain and geographically close to Liberty, and we analyze more intensively effects that are of greatest concern.

We also focus our effort by using, where possible, guiding principles from existing standards (see the following), criteria, and policies that control management of the natural resources of concern. Where existing standards, criteria, and policies are not available, our experts use their best judgment on where and how to focus the analysis.

3. Guiding Principles of the Analysis

The Endangered Species Act of 1973 and the Liberty scoping process are appropriate vehicles to identify species that are potentially at risk from incremental cumulative effects from the Liberty Project. Effects on listed species identified for the Liberty Project by the National Marine Fisheries Service and the Fish and Wildlife Service under Section 7 of the Endangered Species Act are covered by this cumulative-effects analysis. We also review the effects on each of the other species identified through scoping and include them, as appropriate.

We assess cumulative effects on those species listed as “endangered,” “threatened,” “proposed,” or “candidate” on the North Slope, in the Beaufort Sea, and along the transportation corridor to west coast ports that the National Marine Fisheries Service and the Fish and Wildlife Service indicate that we should assess. We assess endangered and threatened species in more detail than proposed or candidate species. We assess other cumulative effects on natural resources and the human environment in these same areas but in less detail than listed species, unless we find that they are likely to be “significant cumulative effects” under Council on Environmental Quality guidelines. We also include effects along migration routes of species, as appropriate.

The management of seals by the National Marine Fisheries Service and polar bears by the Fish and Wildlife Service under the Marine Mammal Protection Act of 1972 provides for monitoring these species’ populations and managing/mitigating potential effects of development on these species. For example, the Fish and Wildlife Service implements measures to protect polar bear den sites through a Letter of Authorization under the Marine Mammal Protection Act.

The State of Alaska, Department of Fish and Game monitors caribou, including the Central Arctic Herd, by a census of caribou calving and caribou distribution on the oil fields. These monitoring efforts provide a means of indicating if significant cumulative effects on caribou have occurred or are occurring on the North Slope and help to develop measures to minimize effects.

We assess cumulative effects to all other species over the range that the species may be affected by activities associated with the Liberty Project and also include effects along the migration routes of some species, as appropriate. Potential effects to marine benthic communities associated with the Boulder Patch could be substantially reduced or eliminated as a result of recommendations from the Arctic Biological Task Force. The Arctic Biological Task Force makes recommendations to the MMS Regional Supervisor, Field Operations, regarding biological populations or habitats that may require additional protection. Lessees may be required to modify operations to ensure these populations or habitats are not adversely affected. The Arctic Biological Task Force is composed of designated representatives of Federal agencies (MMS, Fish and Wildlife Service, National Marine Fisheries Service, and the Environmental Protection Agency); State agencies (Alaska Departments of Natural Resources, Environmental Conservation, Fish and Game, and Governmental Coordination), and the North Slope Borough.

Water quality on the North Slope is regulated and/or monitored through various permitting and regulatory programs administered by the Environmental Protection Agency; the Alaska Departments of Natural Resources, Environmental Conservation, and Fish and Game; and the North Slope Borough. These programs have been established to protect against the significant degradation of water quality associated with specific human/development activities. In evaluating the cumulative effects to water quality, we consider the collective impacts associated with permitted/regulated activities as well as other nonregulated activities and/or naturally occurring events.

Air quality is regulated under the Prevention of Significant Deterioration permitting process. For sources located in the outer continental shelf (such as the proposed Liberty Project), the Prevention of Significant Deterioration program is administered by the Environmental Protection Agency. For sources located in State waters and onshore, the Prevention of Significant Deterioration program is administered by the Alaska Department of Environmental Conservation. Minor sources of air pollutants are not subject to Prevention of Significant Deterioration permitting requirements. The analysis of cumulative effects to air quality in this EIS considers the contribution of major and minor sources of air pollution on the North Slope.

Wetlands are mitigated through the Section 404 Regulatory Program under Section 404 of the Clean Water Act, administered by the U.S. Army Corps of Engineers. In addition, the Administration has a No-Net-Loss goal for wetland functions and values, as stated in the White House Office on Environmental Policy entitled *Protecting America’s Wetlands: A Fair, Flexible, and Effective Approach*, dated August 24,1993. The *Memorandum Of Agreement Between The EPA And The U.S. Army Corps of Engineers Concerning The Determination Of Mitigation Under The Clean Water Action Section 404(B)(1) Guidelines* provides a sequence for mitigation that includes avoiding and minimizing of and compensating for wetland losses. Under the Memorandum of Agreement, it is recognized that in areas such as the North Slope of Alaska (where there is a high proportion of wetlands), minimizing

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wetland losses will be the primary method of mitigation. However, compensatory mitigation could be required for unavoidable losses to high-use wetlands. Minimizing wetland losses also includes selective use of surrounding wetlands over high-use wetlands, for example, minimizing the impact from the placement of fill material into waters of the U.S. Therefore, potential cumulative impacts to wetland resources are tempered through Federal, State, and local regulatory programs. Including appropriate best management practices and environmental conservation conditions to oil and gas leases and exploratory, development, and production phases substantially lowers the likelihood of collective development actions that result in potential significant impacts to wetlands. We analyze the potential impacts resulting from the placement of fill material and the potential impacts resulting from oil-spill scenarios.

For the human environment (subsistence activities, sociocultural systems, and the economy), we focus our evaluation of cumulative effects associated with oil-development activities on the North Slope local environment, because this is where most significant cumulative effects are expected to be concentrated. We consider effects along the bowhead migration route in the Beaufort and Chukchi Seas since villages share subsistence resources based on abundance and hunting success. However, we also give some consideration to effects on the human environment along the transportation route.

Executive Order 12898, *Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations*, and an accompanying Presidential memorandum, require each Federal Agency to make the consideration of environmental justice part of its mission. The existing demographics (race, income) and subsistence consumption of fish and game are discussed, disproportionate environmental and health effects on Alaskan Natives are identified, and mitigating measures and their effects are presented.

Executive Order 13084, *Consultation and Coordination with Indian Tribal Governments*, requires the MMS to consult with Inupiat tribal governments on the North Slope on “Federal matters that significantly or uniquely affect their communities,” so an effective process is established that “permits elected officials and other representatives of Indian tribal governments to provide meaningful and timely input.” We have met with local tribal governments to discuss subsistence issues relating to the Liberty Project and have established a dialogue on environmental justice with these communities. Mitigation in place for the Liberty Project (measures developed for Beaufort Sea Sale 144) evolved through negotiations with local, borough, and agency representatives, and Inupiat Traditional Knowledge had a large part in developing mitigation and in the timing of project activities. Local Inupiat government representatives have been members of our OCS Advisory Committees that have met to discuss and resolve issues that arise from the 5-Year Plan and recent lease sales. Conflict avoidance agreements between the oil industry and Inupiat whalers are an important mechanism for overcoming conflicts.

The cumulative effects on archaeological resources can be minimized through required surveys, consultations with the State Historical Preservation Officer to identify potential archaeological sites, and requirements to plan and schedule activities to avoid these locations. We analyze the potential for disturbances of archaeological resources on the North Slope and in the Beaufort Sea as well as the potential effects from cleanup of oil spills along the transportation route.

4. Scope of the Analysis

Oil and gas activities occur on the outer continental shelf in Alaska, the Gulf of Mexico, and California and are cited in the most recent 5-year EIS. In this EIS we evaluate the cumulative effects of transporting Alaskan oil along the U.S. west coast. To be consistent with the 5-Year OCS Oil and Gas Program, the Liberty cumulative analysis also evaluates the effects for transporting oil through the Trans-Alaska Pipeline System and tankering from Valdez to U.S. west coast ports. Activities other than those associated with oil and gas also are considered. We also include by reference certain cumulative effects that are more national in scope, for example, global warming and alternative energy development

Oil and gas activities considered in the analysis include past development and production, present development, reasonably foreseeable future development, and speculative development. Some activities beyond the 20-year life of the Liberty Project are considered too speculative at this time to include, while other such activities are included in this analysis. Furthermore, we exclude future actions from the cumulative effects analysis if those actions are outside the geographic boundaries or time frames established for the cumulative effects analysis. We address uncertainty through monitoring, and note that monitoring is the last step in determining the cumulative effects that may ultimately result from an action.

5. “Significance”

As directed by the Council on Environmental Quality National Environmental Policy Act regulations (40 CFR 1502.16), we discuss direct and indirect impacts (effects) and their significance on physical, biological, and human social resources. The specific resource topics considered (for example, endangered species or water quality) are those listed here in the introductory paragraph. Our analysis considers the “context” and “intensity” of the impact as mentioned by the Council on Environmental Quality in characterizing “significantly” (40 CFR 1508.27). The context aspect considers the setting of the proposed action, what the affected resource may be, and whether the effect on this resource is local or more regional in extent. The intensity aspect considers the severity of the impact taking into account such factors as whether the impact is beneficial or adverse, the uniqueness of the resource (for example, threatened or endangered species), the cumulative aspects of the impact, and whether Federal, State, or local laws may be violated. When considering cumulative effects, the geographic area and timeframe are extended to include past, present, and reasonably foreseeable activities. Overlapping zones of influence and the incremental contribution of the proposed activity also are evaluated in the cumulative case.

6. General Conclusions

Conclusions about effects on specific resources follow later in this section. Our general conclusions of this cumulative analysis are:

- Potential cumulative effects on the bowhead whale, subsistence, spectacled eider, boulder patch, polar bear, and caribou are of primary concern and warrant continued close attention and effective mitigation practices.
- The incremental contribution of the Liberty Project to cumulative effects is likely to be quite small. Construction and operations related to the Liberty Project would be confined to a relatively small geographic area, and oil output would be a small percentage (approximately 1%) of the total estimated North Slope/Beaufort Sea production.
- The Liberty Project would contribute a small percentage of risk (about 6% [0.07 spills out of 1.09 total]) to resources in State and Federal waters in the Beaufort Sea from potential offshore oil spills. Any subsequent spills are not expected to contact the same resources or to occur before those resources recover from the first spill.

7. Other Information about Cumulative Effects

- We recognize the importance of readily available abiotic standards to determine environmental quality. Abiotic measurements, for example, air and water quality, often provide a good indication of the quality of biological and cultural resources. We also recognize that as we move from the abiotic, to the biotic, to the human condition, the variables increase, making it more difficult to determine cumulative effects on the quality of life. Similarly, as we move from the terrestrial environment to the offshore environment, the variables of environmental quality increase. Migratory species present additional variables that reflect habitat and species condition outside the primary study areas. Humans introduce even more variables with their mobility and behavioral diversity. Hence, as we progress from abiotic to biotic, or from freshwater to marine, or from terrestrial and marine to sociocultural effects, our analysis, by necessity, becomes more difficult and less conclusive (Fig. V-1).
- Concern about the potential for cumulative effects should be weighed with the following information:
  - Expected oil and gas activities are likely to have fewer impacts on the environment than those activities conducted in the early years of the region’s development. More rigorous environmental standards and more environmentally prudent industry practices now exist, which include smaller facility “footprints,” fewer roads, directional drilling from onshore, elimination of most discharges into the water, practices that avoid damage to the tundra, and better working relations with the local residents.
  - Current industry practices and the environmental state of the North Slope/Beaufort Sea region frequently are observed and assessed, and much of this information is available to the public. This information and the ongoing dialogue about environmental issues among Federal, State, and local government agencies; Inupiat regional and village corporations; industry; interest groups; and the public should continue to increase environmental awareness and encourage environmentally sound practices that, in turn, should help reduce the potential for environmental damage.
  - A key element of the transportation system for development of North Slope/Beaufort Sea oil is the Trans-Alaska Pipeline System pipeline. The pipeline is 800 miles long, stretching from Pump Station 1 at Prudhoe Bay to the Valdez Marine Terminal and, if we choose a corridor width of about 100 feet, it represents an area of about 16 square miles. This pipeline is expected to continue to serve as existing infrastructure for all foreseeable future oil production, eliminating the need for the construction of new oil pipelines other than feeder pipelines.
  - Following the *Exxon Valdez* oil spill, substantive improvements have been made in tanker safety to reduce the potential for oil spills from tanker accidents. These include a mandatory phase-in of double-hulled tankers, better navigational systems, and tanker escorts. In addition, oil-spill-response capabilities for tanker-related oil spills in Prince William Sound have been increased substantially through additional equipment, personnel, training, and exercises. These initiatives were developed

specifically to reduce the potential for future tanker accidents and to lessen effects, should spills occur.

- If a major oil spill occurred, there likely would be a great slowdown in new development during which additional safeguards certainly would be put in place and new ideas of pipeline placement and design would be researched. Just as the additional safeguards resulting from the *Exxon Valdez* oil spill, the likelihood of an additional oil spill from the same causative factors and to the same resources would be reduced. This emphasis on preventing a similar incident further would ensure the full recovery of those resources from the initial spill.
- The actual size and location of future oil and gas developments on the North Slope and in the Beaufort Sea are uncertain. The actual effects on natural resources and the human environment that may result from such developments also are uncertain. Nevertheless, we have developed our best estimate of what those activities and effects may be. However, it is likely that projected actions or effects may not happen in a way that fits neatly into the scenarios we have established for this EIS. Therefore, monitoring programs are being established both by the MMS and industry to provide feedback to decisionmakers who could amend mitigation provisions, if appropriate, at a later date.

In Section V.B, we describe the activities and projects we consider in this analysis. These activities include past development and production, present development, reasonably foreseeable future development, and speculative development. Some activities beyond the 20-year life of the Liberty Project are considered too speculative at this time. Activities other than oil and gas activities also are considered. In Section V.C, we present the assumptions used by each resource specialist.

B. ACTIVITIES WE CONSIDERED IN THIS CUMULATIVE-EFFECTS ANALYSIS

Oil and gas development is the main agent of industrial-related change on the North Slope. Oil and gas exploration and production activities have occurred on the Alaska North Slope/Beaufort Sea region for more than 50 years. Past industrial development that occurred in association with this historic production included the creation of an industry support community and airfield at Deadhorse and an interconnected industrial infrastructure that includes roadways, pipelines, production and processing facilities, gravel mines, and docks. In 1977, the Trans-Alaska Pipeline System was developed to transport North Slope crude oil to a year-round marine terminal in Valdez, Alaska, and it continues today and for the foreseeable future to transport the entire production from the North Slope.

We focus our analysis on the following:

- Oil and gas discoveries that have a reasonable chance of being developed during the 15-20 year life of the Liberty field.
- Exploration and development of additional undiscovered resources (onshore and offshore) that could occur during the 15-20 year life of the Liberty field.
- Some exploration and development activities that could occur after the 15-20 year life of the Liberty field from future State and Federal lease sales.
- Transportation of oil in the Trans-Alaska Pipeline System and tankering of oil to western ports.
- Activities other than oil and gas such as sport and subsistence hunting and fishing, commercial fishing, sport harvest, loss of overwintering range, tourism, and recreational activities.

Table V.1a lists North Slope fields and discoveries. Tables V.B-la and 1b list the current and proposed transportation projects and future lease-sale activities we consider in this cumulative analysis. Map 3a shows the location of fields and discoveries in Table V.B-1a and areas of exploration. “Fields” refers to a geologic structure with proven reserves that has been developed and is producing crude oil. Fields can contain numerous reservoir pools produced through a common infrastructure. “Discoveries” refers to a pool with potential reserves, such as Liberty, that has not been developed. Some discoveries require additional drilling to confirm that oil or gas is commercially recoverable. Poor test results in some “discoveries” may be referred to simply as shows. The development timing of resources listed as prospects, pools, or shows is speculative and could occur after Liberty production has ended (more than 20 years).

For purposes of this cumulative analysis, we divide oil and gas discoveries into the following categories:

- **Past Development/Production:** 23 fields, with Endicott, Eider, and Sag Delta North offshore.
- **Present Development/Production:** 3 discoveries that are expected to start up within the next few years, with Northstar and Liberty offshore.
- **Reasonably Foreseeable Future Development:** 15 discoveries that might be developed within the next 15-20 years, with Sandpiper, Flaxman Island, Kuvlum, Thetis Island, Stinson, and Hammerhead offshore. Additional onshore resources (estimated 2.30 billion barrels) and offshore resources (estimated 0.45 billion barrels) currently are undiscovered.
- **Speculative Development:** Additional new discoveries could occur after 20 years, with 12 past onshore discoveries. The development chance is too uncertain for detailed analysis at this time. Additional exploration activities (wells and seismic surveys) are likely to occur and have been factored into the analysis.

We focus on the first three categories and consider exploration activities of the fourth category. We recognize that oil companies may produce oil from pools in the speculative development category. However, there is no way to know this with any degree of certainty, because insufficient information exists to estimate the development activities associated with undiscovered pools. Some discoveries date back to 1946 without subsequent development. It is possible that oil companies also would not develop some prospects in the reasonably foreseeable category within the 15-20-year timeframe of the Liberty field. We estimate a total resource amount for the speculative category from industry and government reports. Onshore and offshore-undiscovered resource estimates are based on MMS's 1995 National Assessment minus discoveries included as possible outer continental shelf projects (Table V.B-7c).

1. Past Development/Production

This category includes producing fields on the North Slope and nearshore areas of the Beaufort Sea. Infrastructure, cumulative production, and remaining reserves are well defined. Individual oil pools can be developed together as fields that share common wells, production pads, and pipelines. Fields can be grouped into production units with common infrastructure, such as processing facilities. Impacts are associated with development that occurred over the past 3 decades, and there are data from monitoring that accurately reflect some of the long-term effects.

This category contains 24 discoveries, all of which are now producing oil (see numbers 1 through 24 in Table V.B-1a). Table V.B-2 lists production and reserve data, and Table V.B-3 lists infrastructure and facilities for these producing fields. All these fields except Endicott, Sagavanirktok Delta North, Eider, and Badami are onshore on State leases. Endicott is an offshore State field that began production in 1987 and, through 1996, had produced 330 million barrels of oil. The Badami oil pool also is mainly offshore, but industry drilled into the offshore area from an onshore site. Badami is of particular interest, because the proposed Liberty Project pipeline would tie into Badami's common-carrier pipeline. Badami began producing on August 21, 1998, although production is suspended at the present time.

2. Present Development/Production (within the next few years)

This category includes fields that are in advanced planning stages for development but that have not begun production. Infrastructure components, scheduling, and reserve estimates are fairly well defined, although reserve volumes could be revised later. Commonly, new planned developments will be tied into existing infrastructure, and they depend on the continued operation of this infrastructure.

This category contains three discoveries: Northstar, Liberty, and Fjord (numbers 25 through 27 in Table V.B-1a). Alpine is included in the past development category because production is expected soon (late-2000). Table V.B-4 lists reserve estimates, and Table V.B-5 lists the infrastructure the oil companies propose for these discoveries. Alpine and Fjord are onshore on State leases. Northstar is offshore on a unit composed of both State and Federal leases. The Liberty Project is on an offshore Federal lease.

During 1996, ARCO announced that the Alpine discovery in the Colville River Delta was producible and contained an estimated 429 million barrels of recoverable oil reserves. This development may come online in late-2000 and could produce 18-29 million barrels annually. Produced crude would be transported through a 34.2-mile long pipeline to facilities at Kuparuk, where Alpine's production will be commingled with Kuparuk's output (U.S. Army Corps of Engineers, 1997).

BPXA is planning to produce from both the State and Federal oil reserves of the Northstar Unit from a manmade gravel island located on a State tract. The U.S. Army Corps of Engineers, as the Lead Federal Agency (with other State and Federal resource agencies as cooperating agencies), has prepared a Final Environmental Impact Statement for the Beaufort Sea Oil and Gas Development/Northstar Project, dated February 1999 (U.S. Army Corps of Engineers, 1999). BPXA estimates that the Northstar project would produce 145 million barrels of oil over the next 15 years.

Liberty is in this category for purposes of analysis in this EIS and is the subject of this EIS. Liberty's developmental plan is discussed in Section II.A of this EIS.

The MMS developed the information about reasonably foreseeable future development and production and considers it the best available information. The U.S. Army Corp of Engineers, a cooperating agency for this EIS, disagrees with this view of reasonably foreseeable projections and with the geographic scale used by MMS for evaluation of onshore cumulative impacts. The Corps of Engineers' approach for onshore cumulative impact analysis would bound the cumulative impact analysis by using ecologically relevant geographic boundaries (for example, watersheds) and potential resource affected (for example, caribou movement and migration) within a reasonably foreseeable future. For example, the Corps of Engineers believes wetland losses in a watershed in one area of the North Slope are not necessarily cumulative with losses in another watershed elsewhere on the North Slope.

The Corps of Engineers does not concur with the listing in Table V.B-1a of present development projects and reasonably foreseeable future development and production projects. The Corps of Engineers believes many of the projects mentioned as reasonably foreseeable are in fact speculative and not reasonably foreseeable. For instance, the Corps of Engineers would revise MMS's reasonably foreseeable North Slope projects to start with Meltwater, Liberty, Nanuk, and Fjord.

In summary, the MMS view of reasonably foreseeable future development and production is, in general, broader than that of the Corps of Engineers'. Also, the cumulative effects described in this EIS are greater in scope than the cumulative effects envisioned by the Corps of Engineers for the Liberty Development Project.

3. Reasonably Foreseeable Future Development/Production (within the next 15-20 years)

This category includes activities that are reasonably foreseeable within the timeframe of the Liberty Project (15-20 years). It is reasonable to expect that these activities would begin with the development of discoveries in close proximity to existing (past and present fields) to share infrastructure. We have attempted to rank the chance of development according to resource size and proximity to existing infrastructure. Resource volumes are uncertain in this category. Generally, there is inadequate drilling data to define reserves or engineering studies to support development. Also, we cannot predict the development timing for future fields. Many of these discoveries were made decades ago and remain noncommercial today. Without technology advancements and higher petroleum prices, many of these discoveries could remain undeveloped.

While the listing of reasonably foreseeable future developments includes only discoveries, there could be significant amounts of oil produced by enhanced oil recovery from existing fields as well as from undiscovered satellite pools close to infrastructure areas. Enhanced recovery adds additional production from known reservoirs, creating "reserve growth." For example, the Prudhoe Bay field was originally estimated to hold 9.6 billion barrels of reserves, and now it has reserves approaching 13 billion barrels. More than 3 billion barrels were added by using enhanced recovery technologies. In addition, industry has indicated that they have a large number of prospects very close to existing infrastructure that may become future satellite pools. Although both of these new resources (reserve growth and satellites) are as yet undiscovered, it is reasonable to assume that a significant portion would be brought into production in the timeframe of the Liberty Project (20 years or less). For purposes of analysis, we assume that half of the total (4 billion barrels) estimate for enhanced recovery and satellite fields (or 2 billion barrels) would be brought into production in the foreseeable future. Because satellite fields largely would be developed from existing infrastructure, the incremental addition of new infrastructure is minor.

This category includes 15 discoveries that oil companies may develop in the next 15-20 years (see numbers 28 through 43 in Table V.B-1a). Table V.B-.6a lists the resource estimates. Offshore discoveries in this category are Sandpiper, Flaxman Island, Kuvlum, Hammerhead, Thetis Island, and Stinson. Gwydyr Bay and Kalubik are offshore discoveries that are likely to be developed from onshore sites. Onshore discoveries include Sourdough, Mikkelsen, Yukon Gold, Point Thomson, Pete's Wicked, Nanuk, and Sikulik (near the existing Barrow gas fields). Sandpiper, Hammerhead, and Kuvlum are on Federal leases; all others are on State leases or North Slope Borough lands. The discussion of reasonably foreseeable future development/production will include the effects of production decline from existing fields, the current proposals for new development, and estimates of potential development associated with recent and proposed lease sales.

Tables V.B-6a and b indicate the possible development infrastructure, should these discoveries be commercially developed. Oil from the Nanuk, Kalubik, and Thetis Island discoveries could feed into the Alpine pipeline system, should they be developed. Oil produced from the Gwydyr Bay, Pete's Wicked, and Sandpiper discoveries could be transported through the Northstar pipeline, while the Badami field trunk pipeline would provide transport for other discoveries listed in Table V.B-6a. An indication of the infrastructure that may be required if these discoveries are developed is listed in Table V.B-6b. Outlined on Map 3 are the geographic boundaries of the Alpine, Northstar, and Badami fields and the discoveries these fields may service.

It is important to recognize the distinction between exploration/development activities and production. The discussion of exploration/development activities is related primarily to disturbance effects, whereas the estimated production volumes relate directly to oil-spill risk. We have attempted to rank the chance for commercial development of these discoveries from highest to lowest (Table V.B-1a). The ranking could also be viewed as an approximate timetable for production startup. Discoveries near the top of the list are expected to begin production sooner and are likely to be totally produced and abandoned within the timeframe of the Liberty development (20 years or less). Discoveries near the bottom of the list are expected to start production much later, and most of their oil production may occur after 20 years. This means that oil spills may occur from these possible developments long after the Liberty field is abandoned.

4. Speculative Development (after 20 years)

This category includes discoveries and undiscovered resources that are very unlikely to be developed in the timeframe of the Liberty Project (less than 20 years). Some of the discoveries listed in Table V.B-1a were made 50 years ago and remain noncommercial to industry. There are a variety of reasons, including very remote locations, low production rates, and lack of gas-transportation systems that will remain in effect in the foreseeable future. With respect to undiscovered resources, it is not reasonable to estimate new infrastructure or predict the effects of development for prospects that have not been located or even leased to industry for exploration. Accurate predictions of the location, size, or development schedule, are not possible at this time.

Various government and industry groups publish resource estimates that often vary widely for a given area. However, these groups use very different methodologies and reporting criteria. It is difficult to discern how these speculative undiscovered resource estimates would translate in future infrastructure and effects. The resources listed in Table V.B-7d fall beyond the definition of reasonably foreseeable.

With respect to the offshore resource estimates, the leasing history for the Beaufort Sea suggests that the majority of production is likely to occur beyond the timeframe assumed for the Liberty Project. Therefore, the cumulative analysis largely discounts the effects of new offshore development, particularly in deeper water areas of the Beaufort shelf. Any new development or additional oil production is likely to occur in nearshore areas adjacent to existing infrastructure. This incremental addition is covered adequately under Reasonably Foreseeable Future Development/Production (20% of the 2.27-billion barrel undiscovered, economically recoverable, resource estimate).

Speculative resources include both discovered (uneconomic) and undiscovered (speculative) resources that may be developed more than 20 years after the development of Liberty (Tables V.B-7c and 7d). Future development depends on favorable economic conditions. This category also includes undiscovered oil resources expected to be developed as a result from future State and Federal lease sales (Table V.B-1c). Table V.B-7c lists speculative production from three sources: (1) enhanced recovery and satellite onshore accumulations near existing onshore infrastructure (50% of the 4.0-billion barrels total); (2) another 0.3 billion barrels is assumed to be discovered and developed in the northeast National Petroleum Reserve-Alaska; and (3) a large portion of the currently undiscovered resource base for offshore (80% of the 2.27-billion barrels total). Because these resources are undiscovered, no specific location or potential field size can be provided. Although the individual resource volumes are not known, this category also includes 12 discoveries that may be developed after 20 years (see numbers 44 through 53 in Table V.B-1a). All these discoveries are located onshore.

Development of gas resources on the North Slope is included in the speculative category, because gas has been uneconomic to produce for several decades and may continue to be uneconomic in the future. The largest gas accumulation on the North Slope is in the Prudhoe Bay field (46 trillion cubic feet originally in-place, 22 trillion cubic feet now available for sale). Various plans have been studied to bring North Slope gas to market, but no plan has overcome the high project cost and marketing hurdles. Because known gas resources are uneconomic today, it is difficult to predict the timing or scale of future gas production activities. According to general consensus, gas sales from Prudhoe Bay could start as early as 2010. However, ample supplies exist in the Prudhoe Bay field to supply a large-scale gas export project for at least 20 years. The surrounding oil fields also have available gas resources that could feed into the North Slope gas transportation system. It is very unlikely that development of remote, undiscovered, and higher cost gas resources would occur while there are adequate supplies of known, readily available reserves. The existing North Slope oil infrastructure is capable of handling large amounts of natural gas (26 trillion cubic feet have been cycled through its facilities to date).

These four development categories represent all known oil and gas sources that potentially could be developed on the North Slope and Beaufort Sea. The analysts preparing this EIS focus on the first three oil and gas development categories and consider the fourth category of discoveries with respect to seismic and associated exploration activities associated with future State and Federal lease sales. Other activities and issues could be analyzed as they apply to particular resource topics. These areas of additional evaluation may include cumulative effects from activities related to development in migratory overwintering ranges, environmental contamination, subsistence harvest, sport harvest, commercial fishing, marine shipping, tourism, and recreational activities.

5. Oil Production on the North Slope of Alaska

a. Production Through 1999

Since the first production well was drilled on the Prudhoe Bay structure, North Slope developments produced 12.924 billion barrels of oil by the end of 1999 (Table V.B-7a). Production on the North Slope peaked in 1988 at 2.0 million barrels of oil per day, declining to its current rate of 0.95 million barrels per day. Of the 18 producing fields on the North Slope, the most productive, in order, are Prudhoe

Bay, Kuparuk River, Point McIntyre, and Endicott. Map 3a shows producing fields and potential development areas within the North Slope.

b. Production Estimate We Use for This Cumulative-Effects Analysis

Tables V.B-7b and -7c show the reserve and resource estimates we use for analyzing cumulative effects. We estimate a low range of 6 billion barrels, a mid-range of 10 billion barrels, and a high range of 14 billion barrels of oil reserves and resources that may be produced on the onshore North Slope and in the Beaufort Sea over the lifetime of the Liberty Project.

(1) The Low Range—Past and Present Production

The low end of the range for this cumulative analysis is 6 billion barrels (rounded), which includes past and present production (Tables V.B-7b and -7c). This includes reserves (5.738 billion barrels) in currently producing fields (Table V.B-2) and resources (0.328 billion barrels) in discoveries in the planning or development stage (Table V.B-4). The Liberty Project represents approximately 2.0% by reserve volume of the past and present production volumes (Table V.B-7b).

(2) The Mid-Range—Past, Present and Reasonably Foreseeable Future Production

The mid-range for the cumulative analysis is 10 billion barrels (rounded), which includes past, present, and reasonably foreseeable future production. This includes the 6 billion barrels (rounded) from the low range (discussed above) plus discoveries that may be developed in the next 20 years. Reasonably foreseeable future production (4.156 billion barrels) consists of discoveries totaling 0.550 billion barrels onshore and 0.950 billion barrels offshore (Table V.B-6). In addition, undiscovered onshore resources of 2.300 billion barrels in satellite accumulations and new fields in the National Petroleum Reserve-Alaska, plus 0.356 billion barrels from tracts expected to be leased on the outer continental shelf (Tables V.B-7b and -7c). The Liberty Project represents about 1.2% by reserve volume of the past, present, and reasonably foreseeable future production (Table V.B-7b).

(3) The High Range—Past, Present, Reasonably Foreseeable Future, and Speculative Production

The high range for the cumulative analysis is 14 billion barrels (rounded), which includes existing, planned, possible, and speculative production. This includes 10 billion barrels from the mid-range (discussed above) plus speculative future production (3.724 billion barrels), which includes undiscovered resources that may be developed after 20 years. Speculative production includes an estimated 2.300 billion barrels in currently undiscovered onshore resources in satellite fields and enhanced oil recovery (2.000 billion barrels), plus the remaining half of the leased and undiscovered volume in the National Petroleum Reserve-Alaska (0.300 billion barrels) (Table V.B-7c). It also includes an estimated 1.424 billion barrels of undiscovered offshore resources that could be discovered as a result of future Federal lease sales. The Liberty Project represents 0.8% by reserve volume to the total of past, present, reasonably foreseeable future, and speculative production (Table V.B-7b).

6. State Lease Sales We Consider in this Cumulative-Effects Analysis

Since December 1959, the State has held 32 oil and gas lease sales involving North Slope and Beaufort Sea leases. More than 4.6 million acres have been leased; some of the areas have been leased more than once, because some leases had expired or were relinquished. Historically, only about half of the tracts offered in State oil and gas lease sales have been leased. Of the leased tracts, about 10% actually have been drilled and about 5% have been developed commercially. About 78% of the leased areas are onshore, and about 22% are offshore. From the early 1960's through 1997, 401 exploration wells were drilled in State onshore and offshore areas. During this period, the number of exploration wells drilled annually has ranged from 2-35. From 1990 through 1998, the number of exploration wells drilled annually has ranged from about 7-12; the average number is about 10. Fifty-three of the exploration wells have resulted in discoveries—a success ratio of about 5%.

The State develops and approves an oil and gas leasing plan for a 10-year period, reassesses the plan, and publishes a schedule every other year. All of the North Slope and Beaufort Sea's commercially producible crude oil is on 931 active State leases (as of November 1999)—1.35 million acres onshore along the Slope, 498,000 acres offshore in the Beaufort Sea, and 456,000 acres of active leases that straddle on and offshore acreage. All production to date is from State leases and totals 12.1 billion barrels (Table V.B-7a). The latest State lease sale, State Lease Sale 87, was held in June 1998. Between 1999 and 2001, the State is expected to hold the following annual areawide lease sales:

- Beaufort Sea sales extending from Barrow to the Canadian border;
- Onshore sales on the Arctic Slope, including unleased State lands between the Arctic National Wildlife Refuge and the National Petroleum Reserve-Alaska; and
- Foothills sale extending into the foothills of the Brooks Range.

The State has not estimated oil and gas resources for these future lease sales (see Table V.B-1c). As indicated above,

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we estimate 4.0 billion barrels in undiscovered resources on the North Slope. These include both leased and unleased State properties. Most are expected to be producible only as satellites through future field infrastructure.

7. Federal Lease Sales We Consider in this Cumulative-Effects Analysis

We consider Federal outer continental shelf and northeast National Petroleum Reserve-Alaska lease sales in this analysis. Although no significant production has yet occurred from the Federal outer continental shelf off Alaska, possible future production from Liberty is estimated at 120 million barrels (Table V.B-7c). As indicated above, we also estimate speculative future production from the outer continental shelf of 2.27 billion barrels of currently undiscovered resources, from the base case of the MMS's 1995 National Assessment of the Beaufort Sea less production from "possible outer continental shelf projects"(Tables V.B-7b and 7c). We estimate speculative future production from leases on the northeast National Petroleum Reserve-Alaska would be 0.30 billion barrels.

Since December 1979, the U.S. Department of the Interior has held seven lease sales in Federal waters of the Beaufort Sea. The latest, Sale 170, was held in August 1998. Overall, 660 leases have been issued in the Beaufort Sea totaling 2.8 million acres. About 30 wells have been drilled on Federal leases, with 9 wells determined producible. All wells have been plugged and abandoned, because field economics have not favored production. There are 82 active leases on Federal submerged lands in the Beaufort Sea; the Kuvlum and Hammerhead are potentially producible units although not currently leased (Map 3a), but they have no estimates of available resources. The Northstar Unit contains two Federal tracts. These tracts contain 20-25%of Northstar's estimated 145 million barrels of oil reserves.

Existing outer continental shelf leases in the Beaufort Sea are estimated to contain 220-550 million barrels of oil. The lower number represents potential development at $18/barrel and includes the Liberty Prospect. The higher number assumes a price of $30 per barrel, at which industry is likely to develop discovered but noncommercial fields such as Kuvlum, which is no longer active. Tracts available for lease in Sale 170 but not yet explored may contain 210-450 million barrels of oil.

The Bureau of Land Management held its most recent lease sale in the northeastern part of the National Petroleum Reserve-Alaska in May 1999. Overall, 133 tracts received bids with high-bonus bids totaling $104.6 million. Assuming multiple sales and the preferred alternative of this area, a speculative estimate of production ranges from 130-600 million barrels of oil.

8. Classified Drilling

In addition to the discoveries mentioned above, a number of wells have been drilled that are "classified" (or "tight holes" in oil field jargon). If a well is termed classified, no information is released to the public. Presumably, some of these may include discoveries that may be developed in the future but, without data, no useful estimate of their contribution to cumulative effects can be made.

9. Infrastructure and Transportation

Given the decline of resources in the fields surrounding Prudhoe Bay, the infrastructure and transportation system (including the Trans-Alaska Pipeline System pipeline) should be able to process and transport any oil that Liberty or other small projects produce. New fields would use infrastructure at the edge of the core area. These can be envisioned as the western sector or Alpine Group, which would accommodate the National Petroleum Reserve-Alaska; the central or Northstar Group; and the eastern sector or Badami Group, which will include Liberty (Map 3b, Tables V.B-6a and 6b).

Currently, the Trans-Alaska Pipeline System terminal at Valdez handles about 1.10 million barrels of crude daily. At peak production, Liberty would produce about 22 million barrels of crude oil annually. The daily production rate of Liberty would be approximately 2% of the throughput the pipeline system now handles. If we estimate future production on the North Slope (including offshore) at the high end of projections, oil tankers still could be moving this daily amount of oil (about 1.0 million barrels) from Valdez in 2009. In this year, Liberty will add less than 1% to oil-tanker traffic (see Figs.V-2 and V-3 for oil tanker routes).

a. Tanker Traffic and Routes

Potential crude oil (and possibly liquefied natural gas tankerage from Valdez to the Far East will join existing liquefied natural gas tanker traffic from the liquefied natural gas plant in Nikiski, Alaska. Every 10 days, the Nikiski plant loads a tanker with 80,000-cubic meters of liquefied natural gas for a round trip to Tokyo, which it has been doing since 1968 without significant spillage. Because liquefied gas would boil off and disperse quickly when exposed to normal air temperatures and winds in the North Pacific, it is not a major environmental threat along the tanker route.

On November 28, 1995, President Clinton signed legislation (30 U.S.C. 185(s)) that authorizes exporting crude oil from Alaska's North Slope in U.S. flag tankers, unless the President finds exports are not in the national interest.

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Figure V-3 shows the probable route that tankers bound from Valdez to the Far East would travel. They could carry up to 1.8 million barrels each; however, such estimates are highly speculative, because they depend on opportunities for short-term contracts. The routing shown in Figure V-3 would bring the tankers more than 200 miles offshore of the Aleutian Islands—a distance that should protect the biological resources of the Aleutian Chain from pollution.

b. Trans-Alaska Gas Transportation System

If the price per barrel of crude oil remains between $20 and $30, building a gas-transportation system may be viable. The latest of a variety of proposed systems would be designed to deliver natural gas from the North Slope at up to 2.3 billion cubic feet per day to a liquefaction plant in Valdez. The natural gas would be moved through a 42-inch pipeline built next to the Trans-Alaska Pipeline. The proposed project would consist of a plant to liquefy about 2 billion cubic feet per day of natural gas, four tanks to store 3,200,000 barrels of liquefied natural gas, a marine loading area, and a dock for loading cargo and personnel. The liquefied natural gas plant most likely would be in Anderson Bay, 3 miles east of the Valdez narrows on the south shore of Port Valdez (other options are being considered). The site is 3.5 miles west of the existing Trans-Alaska Pipeline System terminal and 5.5 miles from Valdez. When completed, it would occupy 390 acres of a 2,630-acre site owned by the State. A fleet of 15 liquefied natural gas tankers is anticipated would be available to carry 125,000 cubic meters of liquefied gas per trip to destinations in Japan, Taiwan, and Korea. Full development would require 275 liquefied natural gas tanker loadings a year (Federal Energy Regulatory Committee, 1995). A final EIS was issued for the plant in March 1995, but no agreements exist with the resource holders. Please see Table V.B-1b for more information on the Trans-Alaska Gas System and other projects that could move gas from the North Slope to market. However, given the uncertainty associated with construction of such a transportation system in the foreseeable future, its potential effects are not included in this cumulative analysis.

c. Transportation for "Roadless" Development

Ongoing and planned oil development projects such as Badami, Liberty, Alpine, and Northstar would not have permanent gravel roads connecting to Prudhoe Bay. Transportation to these fields would be via aircraft and marine vessels; in winter, temporary ice roads also would be used (Table V.B-8).

10. Water and Gravel Resources

a. Water Resources

The Arctic Coastal Plain is the predominate feature of the North Slope. It is a mosaic of tundra wetlands with extremely low relief and poor drainage and numerous shallow lakes, ponds, marshes, and slow-moving streams. Shallow permafrost is evidenced by polygonal-patterned ground formed by ice wedges that freeze within contraction cracks in the soil. Permafrost prevents water from entering the ground, and the low relief limits runoff. The coastal plain extends south approximately 30 miles into the coastal lowlands, which are dominated by tundra vegetation, meandering streams, and thousands of shallow thaw lakes.

Approximately 26% of the coastal plain is covered by waterbodies (USDOI, BLM, 1979). The onset of snowmelt and subsequent runoff begins earlier in the foothills and moves north as summer progresses. Snowmelt is a dominant factor, because it contributes the majority of the annual runoff and helps maintain a saturated layer of surface soils. Stream flow generally is nonexistent in the winter. It begins in late May or early June as a rapid flood event or “breakup” that, combined with ice and snow damming, can inundate extremely large areas in a matter of days. More than half of the annual discharge from a stream can occur during a period of several days to a few weeks (Sloan, 1987).

BPXA estimates the freshwater needs during the construction and development-drilling phase would be approximately 120 million gallons per year. After construction, the annual freshwater needs for ice roads would be reduced to about 20 million gallons. There are more than 30 different permitted water sources that may be used for ice-road construction and other water needs. These sources include existing and abandoned mine sites, one of which includes 6 million gallons at the Duck Island mine site (see Alternative VI). Available permitted lakes range in size from approximately 0.1-0.5 miles in surface area.

The 120 million gallons of water would equal 368 acre-feet of surface (1.0 acre-foot = 326,000 gallons). This volume represents a water drawdown of 12 inches from a 368-acre lake or two smaller, 184-acre lakes. Two of the larger lakes, four smaller lakes, or some combination would accommodate a drawdown of 6 inches. The permitted lakes are available throughout the area and ideally located to minimize travel for construction and maintenance purposes (Map 3c).

Water requirements for other onshore exploration and development during the seasonal construction phase has been estimated at about 37 acre-feet for each field, which would require water from an additional 12 acres of lake per field (US Army Corp Engineers, 1999).

Biotic communities present within the permitted freshwater lake systems are not expected to be adversely affected with these fluctuations in water level, as the natural environment and the dynamics of seasonal flux are more rigorous conditions that the biota has accommodated (see Sec.V.C.7, Vegetation-Wetland Habitats). Cumulative effects on water resources would not be expected, as local freshwater needs would be replaced by natural processes and no additional construction activities are expected during construction of the Liberty Project.

b. Gravel Resources

Gravel sources adjacent to the proposed Liberty Island location are indicated on Map 3c. In all three categories of gravel sources listed in the legend for Map 3b, the total amount of surface covered is 2.743 square miles, or 1,756 acres. The proposed gravel source for the Liberty Project covers .083 miles, or 53 acres. Beyond the Liberty site, the nearest gravel sources are a small-rehabilitated source on the Shaviovik River Delta and the active Duck Island site located on the Sagavanirktok River Delta. Both of these sites are approximately 11-12 miles from the landfall of the Liberty pipeline.

C. ANALYSIS OF CUMULATIVE EFFECTS BY RESOURCE

Assumptions Used in the Analysis: The analysis of cumulative effects differs from the analysis of the Proposal in part, because it considers an expanded geographic area and extended timeframe. This is needed to include additional effects on the physical, biological, and human environments of development of the oil and gas discoveries and other activities described in Section V.1. The geographic area is further expanded to include the migratory and transitory nature of many resources. The timeframe includes development of discoveries that may occur during the 15-20-year life of the Liberty Project and includes exploration activities of new discoveries over the next 30-40 years.

The cumulative-effects analysis further differs from the Proposal by assessing the combined effects of past, present, and reasonably foreseeable future activities. To determine the effects of the Proposal (Sec. III), we used the existing environment (Sec. V), as a baseline. However, this is not appropriate for cumulative-impact assessments, because it makes the effects of past and present actions part of the baseline rather than contributing to cumulative impacts (McCold and Saulsbury, 1996). The National Environmental Policy Act requires us to describe the incremental contribution of the Proposal to the existing baseline at the present time. This baseline changes over time with additional uses, and the National Environmental Policy Act also requires an accounting of the environment over time. This means that our baseline for this cumulative-effects analysis must include past, present, and reasonable foreseeable activities. In both the Proposal and cumulative-effects analysis the incremental contribution of the proposed activity is relatively small and may be reduced in significance as new activities occur. There is, however, greater uncertainty in determining cumulative effects than in determining the individual project-specific effects. We recognize the importance of ongoing environmental change and attempt to quantify the factors causing this change, including recovery, and identify thresholds of environmental response, when possible.

To calculate the likely number of estimated oil spills in our analysis of cumulative effects, we decided to use the mid-range production estimate, which includes our estimate of past, present, and reasonably foreseeable future production for the North Slope/Beaufort Sea (Table V.B-7b). The incremental contribution of the Liberty Project by volume of oil is a very small portion (about 1%) of the mid-range production estimate. To determine the number of oil spills, we multiply the offshore and onshore reserve estimates by the spill rate per billion barrels produced. While the most likely number of oil spills greater than or equal to 500 barrels from all past, present, and future activities is estimated to be one, the most likely number of spills from Liberty is estimated to be zero (see Appendix A, Table A-35). The mean number of estimated spills for the North Slope/Beaufort Sea area statistically is 1.09, of which Liberty is estimated to contribute statistically only 0.07, or about 6%. While the number of spills may vary as a result of new resource estimates and assumptions, the relative contribution of Liberty is expected to be the same or proportionally smaller).

Analysis of possible oil spills from tankering oil to the west coast includes consideration of the *Exxon Valdez* oil-spill effects in Prince William Sound, a large spill in the Gulf of Alaska, and smaller spills along the tanker route. The most likely number of oil spills greater than or equal to 1,000 barrels from Trans-Alaska Pipeline System tankers is 9, and the most likely number of spills from Liberty is estimated to be zero. The mean number of estimated spills is 9.92, of which Liberty is estimated to contribute statistically only 0.12, or about 1%. We estimate six spills with an average size of 3,000 barrels, four of which occur in port and two at sea. We assume two spills with an average size of 13,000 barrels, both which occur at sea. Finally, we assume one spill at sea in the Gulf of Alaska of 200,000 barrels. The basis for the above assumption is described in Appendix A and Section IX.

In-port spills, where contingency measures are in place, would be cleaned up relatively quickly. Spills originating 80-100 nautical miles offshore would have a 5-10% chance of contacting the shoreline within 30 days (LaBelle and Marshall, 1995). Recent new shipping lanes and port routes have been initiated by the National Oceanic and

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Atmospheric Administration requiring tankers to travel at least 50 nautical miles offshore central California to better protect three marine sanctuaries—Monterey Bay, the Gulf of the Farallones, and the Channel Islands. The estimated six spills at sea and the one larger spill is not expected to occur within the same location or contact the same resources before recovery of the affected resource. Recovery periods would be lengthened if more than one spill affected the same population within a short interval, a situation that is unlikely.

Monitoring studies are available of biological populations that have experienced past and are experiencing present industry activities. However, where available, they have been factored into the abundance and distributional status and trends of the populations. Natural population fluctuations also are an important consideration but often are not well defined because of the extensive habitat and wide-ranging migratory patterns of many arctic species. Some populations, such as polar bears and some caribou herds, have increased over the past 30 years while others, such as the spectacled eider, have decreased. However, the exact causes of these population changes are difficult to determine.

With the somewhat ubiquitous distribution of many of the resources on the North Slope, an overlap of impact zones from activities of several projects is not well defined. Figure V-4 shows the distribution of polar bears and ringed seals and the spring and fall migration routes of bowhead whales in the Beaufort, Chukchi, and Bering Seas. Caribou calving areas in northern Alaska also are shown in Figure V-4. Nonmobile populations, such as those comprising the Boulder Patch in the Beaufort Sea, could be more heavily affected by specific projects. In this case, the Endicott, Northstar, and Liberty projects are weighed more heavily. Also, oil spills and disturbance factors are highly unlikely to occur at the same time and place to increase the magnitude of effects. Thus, for the most part, resources are expected to have recovered from a perturbation before providing any measurable increase in cumulative effects.

The analysis of each resource has been weighed with respect to past, present, and future activities, as appropriate, to best predict the effects of the Liberty Project on that resource. For instance, the threatened spectacled eider has experienced stress from past and present environmental factors and human activities, and this stress is likely to continue in the future. Thus, the effects from Liberty on these eiders are of concern. Effects from past oil and gas activities and those presently ongoing are part of the present population condition.

As indicated above, future actions resulting from the development of existing discoveries are on a certainty scale of past development (those currently in production), present development (within 10 years), reasonably foreseeable future developments (within 10-20 years), and speculative development (after 20 years). The most heavily weighed are those past and present onshore activities at Endicott, Sagavanirktok Delta North, Eider, and Northstar offshore. Next in consideration of offshore activities are the reasonably foreseeable future developments at Sandpiper, Kuvlum, Hammerhead, and Flaxman Island. Reasonably foreseeable future onshore developments could consist of eight relatively small fields of no measurable consequence to the environment at this time.

Speculative future development after 20 years is highly uncertain and includes 12 smaller onshore discoveries, and some exploration and development activity resulting from future State and Federal lease sales has been included (see Sec.V.B). While future projections are highly speculative, effects are based on present state-of-the-art technology. Industry has been developing technology and strategies to reduce the impacts associated with exploration and development activity, and it seems reasonable to expect this trend to continue. Thus, future impacts might be less than are estimated in this cumulative analysis. Further, in the event of a major oil spill, additional design criteria, safeguards, and protective measures would be instituted as evidenced by the *Exxon Valdez* oil spill. For purposes of analysis, we have assumed no additional mitigation that would be very unlikely and, in that respect, this analysis overestimates cumulative effects.

Analysis of Cumulative Effects by Alternatives: The National Environmental Policy Act and Council on Environmental Quality regulations recognize the cumulative problem as complex and require, along with the proposal and alternatives, an analysis of cumulative effects. Because the incremental contribution of a proposed action is usually small and each new project ups the ante on the baseline condition, congress covered this contingency with the cumulative analysis. The purpose of the analysis was a consideration of where we had been and where we were going with development of our resources. This analysis is on a scale of projects past, present, and in the next 15-20 years in the case of Liberty. This scale puts in perspective the sensitivity of the cumulative analysis. This means that impacts that can be identified in the analysis of a proposed project, may or, more than likely, will *not* translate to an effect in the cumulative analysis.

An example of scale is the lease sale EIS, which usually involves major tract deletion alternatives. These are usually measurable differences for some resources, but for many resources there is no change in the effects of the alternatives from the proposed action. The cumulative case for each alternative, even in these massive lease sale areas in Alaska, has never been considered to yield any useful information, as there has never been a measurable effect of an alternative at the cumulative level. For a site-specific development project such as the Liberty project the alternatives of (1) pipeline route, (2) pipeline design, (3) sheetpile protection, (4) gravel source, and (5) pipeline burial depth, are on a scale of lesser environmental sensitivity and even less likely to translate to cumulative effects.

The extended geographic scale and timeframe of the cumulative analysis reduces the sensitivity of this analysis and treatment of alternatives. In the case of migratory birds, fishes and mammals the extensive geographic range of some of these species includes factors far removed from the site of the proposed action that can be limiting to the resource that spends but a small part of its time in the zone of influence of the proposal. The extended timeframe when projecting the past and future impact on the resource further reduces the sensitivity of the cumulative analysis as to the importance of the proposed action and is even less likely to detect a measurable change from the respective alternatives which are proposed for the Liberty Project.

In summary, the alternatives of the Liberty EIS have not been analyzed for cumulative effects, because there is very little change in the level of effects identified in the proposed action from the alternatives. This is to be expected, because the level of impacts from the Liberty Project is very small. The measurable effects of the proposed action do not necessarily translate to measurable effects in the cumulative case because of the larger scale and timeframe required for the cumulative analysis. The alternatives offer some change in the level of effects, but this is not measurable with the Liberty cumulative analysis.

Supporting Information: The following cumulative analysis builds on information contained elsewhere in this EIS. . Sections II.A.2, 3, and 4 describe BPXA's Oil Discharge Prevention and Contingency Plan (BPXA, 2000b); Spill Response Plan, Safety Systems for Oil Spill Prevention, and Pipeline Safety. Section III.C.1 discuses Project Integrity. Sections III.C.2 and 3, and III.D contain our analyses of potential effects. Section VI describes the existing environment. Section IX provides analyses of low probability, very large oil spills from blowouts and tankers. Appendix A, Oil-Spill-Risk Analysis, explains and provides information used by the analysts for estimating the probabilities and locations of potential oil spills used in this EIS, including information about the size, location, and distribution of tanker spills.

We also have evaluated the cumulative effects on the North Slope and from transporting North Slope oil to U.S. west coast and Asian markets in the Outer Continental Shelf Oil and Gas Leasing Program: 1997-2002 Final EIS (USDOI, MMS, Herndon, 1996a:IV-264-464); Northeast National Petroleum Reserve-Alaska, Final EIS (USDOI, BLM and MMS, 1998:IV-H-1-26); Beaufort Sea Planning Area Oil and Gas Lease Sale 170, Final EIS (USDOI, MMS, 1998:IV-G-1-31); and, the Beaufort Sea Planning Area Oil and Gas Lease Sale 144 Final EIS, (USDOI, MMS, 1996a:IV-H-1-31).

Summary of Cumulative Effects by Resource: A brief summary of the effects from the Liberty Project and the relative contribution of those effects to other past, present, and future activities are presented in TableV.B.9, with the more detailed analysis in the subsequent Sections V.C-1 through 13.

In the following sections, we analyze the potential cumulative effects to individual resources. Each subsection consists of a summary and conclusion for cumulative effects of North Slope activities and along the transportation route. Next, we present a determination of the contribution of Liberty to the cumulative effects followed by the details supporting the analysis of the resource.

1. Threatened and Endangered Species

a. Bowhead Whale

(1) Summary and Conclusions for Beaufort Sea, North Slope, and Transportation Activities on the Bowhead Whale

Bowhead whales might experience cumulative effects from outer continental shelf activities, such as oil spills or noise from drilling, vessel and aircraft traffic, construction, seismic surveys, or oil-spill-cleanup activities, and from non-outer continental shelf activities. Bowhead whales temporarily may move to avoid noise-producing activities and may experience temporary, nonlethal effects, if oil spills occur during activities associated with Liberty or other past, present, or reasonably foreseeable future development projects in the arctic region.

We do not expect bowhead whales to die from noise produced while exploring, developing, and producing offshore oil and gas, but some could experience temporary, nonlethal effects. Some bowheads temporarily may move to avoid vessels and activities conducted for seismic surveys, drilling, and construction. Contact with spilled oil in the Beaufort Sea could cause some temporary, nonlethal effects to some bowhead whales, and a few could die from prolonged exposure to freshly spilled oil. Bowhead whales should not be affected by oil spills or activities associated with the transport of oil through the Trans-Alaska Pipeline System or by marine transportation along the tanker routes to market.

Activities that are not related to oil and gas also could have cumulative effects on bowhead whales. A small number of whales may be injured or killed as a result of entrapment in fishing nets or collisions with ships. Native whalers from Alaska harvest bowheads for subsistence and cultural purposes under a quota authorized by the International Whaling Commission. Native whalers from Russia also are authorized to harvest bowhead whales under a quota authorized by the International Whaling Commission.

Contribution of Liberty to Cumulative Effects: The Liberty Project's contribution to cumulative effects is expected to be limited to temporary avoidance behavior by a few bowhead whales in response to vessel traffic.

The Liberty Project represents a small proportion (about 1%) of past, present, and reasonably foreseeable oil and gas development projects in the Beaufort Sea area and is estimated to contribute about 6% of cumulative offshore spills. Liberty's estimated statistical contribution of spilled oil is 0.07 spills (out of an estimated mean number of 1.09 spills), with the most likely number of spills being zero (Table A-35). Bowhead whales should not be affected by oil spills or activities associated with the transport of oil to markets. More information on the effects of noise and oil spills on bowhead whales can be found in Sections III.C.3 and III.C.2, respectively.

Underwater industrial noise, including drilling noise, measured from artificial gravel islands, has not been audible in the water more than a few kilometers away. Because the bowhead whale's main migration corridor is 10 kilometers or more seaward of the barrier islands, drilling and production noise from Liberty Island likely would not reach many migrating whales. It also would be unlikely to affect the few whales that may be in lagoon entrances or inside the barrier islands because of the rapid attenuation of industrial sounds in a shallow-water environment. Whales usually are not found near the Liberty island.

Marine-vessel traffic outside the barrier islands probably would include only seagoing barges transporting equipment and supplies from Southcentral Alaska to the Liberty location, most likely between mid-August and mid- to late September. Barge traffic continuing into September could disturb some bowheads during their migration. As described in Section III.C.3 some whales could be affected by noise from vessel traffic. Whales may avoid being within 1-4 kilometers of barges. Fleeing behavior usually stops within minutes after a vessel has passed but may last longer. Vessels and aircraft inside the barrier islands should not affect bowhead whales. Because island and pipeline construction would occur during the winter and well inside the barrier islands, they are not likely to affect bowhead whales.

(2) Details of Cumulative Effects on Bowhead Whales

(a) Projects That May Affect Bowhead Whales

In addition to Liberty, two projects—Endicott, a past development project currently producing oil; and Northstar, a present development in the construction stage—may affect bowhead whales. The Kuvlum and Hammerhead units, both reasonably foreseeable future development projects, are within the bowhead whale's normal fall-migration route. The Sandpiper and Flaxman Island units, also reasonably foreseeable future development projects, are not within the bowhead whale's normal fall-migration route. Endicott, Northstar, and Flaxman Island are all or mostly on State lands. These projects and their potential effects on whales are discussed later. Other Federal and State sales in the Beaufort Sea that are scheduled through 2001 could lead to more noise and disturbance from exploratory activities. Other types of projects mentioned above likely would not affect whales. These include the Trans-Alaska Pipeline System; building and construction of the Trans-Alaska Gas System, Alaska Natural Gas Transportation System; converting natural gas to liquefied natural gas; or tankering crude oil from Valdez.

Activities conducted on the outer continental shelf in the Beaufort Sea as a result of previous Federal lease sales since 1979 apparently have not had adverse effects on the bowhead whale population. Although numerous exploration wells have been drilled from a variety of platforms ranging from gravel islands to submersibles, and extensive seismic surveys have been conducted, no bowhead whale mortality has been reported. The bowhead whale population has continued to increase over that timeframe. However, Inupiat whalers have stated that noise from these activities at least temporarily displaces whales farther offshore, especially if the operations are conducted in the main migration corridor. There are indications that whales may avoid areas where seismic surveys or drilling operations are being conducted. Recent monitoring studies (Miller et al., 1997, 1999; Miller, Elliot, and Richardson, 1998) indicate that most whales migrating in the fall avoid an area with a radius about 20-30 kilometers around a seismic vessel operating in nearshore waters.

The potential for oil-industry activities outside of the Alaskan Beaufort Sea appears to be limited. Two Federal lease sales previously were conducted in the Chukchi Sea and exploration activities were conducted, but no producible wells were discovered. A Chukchi Sea/Hope Basin sale scheduled in the 1997-2002 OCS oil and gas leasing program has been deferred, and it is speculative whether such a sale will be held in the future. Currently, there are no plans for future oil and gas exploration activities in the Bering Sea. In the Canadian Beaufort Sea, the main area of industry interest has been around the Mackenzie River Delta and offshore of the Tuktoyaktuk Peninsula. Although there have been oil discoveries in these areas, there has been little industry interest in the area in recent years.

(b) Effects of These Projects on Bowhead Whales

Some effects on bowhead whales may occur because of activities from previous and proposed lease sales of State and Federal areas offshore. Generally, bowhead whales remain far enough offshore to be mainly in Federal waters, but they move into State waters in some areas, such as the Beaufort Sea southeast and north of Kaktovik and near Point Barrow. We detailed these potential effects in the Beaufort Sea Sale 170 Final EIS (USDOI, MMS, 1998) and in Section III.C.3 of this EIS.

Cumulative risks from oil spills to whales in the Beaufort Sea would be higher than risks from the Liberty Project alone. The Liberty Project represents a small proportion (about 1%) of past and present oil and gas development projects in the Beaufort Sea area and is expected to contribute about 6% of cumulative offshore spills. Liberty's estimated statistical contribution of spilled oil is 0.07 spills (out of an estimated mean number of spills of 1.09), with the most likely number of spills being zero (Table A-35 in Appendix A). The assumed spill size for the cumulative case is a range of 125-2,956 barrels. Because more oil spills are likely to occur under the cumulative case than for the Liberty Project alone, whales are more likely to contact spilled oil, and oil-spill effects may be greater. However, oil has more of a chance of contacting the bowhead's habitat than the whales themselves. Individuals exposed to spilled oil may inhale hydrocarbon vapors, experience some damage to skin or sensory organs, ingest spilled oil or oil-contaminated prey, feed less efficiently because of baleen fouling, and lose some prey killed by the spill. Prolonged exposure to freshly spilled oil could kill or injure a few whales.

Overall, exposure to noise from oil and gas operations should not kill any bowhead whales, but some could experience temporary, nonlethal effects. Major changes in the bowhead's migration route through the Beaufort Sea are unlikely to result from this noise, although some individuals may be diverted further offshore. Inupiat whalers have stated that noise from some drilling activities, especially drilling from drillships with icebreaker support in the main migration corridor, displaces whales farther offshore away from their traditional hunting areas. Inupiat whalers also have stated that noise from seismic activities displaces whales farther offshore. Cumulative effects could include behavioral responses to seismic surveys; aircraft and vessel traffic; exploratory drilling; construction, including dredging; and development drilling and production operations that occur at varying distances from the whales. Detailed discussions of how these activities may affect bowheads can be found in the Final EIS's for Beaufort Sea Lease Sales 144 and 170 (USDOI, MMS, 1996a; USDOI, MMS, 1998)and in Section III.C.3 of this EIS. In general, bowheads may try to avoid vessels or seismic surveys if closely approached, but they do not respond much to aircraft flying overhead at altitudes of 1,000 feet or more. Bowheads also try to avoid close approaches by motorized hunting boats. Bowheads have been sighted near drillships, although some bowheads probably change their migration speed and swimming direction to avoid getting close to them. Whales appear less concerned with stationary sources of relatively constant noise than with moving sources. Bowheads do not seem to travel more than a few kilometers in response to a single disturbance, and behavioral changes are temporary, lasting from minutes (for vessels and aircraft) up to 30-60 minutes (for seismic activity). New information on the effects of seismic noise on bowheads is now available from marine mammal monitoring programs conducted in 1996-1998 (Miller et al., 1997, 1999; Miller, Elliot, and Richardson, 1998). In summary, the LGL and Greeneridge 1996-1998 monitoring studies found no indication during survey efforts that the general migration corridor was farther offshore on days with seismic airguns operating compared to days without seismic airguns operating. However, aerial survey results indicated that bowheads tended to avoid the area around the operating source, perhaps to a radius of about 20 kilometers. Sighting rates within a radius of 20 kilometers of seismic operations was significantly lower during seismic operations than when no seismic operations were occurring. Within 12-24 hours after seismic operations ended, the sighting rate within 20 kilometers was similar to the sighting rate beyond 20 kilometers. There was little or no evidence of differences in headings, general activities, and swimming speeds of bowheads with and without seismic operations. The observed 20 kilometer (12.5 miles) area of avoidance is a larger avoidance radius than 7.5 kilometers (4.7 miles) documented by previous scientific studies and smaller than the 48 kilometers (30 miles) suggested by subsistence whalers. The whales' avoidance of the seismic operations during the 1996-1998 whaling seasons did not affect subsistence whaling.

Development projects such as Endicott or Northstar are not likely to harm bowhead whales (Map 1). Endicott is inside the barrier islands in relatively shallow water. Support traffic is over the causeway. Operations for both projects would occur from gravel structures, which limits how far noise would travel. Although Northstar is not inside the barrier islands, it is well shoreward of the bowhead's fall migration route. Studies discussed in Section III.C.3.a indicate that noise from oil and gas operations on gravel islands is substantially attenuated within 4 kilometers and not detectable at 9.3 kilometers. In 1996, LGL (Miller et al., 1997) found nearly all the bowhead whales in the vicinity of Northstar in 15-40 meters of water, about 10-50 kilometers from shore. In 1997, LGL (Miller, Elliott, and Richardson, 1998) found nearly all the bowhead whales in the vicinity of Northstar in 10-40 meters of water. Sightings were concentrated in waters from less than 10 meters to 30 meters deep about 5-35 kilometers from shore. Only two sightings occurred seaward of the 50-meter-depth contour. Helicopters and vessels likely would operate well shoreward of the bowhead's migration corridor. The potential for spilled oil from these projects to reach bowhead whale habitat or to contact whales is minimal.

Some bowhead whales could be disturbed if development proceeds at the Kuvlum and Hammerhead units or other reasonably foreseeable future development projects, such as the Sandpiper or Flaxman Island units (Map 3b). The Kuvlum and Hammerhead units are within the bowhead whale's normal fall-migration route. Development of these units likely would share infrastructure with the Badami group. Each unit likely would have its own production pads and wells and a pipeline connecting it to an existing or planned field associated with Badami. Installing production platforms and constructing pipelines could disturb some bowhead whales on their fall migration, if pipeline construction in deeper water occurred during the open-water season. If helicopters from Deadhorse pass low overhead, they could cause bowheads to dive. Whales would try to avoid close approach by vessels. Behavioral studies have suggested that bowhead whales may get used to noise from distant ongoing drilling, dredging, or seismic operations, but they still may exhibit some localized avoidance (Richardson and Malme, 1993). We do not have enough evidence to know whether or not industrial activity continuing for several years would keep bowheads from using an area, and no documented evidence shows that noise from outer continental shelf operations would act as a barrier to migration. The Sandpiper and Flaxman Island units are not within the main bowhead whale fall migration route. Sandpiper is near Northstar, and the effects on bowheads from development at that location likely would be similar to those expected from Northstar. Flaxman Island is closer to the bowhead whale's main fall migration route, but it is a barrier island. In general, noise from oil and gas activities on gravel islands does not travel more than a few kilometers. Development of the Sandpiper unit likely will share infrastructure with the Northstar group. The unit likely would have its own production pads and wells and a pipeline connecting it to Northstar. Development of the Flaxman Island unit likely would share infrastructure with the Badami group. The unit likely would have its own production pads and wells and a pipeline connecting it to a past or present development project associated with Badami.

(c) Other Effects on Bowhead Whales

Activities that are not oil and gas related also affect bowhead whales. Incidental take of bowhead whales apparently is rare. Between 1976 and 1992, only three ship-strike injuries were documented out of a total of 236 bowhead whales examined from the Alaskan subsistence harvest (George et al., 1994). The low number of ship-strike injuries suggests that bowheads either do not often encounter vessels or they avoid interactions with vessels, or that interactions usually result in the death of the animals. The bowhead whales' association with sea ice limits the amount of fisheries activity occurring in bowhead habitat. A young bowhead was reported to have died after being entrapped in a fishing net in Japan (Sheldon and Rugh, 1996) and another in northwest Greenland in a net used to capture beluga whales. There are no observer program records of bowhead whale mortality incidental to commercial fisheries in Alaska. Based on the lack of reported mortalities, the estimated annual mortality rate incidental to commercial fisheries is zero whales per year from this stock (Hill and DeMaster, 1999).

Subsistence whaling authorized by the International Whaling Commission is another outer continental shelf activity that affects the bowhead whale. Bowheads are harvested by Alaska Natives in the northern Bering Sea and in the Chukchi Sea on their spring migration and in the Beaufort Sea on their fall migration. Requests to harvest bowheads also have been made by Canadian and Russian Natives. The Canadian Government granted permission in 1991 to kill one bowhead, and a bowhead was harvested in Mackenzie Bay in the fall of 1991. Additional permits were granted in 1993 and 1994, but no bowheads were harvested in either year. There has been a renewed interest by villages along the Russian Chukchi Sea coast to hunt bowhead whales. At the 1997 International Whaling Commission, the Commission approved a combined quota allowing an average of 56 bowheads to be landed each year to meet the needs of Eskimos in Alaska and Russia.

There currently is a 5-year block quota of 280 bowhead whales landed, authorized by the International Whaling Commission for 1998-2002 (64 *FR* 28413). The number of bowheads struck in each year may not exceed 67, except that any unused portion of a strike quota from any year may be carried forward. No more than 15 strikes may be added to the strike quota for any one year. There were 15 unused strikes available after the 1997 harvest, so the combined strike quota for 1998 was 82 (67 + 15). There were 15 unused strikes available after the 1998 harvest, so the combined strike quota for 1999 was 82 (67 + 15). The Eskimos in Alaska and the Chukotka Natives in the Russian Far East shared the 82 combined strike quota for 1998 and 1999. In 1999, the Chukotka Natives in the Russian Far East were allowed no more than 7 strikes, and the Alaska Eskimos were allowed no more than 75 strikes. The quota for Alaska Eskimos is divided among 10 Alaskan villages in the Bering, Chukchi, and Beaufort seas. This compares with the previous quota of 266 strikes, or 204 bowhead whales landed, authorized by the International Whaling Commission for 1995-1998 to be divided among 10 Alaskan villages (Sheldon and Rugh, 1996). This level of harvest was approved by the International Whaling Commission under the supposition that it still would allow for continued growth in the bowhead population. It is likely that the bowhead whale population will continue to be monitored and that the harvest quota will be set accordingly to maintain a healthy bowhead population level.

The incremental contribution of effects from the Liberty Project to the overall effects under the cumulative case is not likely to cause an adverse effect on the bowhead whale population.

(3) Transportation Effects on Bowhead Whales

Bowhead whales are a marine species that winter in the Bering Sea and migrate through the Chukchi Sea into the Beaufort Sea every spring. In the fall, they migrate back through the Chukchi Sea into the Bering Sea. Bowhead whales and their habitat are far removed from the tanker transportation routes to the Far East and to southern California. Therefore, they would not be affected by overland transportation of oil through the Trans-Alaska

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Pipeline System or by marine transportation along the tanker routes.

b. Eiders

(1) Summary and Conclusions for Beaufort Sea, North Slope, and Transportation Activities for Eiders

A large offshore oil spill may result in significant losses by contacting prebreeding or postbreeding eiders staging in offshore or nearshore areas. A large onshore spill may contact nesting eiders or young, but these are likely to represent only a minor proportion of the regional population (which is about 3% of the total population). Although tanker spills of arctic oil in the Gulf of Alaska are not expected to reach areas where most Steller's eiders winter, from the Aleutian Islands to Cook Inlet, any substantial mortality is likely to prolong its recovery from threatened status. The numerous small spills, whether offshore (platform) or onshore (pipeline or other source), could cause substantial losses over the 30-40-year life of projects considered in this cumulative analysis, and interfere with the recovery of these eider species.

Spectacled eiders may be displaced from preferred broodrearing, staging, or migrating areas near helicopter corridors, causing extra short-term energy use, or movement to less desirable areas where forage is of lower quality. Predators may destroy nesting efforts of birds flushed by helicopters or personnel, or they may be attracted to nests near human activity sites. Long-term displacement from the vicinity of frequently used onshore air corridors may result in lowered production. Vehicle traffic along roads serving present and future projects may reduce nesting. Any population effect of these situations is expected to be minor. Because of a smaller "footprint," the effect of future projects' infrastructure on bird populations, although additive to natural losses, is expected to be less severe than previous development in the Prudhoe Bay region.

Although the chance of oil spill occurrence is small (1-6%), the potential is higher for contact with spectacled eider concentrations present at certain times of year in certain areas, where projects assumed in the cumulative case will occur. Also, as a result of the apparent decline in its population and the challenge of recovering spilled oil, particularly in broken-ice conditions, there is uncertainty as to the ultimate effect of any spills on the eider population. Although Fish and Wildlife Service survey data do not show a significant decline in the coastal plain spectacled eider population, the potential exists for a significant adverse effect from an oil spill on this population, particularly that segment nesting in the eastern portion of the range. Mortality resulting from the cumulative effects of projects would be additive to natural mortality and interfere with the recovery from any declines in the coastal plain eider population. Therefore, recovery of the population from even small losses is not likely to occur quickly. Recovery from such a loss would not be expected to occur while the circumstances that led to its listing as threatened continue. Any loss of eiders from small spills or disturbance is not expected to prevent the population's recovery from declines but could negatively affect the rate of recovery.

Contribution of Liberty to Cumulative Effects: Although development of the Liberty Prospect represents a small proportion of cumulative oil spill risk, it could contribute significantly to cumulative effects if a large oil spill contacted eiders staging in offshore or nearshore areas. The number typically at risk in the Liberty area is unknown but may be relatively small.

Losses of spectacled eiders from one 720-1,142 barrel onshore spill estimated for Liberty (estimated mean number = 0.01, Table A-35) are expected to be fewer than 20 individuals. Substantially greater mortality could result from the numerous small spills that are projected for the 30-40-year life of oil and gas projects considered in this cumulative analysis.

Disturbance of eiders by helicopter-support traffic for Liberty is expected to be about twice that required for Northstar and considerably greater than for Alpine during construction, and current traffic supporting the Badami project (Table V.B-8). This difference would decrease to about one-fifth of the total for these projects during the operating phase. Habitat alteration associated with Liberty onshore construction is expected to be only about 0.6% of the total altered by Prudhoe Bay region projects (roads, pads, airstrips, gravel mines Tables V.B-3 and V.B-5). Considering only Badami, Alpine, and present development projects, Liberty represents 13% of the total habitat destroyed (Tables V.B-3 and V.B-5). A comparison of gravel mine areas and preferred tundra wetland nesting habitat projected to be disturbed by Liberty with that disturbed at Prudhoe Bay shows that Liberty would disturb 2.1% and 0.01%, respectively, of the area altered by Prudhoe Bay development. Although the Liberty Project is expected to contribute substantially to cumulative noise and habitat disturbance effects, but this contribution will decrease considerably after construction is completed.

Tanker spills of arctic oil, including only 0.13 (Table A-35) potentially attributable to Liberty of 11.13 total (about 1%), are unlikely to reach the most densely populated Steller's eider wintering areas.

Overall cumulative effects of Liberty would be additive to effects from all projects. Only in the case of a large offshore oil spill would Liberty be expected to increase cumulative adverse effects to potentially significant population level consequences.

(2) Details of Cumulative Effects on Eiders

(a) Projects and Activities that could Contribute to Cumulative Effects

In addition to development of the Liberty Prospect, other Federal and State projects and associated activities that could contribute to cumulative effects on migratory eiders seasonally occupying the North Slope are outlined in Section V.B. Other projects and activities occurring on the North Slope, along migration routes, or on the winter range also could contribute to cumulative effects. These include subsistence harvests, commercial fishing, environmental contamination, marine shipping. and recreational activities. These projects and activities could result in (1) additional oil or other toxic pollution effects (see the discussion in Sec. III.C.2.a(2)); (2) additional disturbance during breeding and postbreeding periods; and (3) habitat degradation beyond what already has occurred in the Prudhoe Bay region.

(b) Oil Spills

Although the potential effects of spills are uncertain, a large offshore oil spill assumed to occur during the life of relevant oil and gas projects (1.09 spills of 125-2,956 barrels estimated to occur within about 30-40 years, Table A-35) could result in significant eider losses, if it occurred during the prebreeding or postbreeding seasons when birds are staging after or before migration. A large onshore spill during the summer season may cause the loss of small numbers of nesting eiders. Most small spills, whether originating from field pipelines or spills of refined products, are expected to be cleaned up before many eiders are contacted.

If an onshore 720-barrel spill occurred during the summer season and entered freshwater aquatic habitat, eider mortality is expected to be 10 or fewer individuals. By comparison, and equally uncertain, some mortality could result from the small spills that are projected (23 spills, most of which are less than a gallon) for the 15-20 year production life of Liberty assumed in this cumulative analysis. A large offshore spill during the summer season could contact eiders staging offshore, although the number at risk in the Liberty area is not known. Development of the Liberty Prospect potentially could contribute significantly to cumulative effects in the highly unlikely event that a large offshore oil spill were to occur during this season.

(c) Disturbance

1) Traffic Disturbance

High levels of air, vessel, and vehicle traffic have been associated with petroleum exploration and development in the Beaufort Sea region.

2) Aircraft and Vessel Disturbance

Relatively large numbers of helicopter trips and substantial vessel traffic would be required to support offshore developments such as Liberty and Northstar. Roadless development such as Alpine, Badami, and that projected for the National Petroleum Reserve-Alaska also may require substantial air support for development, although most construction would be done during winter. If 10-20 helicopter trips per day during summer construction (1-2 years) and three trips per week during production estimated for Liberty (Table V.B-8) are typical estimates of support activity for offshore development, two or more developing simultaneously plus ordinary traffic to producing fields would result in substantial increases in air traffic amounting to perhaps 30-40 trips per day. Regardless of any stipulations concerning flight restrictions, continued activity at this level to support developing fields and future development is likely to result in some low-altitude flights over nesting, broodrearing, staging, or migrating birds. Such disturbance is expected to result in short-term excess energy use by disturbed individuals and displacement of birds from the vicinity of routinely used air corridors. Displacement from the vicinity of transportation corridors and offshore or onshore facilities may last a few minutes to less than 1 day and/or be long term (1 year or more), with potential loss of young produced and survival of adults or young. To a lesser degree, foraging eider flocks are likely to avoid transport vessel lanes from Prudhoe Bay, the principle transshipment point.

Unless support of Liberty offshore activities during the summer breeding season is by boat, disturbance of birds by helicopter traffic is expected to be proportionally greater than support of individual onshore projects that are supplied by fixed-wing aircraft or ground transportation.

3) Vehicle Disturbance

Substantial numbers of gravel truck passages per day plus other vehicle traffic along about 350 miles of existing roads (Table V.B-3) were associated with the construction of causeways, pads for facilities, and roads in the expanding oil development around Prudhoe Bay. Frequent summer traffic in particular can disturb nesting eiders. Even lower, postconstruction traffic levels may continue to disturb eiders throughout the life of the field. Although the Liberty Project essentially is roadless, satellite expansion of the Prudhoe Bay development would require new access roads. Vehicle use of these roads may have additive though minor effects on the regional eider population (BPXA, 1998a), because relatively few birds would be affected. Also, at least some eiders apparently do not avoid nesting in the vicinity of roads or facilities (TERA, 1995a).

4) Other Disturbance Factors

Human presence, construction and drilling activities, spill cleanup, and predators attracted to oil and gas development areas vary considerably in how much disturbance they cause. The presence of unconcealed humans, whether associated with oil and gas, hunting, or recreational activities, is disturbing to birds, especially during nesting and broodrearing periods. Common experience confirms that such presence generally causes birds to move from the immediate area of disturbance and may displace them for several hours or longer. Cumulative effects of such disturbance, with several activities occurring in the same period or one after the other through the summer season, could cause decreased production and survival of young or recruitment into the population. Attracted predators and hunting, of course, may cause direct mortality. Predators such as foxes attracted to nesting areas may cause losses up to total failure for the season. Most such disturbance associated with commercial activities could be controlled by stipulations.

(d) Habitat Alteration

Past development in the Prudhoe Bay region has resulted in habitat loss by the gravel burial of 6,921 acres, plus 1,512 acres of gravel mines, and 756 acres of reserve pits (Table V.B-3). Future development is expected to occur with a much smaller "footprint." For example, local roads, pads, and airstrips for the Alpine and Badami projects are estimated to cover less than 100 acres for each development (Table V.B-5). Presumably, the cumulative effects of future projects' infrastructure on eider populations, although additive, would be less severe because of the smaller areas involved. Effects from dust fallout, thermokarst, and hydrologic change (USDOI, MMS, 1998) would be restricted to much smaller areas and, thus, result in smaller habitat loss. The total area covered by roads/pads/airstrips for development of the Badami, Alpine, Northstar, and Liberty prospects is 289 acres plus 170 acres of gravel mines. By comparison, these projects contain 12.5% as much estimated oil reserve as the Prudhoe Bay region but are estimated to cover only 5% as much area.

Habitat alteration associated with Liberty onshore construction (gravel mine and 2 small pads) is expected to contribute about 0.6% of that altered by Prudhoe Bay region projects (roads, pads, airstrips, gravel mines, pits). However, the Liberty pads would cover less than 1 acre of well-vegetated tundra wetland habitat preferred by birds for nesting, the remainder being river gravel island, while Prudhoe region developments cover 6,921 acres of tundra. Considering just gravel structures covering tundra, Liberty would disturb 0.01% of the Prudhoe region. Comparison of gravel mine areas alone indicates that Liberty would disturb 2.1% of that altered by Prudhoe region development.

(3) Transportation Effects on Eiders

Oil produced by development of the Liberty Prospect is expected to represent only a small fraction of future oil spills of arctic oil from Trans-Alaska Pipeline System tankers (0.13 spills or about 1% of 11.13 total estimated tanker spills, Table A-35). Although few of these spills are expected to reach areas where most Steller's eiders overwinter, from the Aleutian Islands to Cook Inlet, this declining species is not likely to recover from any substantial oil-spill mortality that might occur. For example, the recovery period for the harlequin duck affected by the *Exxon Valdez* oil spill already has spanned 2-3 generations; recovery from a large spill may require a lengthy period, and it is complicated by other factors before and after the spill that increase mortality and/or decrease production of offspring. Spectacled eiders do not occur in areas that could be contacted by Trans-Alaska Pipeline System tanker spills.

Most Trans-Alaska Pipeline System tanker spills (10 of 11, Table A-37) are expected to average 3,000-13,000 barrels. Steller's eiders are not found where most of these spills would occur or contact. At-sea spills of these average sizes are not expected to reach large areas of habitat that are critical to the survival of eiders; if they do, the oil is expected to be much less harmful as a result of weathering and dispersion in the water. However, any substantial mortality is likely to prolong the recovery of the Steller's eider from threatened status

According to spill simulations by LaBelle, Marshall, and Lear (1995), the probability of a tanker spill greater than or equal to 1,000 barrels occurring 200 miles offshore along a Far East route and contacting sensitive coastal bird habitats within 30 days during the summer season is less than 0.5%. If a spill occurred, the probability of contact in eider winter habitat within 30 days would be less than 5% in the lower Cook Inlet area and less than 24% in the Kodiak Island area. Elsewhere, contact probabilities are less than 0.5%. In general, the effect of tanker spills on the Steller's eider is expected to be about the same as described above and in Section IX.B.3.a(4).

c. Other Threatened and Endangered Species

(1) Summary and Conclusions for Cumulative Effects on Threatened and Endangered Species Along the Transportation Routes

Species discussed in this section are found only along the transportation routes from Valdez to southern California. Species along the transportation routes could experience effects from tanker spills during transport of Trans-Alaska Pipeline System oil and oil from Liberty development to market. Overall, the potential for an oil spill to affect salmonids, including bull trout, appears limited. Implementation of the provisions of the Oil Pollution Act of 1990 should significantly reduce the frequency and magnitude of spills associated with oil tankers. If an oil spill coincided with the outmigration of smolt, some smolts could be exposed to spilled oil. An oil spill could cause slower growth for smolts, which could result in an incremental reduction in survival to adulthood but probably would not result in population-level effects. It is unlikely that any adverse effects would occur to either salmon or bull trout as a result of a tanker spill. It is unlikely that an oil spill would affect designated critical habitat for marbled murrelets, because the critical habitat is inland coniferous forests. It also is unlikely that an oil spill would affect proposed critical habitat for western snowy plovers. If an oil spill occurred from a tanker carrying oil from Liberty and the spill contacted proposed critical habitat, the intertidal food sources for this species may be adversely affected, resulting in slow growth and development and/or death of the chicks. No significant mortality of short-tailed albatrosses is expected to result from a tanker spill along the transportation route.

Contribution of Liberty to Cumulative Effects: Oil transportation from Liberty to ports along the west coast of the United States likely would contribute little to cumulative effects on species along transportation routes. Oil produced from the Liberty Project represents a small proportion (about 1%) of potential tanker spills between Valdez and west coast markets.

(2) Details of Cumulative Effects on Other Endangered Species

Species discussed in this section are found only along the transportation routes from Valdez to southern California. These are discussed in the following section.

(3) Transportation Effects on Endangered Species Along the Transportation Routes

In this section, we summarize and incorporate by reference three sources that discuss the risk of oil spills on species along transportation routes from tankering of oil to U.S. ports on the west coast and to ports in the Far East (Figs.V-2 and V-3):

- Cook Inlet Sale 149 Final EIS (USDOI, MMS, Alaska OCS Region, 1996), species in the Gulf of Alaska and along the U.S. west coast, particularly the southern sea otter and marbled murrelet.
- Beaufort Sea Sale 144 Final EIS (USDOI, MMS, 1996a), species along transportation routes to ports in the Far East.
- Northeast National Petroleum Reserve-Alaska Draft Integrated Activity Plan/Environmental Impact Statement (USDOI, BLM, and MMS, 1997), additional species in the Gulf of Alaska/U.S. west coast.

We also refer to the analysis of a 200,000-barrel tanker spill in the Gulf of Alaska Sale 158 Draft EIS USDOI, MMS, Alaska OCS Region, 1995) discussed in Section IX.B of this EIS for effects of a large oil spill on species in the Gulf of Alaska. Finally, we analyze the effects of a tanker spill on additional species not included in previous Section 7 consultations.

(a) Summary of These Incorporated References

The analysis of oil-spill risk on some species along transportation routes from Alaska to ports on the U.S. west coast (Fig. V-2), particularly the southern sea otter and the marbled murrelet, can be found in the Cook Inlet Planning Area Oil and Gas Lease Sale 149 Final EIS (USDOI, MMS, Alaska OCS Region, 1996). That EIS discusses potential effects of an oil spill on these species as a result of tankers transporting oil from the Cook Inlet sale area to California ports. Potential effects include oil contamination of their insulative capabilities resulting in hypothermia, inflammation/lesion of sensitive tissues following oil contact, tissue or organ damage from ingested oil, emphysema from inhaled vapors, and possibly death. Potential indirect effects from an oil spill include a reduction in available food resources due to mortality or unpalatableness of prey organisms. Mortality of southern sea otters resulting from any spill of oil (estimated probability of occurrence is 6% in the potentially affected area) tankered from southern Alaska to southern California is expected to be moderate (an estimated 23 individuals), with an estimated 1-year-recovery time (less than 1 generation), although conditions prevailing at the time of a spill could cause much greater mortality to occur. Mortality of marbled murrelets resulting from any spill of oil (estimated probability of occurrence is 6% in the potentially affected area) tankered from southern Alaska to northern California is expected to be high (estimated 30-144 individuals, 2-9% of the California population), with an estimated 3- to 15-year (2-8 generations) recovery time.

The analysis of oil-spill risk on species along transportation routes to ports in the Far East (Fig. V-3), including the threatened Aleutian Canada goose, the threatened Steller's eider, the endangered short-tailed albatross, the Steller sea lion, and several species of endangered whales, can be found in USDOI, MMS, Alaska OCS Region (1996) and in the Beaufort Sea Planning Area Oil and Gas Lease Sale 144 Final EIS (USDOI, MMS, 1996a). In Alaskan waters, the probable oil-tanker route lies seaward of the 200-mile Economic Exclusion Zone boundary except in the northcentral Gulf of Alaska, where it exits Prince William Sound. Oil spilled along most of this route would tend to be moved parallel to the Alaska Peninsula and Aleutian Islands, particularly by the Alaskan Stream, rather than towards the coast where vulnerable populations might be contacted. Oil spilled from a tanker soon after exiting Prince William Sound could contact the Kodiak and Alaska Peninsula areas.

Aleutian Canada geese, which nest in the Aleutian and Semidi islands, do not appear to spend significant time in marine habitats during the breeding period, suggesting little risk of oiling from a tanker spill. However, occasional sightings of this goose in the Kodiak area during the spring-migration period, and the presence of Steller's eiders during the winter season in coastal areas from the eastern Aleutian Islands to Cook Inlet, suggest that small portions of these populations could be vulnerable to a spill in the northern Gulf of Alaska during the spring and winter, respectively. Although short-tailed albatrosses are rare anywhere outside the breeding area south of Japan, small numbers have been reported from the Gulf of Alaska in recent decades (Hasegawa and DeGange, 1982; Sherburne, 1993), suggesting that individuals occasionally may be present in the vicinity of tanker routes to U.S. west coast ports. Currently, the world population of this species is less than 1,000 individuals.

Rookeries and haulouts of Steller sea lions are scattered from Prince William Sound to the western Aleutians. Sea lion pups are more vulnerable than juveniles and adults but remain at the rookery and, thus, are not likely to be oiled directly. Several species of endangered whales also occur in waters adjacent to the route, but they are not likely to experience any mortality from exposure to spilled oil. Overall, for the reasons discussed above, the effects on the listed species are expected to be minimal.

Additional information on the effects of oil on sea lions has become available as a result of the *Exxon Valdez* oil spill. No changes in sea lion distribution, abundance, mortality, pup production, or other potential effects were attributed to the *Exxon Valdez* oil spill (Calkins and Becker, 1990), although the population's continuing decline may have masked some effects. Calkins et al. (1994) tried to measure effects of the *Exxon Valdez* oil spill on sea lions. Sea lions were seen swimming in or near oil slicks, oil was seen near numerous haulout sites, and oil-fouled rookeries were observed at Seal Rocks and Sugarloaf Island. The authors tried to detect effects both at the individual level and at the population level. Sixteen sea lions were collected and 12 were found dead during response and cleanup efforts. Tissues taken from some of these animals were tested for toxicological effects. Toxicant levels were not consistently high enough to confirm contamination. The study showed that some sea lions that were exposed to oil were metabolizing and excreting metabolites of aromatic hydrocarbons into the bile. At the population level, data collected on premature pupping showed significantly higher premature pupping ratios at a haulout site nearer the oil spill compared to a haulout site farther away. However, overall pup abundance was not shown to have been significantly affected by the spill. None of the data presented or analyzed in this study provided conclusive evidence of an effect of the *Exxon Valdez* oil spill on Steller sea lions.

Zimmerman, Gorbics, and Lowry (1994) flew aerial and photographic surveys on the days following the *Exxon Valdez* spill. They estimated that 5-10% of the animals at oiled sites appeared to be oiled and none appeared to be debilitated. The number of animals at oiled sites did not appear to decrease relative to unoiled sites. Based on these observations, the preliminary conclusion was that Steller sea lions were not being acutely affected by the oil spill. Later, during collection and disposal of dead animals, cleanup crews found only small numbers of dead sea lions. An estimated six aborted sea lion fetuses were found, but it is not known if this is abnormally high because there were no baseline data. During the first 4 months following the spill, 14 more dead sea lions were found, but several of these were judged to have died before the spill. These studies suggest relatively low effects of an oil spill on sea lions.

The analysis of oil-spill risk on additional species along transportation routes from Valdez to U.S. ports on the west coast can be found in the Northeast National Petroleum Reserve-Alaska Final Integrated Activity Plan/Environmental Impact Statement (USDOI, BLM and MMS, 1998). That EIS discusses potential effects of an oil spill on various birds; mammals; fishes, including salmonids; invertebrates; and plants as a result of tankers transporting oil from Alaska to California ports. The potential for an oil spill to affect salmonids appears limited. If an oil spill coincided with the outmigration of smolt, some smolts could be exposed to spilled oil. An oil spill could cause slower growth for smolts, which could result in an incremental reduction in survival to adulthood but probably would not result in population-level effects. It is unlikely that any adverse effects will occur to the other coastal species identified as a result of a tanker spill.

(b) Additional Species along the Transportation Route

Additional species not included in those previous consultations are included here. These species include a number of salmon species and Evolutionarily Significant Units—the Upper Columbia River Spring-Run Chinook Salmon; Central Valley California Spring-Run and Fall/Late Fall-Run Chinook Salmon; Southern Oregon and California Coastal Chinook Salmon; Puget Sound Chinook Salmon; Lower Columbia River Chinook Salmon; Upper Willamette River Chinook Salmon; Columbia River Chum Salmon; Hood Canal Summer-Run Chum Salmon; Oregon Coast Coho Salmon; and Ozette Lake Sockeye Salmon; and bull trout. Salmon in these Evolutionarily Significant Units occur in waters of Washington, Oregon, and California along the oil-transportation route from Alaskan ports to U.S. ports on the Pacific coast, have been proposed for listing as either threatened or endangered by the National Marine Fisheries Service and, thus, are included in this EIS. In addition, the bull trout, which was proposed for listing as threatened by the Fish and Wildlife Service on June 10, 1998, is included.

Also addressed are designated critical habitat for threatened marbled murrelets, proposed critical habitat for threatened western snowy plovers, and updated information on the short-tailed albatross, which has been proposed for listing as endangered in the United States (63 *FR* 58692).

Oil-Spill-Risk Information Pertinent to the Transportation Route: We expect most oil produced from Liberty to be shipped to U.S. ports on the west coast rather than to ports in the Far East. Based on the Oil-Spill-Risk Assessment Model, the estimated mean number of tanker spills from oil produced at Liberty is 0.12 spills (Table A-35), with the most likely number of tanker spills estimated at zero over the project's production life. This compares to an estimated mean number of tanker spills of 9.92 spills for all past, present, and reasonably foreseeable future production from the North Slope/Beaufort Sea, including Liberty, with the most likely number of tanker spills estimated at 9 over the Liberty Project's production life. Oil produced from Liberty represents approximately 1% of all past, present, and possible future production from the North Slope/Beaufort Sea area to be transported by tanker (Table A-35) and about 1% of potential tanker spills for oil transported by tanker from Valdez (Table A-35). Tankers carrying oil from Liberty to ports along the west coast of the United States likely would contribute little to cumulative effects on species along transportation routes.

In general, the level of effects of a tanker oil spill depends on a number of factors. These factors include the distance the tanker spill occurs from shore, the volume of oil spilled, the degree of oil weathering and evaporation, the weather and oceanographic conditions at the time of the spill, the season during which the spill occurs, and the sensitivity of the organisms.

Tanker spills that occurred from 1977 through 1992 are listed in Table A-36. The distribution of tanker spills by size in Table A-37 includes one tanker spill greater than 200,000 barrels (which we discuss in Sec. IX), two spills that averaged 13,000 barrels, and six spills that averaged 3,000 barrels. Based on Table A-36, three spills are expected to occur in ports, where containment and cleanup equipment and manpower would be available and weather and sea conditions are not likely to be a factor. Spills occurring at sea along the tanker route likely would be from 100-200 miles offshore. Considering that the average size of these spills is relatively small and that weathering and dispersion of the oil substantially would reduce potential effects to coastal species before the oil reached the shoreline, it is likely that effects to species along the coast and in nearshore waters would be relatively low.

LaBelle and Marshall (1995) simulated oil-spill trajectories from tanker routes off the U.S. west coast. The oil-spill trajectories were mapped as "risk contours" (expressed in terms of oil-spill travel time at sea) showing the chance of contact to environmental resource areas, assuming an oil spill occurred (conditional probabilities). An oil spill at 100 nautical miles offshore would have a 5% chance of contacting the shoreline within 30 days, while an oil spill at 80 nautical miles offshore would have a 10% chance of contacting the shoreline within 30 days off the California coast. The contour lines are farther offshore off Washington and Oregon.

LaBelle et al. (1996) simulated oil-spill trajectories from 28 segments along a hypothetical transportation route from the Gulf of Alaska to California and northern Mexico. The trajectories simulated by the model represent hypothetical pathways of oil slicks. This model shows conditional probabilities that a spill occurring along the transportation segment into San Francisco Bay (T26) has a 47% chance of contacting the land segment immediately to the north and south of San Francisco Bay (Land Segment 11) in 30 days. A spill occurring along transportation segment (T20), just south of the entrance to San Francisco Bay but farther offshore, would have a 10% chance of contacting Land Segment 10, an important sea otter habitat area. By comparison, the model showed no combined probabilities (oil-spill occurrence and contact) greater than 3% for any land segment, including the land segment immediately to the north and south of San Francisco Bay (Land Segment 11).

Ford and Bonnell (1995) conducted computer simulations of oil spills ranging in size from 31,250-1 million barrels at random locations within 25 nautical miles of southern sea otter range. This modeling study indicated that a 31,250-barrel spill (close to the average size Trans-Alaska Pipeline System tanker spill (25,700 barrels) (Anderson, personal communication) at 25 nautical miles offshore had a 39.5% chance of contacting sea otters. The study estimated that 456 and 552 sea otters would be contacted by oil in 90% and 95% of the simulations, respectively. It should be noted this model likely represents a worst-case scenario, because it assumes that a spill would occur (conditional probabilities) and the origin of the spill would be a random location 25 nautical miles or less from shore (tankers carrying oil from Alaska are from 100-200 miles offshore except when entering a port). Conditional probabilities assume that a spill already has occurred, and the chance that the spill would contact specific resource areas depends only on the winds and ocean currents. Combined probabilities, which are referenced in the study discussed in the preceding paragraph, depend not only on the physical conditions, but also on the chance of spill occurrence, the estimated volume of oil to be transported, and the oil-transportation scenario.

Perhaps the most pertinent information from Ford and Bonnell (1995) is the number of sea otters likely to be contacted by a spill along a line extending west from San Francisco seaward to deeper water. A series of six launch points were spaced along this line in increments of 10-nautical miles. According to the model, spills originating farther seaward along this line are more likely to contact large numbers of sea otters than spills originating closer to shore. Inshore spills are more likely to beach before reaching areas of high sea otter density, whereas spills originating farther offshore drift for a longer period of time and are carried farther south. These spills are likely to spread over a larger area and are likely to contact a larger portion of sea otter range, although the spills would undergo weathering and a reduction in toxicity with time. The model simulated a 250,000-barrel spill at each location on the line extending seaward from San Francisco. The study estimated that in 90% of the simulations, 1,000-1,249 sea otters would be contacted by spilled oil at 50 and 60 nautical miles from shore; 750-999 sea otters would be contacted by spilled oil at 20, 30, and 40 nautical miles from shore; and 500-749 sea otters would be contacted by spilled oil at 10 nautical miles from shore. This simulation likely represents a worst-case scenario, because it uses conditional probabilities and a spill size significantly larger than the average Trans-Alaska Pipeline System tanker spill size of 30,000 barrels.

The following discussion describes the most likely impacts to listed and proposed species as a result of a tanker spill along the transportation route.

1) Marbled Murrelet

Critical habitat for the marbled murrelet was designated in 1996 (61 *FR* 26255). Only terrestrial nesting habitat was designated as critical habitat. Marbled murrelets are very vulnerable to impacts from oil spills due to their extensive use of nearshore waters for foraging. They may be adversely affected if oil spilled from a tanker contacts their marine foraging habitat and affects their food supply, and there may be direct mortality for any murrelets that come into contact with spilled oil. These potential adverse effects to the species are discussed in more detail in the previous Endangered Species Act consultation for Cook Inlet Lease Sale 149. The potential effects of oil spills associated with tankers carrying oil from the Liberty Project are not likely to adversely affect designated critical habitat for this species, because the coniferous forest habitats are inland from the coast.

2) Western Snowy Plover

Numerous areas along the coast of Washington, Oregon, and California were designated as critical habitaton January 6, 2000 (64 *FR* 68507). These areas are listed in Section VI.A.1.b(1)(b). Oil spills associated with tankers carrying oil from the Liberty Project adversely may affect this species by contaminating proposed critical habitat. Oil contamination of the habitat could affect the intertidal food supply, resulting in slow growth and development and/or death of the chicks. However, there is a low probability that an oil spill from oil produced at Liberty would occur and contact the proposed critical habitat. Oil produced from the Liberty Project represents a small proportion (about 1%) of past, present, and reasonably foreseeable future production from the North Slope and the Beaufort Sea and about 1% of potential tanker spills. Also, implementation of provisions of the Oil Pollution Act of 1990, including improved navigational safety systems and replacement of existing tankers with double-hulled models, should significantly reduce the frequency and magnitude of spills associated with oil tankers carrying oil from the Liberty Project. It is unlikely that proposed critical habitat discussed in this assessment will be adversely affected by oil produced at Liberty and transported by tanker to ports on the U.S. west coast or in the Far East.

Some new information is available regarding impacts of spilled oil on western snowy plovers. A recent study by Stern et al. (2000) assesses the impacts of spilled fuel oil on western snowy plovers along the Oregon coast. The freighter *New Carissa* ran aground on the Oregon coast about 4 kilometers north of the Coos River and spilled an estimated 20,000-140,000 gallons of fuel oil into the ocean. As a part of previous field studies, 972 breeding adults and recently hatched chicks along the Oregon coast had been banded, resulting in approximately 80-90% of the breeding population being individually identifiable. The banded plovers allowed for the study to track and compare disappearance rates and productivity of individually oiled and non-oiled birds.

Between February 10 and April 16, 1999, 62% (n=73) of the individually marked plovers between Cape Blanco and Heceta Head were sighted with some oiling. There were impacts to specific individuals and there may have been impacts to specific sites. Seventeen plovers were oiled to such an extent that they were trapped, cleaned, rehabilitated, and released. At least one of these birds died later and the fate of four others is unknown. Seven of the remaining 12 birds remained on the Oregon coast to breed and the other five birds dispersed to other breeding areas and then returned to the Oregon coast in the late summer and early fall. For the first time since 1990, there was no nesting by plovers and extremely limited use by plover broods on the Coos Bay North Spit South Beach, the area most directly affected by the *New Carissa* incident. There were also several instances when banded plovers and at least one severely oiled unbanded plover disappeared under circumstances that may be associated with the incident. The study concluded at the population level, that neither the abundance nor the productivity of breeding plovers along the Oregon coast was overtly affected by this incident.

3) Short-tailed Albatross

Threats to the recovery of this species to more secure population levels include habitat destruction by volcanic activity and monsoon rains on the only breeding island currently occupied, drowning as a result of hooking on longline fishing gear, and exposure to contaminants. Although few individuals have been reported killed in the eastern Pacific over the past 15 years, apparently three were killed by fishing gear in September 1998. If this recent mortality signals an increasing level of incidental take, any individuals killed by contacting an oil spill could represent a serious adverse effect. However, the low frequency of sightings away from the breeding island suggests that few individuals would be expected to occur in the vicinity of tanker routes through the Gulf of Alaska to Far East ports over the period of Liberty production. In addition, the chance of a tanker spill occurring and contacting areas frequented by short-tailed albatrosses (for example, Aleutian Islands) is less than 0.5% (LaBelle, Marshall, and Lear, 1996), which suggests that no significant mortality of short-tailed albatrosses is expected to result from any spill containing oil produced from the Liberty Project. The probability of spills and albatross contact in the Japan area and approaches to the Asian mainland are likely to be greater.

4) Salmon

Contact with sufficient concentrations of spilled oil may affect fish populations in several ways:

- eggs and larvae may suffer increased mortality due to coating or direct toxic effects;
- adults may fail to reach spawning grounds in critical, narrow, or shallow contaminated waterways;
- fecundity or spawning behavior may change;
- local food species of the adults, juveniles, fry, or larvae may be adversely affected or eliminated; and
- sublethal effects may reduce fitness and affect the ability to endure environmental perturbations.

However, concentrations of petroleum hydrocarbons are toxic to fishes only a short distance from, and for a short time after, a spill event (Malins, 1977). Available information indicates that concentrations of petroleum hydrocarbons found beneath an oil slick are less than 0.1 parts per million. This is well below toxic levels for fish eggs and larvae (sublethal effects on eggs, larvae, and adults at 0.01-1.0 parts per million; lethal effects on eggs and larvae at 0.1-1.0 parts per million, and on adults at 1-100 parts per million) (Malins, 1977; Meyer, 1990).

There is some evidence that pelagic fishes (salmon) are able to detect and avoid hydrocarbons in the water (Weber et al., 1981), although some salmon may not avoid oiled areas. If exposed to sublethal amounts of spilled oil, may become temporarily disoriented; but they eventually would return to their home stream (Martin, 1992). Adult salmon appear to be relatively unaffected by oil spills and are able to return to natal streams and hatcheries even under very large oil-spill conditions, as evidenced by pink and red salmon returning to Prince William Sound and red salmon returning to Cook Inlet after the *Exxon Valdez* oil spill. Eggs of pelagic fish that spawn upstream in rivers and streams, such as the salmonids referenced above, would be unaffected by an oil spill. Potential effects on outmigrating smolts are less clear. Based on Malins (1977), some smolts may experience sublethal effects if a large oil spill occurred in the mouth of the river, bay, or estuary during the time that outmigrating smolts reached that area. This probably is an unlikely scenario.

It also has been suggested that the *Exxon Valdez* spill caused a reduction in food available to pink salmon populations in Prince William Sound, and that this has caused reduced survival and subsequent failures in pink salmon runs. Studies examining growth, survival, and availability of prey for juvenile pink salmon have produced conflicting results. One study examined juvenile pink and chum salmon contaminated by ingesting crude in 1989 from the *Exxon Valdez* spill (Wertheimer et al., 1993). Oil was present in 1% and 3%, respectively, of these salmon that were collected at oiled sites in 1989; however, there was no evidence of oil contamination in these same areas in 1990. Juvenile salmon were more abundant in unoiled areas, and this difference continued in 1990 after oil-exposure levels diminished. The observed difference was attributed to geographic differences in production and migration rather than oil exposure. The diet composition and feeding efficiency of these fish was unaffected by the oil spill. Juvenile pink salmon were smaller and slower growing in oiled areas in 1989 but not in 1990. There was no evidence of a reduction in available prey to pinks and chums in oiled areas in 1989 or 1990. The slower growth of pink salmon juveniles in 1989 was attributed to the metabolic cost of depurating the hydrocarbon burden. The slower growth may have caused an incremental reduction in survival to adulthood.

Overall, the potential for a spill of oil produced at Liberty to affect these species appears limited. There is a small percentage chance that oil from Liberty would be spilled along the transportation route. Tanker routes usually pass well offshore of the coast, unless the tanker is approaching or entering a port. In the event that an oil spill occurred and coincided with the outmigration of smolt, some smolts could be exposed to spilled oil. If this occurred, an oil spill could cause slower growth for smolts, which could result in an incremental reduction in survival to adulthood but probably would not result in population-level effects. It is likely that the effects to salmonids from habitat destruction as a result of agriculture, forestry, mining, hydropower, and road construction and from overfishing, as discussed in Section V, would be greater than the effects of an oil spill.

5) Bull Trout

The Coastal-Puget Sound population segment of the bull trout is found only in the State of Washington. Habitat degradation, dams and diversions, and interactions with non-native fish currently are considered the major factors adversely affecting the Coastal-Puget Sound population segment. This includes activities such as flood-control structures; hydroelectric projects; water-diversion structures, including irrigation withdrawals; forest practices; agricultural cultivation; grazing; urbanization; and industrial development. Information on anadromous forms of this species appears to be somewhat limited and the presence of anadromous forms somewhat uncertain (63 *FR* 31693).

No information is provided in 63 *FR* 31693 concerning the potential effects of an oil spill on the bull trout in spite of the numerous oil tankers transporting oil along the coast and into Puget Sound. The probability of oil from the Liberty Project being spilled is low. Oil produced from the Liberty Project represents a small proportion (about 1%) of past, present, and reasonably foreseeable future production from the North Slope and the Beaufort Sea and about 1% of potential tanker spills from oil transported by tanker from

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Valdez, Alaska. There is an even smaller likelihood of a project-related oil spill occurring within Puget Sound and the Strait of Juan de Fuca and contacting bull trout habitat. Tanker routes usually pass well offshore of the coast, unless the tanker is approaching or entering a port, and the majority of this population segment in Puget Sound is fairly distant from where oil tanker traffic is likely to occur. Most of the bull trout are found in fluvial habitat that is not likely to be impacted by an oil spill. Furthermore, implementation of the provisions of the Oil Pollution Act of 1990 significantly should reduce the frequency and magnitude of spills associated with oil tankers carrying oil from the Liberty Project. It is unlikely that bull trout will be exposed to spilled oil from the Liberty Project.

There is a small percentage chance that oil produced from Liberty would be spilled along the transportation route. In the event that an oil spill occurred and coincided with the outmigration of juveniles into a coastal marine environment, some juveniles could be exposed to spilled oil. Spilled oil also could affect the bull trout's food supply in the marine habitat. If these events occurred, an oil spill could cause slower growth for juveniles, which could result in an incremental reduction in survival to adulthood but probably would not result in population-level effects. Oil spill response and cleanup capabilities would reduce the potential for spilled oil to adversely affect this species. Overall, the potential for an oil spill from oil produced at Liberty to adversely affect these species appears limited.

2. Seals, Polar Bears, Sea Otters, and Other Marine Mammals

a. Summary and Conclusions for Beaufort Sea, North Slope, and Transportation Activities on Seals and Polar Bears

Liberty and other ongoing or planned projects (Map 3a) may affect ringed and bearded seals and polar bears by causing noise and disturbance, altering habitat, and accidentally spilling oil. The overall effects (mainly from one oil spill assumed for this analysis and assuming high losses of perhaps up to 61 [Amstrup, Durner, and McDonald, 2000]) and a few thousand seals) should last no more than one generation (about 5-6 years) for ringed and bearded seals and perhaps 7-10 years for polar bears. The more likely loss would be 3-6 bears (see Sec. III.C.2.b) or less than 12 bears/spill (Amstrup, Durner, and McDonald, 2000; see Appendix J-1) and fewer than 150 seals (see Sec. III.C.2.b). In the likely cumulative case, seal and polar bear populations are expected to recover within 1 year, assuming only one large spill occurs.

Only three "lethal takes" of polar bears were related to industrial activities on the North Slope over the past 20 years (Gorbics, Garlich-Miller, and Schliebe, 1998). These small losses of polar bears have had no effect on the population. More than 40 exploration-drilling units (gravel islands, drill ships, and other platforms) have been installed or constructed in the Beaufort Sea as a result of past Federal and State oil and gas leases. These activities may have displaced a few bears during island construction but have had no effect on the polar bear population. The Fish and Wildlife Service concluded that existing onshore development, proposed exploration activities, and the Northstar development would have negligible effects on polar bears (65 *FR* 16828).

Development would alter a small amount of the habitat at Liberty's one production island site versus an estimated 40 past or existing exploration and production platforms in the Beaufort Sea. These platforms have not had any apparent lasting additive or synergistic effect on seal and polar bear distribution and abundance in the Beaufort Sea. The number of production platforms in the Beaufort Sea over the next 20 years is uncertain, but a reasonable estimate would be about six, which includes both Liberty and Northstar. That number is expected to have little or no effect on the ice habitats of seals and polar bears in the Beaufort Sea. Potential cumulative oil spills along the tanker route to the U.S. west coast could have long-term (more than one generation or perhaps 5-10 years) effects on other marine mammals.

Contribution of Liberty to Cumulative Effects: Liberty's contribution is expected to be about 1% of the local short-term disturbance and habitat effects on seals and polar bears. Liberty should only briefly and locally disturb or displace a few seals and polar bears. A few polar bears could be temporarily attracted to the production island with no significant effects on the population's distribution and abundance. Liberty would contribute about 6% to potential offshore oil spills and potential effects on seals and polar bears (0.07 out of 1.09 mean total spills, as shown in Table A-35). The estimated 5-30 bears or 12 or fewer polar bears (Amstrup, Durner, and McDonald, 2000) lost to a large (715-2,956-barrel or a 5,912 barrel spill assumed by Amstrup, Durner, and McDonald [2000]) spill under the project analysis represents a severe event. The more likely loss from Liberty development would be no more than three to six bears, assuming a bear density of one bear per 25 square kilometers. Liberty is expected to contribute only 0.07 spills and about an equal fraction of the potential oil-spill effects on other marine mammals along the tanker route to the U.S. west coast.

b. Details of Cumulative Effects on Seals and Polar Bears

(1) Effects of Oil Spills on Seals and Polar Bears

Cumulative risks from oil spills assumed for purposes of analysis to seal and polar bear habitats in the Beaufort Sea would be higher than risks from the Liberty Project alone (0.07 mean number of spills). That compares to 1.09 mean number of spills for the cumulative analysis (Table A-35). Spills that might occur in the Beaufort Sea during the summer or that occurred during the winter and persist after meltout pose the highest risk to the marine mammals' flaw-zone habitats, which are offshore from Foggy Island Bay eastward to Flaxman Island and westward to Harrison Bay (Map 3b). During winter, ringed and bearded seals and polar bears could contact oil spills in this habitat. During the summer (open-water) season, resident ringed and bearded seals, polar bears, and migrant seals in the western Beaufort Sea could contact spills that occurred to the east during winter, contacted the flaw-zone habitat, and then melted out (see Map 2B).

The most noticeable cumulative effects of potential oil spills would be from direct oiling of ringed or bearded seals and polar bears. These species could suffer the following estimated mortalities should a spill occur:

- perhaps 300-400 ringed seals out of an estimated population of about 40,000;
- perhaps 10-100 bearded seals out of a population of several thousand; and
- perhaps 10 up to 61 polar bears out of a population of 1,800. (The more likely loss would be three to six bears, bears assuming a bear density of one bear per 25 square kilometers or fewer than 12 bears per spill (see Sec. III.C.2.b, Effects of a Major spill on Seals and Polar Bears, and Amstrup, Durner, and McDonald [2000]).
- We assume environmental degradation resulting from the oil spill is below the level that would alter reproduction and survival of the polar bear population.

If a large spill occurred during the fall freezeup or during the spring breakup, significant effects to polar bears could occur. However, the likelihood of an oil spill that would kill a significant number (20 or more) of polar bears was found to be low, 0.3-1% (65 *FR* 16828).

Seals are likely to replace their losses within 1 year, and additive and synergistic effects are not expected. In addition to direct contact with oil, ingesting oil or loss of thermal insulation could cause the death of very young seal pups, highly stressed adults. The polar bear population is expected to recover from these losses within one generation (7-10 years).

(2) Effects of Noise and Disturbance on Seals and Polar Bears

(a) Seals

In the Beaufort Sea, noise and disturbance from on-ice seismic surveys during any one year would affect breeding ringed seals in that area for no more than 1 year, because only a small fraction (less than 1%) of the population is likely to be exposed to and potentially disturbed by the operations. Subsequent surveys in other areas during other years have disturbed different seals and would be expected to in the future. A few pups are likely to be lost, because mothers may abandon maternity lairs or because seismic vehicles may destroy snow lairs along the shot line. Past seismic exploration on the sea ice over several years might have killed some pups and displaced some seals locally very near seismic lines (within 150 meters) during operations for that ice season (Burns et al., 1983; Link, Olson, and Williams, 1999). However, these additive effects probably were not significant to the seal population above losses to polar bears and changes in sea ice.

Noise and disturbance effects on seals and polar bears in the Beaufort Sea from an estimated total of more than 450 helicopter trips per month and at least 200 vessel trips per month should last only a few minutes to less than an hour for any one disturbance event. Disturbance reactions of seals would be brief; they would return to normal behavior patterns and distribution shortly after the boat or aircraft has left the area. Effects are not expected to be additive or synergistic, because disturbance reactions most likely would involve different animals and occur in different areas. Seals also may get used to aircraft and vessels, if they saw them often and routinely.

Ringed and bearded seals have been exposed to oil-exploration activities in the Beaufort Sea, including seismic surveying, drilling, air and vessel traffic, dredging, and gravel-dumping (Maps 3a and 3b). These activities in the Beaufort Sea, barge traffic to the North Slope, and some icebreaker activity to support oil exploration might increase in the future. These activities could affect how seals are distributed near the activity for one season or less than 1 year during high levels of activity. However, some seals will get used to marine and air traffic, industrial noise, and human presence. Displacement from cumulative industrial activities is not likely to affect the overall abundance, productivity, or distribution of ringed and bearded seals in Alaska's Beaufort Sea.

(b) Polar Bears

Individual air and vessel traffic disturbances assumed for this analysis likely would disturb a few polar bears for a few minutes to less than an hour. Seismic operations, ice-road traffic, and other activities could disturb some coastal denning sites in Alaska. A few females may have abandoned maternity dens because of noise and humans nearby, and some cubs might have been harmed. However, the number of bears disturbed in any given year is likely to be very low (probably no more than 1-3 animals). Bears disturbed in one year are not expected to be disturbed the next year, because they would not den at the same location due to changes in snow cover. Current information of the distribution of den locations near oil facilities does not show that bears were permanently displaced from denning habitat. There is no clear indication that disturbance from oil exploration and development has had an additive or synergistic effect on the polar bear population. "Two hunters from Nuiqsut reported that polar bear activity has decreased in recent decades around Prudhoe Bay and west, to the Colville River," while " some hunters stated that the number of polar bears varies from year to year but has remained stable overall" (Kalxdorff, 1997).

The Marine Mammal Protection Act requirements should prevent excessive disturbance to polar bears. Letters of Authorization for incidental take of polar bears requested by industry and issued by the Fish and Wildlife Service recommend a 1-mile buffer around occupied polar bear dens. Compliance with the Letter of Authorization is expected to avoid any significant disturbance of polar bears in the Beaufort Sea.

A very small number of polar bears have been and could be killed in encounters with humans near industrial sites and settlements associated with cumulative oil development. In the Northwest Territories in Canada, conflicts with humans near industrial sites from 1976-1986 accounted for 15% (33 out of 265) of the polar bears killed (Stenhouse, Lee, and Poole, 1988). Some of these losses were unavoidable, and the polar bear population recovered through recruitment within 1 year. Four bears were unavoidably killed after being attracted to offshore platforms in the Canadian Beaufort Sea during 5 years of intensive oil exploration (Stirling, 1988). Fewer losses of polar bears in arctic Alaska are expected, because the Marine Mammal Protection Act requires that the oil industry to avoid killing any bears. Polar bear loss in Alaska is not likely to exceed more than one animal per year and probably would be less. Only three lethal takes of polar bears were related to industrial activities on the North Slope over the past 20 years (Gorbics, Garlich-Miller, and Schliebe, 1998). These losses have not significantly increased the mortality rate of the polar bear population over that from subsistence harvest and natural causes. The loss rate in Canada over a 5-year period was higher than that in Alaska but was not significant to the population, which increased at 2.4% per year. The Marine Mammal Protection Act has kept losses low in Alaska. The act did not cover bears during the extensive oil explorations in Canada.

(3) Effects of Habitat Alteration

More than 40 exploration-drilling units (gravel islands, drill ships, and other platforms) have been installed or constructed in the Beaufort Sea as a result of past Federal and State oil and gas leases. Several million cubic yards of gravel and dredge-fill material have altered at least a few square kilometers of benthic habitat in the Beaufort Sea. Alterations from island construction, trench dredging, and pipeline burial are expected to affect some benthic organisms and some fish species within 1 kilometer for less than 1 year or season. These activities also may temporarily affect the availability of some local food sources up to 1-3 kilometers (0.62-1.9 miles) distance during island construction. These activities are not expected to affect food availability over the long term for the following reasons:

- Common prey species for seals, such as arctic cod, have a very broad distribution and would not suffer from the fractional loss of benthic habitat associated with platforms and pipelines.
- Ringed and bearded seals are able to forage over large areas of the Beaufort Sea; they do not rely exclusively on the abundance of local prey.
- Gravel islands used for oil production may provide habitat for some prey species. They are not likely to affect the availability of seals as prey for polar bears in the Beaufort Sea.

Drilling units for exploration and platforms for future production (including gravel islands) in the Beaufort Sea are likely to have only local effects on ice movements and fast-ice formation around the structures. These local changes in ice movements and ice formation are not likely to change the seal distribution. Noise, movements, and human presence associated with installing platforms and other construction activities could displace some seals and polar bears within 1 mile of the activity for 1 season or year. Exploration platforms have not had any apparent lasting effect on seal and polar bear distribution and abundance in the Beaufort Sea. The number of production platforms in the Beaufort Sea over the next 20 years is uncertain. A reasonable estimate would be about six platforms, which includes Liberty and Northstar. That number is not expected to affect ice habitats of seals and polar bears in the Beaufort Sea. Natural variation in ice conditions and resulting changes in the distribution of seals and polar bears are likely to reverse or overwhelm any local reduction (or increase) in their distribution because of cumulative exploration and production.

(4) Effects of Hunting and Harvest on Seal and Polar Bear Populations

International subsistence hunting of seals and polar bears would have no more than a very short-term effect on the abundance of these species (USDOI. MMS, 1998).

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c. Transportation Effects on Sea Otters, Harbor Seals, and other Marine Mammals

Although Liberty is not expected to contribute any tanker spills to the cumulative analysis (mean number of spills 0.12 in Table A-35), potential future oil-spill effects from tanker transportation of arctic oil (including Liberty oil) from the Trans-Alaska Pipeline System terminal at Valdez could have cumulative effects on marine mammals, especially sea otters, in Prince William Sound and the Gulf of Alaska. There also could be local effects on harbor seals, as resulted from the 1989 *Exxon Valdez* oil spill. It is likely that local assemblages of sea otters in heavily contaminated coastal areas of Prince William Sound would take more than one to two generations, or 5-10 years or longer, to recover from the spill.

Future transportation of North Slope oil through Prince William Sound could have a long-term (5 years or longer) effect on seas otters and harbor seals (see Sec. VIII.B). The contribution of Liberty to tanker spills is estimated to be 0.12 spills (Table A-35). The number of cumulative tanker spills is estimated to be 6 with average size of 3,000 barrels ; for purposes of analysis, one spill is assumed to be 200,000 barrels, while the other 5 are assumed to be less than 15,000 barrels, of which 2 spills would be 13,000 barrels average size. These spills are expected to have similar effects on sea otters and harbor seals as described but cause fewer losses of otters and seals. Recovery of populations is expected within 1 or 2 years after the spills, assuming the same populations and habitats are not affected. If two or more of these spills affect the same populations and habitats within 1 or 2 years of the previous spill, recovery would take longer (perhaps 10 years or more).

If tanker spills associated with oil development in arctic Alaska, including Liberty, occurred south of the Gulf of Alaska, other nonendangered marine mammals and their habitats could be affected along the transportation routes or at marine ports. The effects of tanker spills on these marine mammals and their habitats are expected to be about the same as described above and in Section IX.B for seals, sea otters, and cetaceans in the Gulf of Alaska.

3. Marine and Coastal Birds

a. Summary and Conclusions for Beaufort Sea, North Slope, and Transportation Activities on Marine and Coastal Birds

The large offshore oil spill in the Beaufort Sea assumed for the cumulative analysis may result in substantial bird mortality, primarily of waterfowl and shorebirds staging offshore, in lagoons, or along beaches. In the case of molting long-tailed ducks, average losses (approximately 1,000-2,000 individuals) would be significant and potentially could exceed 10,000 individuals. Likewise, mortality of common eiders exceeding 100 individuals would be considered a significant loss. Loons staging in spring could experience substantial losses, perhaps tens of individuals, from spills entering leads or nearshore waters. Small spills are not expected to cause significant mortality. Most onshore spills assumed for this analysis are likely to be contained and cleaned up; a spill entering a lake could cause substantial losses, up to hundreds of individuals, of molting and broodrearing waterfowl plus smaller losses of nesting waterfowl, shorebirds, and passerines. Tanker spills in the Gulf of Alaska could cause substantial losses of migrating shorebirds and waterfowl that use Beaufort Sea habitats during the breeding season, or of overwintering loons, sea ducks, and gulls.

Helicopter traffic supporting several projects at a time or in sequence may cause birds to leave preferred broodrearing, molting, staging, or migration areas along air routes to less favorable foraging areas. Such displacement and loss of energy may result in lowered production and survival of young. Using vessels instead of helicopters would lessen airborne disturbance while increasing offshore surface disturbance. Mortality resulting from collisions of birds with present offshore production islands/structures is expected to be relatively low. Increasing numbers of structures associated with greater offshore production in the foreseeable future potentially could result in substantial mortality for several species of waterbirds. Vehicle traffic along roads serving present and future projects is expected to cause minor reductions in nearby shorebird and waterfowl nesting populations. Human presence that disturbs nesting or broodrearing birds, or attracts predators, may result in predation of unprotected eggs or young. Because of a smaller disturbed area, the effect of future projects' infrastructure on bird populations, although additive to natural losses, is expected to be less severe than previous development in the Prudhoe Bay region.

Overall cumulative effects of oil industry activities on marine and coastal birds potentially could be substantial—significant in the case of long-tailed ducks and common eiders—primarily as a result of mortality from oil spills. Although the chance of oil spill occurrence is small (1-6%), the potential is higher for contact with bird concentrations present at certain times of year in certain areas where projects assumed in the cumulative case will occur. Also, as a result of the apparent decline in populations of some species (for example, several sea duck species) and the challenge of recovering spilled oil, particularly in broken-ice conditions, there is uncertainty as to the ultimate effect of any spills on bird populations. Disturbance may cause some minor loss of productivity and lowered survival of birds occupying areas with high industry-activity levels. Most projects and activities not associated with petroleum development, individually or in combination, probably affect bird populations as much or more than potential effects of petroleum development and may have contributed importantly to recent declines in these populations.

Contribution of Liberty to Cumulative Effects: Development of the Liberty Prospect is expected to contribute about 6% of potential offshore oil spills and roughly proportional effects on birds (0.07 out of 1.09 mean cumulative spills shown in Table A-35). Liberty could contribute substantially to losses of waterfowl and shorebirds occupying lagoons in the area from an offshore spill. Mortality associated with an onshore spill could be up to a few hundred individuals. Bird mortality from the numerous small spills that are projected for the 30-40-year life of the oil and gas projects in this analysis is not expected to be substantial, although if lakes supporting concentrations of molting or broodrearing waterfowl are contacted, mortality would be higher.

Disturbance of birds by supply helicopter traffic for Liberty is expected to be greater than for individual onshore projects due to potential overflight of waterfowl and shorebird molting and staging habitat. Habitat alteration caused by Liberty onshore construction (gravel mine and two small pads) is expected to be about 0.6% of that altered by Prudhoe Bay region projects (roads, pads, airstrips). Comparison of gravel mine areas and preferred tundra wetland nesting habitat separately shows that Liberty would disturb only 2.1% and 0.01%, respectively, of that altered by Prudhoe Bay region development.

Overall effects of Liberty would be additive to effects observed or anticipated for the other projects in this cumulative analysis. In the case of oil spills, it could increase adverse effects and cause significant regional population effects in species such as the long-tailed duck and common eider that concentrate in local lagoons and could cause substantial effects in other waterbird regional populations.

b. Details of Cumulative Effects on Marine and Coastal Birds

(1) Cumulative Projects and Activities

In addition to Liberty, other Federal and State projects and associated activities that could contribute to cumulative effects on birds seasonally occupying or resident on the North Slope are outlined in Sections V.A.2 and V.B. Other projects and activities occurring on the North Slope, along migration routes, or on winter ranges also could contribute to cumulative effects. These include subsistence and sport harvests, commercial fishing, commercial development, environmental contamination, marine shipping. and recreational activities. These projects and activities could result in (1) oil or other toxic pollution effects (see discussions in Secs. III.C.2.c); (2) additional disturbance during all phases of the annual cycle; and (3) habitat degradation beyond what already has occurred in the Prudhoe Bay region.

(2) Oil Spills

A large offshore oil spill assumed for this analysis (most likely number of spills is zero) that occurs during the life of oil and gas projects (cumulative projection of 1.09 spills of 125-2,956 barrels within about 30-40 years) may result in losses exceeding 10,000 individuals if it is released during the season of waterbird presence. This primarily would involve large flocks of postbreeding waterfowl and shorebirds staging offshore, in lagoons, or along beaches before migration. A large onshore spill during the summer season may cause losses of molting and broodrearing waterfowl up to hundreds of individuals if it enters a heavily used lake, plus smaller numbers of nesting waterfowl, shorebirds, and passerines. Small spills, whether originating from field pipelines or spills of refined products, are expected to be cleaned up before substantial losses occur. Likewise, spills from the Trans-Alaska Pipeline System pipeline are not expected to cause substantial losses of these species occurring in the Beaufort Sea region. Tanker spills of North Slope crude oil in the Gulf of Alaska could cause substantial losses of migrating shorebirds and waterfowl that use Beaufort Sea habitats during the breeding season or overwintering loons, sea ducks, and gulls.

(3) Disturbance

Potentially disturbing factors associated with oil and gas development include aircraft, vessel, and vehicle traffic; human presence; construction of facilities and roads/pads; drilling operations; spill cleanup; and attracted predators.

(a) Aircraft and Vessel Disturbance

Large numbers of helicopter trips and substantial vessel traffic would be required to support offshore developments such as Liberty and Northstar. Roadless developments such as Alpine, Badami, and that projected for the National Petroleum Reserve-Alaska also may require substantial air support for development, although most construction would be conducted during winter. If 10-20 helicopter trips/day during summer construction (possibly 1 year) and three trips/week during production estimated for Liberty (Table V.B-8) are typical, estimates of support activity for offshore development (two or more developing simultaneously plus ordinary traffic to producing fields) would result in substantial increases in air traffic amounting to perhaps 30-40 trips/day. Regardless of any stipulations concerning flight restrictions, continued activity at this level to support developing fields and future development is likely to result in some low-altitude flights over nesting, broodrearing, molting, staging, or migrating birds. This is expected to cause short-term energy losses when birds are displaced temporarily (a few minutes to less than 1 day) from air corridors between project facilities off the nest or to less favorable foraging areas. Long-term displacement (1 year or more) from the vicinity of heavily used corridors and offshore or onshore facilities may result in fewer young produced and lower survival of adults and young. Avoidance of vessels by birds is expected to have only minor short-term effects.

If helicopters instead of boats are used to support Liberty activities during the summer breeding season, the disturbance of birds by helicopter traffic is expected to be proportionally greater than support of individual onshore projects that are supplied by fixed-wing aircraft or ground transportation.

(b) Vehicle Disturbance

Substantial numbers of gravel-truck passages per day plus other vehicle traffic along about 364 miles of existing roads (Table V.B-3) were associated with the construction of causeways, pads for facilities, and roads in the expanding oil development around Prudhoe Bay. Frequent summer traffic in particular can disturb molting waterfowl such as snow geese when they attempt to cross roads. Even postconstruction traffic levels (low volume) may continue to disturb some species throughout the life of the field. During development of the Lisburne field, geese and swans appeared tolerant of vehicle traffic on roads during most seasons; however, during broodrearing, they moved away from roads (Murphy and Anderson, 1993). The Lisburne development activities had no apparent effect on overall bird habitat use in the area. However, some species of shorebirds, such as the semipalmated sandpiper and the dunlin, were reduced in density (up to 40%) within about 100 meters of roads during breeding compared to postbreeding periods and undisturbed areas (Troy, 1988; TERA, 1993b). Although the Liberty Prospect area essentially is roadless, expansion of the Prudhoe Bay satellite, projects could require new access roads. Vehicle use of these roads is expected to have additive, though minor, effects on bird populations (BPXA, 1998a).

(c) Other Disturbance Factors

Human presence, construction and drilling activities, spill cleanup, and attracted predators associated with oil and gas development vary considerably in the severity of disturbance they cause. The presence of unconcealed humans, whether associated with oil and gas, hunting, or recreational activities, is disturbing to birds especially during nesting, broodrearing, and molting periods. Such presence generally causes birds to move from the immediate area of disturbance and may displace them for several hours or longer. Cumulative effects of such disturbance, with several activities occurring in the same period or one after another through the summer season, could cause decreased productivity if eggs or young are exposed to predators, or decreased survival of young if left unprotected. Predators and hunters cause direct mortality. Predators such as foxes attracted to island or colonial species’ nesting areas may cause losses of varying severity including up to total destruction of the season’s productivity. Most disturbance associated with commercial activities could be controlled by stipulations (see Sec. I.H.6 for a discussion of mitigating measures). In particular, environmental orientation training, performance of disturbing activities in winter, and routing helicopters for minimal wildlife disturbance would mitigate potential effects of many sources of disturbance.

(4) Habitat Alteration

Development in the Prudhoe Bay-Kuparuk area (Alpine, Badami) has resulted in habitat loss by gravel burial of 6,944 acres, plus 1,512 acres of gravel mines, and 756 acres of reserve pits (Table V.B-3). It is expected that future development would occur with a much smaller disturbed area (footprint). For example local roads, pads, and airstrips for the Alpine and Badami projects are estimated to cover less than 100 acres for each development (Table V.B-3). Presumably, the effect of facilities for future projects on bird populations, though additive, would be substantially less severe because of the smaller areas involved. Such effects as from dust fallout, thermokarst, and hydrologic change (USDOI, MMS, 1998) would be restricted to much smaller areas and thus result in smaller habitat loss. For example, the total area covered by roads/pads/airstrips for the Badami, Alpine, Northstar, and Liberty prospect areas is 289 acres plus 170 acres of gravel mines. These projects are estimated to contain 14.9% as much oil reserve as the Prudhoe Bay region but would cover only 5% as much area.

Habitat alteration associated with Liberty onshore construction (gravel mine and 2 small pads) is expected to contribute about 0.6% of that altered by Prudhoe Bay region projects (roads, pads, airstrips, gravel mines, and pits). However, the Liberty pads would cover less than 1 acre of well-vegetated tundra wetland habitat preferred by birds for nesting, the remainder being river gravel island, while Prudhoe region developments cover 6,921 acres of tundra. Considering just gravel structures covering tundra, Liberty would disturb 0.01% of the Prudhoe region. Comparison of gravel mine areas alone indicates that Liberty would disturb 2.1% of that altered by Prudhoe region development.

Low-flying waterbirds, especially sea ducks and loons, may collide with offshore islands/structures under conditions of poor visibility. Because present offshore production islands/structures will represent a relatively small cumulative obstruction, and birds under most circumstances will see and avoid them, mortality from collisions is expected to be low. Increasing numbers of structures associated with greater offshore production in the foreseeable future potentially could result in substantial mortality for several waterbird species.

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c. Transportation Effects on Marine and Coastal Birds

Oil produced by development of the Liberty Prospect is expected to contribute only a small fraction of oil spills from TAPS tankers (0.13 spills or about 1% of total estimated tanker spills, Table A-35). However, future tanker spills of arctic oil, which may include Liberty oil, could cause serious effects on marine and coastal birds in Prince William Sound and the Gulf of Alaska. In these instances, the contribution of Liberty oil to overall effects is expected to be proportional to its percentage in the particular shipment. The principal example for estimating potential effects in Prince William Sound and the northern Gulf of Alaska are those resulting from the *Exxon Valdez* oil spill, an unusually large spill (Table A-12). Following the *Exxon Valdez* spill, more than 30,000 dead oiled birds were collected, most of them outside Prince William Sound (Piatt et al., 1990). The actual toll probably was 3-10 times this number. Species that have recovered or are recovering include bald eagle, black oystercatcher, marbled murrelet, and common murre *(Exxon Valdez* Oil Spill Trustee Council, 2000). Those that have not recovered or recovery is unknown include common loon, cormorants, harlequin duck, pigeon guillemot, and Kittlitz's murrelet. The recovery period for these species already has spanned two to three generations; obviously, recovery from an event of this magnitude requires a lengthy period and is complicated by other factors before and after the spill that increase mortality and/or decrease production of offspring. Potential effects of a large spill between April and September within 50 miles of shore in the Gulf of Alaska are discussed in Section IX.B.3.

A more realistic projection of the risk from tanker spills is indicated by the average estimated size of tanker spills (Table A-37) that were calculated from tanker spill records (Table A-36). Most spills (10 of 11) are expected to average 13,000 barrels or less (Table A-37). Of these, three would likely occur in ports with readily available containment and cleanup equipment. When the effects have been studied, at-sea spills of this size have not been found to cause serious effects on bird populations. Also, they are not expected to reach large areas of habitat that are critical to the survival of bird populations until the oil is rendered much less harmful by weathering and dispersion in the water. This suggests that for spills of this size, mortality would be relatively low and recovery periods could be relatively short, except for species whose populations are declining and/or have a low reproductive rate. Recovery periods would be lengthened if more than one spill affected the same populations within a short interval, which is unlikely to occur.

If oil produced by cumulative arctic oil development is spilled along transportation routes south of the Gulf of Alaska, other marine and coastal bird populations could be affected. According to spill simulations by LaBelle and Marshall (1995), a large tanker spill assumed to occur 100-200 miles offshore would not be expected to contact sensitive coastal bird habitats for more than 30 days (model spills 80-100 miles offshore contacted shore in 30 days), at which point, the oil would have weathered and dispersed. In addition, bird densities generally are quite low in this pelagic habitat. Shearwaters, kittiwakes, and various species of auks probably are most vulnerable. Also, bird concentrations on offshore islands south of Alaska would be more vulnerable than those occupying coastal habitats. In-port spills are likely to be contained and recovered or cleaned up relatively quickly. Vulnerable species during winter and spring/fall migration would include loons, waterfowl, shorebirds, and some auks; in summer, herons, rails, and various seabirds would be the main groups affected. In general, the effect of tanker spills on these species is expected to be about the same as described above and in Section IX.B.3.c for bird populations in the Gulf of Alaska.

Most projects and activities not associated with petroleum development affect birds at latitudes south of the Beaufort Sea and outside the summer breeding season. Several of these factors, individually or in combination, probably affect bird populations as much or more than potential effects of petroleum development and may have contributed importantly to recent declines in these populations.

4. Terrestrial Mammals

a. Summary and Conclusions for Beaufort Sea, North Slope, and Transportation Activities on Terrestrial Mammals

Terrestrial mammals that would be affected include caribou, muskoxen, grizzly bears, and arctic foxes. About half the Central Arctic Caribou Herd uses coastal habitat adjacent to the Liberty area during summer. Only a small part of muskox, grizzly bear, and arctic fox populations of the Arctic Slope range along the coast of the Liberty area (Foggy Island Bay) (see Sec. VI. A.4 for a description of these terrestrial mammals in the project area). In this section, we discuss how the Liberty Project would add to the cumulative effects of ongoing and planned projects on these species. Map 3a shows the location of these projects.

Oil development in the Prudhoe Bay area is likely to continue to displace some caribou during the calving season within about 4 kilometers (2.48 miles) of roads with vehicle traffic, and a general shift of calving away from the extensive oil fields may persist. Cows and calves of the Central Arctic Herd may, over time, reduce calving and the use of summer habitats near roads with high levels of traffic. If they do, these activities potentially could affect the caribou's productivity and abundance over the long term.

However, this potential effect may not be measurable, because the caribou's productivity greatly varies under normal conditions. Some oil-development projects such as Liberty, Badami, and Alpine would not include roads constructed to connect to Prudhoe Bay and the Dalton Highway. They are not likely to disturb or displace calving caribou or change their movements across the Arctic Slope. Cumulative oil development is likely to have only local effects on the distribution and abundance of muskoxen, arctic foxes, and grizzly bears in the Prudhoe Bay area. Potential cumulative oil spills along the tanker route to the U.S. west coast could have short-term (1-3 years) effects on other terrestrial mammals.

Contribution of Liberty to Cumulative Effects: Liberty's contribution to the cumulative case is expected to be less than 1% of the local short-term disturbance of caribou and zero reduced use of habitat for calving. Liberty should only briefly and locally disturb or displace a few muskoxen and grizzly bears. It should attract few if any foxes to facilities and construction sites, with no effects on distribution and abundance. Liberty would contribute about 6% to potential offshore oil spills and effects on terrestrial mammals (0.07 out of 1.09 mean total spills in Table A-35).

b. Details of Cumulative Effects on Terrestrial Mammals

(1) Overall Effects on Terrestrial Mammals

Cumulative oil and gas activities on the Arctic Slope of Alaska has had some local effects on the Central Arctic caribou herd's calving distribution and use of habitats within 4 kilometers (2.48 miles) of oil field roads and other facilities. A shift in calving activities away from the oil fields may mean the caribou have lost some calving habitat (Nellemann and Cameron, 1998). Aircraft and ice-road traffic (the latter during winter only) from Liberty and other recent projects could disturb some caribou, muskoxen, and other terrestrial mammals for a few minutes to an hour, but they would not affect population distribution or abundance. Caribou would not be disturbed by ice-road traffic during calving, because ice roads melt in the spring and are no longer used when caribou are calving.

Activities such as gravel mining and the construction of roads and gravel pads have reduced local use of nearby habitat because of additive levels of vehicle traffic during operations. Caribou cows with calves tend to avoid roads with vehicle traffic. These effects are long lasting but local (within 4 kilometers of roads with traffic) and would displace some caribou from part of the calving range. If this displacement/avoidance were to include more calving habitat and affect the distribution of more calving caribou, the herd's productivity could be affected. However, we do not now see such an effect, because development in the Prudhoe Bay area has not clearly affected the abundance of the Central Arctic Herd. This herd has declined from 23,000 in 1992 to about 18,000 animals in 1994, and reduced weights of cow-caribou that calve on the oil fields suggest that their productivity may be affected by oil development (Cameron, 1994; Nellemann and Cameron, 1996, 1998). However, this decline may reflect natural changes in forage habitat and in caribou abundance. Recorded differences in calf numbers between cows calving west (on the main oil fields) versus east (of the main oil fields) of the Sagavanirktok River only occurred during years of low overall calf production; however, during years of high calf production, there are no differences (Whitten, 1998, pers. commun.). This finding indicates that factors other than or in addition to oil development are affecting caribou productivity (Whitten, 1998, pers commun.).

Limiting construction at developing oil fields (Liberty, Badami, and Alpine) to winter months and not building roads that connect to Prudhoe Bay would lessen or avoid further disturbance and displacement of caribou from calving areas.

Constructing more than 360 miles of roads to support oil development has increased human access to the arctic caribou herds, muskoxen, grizzly bears, and arctic foxes. However, hunting regulations should keep hunters from overharvesting any of the caribou herds and other terrestrial mammal populations on the North Slope. Ongoing and future oil-development projects such as Liberty, Badami, and Alpine would have smaller "footprints" (fewer and smaller gravel pads, fewer infield roads, and no roads connecting to Prudhoe Bay). This technology is expected to reduce additive effects of development on terrestrial mammal habitats. These measures would greatly reduce the amount of habitat affected by oil development and reduce disturbance of caribou and muskoxen from vehicles, especially during the calving season. Future oil development projects that do not include interconnecting roads should not significantly disturb or displace calving caribou or muskoxen. They also would not greatly change caribou and muskoxen movements across the Arctic Slope.

(2) Effects of Oil Spills

For this cumulative analysis, we assume one large oil spill of 715 to 2,956-barrels would occur in Alaska's Beaufort Sea including areas west of Liberty (Table A-35). If the spill occurred during the open-water season or during the winter and melted out of the ice in the spring, this oil could affect coastal habitats from about Harrison Bay east to about Flaxman Island. Thus, some caribou of the Central Arctic and Teshekpuk Lake herds (the latter herd could be affected by the spill that might occur west of Liberty) could be directly contacted and harmed by the spill along the beaches and in shallow waters while they are escaping from insects. However, even in a severe situation, only a few to fewer than 100 caribou are likely to contact the spilled oil and die from inhaling and absorbing toxic hydrocarbons. Either of the caribou herds would replace these losses within 1 year.

Many small spills (average size of 4 barrels) of either crude oil or petroleum products may occur onshore near pipelines, including the Trans-Alaska Pipeline System, for the cumulative analysis (Table A-35). These minor spills would have a very small additive effect on terrestrial mammal habitats near pipelines, roads, and other facilities (see Sec. V.C.7, Cumulative Effects on Vegetation-Wetland Habitats). Some of these spills would contaminate 1 acre or less of tundra vegetation near the pipeline, road, or gravel pads. Liberty would contribute about 1.3% of the Trans-Alaska Pipeline System pipeline spills (Table A-35). Caribou and muskoxen probably would not ingest oiled vegetation, because they are selective grazers and are particular about the plants they consume (Kuropat and Bryant, 1980). Also, control and cleanup operations (ground vehicles, air traffic, and people) at the spill site would frighten caribou and other terrestrial mammals away from the spill and prevent contact with the oil. Thus, onshore spills from cumulative oil development are not likely to affect caribou, muskoxen, or other terrestrial mammal populations.

(3) Effects of Disturbance on Caribou Movements and Calving

The main sources of disturbance for caribou are traffic from surface-vehicles, human presence, and aircraft near cows with newborn calves. Further oil exploration, particularly helicopter traffic, would briefly disturb some caribou when the traffic passes overhead. This activity has not and would not affect caribou populations. However, during development, concern exists about disturbance from traffic on roads next to pipelines and traffic on roads that cross calving habitats. Caribou hesitate crossing under an elevated pipeline next to a road when vehicles are moving on the road. Their success in crossing depends on motivation. When mosquitoes and oestrid flies pester them, caribou are highly motivated to seek relief. They cross under pipelines more often during the insect season in the Prudhoe Bay-Kuparuk area (Curatolo, 1984), but increased disturbances from vehicle traffic can keep crossing success rates down. However, caribou do successfully cross pipeline-road complexes and many highways in Alaska and Canada with no apparent effect on the herd's distribution or abundance. Although caribou can get used to roads and traffic, cows and calves avoid areas of human activity before and during the calving season (Smith, Cameron, and Reed, 1994).

Several hundred vehicles per day travel along more than 350 miles of roads in the Prudhoe Bay area. This traffic has displaced caribou for a few minutes up to several days within about 1-2 kilometers of the road system (see Map 3b). Road traffic temporarily delays some animals from crossing under pipelines but has not affected the herd's overall distribution or abundance. However, where roads cross calving areas, any vehicle traffic could disturb cows during calving, displacing many of them up to 4 kilometers away from the road (Dau and Cameron, 1986a,b; Cameron et al., 1992; Nellemann and Cameron, 1996). This local displacement continues to persist every year during the calving season. Calving also has shifted to the west and southwest of the Kuparuk oil field (Lawhead et al., 1997; Nellemann and Cameron, 1998). However, during the postcalving season when caribou are harassed by insects (oestrid flies), Central Arctic Herd caribou are attracted to gravel pads, pipelines, and other oil field facilities to avoid or reduce their exposure to insect harassment (Noel et al.,1998; Curatolo and Murphy, 1986). The caribou's use of gravel pads and roads for insect relief may compensate for the loss of foraging habitat at the pad sites and may compensate somewhat for the disturbance they experience when road traffic is present (countervailing effect).

At present, oil development on the North Slope has produced 1,797 kilometers (1,114 miles) of pipelines, 582 kilometers (364 miles) of roads, and 7,126 acres of habitat covered by gravel pads, roads, and other facilities (Table V.B-3). All this activity has caused some additive displacement of caribou in the Central Arctic Herd from part of the calving range with no apparent effect on the herd's abundance or overall productivity. There is no evidence that synergistic effects have occurred.

In theory, reducing calving use of habitats within 4 kilometers of roads on the North Slope eventually could limit the growth of arctic caribou herds within their present ranges. It may even keep the herds from reaching the population size they could achieve on these ranges without development. However, existing cumulative oil development has not been shown to affect caribou abundance or population growth. Recent information suggests the Central Arctic Herd may be calving better east of the oil fields, which could mean that disturbance and local displacement of some cow caribou may affect their productivity (Cameron, 1994; Nellemann and Cameron, 1996, 1998). If future construction activity, especially road traffic, avoided calving concentration areas and was restricted to during and just after calving, caribou would experience less disturbance and displacement from calving areas.

(4) Effects of Oil Development Projects Without Connecting Roads

Liberty, Badami, Alpine, and other recent projects would not have roads constructed that connect with Prudhoe Bay (Map 3b). This measure would save the oil companies millions of dollars and would avoid disturbing caribou during the calving season along the pipeline corridors. The Badami and Alpine projects would have short gravel roads between airstrips, docks, camps, and production pads (see Tables V.B-3 and V.B-5). The Alpine Project, however, is not located in a caribou calving area. Badami is near calving areas near Bullen Point and southward between the Shaviovik and Staines rivers. Vehicles moving along the 4.5 miles of gravel roads between the airstrip and production pad, or the airstrip and dock, could disturb some caribou moving away from insects to and along the coast. This local disturbance would not greatly change caribou movements or displace calving caribou. As more vehicles move along the Endicott Road during Liberty and Badami development, they could temporary disturb more caribou, but they are not likely to affect caribou movements and distribution in the Sagavanirktok River area.

(5) Effects of Construction and Supply Helicopter Traffic

The 10-20 flights per day during 2-3 years of development from Liberty could briefly disturb some caribou, muskoxen, and grizzly bears. Cumulatively, these animal populations see more than 450 helicopter trips/month during busy construction periods on the North Slope. Liberty would increase air traffic by 2-4% overall. Disturbance events are not likely to be cumulative, because they would be rather infrequent and involve different animals and different areas.

(6) Effects of Construction and Supply Ice-Road Traffic

Construction traffic and about 100 supply trips per year for Liberty could briefly disturb some caribou, muskoxen, and grizzly bears during December through early May. This traffic would be highest during the 2 years of development and would continue at a lower level to support project operations during the 15-20 years of production. These animals have experienced ice-road traffic from other projects over the past 20 years without any apparent effect on their abundance or distribution. Ice roads for future and ongoing projects such as Liberty and Northstar also are not expected to affect terrestrial mammal abundance or distribution.

(7) Effects of Ice Roads, Gravel Mining, and Constructing Onshore Pipelines and Gravel Pads

For Liberty, these activities would alter about 45 acres of terrestrial mammal habitats. Existing development has altered more than 7,128 acres.

A gravel road would not be constructed along the Liberty-Badami pipeline to connect to the Endicott pipeline and road. Disturbance of caribou would be limited to helicopter traffic during the summer and winter and ice-road traffic during the winter. Central Arctic Herd caribou see thousands of motor vehicles each month on more than 360 miles of roads in the Prudhoe Bay area during and after calving. This traffic has caused a decrease in calving near roads and temporarily changed the caribou’s movements. Assuming future activities do not include roads connecting the Prudhoe Bay-Dalton Highway road system, this development is not expected to cause further displacement of Central Arctic caribou from calving habitat nor significantly affect caribou movements.

(8) Effects of Interactions with Humans

The onshore activity for Liberty (1.4 miles of onshore pipeline but no camp onshore) is not likely to result in the loss of any bears. However, a few grizzly bears have been killed or removed from the oil fields because of confrontations with people or because the bears were damaging buildings or equipment. Arctic foxes actually have increased around the Prudhoe Bay area, because they have more food (garbage) and shelter (in culverts and under buildings). Future development activities could result in the loss of some additional grizzly bears but, the numbers are likely to be small and not affect the population.

(9) Effects of Altering Habitat

Oil development on the North Slope covers about 7,128 acres (Table V.B-3), and includes more than 360 miles of gravel roads that cross much of the Central Arctic Herd’s calving range. This extensive development actually has destroyed only about 3% of the tundra grazing habitat because of roads, pads, gravel quarries, pipelines, pump stations, and other facilities. Construction in ongoing and future oil developments (such as the Liberty, Northstar, and Alpine projects) would alter much smaller areas of the available grazing habitat.

Roads for development on the North Slope eventually may be open to the public, which would increase access to the caribou herds, muskoxen, grizzly bears, and other terrestrial mammals, possibly leading to more hunting and disturbance. Although people cannot hunt caribou with firearms within 8 kilometers (5 miles) of the Dalton Highway, they can hunt with bows and arrows. Noise and disturbance from this harvest is not expected to significantly affect caribou movements across the Dalton Highway or other roads on the North Slope. Caribou have continued to cross roads and highways, even under heavy hunting pressure and its associated noise and disturbances (Valkenburg and Davis, 1986). However, if the public through future development activities were allowed access to the caribou calving areas during the calving season, such disturbance could have effects on the caribou population.

c. Transportation Effects on River Otters and Brown and Black Bears

Liberty is not expected to contribute any tanker spills to the cumulative analysis (mean number of spill 0.12 in Table A-35). However, potential future oil-spill effects from tanker transportation of arctic oil (including Liberty oil) from the Trans-Alaska Pipeline System terminal at Valdez could have local cumulative effects on river otters and brown and black bears and other terrestrial mammals in Prince William Sound, the Gulf of Alaska, or along the tanker route to the west coast (see Sec. IX.B, Effects of A Tanker Spill in the Gulf of Alaska on Terrestrial Mammals). The potential loss of river otters (perhaps 50-100 individuals) and contamination of intertidal habitats from a 200,000-barrel oil spill is estimated to take more than 1 year to recover (probably 3 years or longer). The potential loss of brown and black bears (perhaps 10 individuals) is estimated to take 1 year for the populations to recover. The number of cumulative tanker spills is estimated to be six with an average size of 3,000 barrels; one spill is assumed to be 200,000 barrels, while the other five are assumed to be less than 15,000 barrels, of which two spills would be an average size of 13,000 barrels. These spills are expected to have similar effects on river otters and bears as described above but cause fewer losses of river otters and bears. Recovery of populations is expected within 1 or 2 years after each spill, assuming the same populations and habitats are not affected by multiple spills. If two or more of these spills affect the same populations and habitats within 1 or 2 years of the previous spill, recovery will take longer.

If tanker spills associated with cumulative oil development in arctic Alaska, including Liberty, occurred south of the Gulf of Alaska, other terrestrial mammals and their habitats could be affected along the transportation routes or at marine ports. The effects of tanker spills on these terrestrial mammals and their habitats are expected to be about the same as described in this section and in Section IX.B.3.d for terrestrial mammals.

5. Lower Trophic-Level Organisms

a. Summary and Conclusion for Beaufort Sea, North Slope, and Transportation Activities on Lower Trophic-Level Organisms

One offshore oil spill of 125-2,956 barrels is estimated for the past, present, and reasonably-foreseeable developments. About half of the reasonably-foreseeable developments would be outside of the barrier islands, so the cumulative risk to river deltas and other sensitive portions of the coastline would not increase proportionally. Also, none of the developments other than Liberty would be near the Boulder Patch, so the cumulative risk to it would be similar to the Liberty-specific risk. Benthos would be disturbed (buried) during pipeline and island construction for the reasonably-foreseeable developments. The total disturbed area would probably be less than 800 acres, and the effect would be moderated by benthic colonization on old exploration islands that were abandoned during the past decade. Based on the assumptions discussed in the following text, a future oil tanker spill in Prince William Sound is estimated to harm 1-10% of the plankton and 40-50% of the intertidal and shallow subtidal marine plants and invertebrates within the affected area. Recovery is expected to take 1 or 2 days for phytoplankton and up to 1 week for zooplankton. Intertidal and subtidal recovery is expected to take 2-3 years in high-energy habitats and up to 7 years in lower energy habitats.

Contribution of Liberty to Cumulative Effects: We do not expect the cumulative effect of oil spills or disturbances from offshore developments (including Liberty) to substantially affect organisms at the lower trophic level. For this reason, and because the Liberty Project itself is estimated to contribute only about 6% of the estimated amount of spilled oil to the cumulative case, the Liberty Project is not expected to make a measurable contribution to the cumulative effect on these organisms.

b. Details of Cumulative Effects on Lower Trophic-Level Organisms

This assessment was based on the cumulative effects of offshore oil spills on coastlines and of disturbance on benthos. One offshore oil spill of 125-2,956 barrels is estimated for this cumulative analysis (Table A-35). The spill risk to coastlines is due partly to two existing developments with offshore facilities—Endicott and Northstar. The risk also would be due also to five reasonably-foreseeable developments with offshore facilities—Sandpiper, Flaxman, Stinson, and Hammerhead/Kuvlum (Table V.B-1a). About half of these developments and prospects would be outside of barrier islands (including Northstar, Sandpiper, and Hammerhead/Kuvlum, reducing slightly the cumulative risk to river deltas and other sensitive portions of the coastline. Further, none of the prospects inside of the barrier islands would be near the Boulder Patch, so the cumulative spill risk to it would be similar to the Liberty-specific risk.

How Disturbance May Affect Benthos: In the cumulative sense, additional benthos would be buried by construction of more offshore pipelines and islands. The reasonably-foreseeable developments with offshore facilities would be Sandpiper, Flaxman, Stinson, and Hammerhead/Kuvlum. None of them would be near the Boulder Patch, so the cumulative risk to it would be the same as the Liberty-specific risk. With regard to typical benthos, the total amount buried during pipeline construction can be estimated from the approximately 100-acre footprint for the Liberty pipeline trench. For all of the reasonably-foreseeable developments, the pipeline footprints probably would be less than 400 acres total. An old exploration island exists for one of the reasonably-foreseeable developments (Sandpiper); however, islands might be constructed for four additional developments over the next decade or so (Flaxman, Stinson, and Hammerhead/Kuvlum). The total amount of benthos covered by these islands probably would be less than 200 acres initially. When Seal and the old Northstar islands were abandoned and allowed to erode outward, they doubled their footprints (Coastal Frontiers Corp., 2000); eventually, about 400 acres of benthos probably would be covered. These effects on benthos would be moderated by benthic colonization on old exploration islands that were abandoned during the past decade (for example, BF-37, Tern, Mukluk, and old Northstar).

c. Transportation Effects on Lower Trophic-Level Organisms

Oil produced from the Liberty Project is expected to contribute only a small fraction of cumulative oil spills from Trans-Alaska Pipeline System tankers (about 1%). However, future tanker spills of arctic oil, which may include oil from the Liberty Project, would be likely to adversely affect lower trophic-level organisms in Prince William Sound, if spills occurred there. If some of these spills were to occur close enough to shore, they also would be likely to adversely affect lower trophic-level organisms in the Gulf of Alaska along the tanker route. One of the future oil tanker spills is assumed to be (for purposes of analysis) at least 200,000 barrels. Based on the assumptions discussed in Section IX.B, the cumulative effects of tanker spills on lower trophic-level organisms are described in Section IX.B and summarized here. Assuming that some of the spilled oil contacts the shore (Prince William Sound or the Gulf of Alaska) in a relatively nonweathered state, a 200,000-barrel oil spill is estimated to harm 1-10% of the plankton within the affected area. Recovery is expected to take 1 or 2 days for phytoplankton and up to 1 week for zooplankton. The spill also is estimated to harm about 40-50% of the affected intertidal and shallow subtidal marine plants and invertebrates. Recovery of these communities is expected to take 2-3 years in high energy habitats and up to 7 years in lower energy habitats. Less than 5% of the subtidal benthic populations are expected to be affected.

Any Trans-Alaska Pipeline System pipeline oil spills occurring on land are estimated to be small in size (about 1 barrel or less) and number (150 or less). Additionally, there are few waterbodies along the Trans-Alaska Pipeline System route supporting lower trophic-level populations. If an oil spill did occur in one of these waterbodies, it would adversely affect the organisms in the immediate area of the spill. However, it would not be expected to have a measurable effect on lower trophic-level populations in the area.

6. Fishes and Essential Fish Habitat

a. Fishes

(1) Summary and Conclusions for Beaufort Sea, North Slope, and Transportation Activities on Fishes

While small numbers of fish in the immediate area of an offshore or onshore oil spill may be killed or harmed, an oil spill assumed for this analysis is not expected to have a measurable cumulative effect on fish populations. Subsistence and commercial fishing are likely to have a measurable cumulative effect on freshwater and migratory fish populations. However, due to a lack of survey information, the cumulative effect of these activities, and the amount of time required for each population to recover, is unknown.

Contribution of Liberty to Cumulative Effects: Marine and migratory fishes are widely distributed in the Beaufort Sea and are not likely to be affected by the Liberty Project. Based on the estimated mean number of oil spills (Table A-35), Liberty is estimated to contribute only about 6% of the spilled oil to the cumulative case. Also, little to none of this oil is expected to contact overwintering areas during winter. Hence, the Liberty Project is not expected to contribute measurably to the overall cumulative effect on fishes.

(2) Details of Cumulative Effects on Fishes

(a) Disturbances from Exploration, Development, and Production Activities

Fishes are sensitive to noise changes between 5-1,000 Hertz (Bell, 1990). Noise-producing activities from aircraft and vessels (summer) plus ice road transportation (winter) would increase with Northstar and Badami (see Table V.B-8). Noise effects on fishes could include local avoidance of seismic surveys, aircraft and vessel traffic, drilling and construction, and production operations. Some overwintering fishes may not be able to avoid noise and disturbances. However, there is no scientific evidence currently available to show that industrial noise and disturbance are likely to harm fishes.

(b) Effects of Discharges from Additional Drilling and Associated Oil and Gas Activities

The cumulative effects from additional drilling and discharges are likely to be local and temporary. Discharges associated with drilling are not likely to measurably affect fishes. Fishes would be displaced from the areas where drilling equipment is installed, but this would affect only a very small area of the Beaufort Sea and would have no measurable effect on fish populations.

(c) Effects from Pipeline Construction

Pipeline construction would kill small numbers of epibenthic invertebrates that fishes feed on. Trenching could temporarily alter the migration patterns of some migratory fishes, if the trenching occurred during migrations. However, epibenthic invertebrates quickly recolonize disturbed areas, and only minor changes in migration routes would be expected. Hence, measurable cumulative effects on fishes due to pipeline construction are not expected.

(d) Effects from Cumulative Oil Spills

The cumulative effect of oil spills occurring and entering offshore waters on arctic fishes (including incidental anadromous species) would depend on the number of spills; the season of the year; and the hydrocarbon concentration, time of exposure, and stage of fish development involved for each spill encountered. However, mortality caused by a petroleum-related spill is seldom observed outside of a laboratory environment. Sublethal effects are far more likely, and these may include changes in growth, feeding, fecundity, and temporary displacement. In summer the nearshore waters of the Beaufort Sea are used for migration and feeding by fishes. A very small number of fish in the immediate area of an offshore summer spill could be killed or harmed; however, they would not be expected to have a measurable effect on fish populations.

Onshore pipeline spills on the North Slope and along the Trans-Alaska Pipeline System in winter would not be expected to affect fishes, because the likelihood of their contacting fish habitat is very low. However, if a summer spill of sufficient size occurred in a small waterbody containing fish with restricted water exchange, the fish and food resources in that waterbody would be likely to be harmed or killed. Recovery would be expected in 5-7 years. However, due to small amount of oil likely to enter freshwater habitat, the low diversity and abundance of fish in most of the onshore area, and the unlikelihood of spills blocking fish migrations or occurring in overwintering areas or small waterbodies (containing many fish or fish eggs) with restricted water exchange, an onshore oil spill associated with Liberty is not expected to have a measurable effect on fish populations. For these reasons, while small numbers of fish in the immediate area of an offshore or onshore oil spill may be killed or harmed, oil spills would not be expected to have a measurable cumulative effect on fish populations.

(e) Effects from the Annual Subsistence and Commercial Harvests

The subsistence harvesting of fishes in the Beaufort Sea area is discussed in the subsistence section of the EIS. Large numbers of freshwater and migratory fishes are killed each year for subsistence and commercial purposes. Hence, these activities are likely to have a measurable and, in some cases, a significant effect on the fish populations. However, due to a lack of survey information, the cumulative effect of these activities on fish populations, and the amount of time required for each individual population to recover, is unknown.

(3) Transportation Effects on Commercial Fishing and Fishes

Oil produced by the Liberty Project is expected to contribute only a small fraction of cumulative oil spills from Trans-Alaska Pipeline System tankers (about 1%). However, future tanker spills of arctic oil, which may include oil from the Liberty Project, likely would adversely affect commercial fishing in Prince William Sound and the Gulf of Alaska. Nine tanker spills are estimated for the cumulative analysis; one is assumed to average 250,000 barrels, two are assumed to average 13,000 barrels, and six are assumed to average 3,000 barrels. Based on the assumptions discussed in Section IX.B, the cumulative effect of tanker spills on commercial fishing is expected to be about the same as described in Section IX.B.3.n. Assuming the 200,000-barrel oil spill occurs within the commercial fishing zones of Prince William Sound or the Gulf of Alaska, it is estimated to result in economic losses to the commercial fishing industry of those areas ranging from 37-64% per year for 2 years following the spill. A large oil spill is not expected to have measurable effects on fish populations, including anadromous species (see USDOI, MMS, Alaska OCS Region, 1985). For this reason, and because sport fishermen commonly fish in oiled waters such as those around the Valdez Oil Terminal and boat harbors throughout Alaska, an oil spill is not expected to have a measurable effect on sport fishing.

b. Essential Fish Habitat

Because none of the lifestages of salmon have been documented to use or inhabit the waters near the Liberty Island development, salmon are not likely to be killed or otherwise affected by disturbance in that area under any scenario, cumulative or otherwise.

The only potential effect on salmon related to the Liberty development would come from an oil spill. The Liberty Project represents a small proportion (about 1%) of past and present oil and gas development projects in the Beaufort Sea area and is expected to contribute about 6% of cumulative offshore spills. Liberty's estimated statistical contribution of spilled oil is 0.07 spills (out of an estimated mean number of 1.09 spills), with the most likely number of spills being zero (Table A-35).

During the summer, adult pink and chum salmon are known to be present in the Liberty area only in the Colville River and its tributaries, which enter the Beaufort Sea about 100 kilometers west of Liberty. In the unlikely event that spilled oil reached the mouth of the Colville River, the most likely potential threat to individual salmon would occur if spilled oil came in contact with spawning areas or migratory pathways. However, salmon are not known to spawn in the Colville or its tributaries, and the risk to spawning areas presumably is small. If spilled oil concentrated along the coastline at the mouths of streams or rivers, the potential movements of a small number of salmon could be disrupted during migrations. However, because only a single spill is considered likely to result from all of the offshore oil and gas related development in the central Beaufort Sea, the incremental increase in risk directly to salmon from Liberty is very small.

The potential adverse effects of a single large oil spill on elements of essential fish habitat (i.e., water quality, salmon prey, and associated vegetation they depend on) are discussed in Section III.C.2.g. Only a single spill is expected to occur as a result of all development in the cumulative case. However, even if additional spills did occur, they would not be likely to contact the same resources or to occur before those resources had recovered from the first spill. Any adverse effects of Liberty on essential fish habitat would be additive to the cumulative case.

Only events in or near marine waters could affect prey or prey habitat near Liberty Island; in the Endicott, Alpine, and Northstar oil fields; the Sandpiper pool, or the Kuvlum and Hammerhead prospects. These events include discharges, construction, and small oil or contaminant spills. Because additional activities are likely to occur in these oil fields, this cumulative analysis involves more drilling discharges and construction-related activities than from Liberty alone. We expect those activities to affect only the organisms near each oil field; thus, they would not measurably affect these organisms near Liberty Island (including those in the Boulder Patch area), and vice versa. Potential effects on potential prey species and algae from Liberty and other nearby developments due to disturbance or degradation of water quality would be countervailed to some degree by the potential enhancements to potential prey habitat expected from the construction of the gravel quarry and island structure.

Commercial and subsistence fisheries exist for some of the potential prey species in several of the river systems in the Liberty area. These fisheries would have the potential to depress potential prey populations, which would have a potential additive negative effect on essential fish habitat in the cumulative case. However, they would have little effect, because salmon are not known to be found in the Liberty area and, thus, their prey are not likely to be limiting in the Liberty area.

Noise-producing activities from aircraft and vessels (summer), plus ice-road transportation (winter) are likely to increase with activities at Liberty, Northstar, and Badami. Noise effects on fish that are potential prey for salmon could include local avoidance of seismic surveys, aircraft and vessel traffic, drilling and construction, and production operations. Some overwintering fish may not be able to avoid noise and disturbances. However, there is no scientific evidence currently available to show that industrial noise and disturbance are likely to harm fishes.

7. Vegetation-Wetland Habitats

a. Summary and Conclusions for Beaufort Sea, North Slope, and Transportation Activities on Vegetation-Wetland Habitats

Oil field development on Alaska's North Slope centers on the Arctic Coastal Plain, which covers about 13 million acres. Existing gravel roads, pads, and other facilities cover more than 7,126 acres (Table V.B-3). About 50 miles of shoreline, including vegetation and wetland, are potentially affected by cumulative development within the Liberty area (Foggy Island Bay). (See Sec. VI.A.7 for a description of the distribution of vegetation and wetland in the project area.) All projects in Maps 3a and 3b either have or would destroy vegetation through the construction of onshore gravel pads, gravel mines, and roads and the burial of pipelines or the installation of vertical support members for elevated pipelines. Sources of past and potential impact include directly digging up and burying vegetation; changes in snow drifting and water drainage; accumulation of dust, salt, and chemicals along roads and near gravel pads; and damage from oil spills and other accidental chemical spills. In terms of acres of land affected, construction causes more than 99% of the effects, with spills having a very minor role. Rehabilitation of gravel pads can result in the growth of grasses-sedges within 2 years after abandonment of the pads. Natural growth of plant cover on abandoned gravel pads would be very slow.

Construction of existing facilities, past exploration pads, and vehicle tracts across the tundra landscape have affected a small percentage of the total tundra-wetland habitats on the Arctic Coastal Plain. However, local additive effects of gravel pads, roads, mines, and other facilities on tundra wetlands are expected to persist decades long after the oil fields are abandoned.

Tanker transportation of oil from Valdez to the U.S. west coast could have potential additive oil-spill effects on vegetation and wetlands that could take impacted wetland 10 years or more for recovery.

Contribution of Liberty to Cumulative Effects: Liberty would contribute only 0.67% of the cumulative disturbance effects on 9,000 acres of tundra and wetlands now affected by oil development. The contribution of Liberty to potential offshore oil spills is about 6% (0.07/1.09 mean total number of spills in Table A-35). Liberty is not expected to significantly contribute any tanker spills to the cumulative case (mean number of spill 0.13 in Table A-35).

b. Details of Cumulative Effects on Vegetation-Wetland Habitats

Development has directly covered about 7,126 acres through the construction of 364 miles of roads, 85 pads, 5 airstrips, and 15 gravel mines. The mines alone cover more than 1,601 acres (Table V.B-3). Development in the Prudhoe Bay and Kuparuk areas has directly affected about 9,000 acres by extracting and filling with gravel and indirectly affected many adjacent acres of vegetation (Walker et al., 1986, 1987). However, the total acreage is a small part of the Arctic Coastal Plain, and these effects probably are not significant to the overall productivity of tundra plants in this area. No synergistic effects are expected.

Ongoing oil-development projects, such as Alpine, Badami, Northstar, and Liberty, would include much smaller acreage than existing and past projects on the North Slope (see Table V.B-3). Advances in drilling technology have allowed industry to drill more wells from fewer exploration and production pads than were required by past exploration and existing oil production in the Prudhoe Bay complex. This technology is expected to reduce additive effects of development on wetlands. Development plans that do not include interconnecting roads to the Trans-Alaska Pipeline System and the Dalton Highway also would greatly reduce the amount of vegetation and wetland affected on the Arctic Slope.

(1) Risks of Offshore Oil-Spills from Liberty Production Contacting Vegetation and Wetland Habitats

Estimated Liberty oil production (0.12 billion barrels) represents about 1% of the total oil production (10.59 billion barrels) onshore and offshore from Alaska's Arctic Slope (Table V.B-7b). Oil developed from the Liberty Project would contribute about 6% of future offshore oil spill (estimated mean number of 0.07 spills from Liberty, divided by total mean of 1.09 of future offshore spill based on Table A-35). Oil spills from Liberty would contribute 1.3% of the total estimated from the Trans-Alaska Pipeline System. The conditional probability of an oil spill starting at the Liberty island location or along the pipeline and contacting vegetation are highest with wetlands in the Foggy Island Bay area west to the Sagavanirktok River Delta within 30 days during the summer open-water season (11-26%) (Tables A-13 through A-18).

(2) Offshore Oil Spills Could Affect Some Vegetation and Wetland Habitats at Particular Sites

We assume one large offshore oil spill ranging from 715 to 2,956-barrels would occur during development over the life of these potential fields (Table A-35). Coastal habitats that include wetland in the Foggy Island Bay area west to the Sagavanirktok River Delta have the highest chances of contacting oil from Liberty. There is only a 0.07% chance of an offshore spill from Liberty, compared to a 1.09% chance estimated for this cumulative analysis (Table A-35). Complete recovery of oiled coastal wetland in the Foggy Island Bay/Sagavanirktok River Delta area could take several decades. We expect similar effects on vegetation and wetland, if the spill oiled vegetation in the Colville, Kuparuk, and other river deltas. Oiled coastal vegetation could take several years to fully recover from this spill and associated cleanup activities.

(3) Cumulative Effects of Onshore Spills on Vegetation and Wetland Habitats

We estimate that a mean or most likely of 4.98 onshore spills greater than 500 barrels (Table A-35) have occurred or will occur and may affect several acres of vegetation on the Arctic Slope, including along the Trans-Alaska Pipeline System. Within the Liberty Project's area, we assume one onshore spill of about 720 barrels would occur (Table A-35). The additive effect of those spills would cause very minor ecological harm; vegetation should recover within a few years but may take more than 20 years. Most onshore spills occur on gravel pads, and their effects do not reach the vegetation. About 20-35% of past crude-oil spills reached areas beyond pads. The corresponding proportion for refined oil probably is much less, but we assume that 20-35% of all onshore spills would occur at or reach beyond gravel pads. These percentages translate to 388-591 spills totaling 1,502-2,628 barrels of oil. Because winter spans most of the year, about 60% of the time spills occur when workers can clean up oil on the snow cover before it reaches the vegetation. Thus, we estimate that 11% of all onshore spills would affect vegetation (37-65 spills). Most spills cover less than 500 square feet, or 0.01 acre, but may cover up to 4.8 acres if the spill is a windblown mist. We assume 98% of the spills would cover 0.01 acre, and 2% would cover 4.8 acres. Over the lifetime of developed oil fields, spilled oil most likely would cover about 6.5 acres (65 spills x 0.1 acre). Overall, past spills on Alaska's North Slope and along the Trans-Alaska Pipeline System have caused minor ecological damage, and ecosystems have shown a good potential for recovery (Jorgenson, 1997).

(4) Effects of Construction of Onshore Pipelines, Gravel Pads, Roads, and Gravel Mining

Oil fields in the Prudhoe Bay area include several hundred miles of pipelines, 83 gravel pads, about 350 miles of roads, and 14 gravel mines (Table V.B-3).

(a) The Effect of Constructing Onshore Pipelines

The Liberty pipeline would remove less than 1 acre of vegetation along the 1.4-mile long pipeline to the Badami tie-in. Vegetation would be removed at excavations for vertical support members (about 90-100 pilings/mile) along the elevated pipeline connecting to the Badami pipeline. The tie-in gravel pad would be a small area (less than 1 acre) of overlapping impacts on tundra vegetation from both Liberty and the Badami pipeline. The pipeline's route to the Badami tie-in avoids crossing wet herbaceous tundra vegetation just west of the Kadleroshilik River.

For this analysis, we assume vertical support beams would support pipelines. The beams would have a diameter of 12 inches and would be placed 55-70 feet apart. Each support beam would disturb about 20 inches of vegetation around it in addition to the vegetation it directly displaces (Jorgenson, 1997, as cited in U.S. Army Corps of Engineers, 1998). The disturbance zone could come from locally deposited excess trench material and possible thermokarsting; it could change the composition of plant species. Each vertical support beam would disturb about 4 square feet of vegetation, 6% of which would be destroyed or replaced. This would result in 0.03 acre being disturbed per pipeline mile, or 0.035 acre from the Liberty Project. This would represent a very small fraction of the acreage affected by the existing 415 miles of pipeline in the Prudhoe Bay area.

Pipelines also could harm vegetation indirectly through snow drifting or shading from the pipeline. Information about snow drifting around pipelines with no parallel road is inconsistent (Jorgenson, 1997, as cited in U.S. Army Corps of Engineers, 1998), but residents of Nuiqsut say it occurs. Any vegetation under a pipeline would receive slightly less direct sunlight during the growing season, potentially leading to a slightly shallower active layer in the soil and slightly reduced photosynthesis by the plants.

(b) Cumulative Effects of Gravel Pads

Gravel fill for the Prudhoe Bay area (pads, roads, airstrips, and pipeline ramps) covers 7,126 acres (Table V.B-3). This cover has directly destroyed some tundra vegetation. Within a few feet of a pad, the dust and gravel may smother the original vegetation. Weedy species and thermokarsting replace it with the latter leading to high-centered polygons with deep moats (Jorgenson, 1997, as cited in U.S. Army Corps of Engineers, 1998).

The type of material used for gravel fill also can affect vegetation, because it sometimes has a salty source. If the material is salty, water draining from or leaching through the pad can pick up the salt and kill plants near the pad. More halophytic (salt loving) plant species eventually colonize these areas, thus changing one plant community to another.

Rehabilitation of gravel pads on the Kuparuk oil field has resulted in the robust growth of grasses-sedges within 2 years, but recovery of shrubs has been slow (Cater, Rossow, and Jorgenson, 1999). Natural recovery of abandoned gravel pads has been slow (30-year period), but grasses-sedges have colonized old pads with plant cover similar to undisturbed adjacent tundra (Bishop et al., 1999).

From 1968-1983, flooding from construction caused the greatest indirect effect on vegetation in the Prudhoe Bay oil field (Walker et al., 1986, 1987). Flooding resulted when roads and pads intercepted the natural flow of water and caused ponding. Thus, the Liberty Project area, through Corps of Engineers permits, would have to identify natural drainage patterns before construction and maintain them during and after construction. Even if such conditions were not required, or were not completely successful, flooding would affect no more land than that affected by dust and snow, as described above. The change in vegetation from flooding could result in more aquatic grasses and sedges verses dwarf shrubs.

The Liberty Project would require two valve stations. These stations and a helicopter pad would require less than 1 acre of gravel fill. We assume the perimeter of this gravel fill would encompass about 11 acres of potential dust effect and changes in moisture, a small fraction of the tundra affected by existing projects.

Gravel pads for future development activities are expected to have similar local effects on vegetation and wetlands.

(c) Cumulative Effect of Gravel Roads and Onshore Ice Roads

There are 364 miles of gravel roads in the Prudhoe Bay development area (Table V.B-3). Construction of these roads has caused the removal or burial of more than 5,000 acres of tundra-wetland-vegetation and has flooded an additional 4,000 acres of adjacent tundra because of changes in water flow due to the roads. However, Liberty, Badami, Alpine, and most other proposed projects would not construct interconnecting access roads next to elevated onshore pipelines tying into the Trans-Alaska Pipeline System and the Dalton Highway. The Badami and Alpine projects would contribute only a few miles of additional roads, and Liberty would not contribute any effects in this area.

Ice roads would melt and become green later in the spring than the adjacent tundra, resulting in "green trails" along their routes. Ice roads tend to compress and flatten (but not kill) the vegetation under them, and we expect this vegetation to recover within a few years. Several hundred to more than a thousand miles of ice roads have been built over the tundra to support oil and gas exploration on Alaska's Arctic Slope. Liberty and future development would include perhaps a few hundred to several hundred miles of ice roads, but most of them would be offshore over landfast ice. Liberty's ice roads would run between Endicott and Foggy Island Bay at the production island site and to the Kadleroshilik River mine site. These ice roads would not affect vegetation or wetlands along the coast, except for short-term local effects where the roads cross the land. Onshore ice roads between gravel mine sites, freshwater supplies, and other support areas would temporarily alter nearby vegetation. Ice and gravel roads for future development activities are expected to have similar local effects on vegetation and wetlands.

(d) Cumulative Effects of Gravel Mining

The 14 mines around Prudhoe Bay have removed more than 1,500 acres of sparsely vegetated river bar-tundra vegetation (Table V.B-3). Gravel mines for the Liberty and Badami projects would and have alter another 45 and 89 acres, respectively. This new acreage represents about 9% (134 divided by 1,500) of the total; however, because gravel comes from sparsely vegetated river bars, these mines would only slightly affect vegetation. Future development is expected to alter similar or less acreage of tundra vegetation for gravel mines and have local effects North Slope wetlands.

(e) Effects of Future Oil-Development Projects

If companies develop the Sourdough and Yukon Gold oil prospects west of the Canning-Staines rivers and the Point Thomson and Flaxman prospects along the Beaufort Sea's coast east of Badami (Table V.B-6), these projects may tie into the Badami pipeline (Maps 3a and 3b). Companies would add more gravel pads, pipelines, mine sites, and other facilities that would cause some further loss of vegetation and wetland between the Sagavanirktok and Canning rivers. Developing the Alpine, Fiord, Colville, and Kalubik prospects in the Colville Delta and possibly other oil prospects in the Prudhoe Bay area (Maps 3a and 3b) would affect vegetation-wetland occurring west of the Sagavanirktok River to the Colville Delta.

Future exploration and development of oil and gas on the National Petroleum Reserve-Alaska would alter or destroy some vegetation and wetland on that part of the Arctic Slope. However, such losses likely would be small compared to the overall amount of vegetation and wetland on the Arctic Slope. Future projects would use much smaller and fewer gravel pads and roads (smaller footprint) than existing oil fields in the Prudhoe Bay-Kuparuk River complex.

c. Transportation Effects on Wetlands

Liberty is not expected to significantly contribute any tanker spills to those estimated for this analysis (mean number of spills, 0.12 in Table A-35). However, transportation of arctic oil (including Liberty oil) from the Trans-Alaska Pipeline System terminal at Valdez could have local cumulative effects on wetland habitats in Prince William Sound, the Gulf of Alaska, and along the transportation route to the U.S. west coast. (See Sec. IX.B, Effects of A Tanker Spill in the Gulf of Alaska on Wetland.) The potential contamination of intertidal wetland habitats from a 200,000-barrel oil spill is estimated to take more than 10 years to recover. A second main effect would be the disturbance of wetlands from cleanup activities. Complete recovery of heavily oiled coastal wetlands from these disturbances and oil could take several decades. For this cumulative analysis, the estimated number of tanker spills is six, with an average size of 3,000 barrels; one spill is assumed to be 200,000 barrels, while the other five are assumed to be less than 15,000 barrels, of which two spills would be an average size of 13,000 barrels (Table A-13). These smaller spills are expected to have similar effects but would cause less contamination of wetland. Recovery is expected within perhaps 10 years after the spills, assuming the same wetland habitats are not affected. If two or more of these spills affect the same wetland habitats within 10 years of the previous spill, recovery would take longer (several decades).

Depending on the amount of oiling, wetland habitats located in warmer climates are expected to recover sooner from a spill than wetlands oiled in arctic climates. If Liberty oil is spilled from tankers along the California coast, oiled wetland habitat may recover within less than 10 years.

8. Subsistence-Harvest Patterns

a. Summary and Conclusion for Beaufort Sea, North Slope, and Transportation Activities on Subsistence-Harvest Patterns

Cumulative effects on subsistence-harvest patterns include effects from Liberty development and other past, present, and reasonably foreseeable projects on the North Slope with one or more important subsistence resources becoming unavailable or undesirable for use for 1-2 years, a significant adverse effect. Sources that could affect subsistence resources include potential oil spills, noise and traffic disturbance, and disturbance from construction activities associated with ice roads, production facilities, pipelines, gravel mining, and supply efforts. The community of Nuiqsut would be most affected, because it is within an expanding area of oil development both onshore (Alpine and the Northeast National Petroleum Reserve-Alaska) and offshore (Northstar and Liberty).

Access to subsistence-hunting areas and subsistence resources, and the use of subsistence resources could change, if oil development reduces the availability of resources or alters their distribution patterns. The most serious concern to North Slope Inupiat is that potential increases in noise from cumulative oil development could disrupt the normal migration of bowhead whales, forcing subsistence whalers into longer hunts farther from shore. This issue has been voiced many times over many years. Recently, Eugene Brower, President of the Barrow Whaling Captains' Association, articulated the issue in a statement he made at the January 6, 2000, meeting of the MMS Regional Offshore Advisory Committee:

> I have the responsibility of talking on behalf of my whaling captains in Barrow. There's 44 captains with 550 plus crew members that have great concern for the lease sales…the area of concern that we're talking about is the whole migration route of the bowhead whale. What goes on in the eastern portion of the Canadian Border all the way through Barrow impacts three villages. [For] their livelihood, we have a great concern…The concern is always the same…but what impacts Kaktovik impacts Barrow and Nuiqsut in the middle. Anything that goes [on] in the east impacts us all the way to Barrow. And I, for one, would never want to see a permanent structure out in the open sea because of the experience we had from…one little platform off Cooper Island, five miles offshore. It was stationary, just idling. Just the noise being emitted from that structure was enough to divert the bowhead whales further out. There was nothing in between the structure and the mainland, 9 miles of water in between them but nothing went through. It was always on the outside. So if you're going to be putting permanent facilities out in the water on the Beaufort Sea, it's going to be making a lot of noise with the gravel pad, whatever structure you put out there. It's going to impact our livelihood (USDOI, MMS, 2000).

An oil spill, if it occurred and affected any part of the bowhead whale's migration route, could taint this culturally important resource. Any actual or perceived disruption of the bowhead-whale harvest from oil spills and any actual or perceived tainting anywhere during the bowhead's migration, summer feeding, and outmigration could disrupt the bowhead hunt for an entire season, even though whales still would be available. In fact, even if whales were available for the spring and fall seasons, traditional cultural concerns of tainting could make bowheads less desirable and alter or stop the subsistence harvest in Nuiqsut and Kaktovik, as well as Barrow for up to two seasons, a significant adverse effect. In terms of other species, this same concern also would extend to polar bears and seals. Native harvests of bowhead and beluga whales by subsistence hunters in the Chukchi Sea region also would be affected by tainting concerns. From Liberty development alone, if an oil spill occurred, subsistence *resources* could be periodically affected in the communities of Nuiqsut and Kaktovik.

Additionally, a large oil spill could cause potential short-term but significant adverse effects to oldsquaw and common eider populations, and a large onshore pipeline spill that contacted the Sagavanirktok River or East Sagavanirktok Creek could kill many fishes and affect these fish populations. A potential loss of polar bears from oil-spill effects could reduce their availability locally to subsistence users, although they are seldom hunted by Nuiqsut hunters except opportunistically while in pursuit of more preferred subsistence resources. More roads on the North Slope increase non-Native access to, competition for, and disturbance of resources—a potential negative impact on subsistence hunters. More roads usually means reduced access or increased effort for subsistence hunters because new roads bring new access and security restrictions imposed by the oil industry, forcing hunters to travel farther to hunt or forcing them to hunt in nontraditional areas.

Ongoing tanker transportation of oil from Valdez to the west coast could cause serious and long-term cumulative effects on some subsistence resources in Prince William Sound and the Gulf of Alaska, especially on marine and coastal birds, sea otters, and harbor seals, with lesser effects on river otters and brown and black bears. Economic losses could be expected for 2 years to the commercial-fishing industry, and a serious loss to the subsistence fishery also would be expected. Effects on species along the tanker transportation route south of the Gulf of Alaska to west coast and California ports are expected to be about the same or less than those described above, because there are few and limited subsistence harvests of any species along this corridor outside of Alaska. The threat of an oil spill to subsistence fisheries, particularly salmon, in the Pacific Northwest and the small subsistence gray whale hunt of the Makah tribe on the Washington Coast along the tankering corridor appears to be limited.

Contribution of Liberty to Cumulative Effects: The Liberty Project represents a small proportion (1.2%) of the total past, present, and reasonably foreseeable oil and gas development in the Beaufort Sea area. While the most likely number of oil spills greater than or equal to 500 barrels from all past, present, and future activities is estimated to be one, the most likely number of spills from Liberty is estimated to be zero. The mean number of estimated spills for the North Slope/Beaufort Sea area statistically is 1.09, of which Liberty is estimated to contribute only 0.07 or about 6%. The assumed spill size for the cumulative case is a range of 125-2,956 barrels. Oil spill and disturbance effects—Liberty's contribution to cumulative effects—periodically could affect subsistence resources, but no harvest areas would become unavailable for use and no resource population would experience an overall decrease. An oil spill affecting any part of the bowhead whale's migration route could taint this culturally important resource. In fact, even if whales are available for the spring and fall seasons, a perception of tainting could make bowheads less desirable and alter or stop the subsistence harvest. Traditional practices for harvesting, sharing, and processing subsistence resources should continue, but oil-spill effects could cause hunters to travel farther than normal to harvest resources.

b. Details of Cumulative Effects on Subsistence-Harvest Patterns

Cumulative effects on subsistence-harvest patterns include effects of Liberty development and other past, present, and reasonably foreseeable projects on the North Slope (see Maps 3a and 3b and Table V.B-1a). Liberty development itself could affect subsistence resources because of potential oil spills, noise and traffic disturbance, or disturbance from construction activities associated with ice roads, pipelines, and landfalls. Noise and traffic disturbance might come from building, installing, and operating production facilities and from supply efforts. See Section III.C.2.h., Effects of an Oil Spill on Subsistence-Harvest Patterns, and Section III.C.3.h, Effects of Disturbance on Subsistence-Harvest Patterns, for a more detailed discussion of effects on subsistence resources and harvest patterns.

To understand effects on subsistence-harvest patterns, we must recognize three major conditions for North Slope communities: (1) they rely heavily on bowhead whales, caribou, and fish in the annual average harvest; (2) subsistence-hunting ranges overlap for many species harvested by both Native communities; and (3) subsistence hunting and fishing are central cultural values in the Inupiat way of life. Chronic cumulative biological effects to subsistence resources would affect their harvests. Potential effects from oil spills and noise disturbance could affect (a) sealing hunting during the winter; (b) whaling, sealing, bird and caribou hunting in spring; and (c) whaling, sealing, bird and caribou hunting during the open-water season.

Access to subsistence-hunting areas and subsistence resources, and the use of subsistence resources could change if oil development reduces the availability of resources or alters their distribution patterns. Cumulative effects to bowhead whales is a serious concern. If increased noise affected whales and caused them to deflect from their normal migration route, they could be displaced from traditional hunting areas, and the traditional bowhead whale harvest could be adversely affected. Ongoing seismic operations are seasonally timed and monitored to prevent conflicts with the migration and the subsistence hunt, and drilling for Northstar development is being monitored to prevent conflicts with whales and whalers. Drilling noise from the Liberty gravel island is not expected to be audible beyond approximately 10 kilometers—about the distance to the barrier islands—and is expected to be further reduced by shallow water depths and deflection off the barrier islands themselves. In addition, projected reasonably foreseeable development projects are all expected to be close to shore and away from traditional bowhead whales harvest areas. Noise effects can be eliminated or substantially reduced by the coordination and location of seismic activities and offshore facility access and helicopter paths to minimize operations in the vicinity of migrating whales. Existing and proposed mitigation and eventual permit conditions for Liberty development and future projects would examine the timing and monitoring of potential noise sources to prevent conflicts to whales and subsistence whalers.

An oil spill, if it occurred and affected any part of the bowhead whale's migration route, could taint this culturally important resource. Any actual or perceived disruption of the bowhead-whale harvest from oil spills and any actual or perceived tainting anywhere during the bowhead's migration, summer feeding, and outmigration could disrupt the bowhead hunt for an entire season even though whales still would be available. Tainting concerns also would apply to polar bears and seals as well as fish and birds. Biological effects to subsistence resources may not affect species' distributions or populations, but disturbance could force hunters to make more frequent and longer trips to harvest enough resources in a given season. For beluga whales, more flexible hunting patterns may reduce the effects of noise and disturbance. Hunters can take belugas in ice leads and open water at different times for a 6-month period, and belugas are not the whale species preferred in these communities. A large oil spill could cause potential short-term but significant adverse effects to long-tailed ducks and common eider populations. Subsistence bird resource could experience short-term, local disturbance, but such disturbance could cause waterfowl to avoid productive subsistence-hunting sites. For the spring subsistence-waterfowl harvest, cumulative loss of habitat from development activities and population losses from oil spills significantly could disrupt harvests. An onshore pipeline spill that contacted rivers and streams could kill many fish and affect these fish populations. A potential loss of polar bears from oil-spill effects could reduce their availability locally to subsistence users, although they are most often hunted by North Slope subsistence hunters except opportunistically while in pursuit of more preferred subsistence resources.

Limited monitoring data prevent effective assessment of subsistence-resource damage; resource displacement; changes in hunters' access to resources; increased competition; contamination levels in subsistence resources; harvest reductions; or increased effort, risk, and cost to hunters. We cannot project effects properly without monitoring harvest patterns and the effectiveness of mitigation measures. Monitoring must include serious attention to traditional Inupiat knowledge of subsistence resources and practices. Development already has caused increased regulation of subsistence hunting, reduced access to hunting and fishing areas, altered habitat, and intensified competition from nonsubsistence hunters for fish and wildlife (Haynes and Pedersen, 1989). These trends show why monitoring of subsistence resources and harvests is vital.

Because oil development and the refounding of Nuiqsut were essentially simultaneous—passage of the Alaska Native Claims Settlement Act precipitated a resurgence of the community and its subsistence culture and, at the same time, allowed the Trans-Alaska Pipeline to be built—it is difficult to disaggregate the cumulative effects of oil development in the region from those of recent processes of profound local social change. Proper assessment of cumulative effects on the North Slope is critical, but separating oil development project effects from those of general social change can be difficult.

c. Native Views Concerning Cumulative Effects on Subsistence-Harvest Patterns

(1) Nuiqsut's Views on Cumulative Effects

Cumulative effects from oil development have been, and continue to be, paramount concerns for North Slope residents. Sam Taalak, Nuiqsut's Mayor in 1982, saw the onslaught of cumulative activity 18 years ago: "We presently live at Nuiqsut and for the moment we're hemmed in from all sides by major oil explorations, even from the coast front" (Taalak, 1983, as cited in USDOI, MMS, 1983a). Leonard Lampe, present Mayor of Nuiqsut, noted that the village has begun to consider the long-term effect of oil development on their subsistence lifestyle and Inupiat culture: "It's time to look at things seriously and ask if it's worth it. That's what the town is asking itself" (Lavrakas, 1996).

Thomas Napageak, Nuiqsut Native Village President and Chairman of the Alaska Eskimo Whaling Commission, recently clarified some of these concerns. In a January 10, 1997, meeting with MMS in Anchorage over a possible Nuiqsut Deferral for Sale 170, Mr. Napageak explained that the people of Nuiqsut have begun to focus on cumulative effects because they are concerned that when the Northstar Project proceeds, it will be out there and affecting the community and its ability to harvest subsistence resources for 15-20 years. Such development directly affects Nuiqsut. Mr. Napageak wanted Sale 170 stipulations to deal with cumulative effects from the sale, and from other projects, and clear language about cumulative effects in the EIS. He wanted to see protective language developed for leases in the Sale 170 area that would extend to, and bind lessees with, leases from past sales (Casey, 1997, pers. commun.).

At a scoping meeting in Nuiqsut for the Northeast National Petroleum Reserve-Alaska Integrated Activity Plan EIS, Mr. Napageak noted again the importance of assessing cumulative effects on subsistence resources and harvests, especially the cumulative and indirect effects of existing and potential oil development on Nuiqsut. He remarked, "federal leasing cannot be examined in isolation as though none of this other development and potential development were going on" (USDOI, BLM, 1997a). At a Bureau of Land Management symposium on the National Petroleum Reserve-Alaska held later the same month, he reaffirmed this concern: "Accumulated impact effects that would hinder the community and the socioeconomics of the community, how it will be affected by Alpine and presumably by NPR-A, these...really need to be considered" (Napageak, as cited in USDOI, MMS, 1997b). At an information update meeting in November 1999 for the Liberty Development Project, Elders Ruth Nukapigak and Marjorie Ahnupkana reaffirmed local concern for ongoing effects from oil development, saying that Eskimo traditions of long ago were going away with the oil companies coming in (Ahnupkana, as cited in USDOI, MMS, 1999).

(2) Kaktovik's Views on Cumulative Effects

Kaktovik resident Michael Jeffrey, testifying for the first MMS lease sale of offshore oil and gas, saw a social impact from government actions. He said there was a cumulative effect on the villagers from having to participate in hearings and meetings. People knew the issues were important, so they had to take time off from working and hunting to attend. Jeffrey believed assessment documents are too technical. To help villagers with them, he suggested extending deadlines in communities that do not speak English, so there would be enough time for agencies to translate documents (Jeffrey, 1979, as cited in USDOI, MMS, 1979b).

(3) Barrow's Views on Cumulative Effects

The North Slope Borough sent written scoping comments and recommendations on the BLM's Northeast National Petroleum Reserve-Alaska Integrated Activity Plan in April 1997. Their comments articulated concerns about potential effects to subsistence hunting and "about the cumulative impacts of all industrial and human activities on the North Slope and its residents. Consideration of these impacts must take into account industrial activities occurring offshore and at existing oil fields to the east; scientific research efforts; sport hunting and recreational uses of lands; and the enforcement of regulations governing the harvest of fish and wildlife resources by local residents. To date, no agency has addressed the concerns of Borough residents over how cumulative impacts might affect life on the North Slope" (North Slope Borough, 1997b). Barrow Mayor Ben Nageak, spoke at public hearings for the National Petroleum Reserve-Alaska Integrated Activity Plan EIS in Barrow in January 1997. He said one of the key issues in developing the Reserve was to identify "a mechanism for recognizing and mitigating the potential cumulative impacts of multiple industrial operations" (Nageak, as cited in USDOI, BLM, 1997c). At a Liberty Development Project information update meeting in November 1999, Ron Brower, head of the Inupiat Heritage Center in Barrow, asked about future leasing and development plans and noted that MMS seemed to be doing projects piece by piece when instead it should be studying cumulative impacts. He believed new data and new development projections were needed and wanted to see a "new blueprint [for development] from aerial flights to underwater impacts" (Brower, as cited in USDOI, MMS, 1998). At the same meeting, Maggie Ahmaogak, Executive

Director of the Alaska Eskimo Whaling Commission, asked that MMS take into account cumulative risks.

(4) Chukchi Sea Communities' Views on Cumulative Effects

Native bowhead and beluga whale hunters in communities in the Chukchi Sea region maintain that they, too, will be affected if important marine mammals are harmed. Just as in the Beaufort Sea communities of Barrow, Nuiqsut, and Kaktovik, the potential tainting of bowhead and beluga whales and seals, in any portion of their respective ranges and habitats, could taint these culturally important resources. Even if these species were available for the spring and fall seasons, traditional cultural concerns of tainting could make them less desirable and alter or stop subsistence harvests.

Following is a summary of effects of oil spills, disturbance, and habitat loss on subsistence resources. For a more detailed description of these effects, see the previous description for each species (Secs. V.C.1-7).

d. Effects of Oil Spills and Disturbance on Subsistence Resources

(1) Bowhead Whales

Bowhead whales may temporarily move to avoid noise-producing activities and may experience temporary, nonlethal effects, if oil spills occur during activities associated with Liberty or other past, present, or reasonably foreseeable future development projects in the arctic region. A few bowhead whales could die from prolonged exposure to freshly spilled oil (Sec V.C.1.a).

(2) Seals and Polar Bears

The overall effects (mainly from oil spills assumed for this analysis and assuming high losses of perhaps up to 78 bears and a few thousand seals) should last no more than one generation (about 5-6 years) for ringed and bearded seals and perhaps 7-10 years for polar bears. The more likely loss would be 1 or 2 bears, and fewer than 100 seals. The more than 40 exploration-drilling units that have operated in the Beaufort Sea in the past 20 years have displaced a few polar bears but have had no effect on the polar bear population (Sec V.C.2).

(3) Birds

Although the potential effects of spills are very uncertain, a large offshore oil spill could result in losses exceeding 10,000 individuals, primarily to waterfowl and shorebirds staging offshore in lagoons or along beaches, if it occurs during the breeding season. Overall cumulative effects of oil industry activities on marine and coastal birds potentially could be substantial, primarily as a result of mortality from oil spills. Disturbance may cause loss of productivity and lowered survival of birds occupying areas with high industry-activity levels (Sec V.C.3).

(4) Caribou and Other Terrestrial Mammals

Oil spilled during the open-water season or during the winter and that melted out of the ice in the spring, could affect coastal habitats from about Harrison Bay east to about Flaxman Island. Thus, some caribou of the Central Arctic and Teshekpuk Lake herds could be directly contacted and harmed by spills along the beaches and in shallow waters while they are escaping from insects. However, even in a severe situation, only a few to less than a hundred caribou are likely to contact the spilled oil and die from inhaling and absorbing toxic hydrocarbons. Either of the caribou herds would replace these losses within 1 year. Development in the Prudhoe Bay area is likely to continue to displace some caribou during the calving season within about 4 kilometers (2.48 miles) of roads with vehicle traffic, and a general shift of calving away from the extensive oil fields may persist. Cows and calves of the Central Arctic Herd may, over time, reduce calving and the use of summer habitats near roads with high levels of traffic. If they do, these activities potentially could affect the caribou's productivity and abundance over the long term. However, this potential effect may not be measurable, because the caribou's productivity greatly varies under normal conditions. Cumulative oil development is likely to have only local effects on the distribution and abundance of muskoxen, arctic foxes, and grizzly bears in the Prudhoe Bay area (Sec V.C.4).

(5) Fishes

Small numbers of fish in the immediate area of an offshore or onshore oil spill could be killed or harmed, but oil spills would not be expected to have a measurable cumulative effect on fish populations. Noise effects on fishes could include local avoidance of seismic surveys, aircraft and vessel traffic, drilling and construction, and production operations. Some overwintering fishes may not be able to avoid noise and disturbances; however, there is no scientific evidence currently available to show that industrial noise and disturbance are likely to harm fishes. Pipeline installation could cause local and temporary effects (Sec V.C.6).

(6) Cumulative Effects on Habitat

Development has directly covered about 7,000 acres through the construction of 350 miles of roads, 85 pads, 4 airstrips, and 14 gravel mines (Table V.B-3). The mines alone cover more than 1,500 acres. Development in the Prudhoe Bay and Kuparuk areas has directly affected about 9,000 acres because of gravel excavation and filling, and indirectly affects many adjacent acres of vegetation. The total affected acreage is a small part of the Arctic Coastal Plain, and cumulative effects probably are not significant to the overall productivity of tundra plants in this area. It is important to remember that ongoing oil-development projects, such as Alpine, Badami, Northstar, and Liberty, require a much smaller acreage footprint than existing and past projects on the North Slope.

Alterations from offshore production platform-island construction, trench-dredging, and pipeline burial are expected to affect some benthic organisms and some fish species within 1 kilometer for less than 1 year or season. These activities also temporarily may affect the availability of some local food sources for these species up to 1-3 kilometers (0.62-1.9 miles) distance during island construction, but these activities are not expected to affect food availability for seals over the long term. The effect of onshore facilities siting—dust fallout, thermokarst, and hydrologic change—for future projects on bird populations, though additive, would be significantly less severe, because they would be restricted to much smaller areas and result in smaller habitat loss. Pads, gravel quarries, pipelines, pump stations, and gravel roads that cross much of the Central Arctic Herd's calving range actually have destroyed only about 3-4% of the tundra grazing habitat for caribou.

If roads on the North Slope are opened to the public, there would be an increase in access to caribou herds, muskoxen, grizzly bears, and other terrestrial mammals, potentially leading to more hunting and disturbance. Increased access increases competition for resources—a potential negative impact on subsistence hunters. Furthermore, more roads usually means reduced access (or increased effort) for subsistence hunters. New road are obstacles to traveling to traditional hunting areas because of security protocols imposed on access roads to and in development areas. Roads and pipelines force hunters to travel farther to hunt or force them to hunt in nontraditional areas.

e. Transportation Effects on Subsistence-Harvest Patterns

(1) Small Onshore Spills from the Trans-Alaska Pipeline System

Considering the small additive effects of onshore oil spills from the Trans-Alaska Pipeline System on individual subsistence resources, measurable cumulative effects on subsistence harvests are not expected.

Small onshore spills, whether originating from field pipelines or from the Trans-Alaska Pipeline System would have a very small additive effect on terrestrial mammal habitats near pipelines, roads, and other facilities. Small spills are expected to be cleaned up before substantial losses occur and cleanup at the spill site would frighten caribou and other terrestrial mammals away from the spill and prevent contact with the oil. Small spills are not expected to significantly affect bird species occurring in the Beaufort Sea region. In winter, onshore pipeline spills on the North Slope and along the Trans-Alaska Pipeline System would not be expected to affect fish, because their likelihood of contacting fish habitat is very low. In summer, fish and food resources in a small waterbody with restricted water exchange likely would be harmed or killed from a small spill of sufficient size. Recovery would be expected in 5-7 years. Small numbers of fish in the immediate area of an onshore oil spill may be killed or harmed, but small oil spills would not be expected to have measurable cumulative effects on fish populations. The additive effect of small onshore spills would cause minor ecological harm to wetlands and vegetation that should recover within a few years but could take more than 20 years. Most onshore spills occur on gravel pads, and their effects do not reach surrounding vegetation. About 20-35% of past crude-oil spills has reached areas beyond pads. Because winter spans most of the year, about 60% of the time spills occur when workers can clean up oil on the snow cover before it reaches the vegetation.

(2) Large Tanker Spill in the Gulf of Alaska

Using experience from the *Exxon Valdez* spill as a gauge, a 200,000-barrel oil spill substantially could reduce or alter subsistence harvests for the residents of Cordova and Yakutat. In Cordova, especially for intertidal resources and some fish species, effects could be experienced for at least 4 years. Lesser effects of shorter duration could be expected for Yakutat. The instantaneous nature of the event would not permit opportunistic "stocking up" of available resources.

(3) Potential Effects of Transporting Arctic Oil from the Trans-Alaska Pipeline System

Oil produced by the Liberty Project is expected to contribute only a small fraction, 0.13 spills or about 1%, of the total estimated cumulative oil spills from Trans-Alaska Pipeline System tankers (Table A-1). In Alaskan waters, the probable oil-tanker route lies seaward of the 200-mile Economic Exclusion Zone boundary except in the northcentral Gulf of Alaska, where the transportation route leaves Prince William Sound. Oil spilled along most of this route would tend to move parallel to the Alaska Peninsula and the Aleutian Islands, rather than towards the coast, where vulnerable resource populations could be contacted. Oil spilled from a tanker after exiting Prince William Sound could contact the Kodiak and Alaska Peninsula areas.

Based on the assumptions discussed in Section IX.B for a large oil spill, future tanker spills of arctic oil, which may include Liberty oil, could cause serious and long-term cumulative effects on some subsistence resources in Prince William Sound and the Gulf of Alaska, especially marine and coastal birds, sea otters, and harbor seals, with lesser effects on river otters and brown and black bears. An economic loss for 2 years following the spill to the commercial-fishing industry in this area would range from

37-64% per year, and would also represent a serious loss to the subsistence fishery. (See Secs.V.C.1, Threatened and Endangered Species; V.C.2, Seals and Polar Bears; V.C.3, Marine and Coastal Birds; V.C.4, Terrestrial Mammals; and V.C.6, Fishes.)

A realistic projection of the occurrence of a tanker spill calculated from tanker spill records indicates most spills (6 of 9) are expected to average 13,000 barrels or less. We estimate six spills with an average size of 3,000 barrels, four of which occur in port and two at sea. We assume two spills with an average size of 13,000 barrels, both which occur at sea, and one spill at sea in the Gulf of Alaska at 200,000 barrels (see Appendix A and Section IX).Four of these spills would occur in ports where cleanup and containment contingencies are in place, contributing to relatively quick containment and cleanup of these in-port spills. Spills of this size at sea have not been found to cause serious effects on bird, fish, and sea mammal populations when the effects have been studied. Additionally, at-sea spills of these average sizes are not expected to reach large areas of habitat critical to these species' survival until after the oil has been rendered less harmful by weathering and dispersion in the water. Recovery periods would be lengthened if more than one spill affected the same population within a short interval—a situation that is unlikely. Therefore, effects on species along the tanker transportation route south of the Gulf of Alaska to west coast and California ports are expected to be about the same or less than those described above and in Section IX.B, keeping in mind that there are few and limited subsistence harvests of any species along this corridor outside of Alaska. The potential for an oil spill to affect subsistence fisheries, particularly salmon, in the Pacific Northwest (see Sec. V.C.1, Threatened and Endangered Species) and the small subsistence gray whale hunt of the Makah tribe on the Washington coast along the tankering corridor, appears to be limited.

Simulated oil-spill trajectories were calculated by LaBelle and Marshall (1995) for tanker routes off the U.S. west coast. Oil-spill trajectories were mapped as "risk contours" (or oil-spill travel time at sea), showing the chance of contact to environmental resource areas, assuming an oil spill occurred (conditional probabilities). Off the California coast, an oil spill at 100 nautical miles offshore would have a 5% chance of contacting the shoreline within 30 days, while an oil spill at 80 nautical miles offshore would have a 10% chance of contacting the shoreline within 30 days. The contour lines are farther offshore off Washington and Oregon.

9. Sociocultural Systems

a. Summary and Conclusion for Beaufort Sea, North Slope, and Transportation Activities on Sociocultural Systems

In this cumulative analysis, effects on social systems (family, polity, economics, education, and religion) could result from industrial activities, changes in population and employment, and changes in subsistence-harvest patterns. These effects would be similar to those described for the Proposal, but the level of effects would increase because activities, collectively, would be more intense. More air traffic and non-Natives in the North Slope region could increase the interaction and, perhaps, conflicts with Native residents. In the past, non-Native workers have stayed in enclaves, which kept interactions down. However, recent activity in the Alpine field has brought non-Natives directly into the Native village of Nuiqsut, and this has added stresses in the community. Already, these workers have made demands on the village for more electrical power and health care.

Increases in population growth and employment could cause long-term disruptions to (1) the kinship networks that organize the Inupiat communities' subsistence production and consumption, (2) extended families, and (3) informally derived systems of respect and authority (mainly respect of elders and other leaders in the community). Cumulative effects on social organization could include decreasing importance of the family, cooperation, sharing, and subsistence as a livelihood, and increasing individualism, wage labor, and entrepreneurship. Long-term effects on subsistence-harvest patterns also could be expected. Chronic disruption could affect subsistence-task groups and displace sharing networks, but it would not displace subsistence as a cultural value. At the same time, revenues from North Slope Borough taxation on oil development produce positive cumulative impacts that include increased funding for infrastructure, higher incomes (that can be used to purchase better tools for subsistence), better health care, and improved educational facilities. We may see increases in social problems, such as rising rates of alcoholism and drug abuse, domestic violence, wife and child abuse, rape, homicide, and suicide. The North Slope Borough already is experiencing problems in the social health and well-being of its communities, and additional development, including offshore oil development on the North Slope, would further disrupt them. Health and social-services programs have tried to respond to alcohol and drug problems with treatment programs and shelters for wives and families of abusive spouses, as well as providing greater emphasis on recreational programs and services. These programs, however, sometimes do not have enough money, and North Slope Borough city governments cannot help as much now that they get less money from the State. Based on experiences after the *Exxon Valdez* spill, Native residents employed in cleanup work could stop participating in subsistence activities, have a lot of money to spend, and tend not to continue working in other lower paying community jobs. Because Nuiqsut is so close to most oil development on the North Slope, cumulative effects could chronically disrupt sociocultural systems in the community—a significant effect; however, overall effects from these sources are not expected to displace ongoing sociocultural systems, community activities, and traditional practices for harvesting, sharing, and processing subsistence resources.

Future transportation of North Slope oil through Prince William Sound could produce cumulative effects on sociocultural systems from the effects of a large spill assumed, for purposes of analysis, to be 200,000 barrels. As a result, the communities of Yakutat and Cordova likely would undergo severe individual, social, and institutional stress and disruption that would last for at least 4 years. Sociocultural effects south of the Gulf of Alaska to U.S. west coast and California ports are expected to be reduced from those described above, primarily because Native subsistence cultures south of Alaska historically have been marginalized by the dominant culture, and there are few Native communities that continue to practice a subsistence way of life. Effects to recreation and tourism would be major economic losses for the tourist industry, with small charter boat, lodge, and sportfishing operations in the Yakutat area being the hardest hit. Tourist levels would be expected to rebound to prespill levels 1 year after the spill. Recreation and tourism effects south of the Gulf of Alaska to west coast and California ports would affect the same tourist industries and resources; however, in coastal areas to the south, marine sanctuaries, shoreside beaches, parks, campgrounds, and recreation areas are more numerous and see more overall visitation. For this reason, economic losses from tourism losses could be greater.

Contribution of Liberty to Cumulative Effects: The Liberty Project's contribution to cumulative effects on the sociocultural systems of the communities of Nuiqsut and Kaktovik could come from disturbance from oil-spill-cleanup activities; small changes in population and employment; and periodic interference with subsistence-harvest patterns from oil spills and oil-spill cleanup. Effects from these sources would not displace ongoing sociocultural systems, community activities, and traditional practices for harvesting, sharing, and processing subsistence resources.

Environmental Justice: Alaska Inupiat Natives, a recognized minority population, are the predominant residents of the North Slope Borough, the area potentially most affected by oil development activity. Inupiat Natives may be disproportionately affected because of their reliance on subsistence foods, and cumulative effects may affect subsistence resources and harvest practices. Effects would focus on the Inupiat community of Nuiqsut, and possibly of Kaktovik, within the North Slope Borough. The sociocultural and subsistence activities of these Native communities could be affected by routine development and accidental oil spills. Possible oil-spill contamination of subsistence foods is the main concern regarding potential effects on Native health (see Sec. III.C.3.i., Effects of Disturbance on Sociocultural Systems, for a more detailed discussion on Environmental Justice).

The Liberty Project's contribution to cumulative effects on the sociocultural systems of the communities of Nuiqsut and Kaktovik could come from disturbance from oil-spill-cleanup activities; small changes in population and employment; and periodic interference with subsistence-harvest patterns from oil spills and oil-spill cleanup. Effects from these sources would not displace ongoing sociocultural systems, community activities, and traditional practices for harvesting, sharing, and processing subsistence resources.

b. Details of Cumulative Effects on Sociocultural Systems

Cumulative effects on sociocultural systems include effects of Liberty development and other past, present, and reasonably foreseeable projects on the North Slope (Table V.B-1a). Cumulative effects on sociocultural systems would come from changes to subsistence-harvest patterns, social organization and values, and other issues, such as stress on social systems (see Impact Assessment Inc., 1990a,b,c; Human Relations Files, 1995; State of Alaska, Department of Fish and Game, 1995b; Impact Assessment, Inc., 1998).

(1) Social Organization

In this cumulative analysis, effects on social systems could result from industrial activities, changes in population and employment, and changes in subsistence-harvest patterns. These effects would be similar to those described for the Proposal, but the level of effects would increase because activities, collectively, would be more intense. More air traffic and non-Natives in the North Slope region could increase the interaction and, perhaps, conflicts with Native residents. In the past, non-Native workers have stayed in enclaves, which kept interactions down. However, recent activity in the Alpine field has brought non-Natives directly into the Native village of Nuiqsut, and this has added stresses in the community. Already, these workers have made demands on the village for more electrical power and health care.

Increases in population growth and employment could cause long-term disruptions to (1) the kinship networks that organize the Inupiat communities' subsistence production and consumption, (2) extended families, and (3) informally derived systems of respect and authority (mainly respect of elders and other leaders in the community). Offsetting such effects are strong efforts by the North Slope Borough, the Alaska Eskimo Whaling Commission, regional and tribal governments, local governments, and village corporations to institutionally foster and protect Inupiat cultural traditions. Cumulative effects on subsistence-harvest patterns (which also would be long term) would affect Inupiat social organization through disruptions to kinship ties, sharing networks, task groups, crew structures, and other social bonds. Effects on sharing networks and subsistence-task groups could break down family ties and the communities' well-being, creating tensions and anxieties that could lead to high levels of social discord. The North Slope Borough, the Alaska Eskimo Whaling Commission, and local whalers have set precedents for negotiating agreements with the oil industry to protect subsistence-whaling practices. Such cooperation is expected to continue. Negotiated agreements exist for development effects onshore at the Alpine Unit north of Nuiqsut. The Bureau of Land Management has convened a Subsistence Advisory Panel for the Northeast National Petroleum Reserve-Alaska Integrated Activity Plan/EIS planning. It consists of Federal and State representatives, plus people from the North Slope Borough and local communities. This group is tasked with investigating conflicts between subsistence activities and oil exploration and development, verifying the levels of conflict, and proposing resolutions to the lessee and the Bureau of Land Management. It is too soon to know how effective this panel will be in resolving such conflicts.

(2) Cultural Values

Cumulative effects on cultural values also could result from industrial activities, changes in population and employment, and changes in subsistence-harvest patterns. These effects would be similar to those described for the Proposal but at higher levels. Cumulative effects on social organization could include decreasing importance of the family, cooperation, sharing, and subsistence as a livelihood, and increasing individualism, wage labor, and entrepreneurship. Long-term effects on subsistence-harvest patterns also would be expected. Chronic disruption could affect subsistence task groups and displace sharing networks, but it would not displace subsistence as a cultural value. Sociocultural cumulative effects of changing norms and values would be expected to affect all five social institutions (family, polity, economics, religion, and education), but the North Slope Borough's institutional infrastructure, the Alaska Eskimo Whaling Commission, community whaling organizations, regional and tribal governments, and regional and village corporations work diligently to develop programs to protect these cultural values (Impact Assessment Inc., 1990a,b,c; Human Relations Files, 1995; State of Alaska, Department of Fish and Game, 1995b; Impact Assessment, Inc., 1998).

(3) Other Issues

For this cumulative analysis, we may see increases in social problems, such as rising rates of alcoholism and drug abuse, domestic violence, wife and child abuse, rape, homicide, and suicide. The North Slope Borough already is experiencing problems in the social health and well-being of its communities, and additional development (including offshore oil development) on the North Slope would disrupt them further. Historically, more income in these communities has connected somewhat to the abuse of alcohol and increased violence. Sources show increases in dysfunctional behavior during the peak of the commercial whaling era and then again during the height of the fur trade. Drinking and violence seemed to ebb when increases declined. Recent evidence of the effects of employment during and just after World War II loosely support these views. Although this evidence is not clear, it can still be assumed that onshore oil development has resulted in large cash flows that lead to significant social changes. These social changes on the North Slope are likely to have influenced the extremely high rate of suicide among the Inupiat (90.8 per 100,000 for the Inupiat versus 35 per 100,000 among the Yup'ik [Travis, 1989]).

The relationship of oil and gas development to aberrant behavior and social pathologies might be seen more clearly in terms of social change and associations rather than direct causality. Oil and gas development has affected all communities in Alaska and, for this reason, finding control communities is difficult; yet these impacts to communities are important to understand, and more cumulative-effects studies need to be conducted. In a general sense, the cumulation of effect occurs as modernization occurs. As change happens, these alterations spread through the social fabric. Such change can be both negative and positive and can be measured to an extent with objective indicators of the opportunity structure or the stratification system such as education, income, occupation, social networks, and social mobility (created through income, education, etc.) (Cluck, 2000, pers. commun.).

Within this change produced by the trends of modernization, the "rational choice" of individuals being affected by this change must be considered. Individuals make decisions, sometimes negative, sometimes positive, and stress or fear of change can reinforce a situation of internal conflict that can lead to negative social pathological effects. At the same time, positive impacts may come from higher incomes (that can purchase better tools for subsistence), better health care, and improved educational facilities. Yet what may be seen on the surface as having positive impacts may, at the same time, produce negative effects by producing apathy or disinterest to older cultural norms known as anomie. For example, an increased used of the Internet versus a reduction in listening to elders. Certain negative effects from social change are inescapable. As technology and opportunity develop, younger individuals readily accept these changes. This is easily seen in less developed countries where rapid change is evident or in the desertion of rural America by young people (Cluck, 2000, pers. commun.).

Both positive and negative impacts from oil and gas development exist in the North Slope Borough. Whether

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they are the more positive ones of increased funding for infrastructure or education or more negative ones associated with a lack of interest by younger people in traditional ways, both have added to social change. Oil and gas development has been one catalyst for such cumulative change on the North Slope, and it needs further study, but it is not a single causal agent (Cluck, 2000, pers. commun.).

In the cumulative case, long-term effects could displace social systems; however, the North Slope Borough is vigilantly protecting the rights and culture of the Inupiat. Health and social-services programs have tried to respond to alcohol and drug problems with treatment programs and shelters for wives and families of abusive spouses, as well as providing greater emphasis on recreational programs and services. These programs, however, sometimes do not have enough money, and North Slope Borough city governments cannot help as much now that they get less money from the State. Partnering together, tribal, city, and the Borough governments may be able to provide programs, services, and benefits to residents. All communities in the North Slope Borough have banned the sale of alcohol for many years, but the possession of alcohol is not banned in Barrow, and many communities are continually under pressure to bring the issue up for a local referendum vote (North Slope Borough, 1998).

(4) Effects of Oil-Spill Cleanup on Social Systems

If an oil spill occurred, cleanup activities for the one estimated offshore spill greater than or equal to 500 barrels occurring over the life of the field (with a spill size of 125-2,956 barrels) and elsewhere could generate many cleanup and response jobs. Based on the *Exxon Valdez* spill, Native residents employed in cleanup work could stop participating in subsistence activities, have a lot of money to spend, and tend not to continue working in other lower paying community jobs. In the event of a much larger spill event, these dramatic changes could cause tremendous social upheaval (Human Relations Files, 1995; State of Alaska, Department of Fish and Game, 1995b; Impact Assessment, Inc., 1990c; Impact Assessment, Inc., 1998). Many North Slope village men have been trained in cleanup procedures and have said they want to be part of any cleanup response (Lampe, 1999). The North Slope Borough would play a large part in structuring any spill response and cleanup (North Slope Subarea Contingency Plan, Environmental Protection Agency, U.S. Coast Guard, and State of Alaska, Dept. of Environmental Conservation, 1999).

c. Transportation Effects on Sociocultural Systems

(1) Large Tanker Spill in the Gulf of Alaska

Sociocultural systems in the community of Cordova could undergo severe individual, social, and institutional stress and disruption from a 200,000-barrel spill, which would last at least 4 years. Lesser effects of shorter duration could be expected for Yakutat. Individuals and the community of Cordova that depend on income from commercial fisheries could experience stress and anxiety from debt burden, income shortfalls, litigation, and fear for the future, should the fisheries they participate in or depend on in other capacities be shortened or terminated because of the accidental spill. Considerable stress and anxiety also would be expected over the loss of subsistence resources, contamination of habitat, fear of the health effects of eating contaminated wild foods, and the need to depend on the knowledge of others about environmental contamination (Fall, 1992; McMullen, 1993). Individuals and the community of Cordova would be increasingly stressed during the time needed to modify subsistence-harvest patterns by selectively changing harvest areas, if such areas were even available. Associated culturally significant activities, such as the organization of subsistence activities among kinship and friendship groups and the relationships among those that customarily process and share subsistence harvests, also would be modified or would decline.

A 200,000-barrel-spill also would be expected to affect individuals and social systems in ways similar to the experience from the *Exxon Valdez* spill. As shown by that spill, some individuals found a new arena for pre-existing personal and political conflict, especially over the dispensation of money and contracts. In the smaller communities, cleanup work produced a redistribution of resources, creating new schisms in the community (Richards, No date). Many members of small communities were on the road to sobriety before the spill; after the spill, some people began drinking again, producing the re-emergence of numerous alcohol-related problems, such as child abuse, domestic violence, and accidents, that were there before (Richards, No date). Institutional effects included additional burdens being placed on local government, disruption of existing community plans and programs, strain on local officials, difficulties dealing with the spiller, community conflict, disruptions of customary habits and patterns of behavior, emotional effects and stress-related disorders, confronting environmental degradation and death, and the violation of community values (Endter-Wada, 1992). Postspill stress resulted from this seeming loss of control over individual and institutional environments as well as from secondary episodes such as litigation, which produced secrecy over information, uncertainty over outcomes, and community segmentation (Smythe, 1990; Picou and Gill, 1993). Attempts to mitigate effects met with a higher priority placed on concerns over litigation and a reluctance to intervene with people for fear it might benefit adversaries in legal battles (Richards, No date; Human Relations Files, 1995; State of Alaska, Department of Fish and Game, 1995b; Impact Assessment, Inc., 1990c; Impact Assessment, Inc., 1998).

(2) Potential Effects of Transporting Arctic Oil from the Trans-Alaska Pipeline System

Oil produced by the Liberty Project is expected to contribute only a small fraction, 0.13 spills or about 1%, of the total estimated cumulative oil spills from Trans-Alaska Pipeline System tankers (Table A-35). In Alaskan waters, the probable oil-tanker route lies seaward of the 200-mile Economic Exclusion Zone boundary except in the northcentral Gulf of Alaska, where the transportation route leaves Prince William Sound. Oil spilled along most of this route would tend to move parallel to the Alaska Peninsula and the Aleutian Islands rather than towards the coast, where vulnerable resource populations could be contacted. Oil spilled from a tanker after exiting Prince William Sound could contact the Kodiak and Alaska Peninsula areas.

Based on the assumptions discussed in Section IX.B for a large oil spill, future tanker spills of arctic oil, which may include Liberty oil, could cause serious and long-term cumulative effects on some subsistence resources in Prince William Sound and the Gulf of Alaska, an economic loss for 2 years following the spill to the commercial-fishing industry that would range from 37-64% per year that would also represent a serious loss to the subsistence fishery (see Sec. V.C.8, Subsistence-Harvest Patterns).

A realistic projection of the occurrence of a tanker spill calculated from tanker spill records indicates most spills (6 of 9) are expected to average 13,000 barrels or less. We estimate six spills with an average size of 3,000 barrels, four of which occur in port and two at sea. We assume two spills with an average size of 13,000 barrels, both which occur at sea, and one spill at sea in the Gulf of Alaska at 200,000 barrels (see Appendix A and Section IX). Four of these spills would occur in ports where cleanup and containment contingencies are in place, contributing to relatively quick containment and cleanup of these in-port spills For this reason, effects on sociocultural systems along the tanker transportation route south of the Gulf of Alaska to west coast and California ports are expected to be reduced from those described above and in Section IX.B, primarily because Native subsistence cultures south of Alaska have historically been marginalized by the dominant culture, and there are few Native communities that continue to practice a subsistence way of life. Other potential sociocultural effects not related to Native subsistence cultures are described in the following text.

(3) Potential Effects On Recreation and Tourism Along the Transportation Route

A 200,000-barrel oil spill would preclude recreation and tourism activities in the coastal areas of the Wrangell-Saint Elias National Park and Preserve, the northern portion of the Tongass National Forest, and portions of Prince William Sound until spill-cleanup operations and natural processes restored the sites. Major economic losses could be expected for the tourist industry in the affected areas following a spill, with small charter boat, lodge, and sportfishing operations in the Yakutat and Cordova being the hardest hit. Tourist levels would be expected to rebound to prespill levels 1 year after the spill.

In the unlikely event of a large spill, effects on recreation and tourism along the tanker transportation route south of the Gulf of Alaska to west coast and California ports could affect the same tourist industries and resources identified above. In coastal areas to the south, marine sanctuaries, shoreside beaches, parks, campgrounds, and recreation areas are more numerous and see more overall visitation. For this reason, economic losses to tourism could be greater. Public perceptions about the desirability of an area could change drastically after a spill event, and visitation could take longer to rebound. A recent agreement between The United Nation's International Maritime Organization and the U.S. Department of Commerce has set the shipping lanes for tankers 25 to 30 miles offshore of the Monterey Bay, Gulf of the Farallones, and Channel Islands national marine sanctuaries, affording these areas greater protection from vessel collisions, groundings, and spills. (CNN.com, 2000).

For tanker routes off the west coast, simulated oil-spill trajectories were calculated by LaBelle and Marshall in 1995. Oil-spill trajectories were mapped as “risk contours” showing the chance of contact to environmental resource areas over time (3-, 10-, and 30-day travel times at sea) assuming an oil spill occurred (conditional probabilities). An oil spill at 100 nautical miles off the California coast would have a 5% chance of contacting the shoreline within 30 days, while an oil spill at 80 nautical miles offshore would have a 10% chance of contacting the shoreline within 30 days. For Washington and Oregon, the contour lines are farther offshore, and it is important to remember that tankers carrying oil from Alaska are from 100-200 miles offshore except when entering a port.

10. Archaeological Resources

a. Summary and Conclusions for Beaufort Sea, North Slope, and Transportation Activities on Archaeological Resources

Archaeological surveys are conducted for individual project clearances. Before a survey is conducted, it is not known what sites would be affected if there is an overlap of activity (Badami, Northstar, etc.).

In addition to the Liberty Project, other activities associated with this cumulative analysis that may affect archaeological resources in the Beaufort Sea include the State’s oil and gas lease sales, State oil and gas fields, oil and gas transportation, noncrude carriers, and any Federal activities. Cumulatively, these proposed projects likely would disturb the seafloor more often, but remote-sensing surveys done before approval of any Federal or State lease actions should keep these effects low. Federal laws would preclude effects to most archaeological resources from these planned activities.

Contribution of Liberty to Cumulative Effects: Liberty's contribution to the cumulative case is expected to be minimal for archaeological resources, because any surface-disturbing activities that could damage archaeological sites would be mitigated by current State and Federal procedures, which require identification and mitigation of archaeological resources in the proposed project areas.

Overall effects of Liberty would be additive to effects anticipated for other future projects and, in the case of oil spills, is uncertain. However, data from the *Exxon Valdez* oil spill indicate that less than 3% of the resources within a spill area would be significantly affected.

b. Details of Cumulative Effects on Archaeological Resources

As shown in Section III.C.1.j, accidental oil spills would most greatly affect onshore archaeological sites, but past cleanups have shown us that spilled oil had little direct effect on archaeological resources (Bittner, 1993). Following the *Exxon Valdez* spill, the greatest effects came from vandalism, because more people knew about the locations of the resources and were present at the sites. Various mitigating measures used to protect archaeological sites while cleaning up oil spills are avoidance (preferred), site consultation and inspection, onsite monitoring, site mapping, scientific collection of artifacts, and programs to make people aware of cultural resources (Haggarty et al., 1991).

The greatest cumulative effect on archaeological resources in the project area is from natural processes such as ice gouging, bottom scour, and thermokarst erosion. Because the destructive effects of natural processes are cumulative, they have affected and will continue to affect archaeological resources in this area.

c. Transportation Effects on Archaeological Resources

The expected effect on onshore archaeological resources from potential future oil-spill effects from tanker transportation of arctic oil (including Liberty oil) is uncertain; however, data from the *Exxon Valdez* oil spill indicate that less than 3% of the resources within a spill area would be significantly affected (Dekin, 1993).

A potential tanker spill would affect archaeological resources by creating surface-disturbing activities resulting from emergency shoreline treatment. Following the *Exxon Valdez* oil spill, Exxon developed and funded a Cultural Resource Program to ensure that potential effects on archaeological sites were minimized during shoreline treatment (Betts et al., 1991). This program involved a team of archaeologists who performed reconnaissance surveys of the affected beach segments, reviewed proposed oil-spill treatment, and monitored treatment. As a result of the coastline surveys, hundreds of archaeological sites were discovered, recorded, and verified. This resulted in the most comprehensive archaeological record of Alaskan coastline ever documented.

Although a number of sites in the *Exxon Valdez* spill area were vandalized during the 1989 cleanup season, the large number of Exxon and government agency archaeologists visible in the field may have lessened the amount of site vandalism that may have occurred (Mobley et al., 1990).

The Dekin study (1993) found that small amounts of petroleum hydrocarbons may occur in most archaeological sites within the study area. This suggests a low-level petroleum contamination that previously had not been suspected. Because the researchers found no evidence of extensive soil contamination from a single definable source (the oil spilled from the *Exxon Valdez*), they "…now add the continuing contamination of soils from small and large petroleum spills in areas where present and past land use coincide" (Dekin, 1993). Vandalism was found to have a significant effect on archaeological site integrity but could not be tied directly to the oil spill (Dekin, 1993).

11. Economy

a. Summary and Conclusions for Beaufort Sea, North Slope, and Transportation Activities on Federal, State, and Borough Economies

We assess cumulative effects on the economy in terms of (1) current conditions, described in SectionVI.B.4; (2) economic effects from the Liberty Project, described in Section III.D.5; and (3) activities considered in cumulative effects analysis, described in Section V.B.

This cumulative case is projected to generate additive employment increases as follows:

- 2,400 direct oil industry jobs at peak, declining to 1,300
- 3,400 indirect jobs in Southcentral Alaska and Fairbanks at peak, declining to 2,000
- 150 indirect jobs for North Slope Borough residents at peak, declining to 50
- 5 to 125 jobs for 6 months for cleanup of an oil spill in the Beaufort Sea
- 10,000 jobs and 25% price inflation for 6 months for cleanup of a tanker oil spill in the Gulf of Alaska

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This cumulative case will generate the following additive annual revenues:

- $125 million Federal
- $77 million State
- $28 million State and North Slope Borough

The net present value of receipts to both Federal and State governments is $1.1 billion.

Contribution of Liberty to Cumulative Effects: Additive contributions of Liberty to the cumulative effect in summary are:

- $100 million in wages and 870 full-time equivalent construction jobs for 1 year in Alaska during 14-18 months of construction
- $4.2 million in wages and 50 jobs annually for operations for 16 years in Alaska
- 1,248 indirect full-time equivalent jobs during the 14-18 months of construction
- 78 indirect full-time equivalent jobs each year for 16 years of operations
- 5 to 125 jobs for 6 months for cleanup of an oil spill in the Beaufort Sea
- 10,000 jobs for 6 months for a cleanup of a tanker spill in the Gulf of Alaska
- $19 million Federal revenue annually for 16 years
- $4 million State revenue annually for 16 years
- $0.3 million revenue to the North Slope Borough annually for 16 years
- $114 net present value to the government, both Federal and State

For a more complete analysis see Section III.D.5. Disruptions to harvesting of subsistence resources could affect the economic well-being of North Slope Borough residents mainly through the direct loss of some part of these resources. See Section V.C.8 for effects on subsistence-harvest patterns.

The contributions of Liberty as a percent of cumulative effects, where figures are comparable, are:

- 36% of direct oil industry jobs at peak
- 4% of direct oil industry jobs off peak during operations
- 37% of indirect jobs in Southcentral Alaska and Fairbanks at peak
- 4% of indirect jobs in Southcentral Alaska and Fairbanks off peak during operations
- 1% of jobs for 6 months for cleanup of an oil spill in the Beaufort Sea
- 1% of jobs for 6 months for cleanup of a tanker oil spill in the Gulf of Alaska
- 15% of Federal revenue
- 5% of State revenue
- 15% of State and North Slope Borough Revenue
- 10% of net present value to the government, both Federal and State

The 1998 Baseline: The baseline figures for 1998 for the effects described above are:

- 4,750 direct oil industry jobs on the North Slope
- 194,000 jobs in Southcentral Alaska and Fairbanks
- 4,650 non-oil industry jobs in the North Slope Borough
- $7.4 million Federal outer continental shelf revenues
- $13.6 million outer continental shelf revenues transferred to the State
- zero revenues to the North Slope Borough from outer continental shelf activity
- $224 million to the North Slope Borough in property taxes onshore
- zero net present value to the government, both Federal and State, of projects on the Beaufort outer continental shelf

b. Details of Cumulative Effects on Federal, State, and Borough Economies

Without the activities considered in the cumulative-effects analysis described in Section V.B, the onshore and offshore oil industry in and near Prudhoe Bay probably would decline. That is, exploration, development and production and its associated direct employment would decline. Accordingly, associated indirect employment in Southcentral Alaska, Fairbanks, and the North Slope Borough and revenues to the Federal, State and North Slope Borough governments would decline. Fluctuations in oil prices and other factors generated fluctuations throughout the Alaska economy from 1975-1995 (McDowell Group, Inc., 1999). The Alaska economy currently is not nearly as dependent on the oil sector as it was in the mid-1980's, when the major crash in the Alaska economy occurred. Employment, both direct and indirect and generated by activities described in Section V.B, create economic opportunity and add benefit to the cash economy of Alaska.

The oil and gas industry with interests in and near Prudhoe Bay and the Trans-Alaska Pipeline System have a strong interest in using the pipeline system many years into the future. The pipeline system represents a tremendous capital investment. Extending the useful life of the Trans-Alaska Pipeline System allows society to receive returns from its investment further into the future than would be the case if oil development on the North Slope ceased.

The oil and gas industry has reduced the costs of drilling wells and bringing new fields into production. This has made it more economic to develop fields that require more pipeline, both onshore and offshore, to connect to the existing pipeline system. Examples of this are the onshore pipelines that in recent years extended eastward and westward from Prudhoe Bay to the Badami and Alpine prospects, respectively. These onshore pipelines, and other possible future extensions proximate to the Beaufort Sea coast, make it more economic to develop offshore prospects. This can be done by extending pipelines northward to the

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offshore, including the outer continental shelf. The Liberty Proposal is an example of such a northward pipeline extension from existing pipeline infrastructure. Future development prospects, which potentially may fit this geographic and economic pattern, are described in Section V.B.

(1) Cumulative Effects on Employment

The cumulative gains in direct employment would include additive jobs in petroleum exploration, development, and production plus related activities. The peak employment estimate of 2,400 jobs during development is projected for year 8, declining to 1,300 jobs by year 30 during production. Commuters from present enclaves would fill most of these jobs during about half of the days in any year. Most would live in Southcentral Alaska when not working on the North Slope. For details, see the Final EIS for Sale 170 (USDOI, MMS, 1998:Sec. IV-G-8).

The oil industry would generate “indirect” jobs through spending by their employees. These additive indirect jobs would peak at 3,400 in year 8. By year 30, indirect jobs will decrease to 2,000. Most workers would live in Southcentral Alaska and Fairbanks. We have used multipliers from the IMPLAN econometric model to estimate indirect jobs. (University of Minnesota, 1989)

Projects in this cumulative analysis would increase employment of the North Slope Borough’s residents to a peak of 150 jobs in year 9, declining to 50 jobs during production. These are additive. Residents of the Borough would get some local jobs funded by the Borough’s higher property tax revenues that come from additional oil and gas facilities (USDOI, MMS, 1998:Sec. IV.G.8). This is an increase from the baseline of 4,650 non-oil industry jobs in the North Slope Borough.

Hiring of Native workers in the North Slope oil industry is discussed in Section III.D.5.

Activities associated with oil-spill cleanup in the cumulative case in the Beaufort Sea could employ about 0.3-1.2% of the workers associated with the *Exxon Valdez* spill—30-125 cleanup workers for 6 months in the first year, declining to zero by the third year following the spill. These are additive workers. See Section III.C.2.k for details of the analysis. A very large spill of 180,000 barrels in the Beaufort Sea would generate short-term employment of 10,000 for 1-2 years, declining to zero by the third year following the spill. See Section IX.B.3.k for details of the analysis. In both the Beaufort Sea and the Gulf of Alaska, Liberty’s contribution to the total probability of spills is 1%.

(2) Cumulative Effects on Federal, State, and Local Revenues

Ongoing development would increase property tax revenues starting in year 2 at an average of about 6% or $6 million each year through the production period. If the Borough’s revenue increases from property taxes, it could employ more residents. (Please refer to the above list for income and employment.)

Not counting the National Petroleum Reserve-Alaska, the cumulative case would generate the following additive annual revenues:
- $41 million Federal share of royalty receipts
- $56 million Federal income tax
- $15 million State share of royalty receipts
- $7 million State income tax
- $4 million State spill and conservation tax.

According to the Final EIS for the Northeast National Petroleum Reserve-Alaska Integrated Activity Plan (USDOI, BLM, and MMS, 1998), oil from the Reserve at $18 a barrel would generate additive annual revenues of:
- $28 million Federal share of royalty receipts
- $3 million property tax to the State
- $48 million severance tax to the State
- $28 million State and North Slope Borough share of royalty receipts

(3) Cumulative Effects on Net Present Value to the Government

The net present value to the government, both Federal and State, is estimated to be $1.1 billion. This is based on the assumption that net present value is ten times the average annual royalty, as is the case for Liberty. Liberty has $114 million net present value (Appendix D-1) and $11 million average annual royalty. Average annual royalty for the cumulative case is $112 million. Therefore, the estimate of additive net present value for the cumulative case is $1.1 billion.

(4) Cumulative Effects of Subsistence Disruptions on the North Slope Borough’s Economy

Disruptions to the harvest of subsistence resources could affect the economic well-being of North Slope Borough residents mainly by the loss of some part of those resources. See Section V.C.8 for effects on subsistence-harvest patterns.

c. Transportation Effects on the Economies

Activities associated with cleaning up a spill of 200,000 barrels of oil in the cumulative case in the Gulf of Alaska could employ about the same number of workers as associated with the *Exxon Valdez* spill: 10,000 cleanup workers worked for 6 months in the first year, declining to zero by the fourth year following the spill, along with price inflation above 25% during the first 6 months of the cleanup operation. These also are additive workers. These workers are also additive workers. See Section IX.B.3.k for the analysis. The same economic effects would occur whether the spill was in the Gulf of Alaska or farther south along the

Canadian or U.S. west coast bordering on the Pacific Ocean. These are additive workers.

12. Water Quality

a. Summary and Conclusions for Beaufort Sea, North Slope, and Transportation Activities on Water Quality

Oil spills from oil and gas development activities would degrade the marine environment through the release of petroleum hydrocarbons. The spills would increase the concentration of hydrocarbons in the water column. For crude oil spills (125-2,956 barrels), hydrocarbon concentrations could exceed the 1.5-parts per million acute-toxic criterion for about a day in an area of about 2 square kilometers (0.8 square miles). The 0.015-parts per million chronic criterion also could be exceeded for 10 or more days in an area of about 12-45 square kilometers (4.6-17.4 square miles). Hydrocarbons from a 1,500-barrel diesel oil spill during open water could exceed the acute-toxic criterion for about 7 days in an area of about 18 square kilometers (7 square miles). Hydrocarbon concentrations could exceed the 1.5-parts per million acute-toxic criterion for less than a day in an area less than a few square kilometers (1 square kilometer is about 0.4 square miles) for small spills. The 0.015-parts per million chronic criterion also could be exceeded for less than a month in an area less than 100 square kilometers (39 square miles) for small spills.

A large crude or refined oil spill (greater than or equal to 500 barrels) would significantly affect water quality by increasing the concentration of hydrocarbons in the water column to levels that greatly exceed background concentrations; however, the chance of a large spill occurring is low. Also, regional (more than 1,000 square kilometers [386 square miles]), long-term (more than 1 year) degradation of water quality to levels above State and Federal criteria because of hydrocarbon contamination is very unlikely.

The greatest effect on water quality from gravel island and pipeline construction and pipeline repair would be additional turbidity caused by increases in suspended particles in the water column. Increases in turbidity generally are expected to be considerably less than the 7,500 parts per million suspended solids used in the analysis as an acute (toxic) criterion for water; exceptions may occur within the immediate vicinity of the construction activity. Turbidity increases from construction and repair activities generally are temporary and expected to occur during the winter and end within a few days after construction stops. Material excavated from the pipeline trench but not used for backfill most likely would be left in an area where active erosion of sediment particles could occur during breakup and open water. The contribution of this material to the natural turbidity is expected to be about the same as the sediments existing at the seafloor surface before being covered. Construction and repair activities are not expected to introduce or add any chemical pollutants.

The discharged waters, mainly seawater, may be a few degrees warmer and contain higher concentrations of suspended sediments and dissolved salts when compared to the ambient water. The discharged water also would contain some chemicals that have been added to prevent some types of biological and chemical activities. Permitted discharge systems would be designed to ensure rapid mixing and dilution of the discharge.

Contribution of Liberty to Cumulative Effects: Liberty's contribution to the effects on water quality can be compared to levels of production or activities. Through 1999, more than 12,924 million barrels of oil have been produced from Alaska's North Slope oil fields (Table V.B-7c). Reserves for these fields are estimated to be 5,738 million barrels (Table V.B-2). Reserves for three possible future projects (Northstar, Fiord, and Liberty; Table V.B-4) are estimated to be 328 million barrels. Reserve estimates for reasonably foreseeable and speculative production are 4.156 and 3.724 billion barrels, respectively. Total future oil production from the North Slope and Beaufort Sea is estimated to be 13,947 billion barrels (Table V.B-7c). Liberty's contribution to this total is estimated to be 120 million barrels, or about 0.86%. Levels of activities also might be used to estimated Liberty's contribution to cumulative effects. There are 43 projects in the past, present, and reasonably foreseeable future development/production projects listed in Table V.1a. Liberty's contribution to the number of projects is about 2%. Seventeen of these projects are located offshore; 6 of the projects are or might be developed from onshore facilities; and 11 are or might be developed from offshore facilities. Liberty's contribution to the total number of offshore projects (17) is about 6% and to the number of offshore projects that are or might be developed from offshore facilities (11) is about 9%.. Based on the total number of projects or the number of offshore projects, Liberty's contribution to the cumulative effects of activities could range from about 2-9%, respectively. Onshore projects have the potential for affecting marine water quality, because seawater is taken into facilities where the water is treated for injection into producing rock formations, and the sediments suspended in the intake water flushed back into the marine environment.

Thus, Liberty's contribution to the cumulative effects on water quality from oil and gas development are estimated to range from less than 1% to about 9%. However, as noted in Sections III.C and D, the effects of offshore construction activities are expected to be short term, lasting as long as the individual activity, and have the greatest impact in the immediate vicinity of the activity. The construction activities are not expected to introduce or add any chemical contaminants. The discharges primarily would consist of treated seawater that may be a few degrees warmer and contain higher concentrations of suspended sediments and dissolved salts when compared to the receiving waters. The water also will contain some chemicals that have been added to prevent biofouling of the system and scaling. Mixing in the receiving waters is estimated to significantly dilute the effluent waters within a few tens of feet from the discharge site.

b. Details of Cumulative Effects on Water Quality in the Beaufort Sea

The past, present, and future activities associated with industrial development most likely to affect water quality are:

- permitted discharges from exploration, development, and production operations;
- accidental oil spills; and
- construction and pipeline activities.

These activities would add substances that may increase the concentration of or be foreign to substances already present in the water column. Efforts through technological advances and the regulatory regime would act to reduce the level of substances discharged into the marine environment. The principal method for controlling pollutant discharges is through Section 402 of the Clean Water Act of 1972, which establishes a National Pollution Discharge Elimination System (Sec. VI.C.2.b). The types of regulated pollutants are summarized in Section VI.C.2.a. The National Pollution Discharge Elimination System was developed to improve water quality by regulating point sources of pollution. This program issues and enforces permits to regulate and control the flow of pollutants into waters and to ensure that the standards of water-quality criteria are met to protect the environment and human health. The permit authorizes the operator to discharge only specified pollutants and establishes other criteria that include effluent limits and predilution requirements, areal and seasonal restrictions, environmental monitoring requirements, chemical analysis and toxicity tests, and reporting requirements. The permittee also is required to develop and implement a Best Management Practices Plan to lessen the number or quantity of pollutants and the toxicity of effluents generated and discharged and ensure the proper operation and maintenance of the treatment facility.

The types and levels of activities associated with the Liberty Project are expected to be similar to those that would be part of other offshore oil and gas development activities. The effects on water quality from these activities also are expected to be similar to those described in Section III for oil spills, discharges, gravel mining, and abandonment. These activities and effects are summarized below.

(1) Oil Spills

During open water, hydrocarbons dispersed in the water column from crude oil spills could exceed the 0.015 parts per million chronic criterion for 10 or more days in an area of 12-45 square kilometers (4.6-17.4 square miles). Hydrocarbons in the water could exceed the 1.5 parts per million acute-toxic criterion during the first several days of a spill in an area of about 2 square kilometers (0.8 square miles). A crude oil spill that occurs in broken sea ice or when the sea melts ice could exceed the 0.015 parts per million chronic criterion for several days in an area of about 2 square kilometers (0.8 square miles). Hydrocarbons from a 1,500-barrel diesel oil spill during open water could exceed the acute-toxic criterion for about 7 days in an area of about 18 square kilometers (7 square miles). During broken sea ice or melting ice conditions, a 1,500-barrel spill could exceed the acute-toxic criterion for about 1day in an area of about 1 square kilometers (0.4 square miles) and the chronic criterion for more than 30 days in an are of about 30 square kilometers (11.6 square miles). The effects from a spill occurring under the ice would be similar to those described for broken ice or melting conditions; the oil would be trapped and essentially remain unchanged until the ice began to melt and breakup occurred.

(2) Construction and Pipeline Repair Activities and Permitted Discharges

Substances deliberately released into the water column from oil and gas development mainly would be those already present in the environment but would include some that are manmade. These releases would come from activities such as:

- constructing solid-fill gravel islands and the digging and backfilling of a trench for the burial of pipelines;
- repairing pipelines that require excavating and backfilling the pipeline trench; and
- discharging permitted wastes associated with continuously flushing the discharge system, treating seawater for injection into producing rock formation generating potable water, sanitary and domestic wastewaters (perhaps on an intermittent basis, and construction dewatering.

Construction, pipeline repair, and discharges would increase the turbidity of the water column by increasing the amount of suspended particles. Increases in turbidity generally are expected to be considerably less than the 7,500 parts per million suspended solids used in the analysis as an acute (toxic) criterion for water quality; exceptions may occur within the immediate vicinity of the construction or pipeline repair activity. Construction- and pipeline repair-related increases in turbidity generally are expected to last only during the activity period and end within a few day after the activity stops. Construction and repair activities are not expected to introduce or add any chemical contaminants.

The permitted discharges primarily would consist of treated seawater. The discharged waters may be a few degrees warmer and contain higher concentrations of suspended sediments and dissolved salts when compared to the ambient water. Increases in turbidity generally are expected to be considerably less than the 7,500 parts per million suspended solids. The discharged water also would contain some chemicals that have been added to prevent some types of biological and chemical activities. Permitted discharge systems would be designed to lessen the size of the zone surrounding the outflow end of the discharge system where the discharge mixes with the receiving waters. Water-quality standards or criteria for substances in the discharge stream must be met outside this mixing zone.

Onshore mining for offshore construction projects is not expected to affect marine water quality, except if the mine is flooded by freshwater or seawater that can flow into the marine environment. Currents and waves in the flooded mine site could suspend fine-grain particles, which would increase the turbidity in the nearshore waters. The gravel mining and reclamation activities are not expected to introduce or add any chemical contaminants.

Abandonment of solid-fill structures and the removal of any slope-protection system would expose the fill material to erosion by ice, waves, and currents. Exposed fine-grained particles would be suspended and increase the turbidity in the water column downcurrent from the island. Increases in turbidity generally are expected to be considerably less than the 7,500 parts per million suspended solids used in the analysis as an acute (toxic) criterion for water quality. The abandonment activities are not expected to introduce or add any chemical contaminants.

The effects of causeways on the nearshore marine environment in the Beaufort Sea is an issue of concern. The Liberty Project does not include construction of a causeway, and it is unlikely that causeways would be part of future offshore petroleum development activities. However, three causeways have been constructed in the past. East Dock was constructed in 1969 on the east side of Prudhoe Bay and extends about 1,300 feet from the shore to a water depth of about 4 feet. West Dock, located west of Prudhoe Bay, was constructed in three segments between 1974 and 1981. This causeway is about 2.5 miles long, includes a 670-foot breach, and extends from the shore to a water depth of about 14 feet. Both East Dock and West Dock were constructed to offload barge-transported supplies and equipment for North Slope petroleum development. A facility to treat seawater for injection into North Slope petroleum reservoirs is located at the north end of West Dock, and the causeway supports the pipeline carrying the treated seawater and provides year-round road access to the treatment facility. The Endicott Causeway extends from shore to two artificial oil production islands located between 1.5 and 2.5 miles off the delta of the Sagavanirktok River east of Prudhoe Bay. The causeway is about 4.4 miles long, includes three breaches that total 1,350 feet in length, supports the pipeline that transports the oil onshore, and provides year-round road access to the production and transportation facilities.

The effects of causeways on water quality depend on the same factors that affect nearshore water quality in the Beaufort Sea throughout the open-water period. These factors include wind direction and velocity; the effects of the winds on nearshore currents, waves, and vertical mixing in the water column; and river and stream freshwater discharge rates (the period of greatest freshwater input occurs from late May to Early June). Observations from the West Dock and Endicott causeways indicate vertical mixing (upwelling) of cold, high-salinity bottom water into warm, low-salinity surface waters may be enhanced (1) in a geographically limited area in the lee of the causeway and (2) by the deflection of nearshore currents around the causeway. The enhanced vertical mixing is most likely to occur under conditions that contribute to regionwide upwelling—sustained easterly winds during early summer that transport the nearshore waters in a westerly and slightly offshore direction.

c. Cumulative Transportation Effects on Water Quality

(1) Nearshore Trans-Alaska Pipeline System Tanker Spills

The effects of a large (greater than or equal to 1,000 barrels) Trans-Alaska Pipeline System tanker oil spill on water quality in the nearshore environment could be similar to that of the 240,500 barrels of oil spilled by the *Exxon Valdez* in Prince William Sound in March 24, 1989. Oil spilled in the nearshore environment would be transported away from the spill site by prevailing winds and currents. The drifting oil will form a water-in-oil emulsion (mousse) that breaks into bands and stringers and could reach areas hundreds of miles away from the spill site. The concentration of hydrocarbons in the water column will be high, hundreds of parts per million, during the first several days following the spill. Over some period of time, perhaps as long as several months in heavily oiled areas, the concentration of hydrocarbons in the water would decrease to background levels. This decrease is the result of a number of processes that include evaporation of the volatile components, dispersion through horizontal and vertical mixing, weathering, biodegradation, deposition along shorelines and in seafloor sediments and photolysis.

Prevailing winds and currents transported the spilled *Exxon Valdez* oil in a southwesterly direction through Prince William Sound and into the Gulf of Alaska where it was carried in a westerly direction along the southern coast of the Kenai Peninsula and into the southern part of Cook Inlet, through Shelikof Strait, and along the coasts of the Alaska Peninsula and Kodiak Island. The information in the following summary is based articles by Neff and

Stubblefield (1991) in *Exxon Valdez Oil Spill: Fate and Effects in Alaskan Waters* and Wolfe et al. (1994) in *Environmental Science and Technology*.

The extent of petroleum hydrocarbon contamination in the area affected by the drifting oil was evaluated by analyzing the total polycyclic aromatic hydrocarbons (PAH's) in water samples collected from March 1989 through August 1990 in a variety of environments. These environments included:

- open-water column: samples collected in the water column to depths of 30 meters outside containment booms;
- surface: samples collected in the upper 50 centimeters or 3 centimeters of the water column and included sheens, if present;
- samples collected inside the primary containment booms;
- nearshore: within 100 meters of the shore; and
- offshore: more than 100 meters from the shore.

Background levels of hydrocarbons in Prince William Sound were determined from water samples collected at stations in areas that were unaffected by the drifting oil.

Applicable ambient water-quality standards for marine waters of the State of Alaska state:

- total aqueous hydrocarbons in the water column may not exceed 15 micrograms per liter (0.015 parts per million or 15 parts per billion)
- total aromatic hydrocarbons in the water column may not exceed 10 micrograms per liter (0.010 parts per million or 10 parts per billion)
- surface waters and adjoining shorelines must be virtually free from floating oil, film, sheen, or discoloration (State of Alaska, Dept. of Environmental Conservation, 1995).

The State of Alaska criterion of a maximum of 0.015 parts per million of total aqueous hydrocarbons in marine waters provides the readiest comparison and is used in this discussion of water quality. This analysis considers 0.015 parts per million (15 ppb) to be a chronic criterion and 1.5 parts per million (1,5 00 parts per billion)—a hundredfold higher level—to be an acute criterion.

During the period from about 4-7 days after the spill, the concentration of petroleum hydrocarbons in the water column was estimated to be 800 parts per billion in an area less than 400 square miles in Prince William Sound; this estimate was based on the National Oceanic and Atmospheric Administration's On-Scene Spill Model. During this period, the sustained winds were 20-25 knots with gusts of 50-70 knots. In the following 5-12 days after the spill, the total PAH concentration was estimated to range from 1-5 parts per billion in an area of about 770 square miles in Prince William Sound and the Gulf of Alaska.

The total PAH concentrations in open-water column samples of Prince William Sound affected by the oil spill ranged from less than 0.01 to less than 10 parts per billion during spring and summer 1989. Most of the samples contained less than 1 part per billion total PAH. Water samples collected in March and April 1989 had the largest number of samples with total PAH concentrations greater than 1 part per billion. The concentrations of total PAH generally decreased with time after the spill, and in offshore areas the concentrations had decreased to background levels within a couple of months. The highest concentrations of total PAH in were found in open-water column samples from heavily oiled bays and adjacent to heavily oiled shorelines. In most of the heavily oiled bays, the total PAH concentrations in the open-water column tended to decrease with time; by May, concentrations were at or below 1 part per billion, and by late June and early July concentrations were below 0.1 part per billion.

After mid-May, the highest concentrations of total PAH in open-water column samples of Prince William Sound were found in samples collected just outside containment booms deployed off shorelines where oil-removal activities were being conducted. Sampling inside and outside of the booms indicated that shoreline cleanup did flush petroleum hydrocarbons into the nearshore water column. However, relatively little of the oil escaped the containment areas, and the PAH concentrations in the water column rapidly returned to low levels after cleanup operations stopped.

Most of the surface water samples collected in Prince William Sound areas affected by the spill contained less than 1 part per billion total PAH. However, some of the samples contained concentrations that ranged from 10-29.3 parts per billion total PAH; the water sample with the 29.3 parts per billion total PAH concentration probably contained oil-sheen material. Throughout summer 1989, the total PAH highest concentrations came from Northwest Bay water samples.

In the western Gulf of Alaska, samples from the open-water column collected offshore in April and May had total PAH concentration that ranged from nondetectable to 0.99 parts per billion, and the average was 0.11 parts per billion; these samples were collected when slicks of oil and mousse were drifting through the area. The average total PAH concentration in water samples collected in nearshore water offshore along the Kenai and Alaska Peninsulas and Kodiak Island in July and August was 0.03 parts per billion; the highest concentration was 0.42 parts per billion. Surface water samples collected in the Gulf of Alaska between April and August 1989 had total PAH concentrations that ranged from less than 0.005-0.31 parts per billion; the average concentration was 0.03 parts per billion.

The total PAH concentration in most of the water samples collected in areas unaffected by the oil spill in Prince William Sound was less than 0.1 parts per billion; several surface samples had total PAH concentrations greater than 0.4 parts per billion, and a number of water column samples had PAH concentrations greater than 0.2 parts per billion. Based on these analyses, the background PAH concentration in Prince William Sound generally is less than 0.1 parts per billion. These PAH's probably come from natural oil seeps located southeast of Prince William Sound.

The toxicity of Prince William Sound water samples collected from 1 and 3 meters below the surface was determined through acute (survival) and sublethal (growth) responses to three widely used marine bioassay organisms. The collection of water samples for the toxicity tests began in April 1989. The mean survival (as a percentage of control) for mysid shrimp (*Mysidopsis bahia*) acute toxicity tests and for the sheepshead minnow 7-day survival test ranged from about 80-120% and about 70-120%, respectively. The mean cell growth (as a percentage of controls) for the marine diatom *Skeletonema costatum* ranged from about 0-220% and the mean weight gain (as a percentage of controls) for sheepshead minnow 7-day growth test ranged from about 40-170%. The toxicity and growth tests indicated that waters in areas affected by spilled oil were not toxic to these sensitive test species and likely would not be toxic to marine organisms indigenous to the Sound.

(2) Offshore Spills (more than 50 miles) from a Trans-Alaska Pipeline System Tanker and Other Tanker Spills in Deep Water

The effects on water quality of a large (greater than or equal to 1,000 barrels) Trans-Alaska Pipeline System tanker oil spill in the offshore (more than 50 miles) marine environment and a tanker spill in the deepwater marine environment would be similar to the effects discussed in Section IX.B.12 for a large spill, 200,000 barrels, in the northeastern Gulf of Alaska. The spills would add substances that may be foreign to or increase the concentration of constituents already present in the water column. However, the area (discontinuous area) affected by the Trans-Alaska Pipeline System tanker spill and the concentration of hydrocarbons dispersed in the water column are likely to be less than were analyzed for the same time periods for the 200,000-barrel spill. Also, the periods when the hydrocarbon concentrations are likely to be greater than the acute (1.5 parts per million) and chronic (0.015 parts per million) concentrations assumed for the analysis would be less than those estimated for the 200,000-barrel spill. Tables A-36 and 37 indicate that Trans-Alaska Pipeline System tanker spills are more likely to be less than 200,000-barrel spill analyzed for the northeastern Gulf of Alaska. Table A-37 shows that for spills of less than 6,000 barrels, the spill average size was about 3,000 barrels, and for spills 9,000-15,000 barrels, the average spill size was about 13,000 barrels. Thus, it was assumed the tanker spill would be less than 200,000 barrels. Differences between the fate and behavior of crude oil from a 7,000-barrel summer spill and a 200,000-barrel spill are shown in Tables A-6 and IX-7; however, the spills are assumed to occur in two different areas and different environmental factors (wind speeds, water temperatures, and wave heights) used to calculate the parameters shown in the tables.

(3) In-Port Tanker Spills

In-port tanker spills would, as noted for other tanker spills, add petroleum hydrocarbons to the environment; concentrations likely would be high, hundreds of parts per billion, but would decrease with time. The effects of the environment on the spill in a port would be similar to the effects as described for a spill in open water. However, the proximity of land to a potential spill area increases the risk of oil contacting shorelines, and the shallow waters of port areas increase the risk of oil being deposited in the sediments. The cycle of depositing and resuspending oil along the shorelines and in shallow-water areas is likely to be more extensive than would occur from an offshore spill. Also, vertical mixing in port areas is likely to be reduced because of decreased wave heights (limited fetch). For tankers carrying North Slope crude oil, in-port tankers spills have been 15,000 barrels or less (Table A-36). Ports regularly used by tankers would have oil-spill-containment and -cleanup equipment readily available.

d. Cumulative Effects of a Trans-Alaska Pipeline System Spill on Freshwater Water Quality

The effects of an oil spill from the Trans-Alaska Pipeline System on water quality would depend on when and where the spill occurred; the average size of pipeline spills is 1.1 barrels (Table A-35). The release of petroleum hydrocarbons from oil spills would degrade the freshwater environment by adding substances that are toxic to freshwater organisms—these substances include the polycyclic aromatic hydrocarbons, use oxygen dissolved in the water during decomposition, and reduce photosynthesis by reducing the amount of light penetrating the surface. The fate of oil spilled into or reaching freshwater would be similar to the fate of oil in the marine environment and would include:

- dispersion,
- dissolution of soluble components,
- evaporation of the volatile components,
- formation of oil-in-water emulsions (mousse),
- deposition along the shoreline or in quiet areas,
- sedimentation (adhesion of detrital particles to oil drops or adsorption of oil drops by sediment particles),
- transportation downstream as part of the suspended sediment or bottom sediment load, and
- chemical and/or biological degradation.

The energy of the aquatic environment affects the fate of the spilled oil; these effects include the persistence of toxic substances and light-blocking surface layer and dissolved oxygen depletion and renewal. Oil spilled into a fast-moving stream or river would be dispersed rapidly downstream and vertically, and the effects of the environment on the physical and chemical characteristics of the oil would occur more rapidly than if the oil were spilled in slow-moving streams or stagnant waters. If the spill happens when the affected area is frozen, cleanup activities would remove most, if not all, of the spilled oil, and the effects on water quality would be minimal.

13. Air Quality

a. Summary and Conclusions for Beaufort Sea, North Slope, and Transportation Activities on Air Quality

The cumulative effects of all projects affecting the North Slope of Alaska in the past and occurring now have caused generally little deterioration in air quality, which remains better than required by national standards. The Liberty Project, combined with the Northstar Project and all other reasonably foreseeable North Slope projects (see TableV.B-1a), would not change this situation.

Contribution of Liberty to Cumulative Effects: Considering that the Liberty Proposal would represent only approximately 1% of the North Slope activity, air emissions from Liberty would have no significant cumulative effects on air quality. See Section III.D.1.m for a discussion of these emissions.

b. Details of Cumulative Effects on Air Quality

Despite considerable oil and gas related activity since 1969, the overall air quality on the North Slope of Alaska remains relatively pristine. See Section VI.C.3 for a discussion of the existing environment.

Table V.B-2 shows that Prudhoe Bay and Kuparuk are the big oil producers. However, their production will continue to decline over the coming years. Air monitoring at a number of sites in the Kuparuk and Prudhoe Bay fields showed that concentrations of nitrogen dioxide, sulfur dioxide, and particulate matter 10 micrometers or less are well within the national ambient air-quality standards. BPXA's air-quality modeling has indicated that emissions from these fields have very little effect on ambient concentrations around the Liberty site. The nearest existing oil-production area is the Duck Island unit, which is about 15-25 kilometers away. The existing oil-production rate from this unit is about the same as the projected peak production rate for Liberty. Air-quality modeling for the Liberty Project indicated that maximum concentrations occur within about 100-200 meters from the facility boundary and are considerably lower at 1 kilometer from the facility. Thus, there would be very little cumulative interaction between Liberty and the nearest existing oil-producing facility.

Table V.B-1a lists possible future projects. The nearest possible development is in the Badami Unit, whose estimated reserves are about the same as those for Liberty. However, Badami is located about 15-30 kilometers away and, thus, there would be very little cumulative interaction between Liberty and any possible development in the Badami Unit. The other potential fields shown in Table V.B-1a are located at much greater distances from Liberty. The sites that have a lower potential for development (Table V.B-1a) are, in most cases, at least 80 kilometers away.

Potential impacts from future lease sales on the outer continental shelf and on land are more difficult to evaluate. However, one can expect that any development would be scattered over a rather large area. Modeling performed for the Lease Sale 144 Final EIS (USDOI, MMS, 1996a) showed that impacts from widely scattered emissions sources on the outer continental shelf are small and well within regulatory standards. The Final 5-Year Program EIS for 1997-2002 (USDOI, MMS, Herndon, 1996a) discusses the cumulative effects of the program in all areas. The relevant major finding was that no major degradation of onshore air quality is predicted. Emissions associated with routine program activities could cause small increases in onshore concentrations of some air pollutants. Emissions should not cause any exceedance of national or state air quality standards. Accidental oil spills could cause rapid and, perhaps, dramatic increases in volatile organic carbon concentrations near the spill, but the duration of these should be too short (generally a few days) to cause major impacts. (USDOI, MMS, Herndon, 1996a:iii)

A more comprehensive discussion occurs in the Impacts on Air Quality section of that document (USDOI, MMS, Herndon, 1996a:IV-302-307; IV-306-307 pertain specifically to Alaska). We incorporate that discussion here by reference. Also, Section III.D.3 of this EIS concludes that from small oil spills there would be a small, very localized increase in concentration of hydrocarbons. Air-quality impacts would be very low.

We could expect very little cumulative interaction between emissions from the proposed Liberty Project and any other existing, planned, or potential oil or gas development projects. For the area as a whole, we could expect the quality of the air to increase in those areas where oil production currently is the greatest and to decline in other areas where future development is expected to take place. It is possible that new development would be relatively scattered and, therefore, regional impacts would be small, except for higher, localized concentrations in the immediate vicinity of production facilities.

Arctic haze is a phenomenon resulting from elevated concentrations of fine particulate matter that are found over the Arctic, primarily in winter and spring. Scientists believe that most of these pollutants are attributed to combustion sources in Europe and Asia. It is not known to what extent local sources in Alaska contribute to arctic haze in the area of the Beaufort Sea. However, the arctic haze phenomenon was first observed in the 1950's, long before oil development started on the North Slope. Also, emissions in the general area are expected to decrease due to a downward trend in oil production and, thus, any possible contribution to arctic haze would be reduced. Projected emissions from the proposed Liberty Project are small compared to the emissions from the Prudhoe Bay and Kuparuk oil field production. For example, actual emissions reported for the Prudhoe Bay oil fields for the year 1994-1995 listed 56,000 tons of NO_x, 1,471 tons of sulfur dioxide, and 6200 tons of particulate matter less than 10 micrograms in diameter (U.S. Army Corps of Engineers, 1999:Table 5.4-7). Projected emissions from the proposed Liberty Project would be less than 2% of those figures. Therefore, any contribution of the proposed Liberty Project to arctic haze would be negligible.

Global Climate Change: The global climate change analysis performed for the proposed Northstar Project estimated that emissions of greenhouse gases (carbon dioxide and methane) from that facility would be approximately 1% of the total greenhouse gas emissions from the existing oil and gas production on the North Slope in Alaska (U.S. Army Corps of Engineers, 1999). This comparison was based on the North Slope production figures for 1996, which averaged about 1.45 million barrels of oil per day. The proposed Liberty facility would be very similar to that for Northstar with respect to both project design and projected production rate. Therefore, the relative contribution to regional greenhouse gas emissions would be about the same, around 1%. It was also estimated that the greenhouse gas emissions from current North Slope oil production (including shipping, refining, end product transportation, and consumption) is about 1% of the global fossil fuel greenhouse gas emissions (U.S. Army Corps of Engineers, 1999). The amount attributed to the production process alone should be a small fraction of this percentage figure.

The cumulative analysis for Liberty considers three ranges of onshore and offshore future production activity. The low range includes reserves in currently producing fields and resources and discoveries in the planning or development stage. The mid range consists of the low range figure plus any reasonably foreseeable future production. Finally, the high range adds in potential speculative future production. If one uses the mid range estimate, which is 10 billion barrels of oil, and assumes that this entire amount is produced over a 20-year period, one obtains an average production rate of about 1.4 million barrels of oil per day. This is very close to the 1996 North Slope oil production rate. While it is difficult to estimate greenhouse gas emissions from future oil and gas production activities in Northern Alaska precisely, one may assume that the greenhouse gas emissions would be proportional to the oil production rate at the same ratio as exists presently. Based on that assumption, the regional greenhouse gas emissions associated with future cumulative production would be about the same as the 1996 North Slope emission levels. This is about 30% higher than current levels (since the 1999 North Slope production rate was about 1.1 million barrels of oil per day). Greenhouse gas emissions associated with production activities can be reduced by using more fuel-efficient power generators and minimizing flaring. Based on the Northstar analysis cited above, the cumulative future oil production in Northern Alaska would produce a relatively small (about 1%) contribution to global greenhouse gas emissions. The contribution of the proposed Liberty project to the regional greenhouse gas emissions would be only about 1%. Nationwide and global greenhouse gas emissions can be reduced by energy conservation, improving energy efficiency, and developing alternative energy sources. Regardless of any downward pressure on the growth of oil consumption in the future as a result of measures to reduce greenhouse gas emissions, the need for continued development of domestic new oil and gas resources will still exist. If Alaska energy sources were not to be developed in the future, resources would have to be produced in other areas of the globe. The impacts on greenhouse gas emissions would be very similar, regardless of the location of the energy source.

c. Transportation Effects on Air Quality

The transportation of crude oil to market by tankers would result in air emissions from the tankers' engines during loading operations, transit, and during unloading. These emissions would consist primarily of nitrogen oxides, sulfur dioxide, and particulate matter. Emissions of volatile organic compounds would also occur during tanker loading and unloading operations. Emissions of nitrogen oxides and volatile organic compounds would be of concern in ports located within ozone nonattainment areas because of their potential to contribute to tropospheric ozone levels. In these areas, local regulations commonly require the use of vapor balance systems to reduce volatile organic compound emissions substantially. For any particular port, the emissions would be intermittent, and nitrogen dioxide, sulfur dioxide, and particulate matter concentrations would be within ambient air quality standards. Impacts from emissions during transit would be very small because emissions would be dispersed over a large area.

A major oil spill would result in a localized increase in ambient volatile organic compounds concentrations due to evaporation from the spill. Details on the effects of an oil spill and impacts associated with in situ burning are provided in Sections III.C.2.m and IX.B.3.m. Overall air quality impacts from transportation would be low.

SECTION VI

DESCRIPTION OF THE AFFECTED ENVIRONMENT

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CONTENTS FOR SECTION VI

Contents

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VI. Description of the Affected Environment

This section describes the environment that the proposed Liberty Project and alternatives would affect. The proposed project is in Foggy Island Bay of Stefansson Sound in the Beaufort Sea northeast of Prudhoe Bay. BPXA's Environmental Report for the Liberty Development Project (BPXA, 2000a) describes the environment in detail, and the Final Environmental Impact Statement (EIS) for the adjacent Northstar Development Project (U.S. Army Corps of Engineers, 1999) also describes the Beaufort Sea area. These documents are incorporated here by reference. Section III of the Sale 170 Final EIS (U.S. Department of the Interior [USDOI], Minerals Management Service [MMS], 1998) and Section III of the Sale 144 Final EIS (USDOI, MMMS, 1996a) also describe the existing environment of the Beaufort Sea and the North Slope of Alaska and are incorporated by reference. Other EIS's that describe the existing environment for the Beaufort Sea and North Slope area include the final EIS's for Sales BF and 71 (USDOI, BLM, Alaska OCS Office, 1979 and 1982) and 87, 97, and 124 (USDOI, MMS, 1984, 1987, and 1990b, respectively).

A. BIOLOGICAL ENVIRONMENT

The following seven resource categories describe the existing biological environment:

- Threatened and Endangered Species
- Seals and Polar Bears
- Marine and Coastal Birds
- Terrestrial Mammals
- Lower Trophic-Level Organisms
- Fishes
- Vegetation-Wetland Habitats
- Essential Fish Habitat

1. Threatened and Endangered Species

a. Threatened and Endangered Species In or Near the Planning Area

The Endangered Species Act of 1973 defines an endangered species as any species that is in danger of extinction throughout all or a significant portion of its range. The act defines a threatened species as one that is likely to become endangered within the foreseeable future. Endangered bowhead whales and threatened spectacled and Steller's eiders (birds) may occur in the general area of the Liberty Project development.

(1) Bowhead Whales

The Western Arctic stock (Bering Sea stock) of bowhead whales migrates through the Alaskan Beaufort Sea semiannually between wintering areas in the Bering Sea and summer feeding grounds in the Canadian Beaufort Sea.

The Western Arctic stock of bowhead whales was estimated to be between 8,000 individuals in 1993 with a range between 6,900 and 9,200 individuals with a 95% confidence interval (Zeh, George, and Suydam, 1995; Hill and DeMaster, 1999). Zeh, Raftery, and Schaffner (1995) subsequently revised this population estimate by incorporating acoustic data that were not available when the earlier estimate was developed. The revised estimate of the population was between 7,200 and 9,400 individuals in 1993, with 8,200 as the best population estimate, and the estimate recognized by the International Whaling Commission. An alternative method produced an estimate of 7,800 individuals with a 95% confidence interval of 6,800-8,900 individuals. The best estimate of the population recognized by the International Whaling Commission was 8,200 whales. An alternative method produced an estimate of 7,800 with a 95% confidence interval of 6,800-8,900 individuals. Zeh, Raftery, and Schaffner (1995) estimate that the Western Arctic stock increased at a rate of 3.2% per year from 1978-1993. The increase most likely is due to a combination of improved data and better counting techniques and an actual increase in the population. The historic population was estimated at 10,400-23,000 whales in 1848, before commercial whaling, compared to an estimate of between 1,000-3,000 animals in 1914, near the end of the commercial whaling period (Woody and Botkin, 1993).

Bowhead whales have an affinity for ice and are associated with relatively heavy ice cover and shallow continental shelf waters for much of the year. Throughout the winter, bowheads frequent the marginal ice zone, regardless of where the zone is, and polynyas (irregular areas of open water). Polynyas in the Bering Sea along the northern Gulf of Anadyr, south of St. Matthew Island, and near St. Lawrence Island, are important wintering areas for bowheads. Bowheads also congregate in these polynyas before starting their spring migration.

The bowheads' northward spring migration appears to coincide with the ice breakup. They pass through the Bering Strait and eastern Chukchi Sea from late March to mid-June through newly opened leads in the shear zone between the shorefast ice and the offshore pack ice. The migration occurs in pulses, or aggregations of whales swimming together, with the first pulse passing Point Barrow in late April or early May, the second pulse in mid-May, and a less well-defined pulse in late May to mid-June (Moore and Reeves, 1993). Several studies of acoustical and visual comparisons of the bowhead's spring migration off Barrow indicate that bowheads also may migrate under ice within several kilometers of the leads. Data from several observers indicate that bowheads migrate underneath ice and can break through ice 14-18 centimeters (5.5-7 inches) thick to breathe (George et al., 1989; Clark, Ellison, and Beeman, 1986). Bowheads may use cues from ambient light and echoes from their calls to navigate under ice and to distinguish thin ice from multiyear floes (thick ice). After passing Barrow from April through mid-June, they move easterly through or near offshore leads. East of Point Barrow, the lead systems divide into many branches that vary in location and extent from year to year. Andrew Oenga, who hunted bowhead whales as a crew member out of Barrow from 1943 to 1960 stated: "I believe from my experience that bowhead whales would reach the leads offshore from Prudhoe Bay by early May" (Oenga, as cited in U.S. Army Corps of Engineers, 1999). The spring-migration route is far offshore of the Liberty development area. Bowheads arrive on their summer-feeding grounds near Banks Island from mid-May through June and remain in the Canadian Beaufort Sea and Amundsen Gulf until late August or early September (Moore and Reeves, 1993).

Some biologists conclude that almost the entire Bering Sea bowhead population migrates to the Beaufort Sea each spring and that few whales, if any, summer in the Chukchi Sea. However, some scientists maintain that a few bowheads swim northwest along the Chukotka coast in late spring and summer in the Chukchi Sea. Records of bowhead sightings from 1975-1991 suggest that bowheads may occur regularly along Alaska's northwestern coast in late summer; however, no one has yet established if these are "early-autumn" migrants or whales that have summered nearby (Moore et al., 1995). Harry Brower, Jr., stated that he has seen whales in the Barrow area in the middle of the summer while the hunters are out hunting bearded seals on the ice edge (Brower, as cited in USDOI, MMS, 1995b).

After summer feeding in the Canadian Beaufort Sea, bowheads begin moving westward into Alaskan waters in August and September. Generally, few bowheads are seen in Alaskan waters until the major portion of the migration takes place, typically between mid-September and mid-October. There is some indication that the fall migration, like the spring migration, occurs in pulses or aggregations of whales (Moore and Reeves, 1993). The pulses may represent segregation by age class, with smaller whales migrating first, followed by large adults and females with calves. Inupiat whalers estimate that bowheads take about 2 days to travel from Kaktovik to Cross Island, reaching the Prudhoe Bay area in the central Beaufort Sea by late September, and 5 days to travel from Cross Island to Point Barrow (T. Napageak, 1996, as cited in USDOC, National Marine Fisheries Service, 1999).

Oceanographic conditions can vary during the fall migration from open water to more than nine-tenths ice coverage. The extent of ice cover may influence the timing or duration of the fall migration. Miller, Elliot, and Richardson (1996) observed that whales within the Northstar region (long. 147°-150° W.) migrate closer to shore in light and moderate ice years and farther offshore in heavy ice years, with median distances offshore of 30-40 kilometers (19-25 miles), 30-40 kilometers (19-25 miles), and 60-70 kilometers (37-43 miles), respectively. Ljungblad et al. (1987) observed during the years from 1979-1986 that the fall migration extended over a longer period, that higher whale densities were estimated, and that daily sighting rates were higher and peaked later in the season in light ice years compared to heavy ice years.

Fall aerial surveys of bowhead whales in the Alaskan Beaufort Sea have been conducted since 1979 by the Bureau of Land Management and MMS (Ljungblad et al., 1987; Treacy, 1988-1998). Over a 16-year period (1982-1997), there were 14 years with some level of offshore seismic exploration and/or drilling activity and two blank years (1994 and 1995) in which neither offshore activity took place during September or October. The parametric Tukey HSD test was applied to MMS fall aerial-transect data (1982-1997) to compare the distances of bowhead whales north of a normalized coastline in two analysis regions of the Alaskan Beaufort Sea from 140°-156° W. longitude (Fig. VI.A-1). While the Tukey HSD indicates significant differences between individual years, it does not compare actual levels of human activity in those years nor does it test for potential effects of sea ice and other oceanographic conditions on bowhead migrations (Treacy, 1998).

East of Cross Island (approx. long. 148° W.), the bowhead migration was not significantly farther offshore in 11 of 14 years having offshore activity when compared to either blank year (1994 or 1995). In 3 years (1983, 1989, and 1991), whales migrated significantly farther offshore than in either blank year. In 1 year (1997), whales migrated significantly closer to shore than in either blank year. A power analysis of the ANOVA (α=0.05, $\beta \leq$0.01) for distance from shore showed minimum detectable differences of 7.8 kilometers in the East Region. West of Cross Island, the bowhead migration was not significantly farther offshore in 13 of 14 years having offshore activity when compared to either blank year. In 1 year (1988), whales migrated significantly farther offshore than in 1994 (no activity). In another year (1983), whales migrated significantly farther offshore than in 1995 (no activity). In 1 year (1997), whales migrated significantly closer to shore than in either blank year. A power analysis of the ANOVA (α=0.05, $\beta \leq$0.01) for distance from shore showed minimum detectable differences of 9.7 kilometers in the West Region (Treacy, 1998).

Further evidence that bowhead whales migrate at varying distances from shore in different years is provided by recent site-specific studies monitoring whale distribution relative to local seismic exploration in nearshore waters of the central Beaufort Sea (Miller et al., 1997; Miller, Elliot, and Richardson, 1998; Miller et al., 1999). In 1996, bowhead sightings were fairly broadly distributed between the 10-meter and 50-meter depth contours. In 1997, bowhead sightings were fairly broadly distributed between the 10-meter and 40-meter depth contours, unusually close to shore. In 1998, the bowhead migration corridor generally was farther offshore than in either 1996 or 1997, between the 10-meter and 100-meter depth contours and approximately 10-60 kilometers from shore.

Aerial surveys near the proposed Liberty Development Project in 1997 (BPXA, 1998a) showed that the primary fall migration route was offshore of the barrier islands, outside the development area. However, a few bowheads were observed in lagoon entrances between the barrier islands and in the lagoons immediately inside the barrier islands, as shown in Figures 4-4 and 4-5 of the Environmental Report submitted by BPXA for the Liberty Development Project (BPXA, 1998a). Because survey coverage in the nearshore areas was more intensive than in offshore areas, maps and tabulations of raw sightings overestimate the importance of nearshore areas relative to offshore areas. Transects generally did not extend south of the middle of Stefansson Sound. Nevertheless, these data provide information on the presence of bowhead whales near the proposed Liberty development area during the fall migration. Probably only a small number of bowheads, if any, came within 10 kilometers (6 miles) of the Liberty area.

Some bowheads may swim inside the barrier islands during the fall migration. Frank Long, Jr., reported that whales are seen inside the barrier islands near Cross Island nearly every year and are sometimes seen between Seal Island and West Dock (U.S. Army Corps of Engineers, 1999). Thomas Brower, Sr., from Barrow, participated in the last commercial whale hunt in 1919. He said that when he went along with the commercial whale hunts, he saw the whaling ships look for the whales near the barrier islands in the Beaufort Sea and in the lagoons inside the barrier islands (Brower, 1980). Brower also said that whales have been known to migrate south of Cross Island, Reindeer Island, and Argo Island during years when fall storms push ice against the barrier islands. Inupiat whaling crews from Nuiqsut also have noticed that the whale migration appears to be influenced by wind, with whales stopping when the winds are light and, when the wind starts blowing, the whales started moving through Captain Bay towards Cross Island (Tuckle, as cited in USDOI, MMS, 1986b). Some bowhead whales have been observed swimming about 25 yards from the beach shoreline near Point Barrow during the fall migration (Rexford, as cited in USDOI, MMS, 1996c).

Data are limited on the bowhead fall migration through the Chukchi Sea before the whales move south into the Bering Sea. Bowhead whales commonly are seen from the coast to about 150 kilometers (93 miles) offshore between Point Barrow and Icy Cape, suggesting that most bowheads disperse southwest after passing Point Barrow and cross the central Chukchi Sea near Herald Shoal to the northern coast of the Chukotsk Peninsula. However, scattered sightings north of 72° N. latitude suggest that at least some whales migrate across the Chukchi Sea farther to the north. After moving south through the Chukchi Sea, bowheads pass through the Bering Strait in late October through early November on their way to overwintering areas in the Bering Sea.

Bowheads are filter feeders, filtering prey from the water through baleen fibers in their mouth. Bowheads apparently feed throughout the water column, including bottom or nearbottom feeding as well as surface feeding. Food items most commonly found in the stomachs of harvested bowheads are zooplankton, including euphausiids, copepods, mysids, and amphipods. Euphausiids and copepods are the primary prey species. Bowheads have been reported feeding in the eastern Beaufort Sea and Amundsen Gulf region in Canada, but the proportion of time spent feeding and the types of prey being consumed are unknown (Lowry, 1993). Bowheads continue to feed opportunistically where food is available as they migrate across the Alaskan Beaufort Sea. Some bowheads appear to feed east of Barter Island as they migrate westward (Thomson and Richardson, 1987). Bowheads occasionally have been observed feeding north of Flaxman Island and, in some years, fairly large groups of them have been seen feeding east of Point Barrow between Smith Bay and Point Barrow. In some years, bowheads also have been observed feeding in the spring just west of Point Barrow. Carbon-isotope analysis of bowhead baleen has indicated that a significant amount of feeding may occur in wintering areas (Schell, Saupe, and Haubenstock, 1987).

A study by Richardson (1987) concluded that food consumed in the eastern Beaufort Sea contributed little to the bowhead whale population's annual energy needs. The North Slope Borough's Science Advisory Committee (1987) believed there were problems in the study's design and length. To respond to these concerns and to better understand the importance of the eastern Alaska Beaufort Sea to bowhead whales, we funded a second study on bowhead whale feeding east of Barter Island, entitled *Bowhead Whale Feeding in the Eastern Alaskan Beaufort Sea: Update of Scientific and Traditional Information* (USDOI, MMS, Alaska OCS Region, 1997). The study emphasizes cooperation among local government, subsistence-whale hunters, scientists, and MMS in its planning and execution. This feeding study is in progress, with fieldwork being conducted from 1998 through 2000. Following the first year of fieldwork on this study, Richardson and Thomson (1999) noted that the average zooplankton biomass in the study area was higher in 1986 than in 1998. Habitat suitable for feeding appears to have been less common in the eastern Alaskan Beaufort Sea in 1998 than it was in 1986. Bowhead whales moved quickly through the area in 1998 and did not stop to feed for any great period of time. In contrast, during 1986, some individual whales stopped to feed in the study area for periods of at least several days. Samples of stomach contents in 1998 indicated that 74% of the whales harvested at Kaktovik had fed recently, and 47% of the whales harvested at Barrow were considered to have been feeding.

Baleen from bowhead whales feeding in the Bering Sea provides a multiyear record of isotope ratios in prey species. Carbon-isotope analysis of zooplankton, bowhead tissues, and bowhead baleen indicates that a significant amount of feeding may occur in areas west of the eastern Alaskan Beaufort Sea, at least by subadult whales (Schell, Saupe, and Haubenstock, 1987). The isotopic composition of the whale is compared with the isotope ratios of its prey from various geographic locations to make estimates of the importance of the habitat as a feeding area. Subadult whales show marked changes in the carbon isotope over the seasons, indicating that carbon in the body tissues is replaced to a large extent from feeding in summer and feeding in the autumn-winter months. In contrast, adult animals sampled show very little seasonal change in the carbon isotope and have an isotopic composition best matched by prey from the western and southern regions of their range, implying that little feeding occurs in summer (Schell and Saupe, 1993).

The isotopic data also indicates, however, that primary productivity in the Bering and southern Chukchi Seas is declining. Schell (1999a) looked at baleen from 35 bowheads that were archived, as well as whales from recent harvest, and constructed an isotopic record that extends from 1947-1997. He inferred from this record that seasonal primary productivity in the North Pacific was higher over the period from 1947-1966, and then began a decline that continues to the most recent samples from 1997. Isotope ratios in 1997 are the lowest in 50 years and indicate a decline in the Bering Sea productivity of 35-40% from the carrying capacity that existed 30 years ago. If the decline in productivity continues, the relative importance of the eastern Beaufort Sea to feeding bowheads may increase (Schell, 1999b).

Information regarding age at sexual maturity or mating behavior and timing for bowhead whales is not known with certainty. Most bowheads mate and calve from April through mid-June, coinciding with the spring migration. Mating may start as early as January and February, when most of the population is in the Bering Sea, but it also has been reported as late as September and early October (Koski et al., 1993). Calving occurs from March to early August, with the peak probably occurring during the spring migration between early April and the end of May (Koski et al., 1993). Females give birth to a single calf probably every 3-4 years.

There is little information regarding natural mortality for bowhead whales in the Bering, Chukchi, and Beaufort seas. Bowhead whales have no known predators except, perhaps, killer whales and subsistence whalers. Attacks by killer whales have occurred, but the frequency probably is low. George et al. (1994) concluded that the relatively low frequency of bite marks likely reflects a relatively low frequency of killer whale attacks and predation pressure. Likewise, the scarcity of observations of vessel-inflicted injuries suggests that the incidence of ship collisions with bowhead whales also is quite low. There also are some reports of bowheads becoming entangled in ropes from crab pots, harpoon lines, or fishing nets. The frequency of occurrence is not known. Some whales likely die as a result of entrapment in ice, but the number is thought to be relatively small (Philo et al., 1993). Little is known about the effects of microbial or viral agents on natural mortality.

(2) Spectacled Eider

(a) Population Status

An estimated 9,500 spectacled eiders seasonally occupy the Arctic Coastal Plain (Larned et al., 1999), about 2.5% of the estimated 375,000 birds in the world population. This value is an index unadjusted for eiders undoubtedly present but undetected. Most of the world population is made up of birds from arctic Russia. Although Fish and Wildlife survey data do not show a significant decline in the Arctic Coastal Plain spectacled eider population, a moderate downward trend of 2.6% per year (90% confidence interval ranges from 7.7% decrease to 2.7% increase) has been noted in the 1990's (USDOI, Fish and Wildlife Service, unpublished data). The Liberty Prospect is near the easternmost extent of the specie's range on the coastal plain, where densities are much lower than to the west.

Numbers occupying this region over the past 6 years have been relatively stable. The size of the nonbreeding population is unknown. It is assumed nonbreeders remain at sea throughout the year until they attempt to breed at 2-3 years, but their location during this period is unknown. Other life history information for this species also is uncertain, although that information available indicates they are long lived with relatively high adult survival, low recruitment to breeding age, and delayed sexual maturity.

(b) Spring Migration

Routes traveled by spectacled eiders during their spring migration are not well known. They have generally been recorded passing Point Barrow in the last week of May or first week of June (Johnson and Herter, 1989). Few spectacled eiders have been recorded using the lead system 5-6 kilometers offshore extending eastward from Point Barrow (Suydam, pers. commun., as cited in TERA, 1999; Woodby and Divoky, 1982). Suydam et al. (1997) recorded only 55 spectacled eiders among 213,477 king and common eiders passing Point Barrow in spring 1994. Low numbers (0.5-0.7 birds per hour) have been recorded at several points in Simpson Lagoon (Johnson and Richardson, 1981), but some of these probably were movements of local birds rather than migrants. This species has been observed to make limited use of areas of meltwater overflow off river deltas. Thus, because relatively few spectacled eiders are seen in marine areas, spring migration may be primarily overland from the Chukchi Sea (TERA, 1999). Local observations that spectacled eiders flew inland north of Wainwright, reported by Myres (1958), support this view.

(c) Nesting

Within the general Liberty area, spectacled eiders are known to nest on the Sagavanirktok River Delta (TERA, 1995a, 1997) and in the vicinity of the Kadleroshilik and Shaviovik rivers (Field et al., 1988; Nickles et al., 1987; TERA, 1995b, 1996a, b; Map 5). Spectacled eiders are dispersed nesters (Derksen, Rothe, and Eldridge, 1981; Warnock and Troy, 1992), occurring at low density (0.03-0.79 birds persquare kilometer, Larned and Balogh, 1997) within about 70 kilometers of the coast. In the Prudhoe Bay area, they are most concentrated west of the Sagavanirktok River within about 25 kilometers of the coast (TERA, 1997; Troy, 1995). Sightings of this species were made in the area south of Foggy Island Bay in 1994 (TERA, 1995b). Three nests were located on study plots in the Kadleroshilik River area; however, nest success was low and few broods were observed in July 1994. Few spectacled eiders are found in the area east of the Shaviovik River; densities determined from aerial surveys ranged from 0.05-0.30 birds per square kilometer (Byrne, Ritchie, and Flint, 1994; Larned and Balogh, 1994). Available information indicates some female spectacled eiders may return to the vicinity of previous nests.

Limited survey data for the Kadleroshilik River area in 1994 (TERA, 1995b) indicate that eider density probably is relatively low throughout the area during summer:

Period	Density per Square Kilometer
Breeding season nests	0.3 nests
Breeding season individuals (average)	0.4 birds
June 14~27 (males present)	1.7 birds
Broodrearing and postbreeding periods	0.0 birds
August 24~30 (fledging period)	1.3 birds

Nest density in the Kadleroshilik area was 0.3 per square kilometer, while the density of birds ranged from 0.0-1.7 per square kilometer. Prenesting and nesting spectacled eiders are most commonly found on large shallow lakes with emergent sedges and grasses and low islands (Larned and Balogh, 1997).

(d) Staging and Fall Migration

Flocks of spectacled eiders staging before migration are expected in offshore waters beyond the barrier islands from late June to September, although the numbers generally are unknown. Average breeding season density of 0.4 birds per square kilometer in the Kadleroshilik River area in 1994 (TERA, 1995b), the low numbers of birds counted on aerial surveys (estimated population index = 61 in the area between Harrison and Mikkelsen Bays; Stehn and Platte, 2000), and relatively low proportion of locations of satellite-tagged birds in the Beaufort Sea, may suggest that fewer than 200 birds occupied the area from Foggy Island Bay to Prudhoe Bay. Although as a result, we typically would expect relatively low numbers of spectacled eiders to be found in offshore waters in the Liberty area during the staging/migration period in early June to September, these observations may underestimate numbers, because the limited aerial surveys may not accurately represent use of the entire area, and a substantial proportion of the “unidentified” eiders may have been spectacled. Observations made offshore by Divoky (1984) suggested that larger flocks may contain hundreds of individuals of this species; he found the largest sitting flocks to contain more than 100 birds and flying flocks more than 300 individuals.

Most male spectacled eiders depart the nesting areas from early June to early July, typically soon after females begin incubating, on average June 22 (±11 days). They migrate a median distance of 6.6 kilometers (average = 10.1 kilometers) offshore (Petersen, Larned, and Douglas, 1999). Locations of satellite transmitter-equipped males in the Beaufort Sea have been primarily in the western Harrison Bay and western Simpson Lagoon areas. Initial locations for many of these tagged individuals have been in the Chukchi Sea, suggesting they migrate overland or only occupy the Beaufort Sea briefly (TERA, 1999). For some individuals, however, the Beaufort Sea may be an important staging and migration route (Petersen, Larned, and Douglas, 1999).

After nesting, spectacled eider females with broods leave coastal plain broodrearing sites (lakes), on average August 29 (±10.5 days). However, because females leave the nesting area after failing to breed or experiencing nest failure or brood loss, which may occur at different stages of the breeding period, they depart over an extended period from the third week of June through the end of August (TERA, 1999). Locations of females with satellite-transmitters indicate they stage and migrate in the Beaufort Sea and, like some males, use Harrison Bay. Half the tagged females were relocated twice in the Beaufort Sea, indicating a residence time of at least 4 days. Aerial surveys in late August 1999 recorded four spectacled eiders, a female with two young and an individual of unspecified sex in western Harrison Bay (USDOI, Fish and Wildlife Service, 1999, pers. commun.). Although satellite-tagged females have been relocated more than 40 kilometers offshore in the Beaufort Sea (TERA, 1999), the median distance for migrating individuals is 16.5 kilometers (average = 21.8 kilometers) offshore (Petersen, Larned, and Douglas, 1999).

(e) Critical Habitat

The U.S. Department of the Interior, Fish and Wildlife Service has proposed to designate approximately 32,336 square kilometers (12,484 square miles) of the North Slope and marine waters within 40 kilometers of the mainland (26,088 square kilometers; 10,073 square miles) as critical habitat (65 *FR* 6114). Within this area, habitats considered essential to the conservation of the species include all deep waterbodies, all waterbodies that are part of basin wetlands, all permanently flooded wetlands, waterbodies containing the plants *Carex aquatilis* (sedge) or *Arctophila fulva* (grass), and all habitat immediately surrounding such areas. Proposed marine waters include flora and fauna in the water column and the underlying bottom community. Spectacled eiders are bottom feeders, presumably capable of diving to depths of 70 meters (the depth of water in the Bering Sea wintering area) (Petersen, Piatt, and Trust, 1998).

(3) Steller's Eider

Because the usual distribution of Steller's eiders only marginally extends east of Prudhoe Bay, and relatively few recent observations have been made east of the Colville River, this species is not expected to be found nesting in the Liberty area.

b. Threatened and Endangered Species Along the Marine Transportation Route

Many of the species found along southern and Far East tanker transportation routes were described in the Cook Inlet Planning Area Oil and Gas Lease Sale 149 Final EIS (USDOI, MMS, Alaska OCS Region, 1996), the Northeast National Petroleum Reserve-Alaska Final Integrated Activity Plan Final EIS (USDOI, BLM and MMS, 1998), the Beaufort Sea Planning Area Oil and Gas Lease Sale 144 Final EIS (USDOI, MMS, 1996a), and the biological evaluations for the consultation for those projects. This section describes additional listed and proposed listed species and critical habitat identified by the Fish and Wildlife Service and the National Marine Fisheries Service along the transportation route that were not included in the previous consultations or EIS's.

(1) Birds

(a) Marbled Murrelet

The marbled murrelet is listed as a threatened species in Washington, Oregon, and California. It is a small seabird that forages in the nearshore marine environment and nests in large trees in coniferous forests. The marbled murrelet population in Washington, Oregon, and California nests in most of the major types of coniferous forests in the western portions of these states, wherever older forests remain inland of the coast. For nesting habitat to be accessible to marbled murrelets, it must be close enough to the marine environment for murrelets to fly back and forth. This species was discussed in previous Endangered Species Act consultations for Cook Inlet Oil and Gas Lease Sale 149 and Gulf of Alaska/Yakutat Planning Area Oil and Gas Lease Sale 158. It is addressed in this EIS to include critical habitat, which was designated for the species on May 24, 1996 (61 *FR* 26255). Only the terrestrial habitat has been designated as critical habitat. No critical habitat has been designated in the marine environment for this species.

(b) Western Snowy Plover

The western snowy plover is listed as a threatened species along the Pacific coast. This species was discussed in previous Endangered Species Act consultations for Cook Inlet Oil and Gas Lease Sale 149 and Gulf of Alaska/Yakutat Planning Area Oil and Gas Lease Sale. It is addressed in this EIS to include designation of critical habitat, which was proposed for the species on March 2, 1995 (60 *FR* 11767) and subsequently designated on January 6, 2000 (64 *FR* 68507). The Pacific coast population of the western snowy plover breeds in loose colonies primarily on coastal beaches from southern Washington to southern Baja California, Mexico. This habitat is unstable because of unconsolidated soils, high winds, storms, wave action, and colonization by plants. Sand spits, dune-backed beaches, unvegetated beach strands, open areas around estuaries, and beaches around river mouths are the preferred coastal habitats for nesting. Other less common nesting habitat includes salt pans, coastal dredged spoil disposal sites, dry salt ponds, and salt-pond levees and islands. The breeding season extends from early March to late September. In winter, plovers are found on many of the beaches used for nesting but they also are found on beaches not used for nesting. In Washington, the main wintering location is Leadbetter Point in Willapa Bay. In California, the majority of wintering plovers concentrate on sand spits and dune-backed beaches, but some also occur on urban and bluff-backed beaches, which are rarely used for nesting. The wintering season extends roughly from October to February but often overlaps the nesting season to some extent.

Two sites are designated as critical habitat in Washington—Leadbetter Point in Willapa Bay in Pacific County and Damon Point in Grays Harbor County. In Oregon, designated critical habitat includes Bayocean Spit in Tillamook County, Heceta Head to Sutton Creek and Siltcoos River North in Lane County, Siltcoos River to Threemile Creek in Lane and Douglas Counties, Umpqua River to Horsfall Beach in Douglas and Coos Counties, Horsfall Beach to Coos Bay in Coos County, and Bandon Park to Floras Lake in Coos and Curry Counties. In California, designated critical habitat includes Humboldt Coast Lagoon Beaches (Stone Lagoon, Big Lagoon) and Eel River Beaches (Eel River North, Eel River South) in Humboldt County, portions of Bodega Bay (Bodega Harbor and Doran Spit) in Sonoma County, Dillon Beach in Marin County, Half Moon Bay Beaches in San Mateo County, portions of Santa Cruz Coast Beaches (Waddell Creek, Scott Creek, Laguna Creek, and Wilder Creek) in Santa Cruz County, portions of Monterey Bay Beaches in Santa Cruz and Monterey Counties (Sunset, Mudowski, Salinas River, Fort Ord/Seaside and Point Sur beaches and Elkhorn slough), Arroyo Hondo Creek Beach, Arroyo Laguna Creek Beach, and portions of Morro Bay Beaches (Toro Creek, Atascadero, Morro Bay) in San Luis Obispo County, Pismo Beach/Nipomo Dunes in San Luis Obispo and Santa Barbara Counties, Point Sal to Point Conception Beaches and Santa Barbara Coast Beaches in Santa Barbara County (Santa Ynez River mouth/Ocean, Jalama, Devereaux, Harbor, and Carpinteria), Oxnard Lowlands (San Buenaventura, Mandalay Bay/Santa Clara River Mouth, Ormond, Mugu) and San Nicolas Island Beaches in Ventura County, Malibu Lagoon in Los Angeles County, and Mission Beach and Bay and South San Diego Coast Beaches (Silver Strand/Delta Beach and Tijuana River Beach) in San Diego County (64 *FR* 68507).

(c) Short-tailed Albatross

The short-tailed albatross was proposed for listing as endangered in the United States on November 2, 1998 (63 *FR* 58692) and subsequently listed as endangered on August 30, 2000 (65 *FR* 46643). This species previously was listed as endangered throughout its range except in the U.S. Short-tailed albatrosses range throughout the North Pacific Ocean and north into the Bering Sea during the nonbreeding season. Occasional sightings of this albatross in the Gulf of Alaska have been reported in recent decades (Hasegawa and DeGange, 1982; Sherburne, 1993). Breeding colonies are limited to two Japanese islands, Torshima and Minami-kojima. Currently, the world population of this species is estimated at approximately 1,200 individuals, with approximately 600 breeding-age birds (65 *FR* 46643). There are no breeding populations of short-tailed albatrosses in the United States, but several individuals have been observed regularly during the breeding season on Midway Atoll in the northwestern Hawaiin Islands. The short-tailed albatross is a surface feeder and is more often observed in coastal areas than other albatross species. Based on the historical record, it is reasonable to assume that individuals of this North Pacific species occasionally may be present in the vicinity of tanker routes through the Gulf of Alaska and along the northeast Pacific coast.

(2) Fishes

There are a number of Evolutionarily Significant Units (ESU's) of salmon that may occur in waters of Washington, Oregon, and California along the oil-transportation route from Alaskan ports to U.S. ports on the Pacific coast. An ESU is a population of the species that is considered distinct, frequently because it is substantially reproductively isolated from other population units of that species. Salmon in these ESU's that occur along the transportation route have been proposed for listing as either threatened or endangered by the National Marine Fisheries Service and, thus, are included in this EIS. In addition, the bull trout, which was proposed for listing as threatened by the Fish and Wildlife Service on June 10, 1998, is included.

(a) Chinook Salmon

Information on chinook salmon was taken from the March 9, 1998, *Federal Register* (63 *FR* 11481). Chinook salmon are easily distinguished from other salmonid species by their large size. Adults weighing more than 120 pounds have been caught in North American waters. Chinook salmon are anadromous and migrate as adults from a marine environment into their natal freshwater streams and rivers, where they spawn and die. Adult female chinook prepare a spawning bed, called a redd, in a stream area with suitable gravel composition, water depth, and velocity. Redds vary widely in size and in location within the stream or river. The adult female chinook may deposit eggs in 4-5 "nesting pockets" within a single redd. After laying eggs in a redd, adult chinook will guard the redd from 4-25 days before they die. Chinook salmon eggs will hatch, depending on water temperatures, between 90-150 days after deposition. Stream flow, gravel quality, and silt load all significantly influence the survival of developing chinook salmon eggs. Juvenile chinook may spend from 3 months to 2 years in freshwater after emergence and before migrating to estuarine areas as smolts and then into the ocean to feed and mature. Chinook salmon remain at sea for 1-6 years (more commonly 2-4 years), with the exception of a small proportion of yearling males (called jack salmon), which mature in freshwater or return after 2-3 months in saltwater.

Two distinct races of chinook salmon have evolved, "stream type" and "ocean type." The stream-type chinook is found most commonly in headwater streams. They have a longer freshwater residency and make extensive offshore migrations before returning to their natal streams in the spring or summer months. Juveniles of stream-type chinooks are more dependent on freshwater stream ecosystems because of their extended residence in these areas. Stream-type (yearling) smolts are larger than their ocean-type (subyearling) counterparts when they enter saltwater and are able to move offshore relatively quickly. The ocean-type chinook commonly is found in coastal streams. They typically migrate to sea within the first 3 months of emergence but may spend up to a year in freshwater before emigration. They also spend their ocean life in coastal waters. Ocean-type chinook salmon return to their natal rivers or streams as spring, winter, fall, summer, and late-fall runs, but summer and fall runs predominate. Juveniles of ocean-type chinook salmon use estuaries and coastal areas more extensively for rearing.

Chinook salmon on the west coast of the United States have experienced declines in abundance in the past several decades as a result of loss, damage, or change to their natural environment. Forestry, agriculture, mining, and urbanization have degraded, simplified, and fragmented habitat. Water diversions for agriculture, flood control, domestic use, and hydropower purposes (especially in the Columbia River and Sacramento-San Joaquin basins) have greatly reduced or eliminated historically accessible habitat and degraded remaining habitat. An estimated 80-90% of the historic riparian habitat has been eliminated in most Western states. Wetlands in Washington and Oregon are estimated to have diminished by one-third, while California has had a 91% loss of its wetland habitat. Loss of habitat complexity and habitat fragmentation also has contributed to the decline of chinook salmon. Sedimentation from extensive and intensive land use activities (timber harvests, road building, livestock grazing, and urbanization) is recognized as a primary cause of habitat degradation in the range of west coast chinook salmon.

Other factors besides degradation of aquatic and riparian ecosystems may have contributed to the decline of these salmonids, including overfishing. Also, increased predator populations from the introduction of nonnative species and habitat modifications significantly may influence salmonid abundance in some local populations, when other prey are absent and physical conditions lead to the concentration of adults and juveniles. Infectious disease can influence adult and juvenile chinook-salmon survival as a result of exposure to numerous bacterial, protozoan, viral, and parasitic organisms in spawning and rearing areas, hatcheries, migratory routes, and the marine environment. Scientific studies indicate that chinook salmon may be more susceptible to disease organisms than other salmonids. Habitat conditions such as low waterflows and high temperatures can exacerbate susceptibility to disease. Abundance and survival of west coast chinook salmon and the quality of their habitat also are affected by a variety of Federal, State, tribal, and local laws, regulations, and treaties that, in many cases, are not adequate to protect them. Extensive hatchery programs have been implemented throughout the range of west coast chinook salmon and have strongly influenced chinook salmon populations in some ESU's. Hatchery programs intended to compensate for habitat losses likely have masked declines in natural stocks.

1) Upper Columbia River Spring-Run Chinook Salmon

This ESU of chinook salmon was proposed for listing as endangered on March 9, 1998 (63 *FR* 11481) and subsequently listed as endangered on May 24, 1999 (64 *FR* 14307). This ESU includes stream-type chinook salmon spawning above Rock Island Dam in the Wenatchee, Entiat, and Methow rivers. Chinook salmon in the Okanogan River apparently are ocean type and are considered part of the Upper Columbia River summer and fall run ESU.

Rivers in this ESU drain the east slopes of the Cascade Range and are fed primarily by snowmelt. The waters tend to be cooler and less turbid than the Snake and Yakima rivers to the south. Although these fish appear to be closely related genetically to stream-type chinook salmon in the Snake River, there are substantial ecological differences between the Snake and Columbia rivers, particularly in the upper tributaries favored by stream-type chinook salmon.

Hatchery programs have had a considerable influence on this ESU, either through hatchery-based enhancement or the extensive trapping and transportation activities associated with the Grand Coulee Fish-Maintenance Project (GCFMP) from 1939-1943. During the GCFMP, all spring chinook salmon reaching Rock Island Dam, including those destined for areas above Grand Coulee Dam, were collected and they or their progeny were dispersed into streams in this ESU. Some ocean-type fish undoubtedly also were incorporated into this program. Spring run escapements to the Wenatchee, Entiat, and Methow rivers were severely depressed before the project but increased considerably in subsequent years, suggesting that the effects of the program may have been substantial. It is probable that the majority of returning spring run adults trapped at Rock Island Dam for use in the GCFMP were probably not native to these three rivers. Widespread transplants of Carson stock spring chinook salmon (derived from a mixture of Columbia River and Snake River stream-type chinook salmon) also have contributed to erosion of the genetic integrity of this ESU.

In spite of considerable homogenization, this ESU still represents an important genetic resource, in part because it presumably contains the last remnants of the gene pools for populations from the headwaters of the Columbia River. Hatchery efforts have recently focused on supplementing naturally spawning populations in this ESU. The potential exists for hatchery-derived nonnative stocks to genetically impact naturally spawning populations, especially given the recent low numbers of fish returning to rivers in this ESU.

The risks associated with interactions between wild and hatchery chinook salmon are a concern.

Access to a substantial portion of historical habitat was blocked by the Chief Joseph and Grand Coulee dams. There are local habitat problems related to irrigation diversions and hydroelectric development and degraded riparian and instream habitat from urbanization and livestock grazing. Hydroelectric development on the mainstem Columbia River has resulted in a major disruption of migration corridors and affected flow regimes and estuarine habitat. Some populations in this ESU must migrate through nine mainstem dams.

Previous assessments of stocks within this ESU have identified several as being at risk or of concern. Nine stocks within the ESU were considered, eight of which were considered to be of native origin and predominantly natural production. The status of all nine stocks was considered depressed. Populations in this ESU have experienced record low returns for the last few years. Six stocks were identified as extinct. Because of a lack of information on chinook salmon stocks that are presumed to be extinct, the relationship of these stocks to existing ESU's is uncertain.

Recent total abundance of this ESU is quite low, with escapements in 1994-1996, the lowest in at least 60 years. Almost all of the remaining naturally spawning populations are small, with fewer than 100 spawners. In addition, both recent and long-term trends in abundance are downward. The National Marine Fisheries Service concluded that chinook salmon in this ESU are in danger of extinction.

Critical habitat, if designated, could include all river reaches accessible to chinook salmon in Columbia River tributaries upstream of the Rock Island Dam and downstream of the Chief Joseph Dam in Washington, excluding the Okanogan River. Also included are river reaches and estuarine areas in the Columbia River from a straight line connecting the west end of the Clatsop jetty (south jetty, Oregon side) and the west end of the Peacock jetty (north jetty, Washington side) upstream to the Chief Joseph Dam in Washington. Excluded are areas above specific dams identified in the March 9, 1998, *Federal Register* (63 *FR* 11481) or above long-standing, naturally impassable barriers (natural waterfalls in existence for at least several hundred years).

2) Central Valley California Spring-Run Chinook Salmon

This ESU of chinook salmon was proposed for listing as endangered on March 9, 1998 (63 *FR* 11481) and subsequently listed as threatened on September 16, 1999 (64 *FR* 50393). This ESU includes chinook salmon that enter the Sacramento River and its tributaries from March to July and spawn from late August through early October, with a peak in September. Mill and Deer creeks and possibly Butte Creek (tributaries to the Sacramento River) are the only streams considered to have wild spring run chinook salmon, and these are relatively small populations with sharply declining trends. Demographic and genetic risks due to small population sizes are thus considered to be high. Historically, spring chinook salmon were the dominant run in the Sacramento and San Joaquin River basins, which represents a large portion of the historic range and abundance of the ESU. However, native populations in the San Joaquin River and its tributaries apparently have all been extirpated.

Spring-run fish in the Sacramento River exhibit an ocean-type life history, emigrating as fry, subyearlings, and yearlings. Recoveries of hatchery chinook salmon indicate that salmon from this ESU are found primarily in coastal waters off California and Oregon. There were minimal differences in the ocean distribution of fall- and spring-run fish from the Feather River Hatchery; however, due to hybridization that may have occurred in the hatchery between these two runs, this similarity in ocean migration may not be representative of wild runs. Substantial ecological differences in the historical spawning habitat for spring-run versus fall- and late-fall-run fish have been recognized. The timing of the spring chinook salmon run was suited to gaining access to the upper reaches of river systems (up to 1,500 meters in elevation) before the onset of prohibitively high water temperatures and low flows that inhibit access to these areas during the fall. Differences in adult size, fecundity, and smolt size also occur between spring- and fall/late-fall-run chinook salmon in the Sacramento River.

Habitat problems are the most important source of ongoing risk to this ESU. Spring run fish cannot access most of their historical spawning and rearing habitat in the Sacramento and San Joaquin River basins due to impassable dams, and spawning currently is restricted to the mainstem and a few river tributaries in the Sacramento River. The remaining spawning habitat accessible to fish is severely degraded. Collectively, these habitat problems greatly reduce the resiliency of this ESU to respond to additional stresses in the future. The general degradation of conditions in the Sacramento River Basin (including elevated water temperatures, agricultural and municipal diversions and returns, restricted and regulated flows, entrainment of migrating fish into unscreened or poorly screened diversions, and the poor quality and quantity of remaining habitat) has severely impacted important juvenile rearing habitat and migration routes.

There appears to be threats to genetic integrity posed by hatchery programs in the Central Valley. Most of the spring-run chinook salmon production in the Central Valley is of hatchery origin, and naturally spawning populations may be interbreeding with both fall/late-fall- and spring-run hatchery fish. This problem is exacerbated by the increasing production of spring chinook salmon from the Feather River and Butte Creek hatcheries, with reports suggesting a high degree of mixing between spring- and fall/late-fall- run broodstock in the hatcheries. Hatchery strays are considered to be an increasing problem because of the management practice of releasing a larger proportion of fish into the Sacramento River Delta and San Francisco Bay.

Four stocks have been identified as extinct (spring/summer-run chinook salmon in the American, McCloud, Pit, and San Joaquin) and two stocks (spring-run chinook salmon in the Sacramento and Yuba rivers) have been identified as being at a moderate risk of extinction.

As discussed, habitat problems were considered to be the most important source of ongoing risk to this ESU. However, the National Marine Fisheries Service also is quite concerned about threats to genetic integrity posed by hatchery programs in the Central Valley and related harvest regimes that may not be allowing recovery of this at-risk population. Based on this risk, the National Marine Fisheries Service concluded that chinook salmon in this ESU are in danger of extinction.

Critical habitat, if designated, could include all river reaches accessible to chinook salmon in the Sacramento River and its tributaries in California. Also included are river reaches and estuarine areas of the Sacramento-San Joaquin Delta, all waters from Chipps Island westward to Carquinez Bridge, including Honker Bay, Grizzly Bay, Suisun Bay, and Carquinez Strait, all waters of San Pablo Bay westward of the Carquinez Bridge, and all waters of San Francisco Bay (north of the San Francisco/Oakland Bay Bridge) from San Pablo Bay to the Golden Gate Bridge. Excluded are areas above specific dams identified in the March 9, 1998, *Federal Register* (63 *FR* 11481) or above long-standing, naturally impassable barriers (natural waterfalls in existence for at least several hundred years).

3) Southern Oregon and California Coastal Chinook Salmon

This ESU of chinook salmon was proposed for listing as threatened on March 9, 1998 (63 *FR* 11481). This ESU includes all naturally spawned coastal spring and fall chinook salmon spawning from Cape Blanco (inclusive of the Elk River) to the southern extent of the current range for chinook salmon at Point Bonita (the northern landmass marking the entrance to San Francisco Bay). Chinook salmon spawn in several small tributaries to San Francisco Bay; however it is uncertain whether these small populations are part of this ESU or wanderers from Central Valley chinook salmon ESU's.

This ESU was subsequently split into a revised ESU (California Coastal chinook salmon ESU) consisting of California coastal populations from Redwood Creek (Humboldt County) south through the Russian River and subsequently listed as threatened on September 16, 1999 (64 *FR* 50393). Other coastal populations to the north of this ESU (and originally proposed as threatened) are now considered part of a separate Southern Oregon and Northern California Coastal chinook salmon ESU that does not warrant listing at this time. The reconfiguration of the original proposed ESU was based on a number of issues, including genetic differences, ecological differences, and migration patterns.

Chinook salmon in this ESU exhibit an ocean-type life history, and ocean distribution is predominantly off the California and Oregon coasts. Life-history information on smaller populations, especially in the southern portion of the ESU, is extremely limited. Additionally, there is limited information on abundance of several spring run populations including, the Chetco, Winchuck, Smith, Mad, and Eel rivers. This ESU is genetically distinguishable from the Oregon Coast, Upper Klamath and Trinity River, and Central Valley ESU's. Life-history differences exist between spring- and fall-run fish in this ESU, but not to the same extent as observed in larger inland basins. In the California Coastal chinook salmon ESU, fall chinook salmon occur in relatively low numbers in northern streams and, only sporadically, in streams in the southern portion of the ESU's range.

The majority of the river systems in this ESU are relatively small and heavily influenced by the maritime climate. Low summer flows and high temperatures in many rivers result in seasonal physical and thermal barrier bars that block the movement of anadromous fish. The Rogue River is the largest river basin in this ESU and extends inland into the Sierra Nevada and Cascades regions.

The spawning abundance of chinook salmon in this ESU is highly variable among populations, with populations in California and spring-run chinook salmon throughout the ESU being of particular concern. There is a general pattern of downward trends in abundance in most populations for which data are available, with declines being especially pronounced in spring-run populations. The extremely depressed status of almost all coastal populations south of the Klamath River is an important source of risk to the ESU. The National marine Fisheries Service has a general concern that no current information is available for many river systems in the southern portion of this ESU, which historically maintained numerous large populations. Although these California coastal populations do not form a separate ESU, they represent a considerable portion of genetic and ecological diversity within this ESU.

Habitat loss and/or degradation is widespread throughout the range of the ESU. Habitat blockages and fragmentation, logging and agricultural activities, urbanization, and water withdrawals were reported as the most predominant problems for anadromous salmonids in California's coastal basins. Habitat problems have been identified for each major river system in California. The most vital habitat factor for coastal California streams was degradation because of improper logging followed by massive siltation, log jams, etc. Road building was cited as another cause of siltation in some areas. A variety of specific critical habitat problems were identified in individual basins, including extremes of natural flows (Redwood Creek and Eel River), logging practices (Mad, Eel, Mattole, Ten Mile, Noyo, Big, Navarro, Garcia, and Gualala rivers), and dams with no passage facilities (Eel and Russian rivers), and water diversions (Eel and Russian rivers). Such problems also occur in Oregon streams within the ESU. The Rogue River Basin in particular has been affected by mining activities and unscreened irrigation diversions in addition to the problems resulting from logging and dam construction. One-third of spring chinook salmon-spawning habitat in the Rogue River was estimated to be inaccessible following the construction of Lost Creek Dam in 1977. Major flood events in 1996 and 1997 probably affected habitat quality and survival of juveniles within this ESU. Although the National Marine Fisheries Service has little information on the effects of these floods on this ESU, effects probably are similar to those discussed in the following subsections for the Oregon and Washington Coastal Region.

Hatchery programs in the Southern Oregon and Coastal California ESU are less extensive than those in Klamath/Trinity or Central Valley ESU's. The Rogue, Chetco, and Eel river basins and Redwood Creek have received considerable releases, derived primarily from local sources. Current hatchery contribution to overall abundance is relatively low except for the Rogue River spring run. The hatchery-to-total run ratio of Rogue River spring chinook salmon, as measured at Gold Ray Dam, has exceeded 60% in some years.

Previous assessments of stocks within this ESU have identified nine stocks as being at risk or of concern. The fall chinook salmon in the Rogue River was the only relatively healthy population identified in this ESU.

There is a pattern of downward trends in abundance in most populations within this ESU for which data are available, with declines being especially pronounced in the spring-run populations. There is a high degree of uncertainty regarding the status of these populations because of the lack of population monitoring. The National Marine Fisheries Service concluded that the extremely depressed status of most coastal populations south of the Klamath River is an important source of risk to the ESU. They further concluded that the California Coastal chinook salmon ESU is likely to become endangered in the foreseeable future.

Critical habitat is not yet determinable for these ESU's and the deadline for designating critical habitat has been extended for no more than 1 year until the required assessments can be made.

4) Central Valley Fall/Late-Fall Run Chinook Salmon

This ESU of chinook salmon was proposed for listing as threatened on March 9, 1998 (63 *FR* 11481). It was subsequently determined on September 16, 1999, that listing is not warranted at this time but the species will be considered as a candidate species (64 *FR* 50393). This ESU includes fall and late-fall chinook salmon that enter the Sacramento and San Joaquin rivers and their tributaries from July through April and spawn from October through February. Both runs are ocean-type chinook salmon, emigrating predominantly as fry and subyearlings and remaining off the California coast during their ocean migration.

Sacramento/San Joaquin Basin chinook salmon are genetically and physically distinguishable from all other coastal forms. There were also a number of life-history differences noted between Sacramento and San Joaquin river basin fall/late-fall-run populations. San Joaquin River populations tend to mature at an earlier age and spawn later in the year than Sacramento River populations. These differences could be due to the generally warmer temperature and lower flow conditions found in the San Joaquin River Basin relative to the Sacramento River Basin. There was no apparent difference in the distribution of marine recoveries from Sacramento and San Joaquin river hatchery populations, nor are there major genetic differences between Sacramento and San Joaquin river-fall/late-fall-run populations.

Although total population abundance in this ESU is relatively high, perhaps near historic levels, the National Marine Fisheries Service identified several concerns regarding its status. They concluded a large proportion of the historic range of this ESU is severely degraded, because the abundance of natural fall chinook salmon in the San Joaquin River Basin is low. Habitat blockage is not as severe for fall/late-fall-run chinook salmon as it is for winter- and spring-run chinook salmon in this region, because most of the fall/late-fall run spawning habitat was below dams constructed in the region. However, there has been a severe degradation of the remaining habitat, especially due to agricultural and municipal water-use activities in the Central Valley (which result in pollution, elevated water temperatures, diminished flows, and smolt and adult entrainment into poorly screened or unscreened diversions). Additionally, stray rates are high, because many hatchery fish are released off station to avoid adverse river conditions, resulting in a much larger proportion of hatchery chinook salmon present in the natural spawning population.

Some of the Sacramento and San Joaquin river basin tributaries are showing recent, short-term increases in abundance. However, the streams supporting natural runs considered to be the least influenced by hatchery fish have the lowest abundance and the most consistently negative trends of all populations in the ESU. In general, high hatchery production and infrequent monitoring of natural production make the assessment of natural production difficult, resulting in uncertainty in assessing the status of this ESU.

Other concerns about salmon in this ESU are the high ocean and freshwater harvest rates in recent years, which may be higher than is sustainable by natural populations given the productivity of the ESU under present habitat conditions. The mixed-stock ocean salmon off California fisheries are managed to achieve spawning escapement goals for two main indicator stocks, the Sacramento River fall chinook and Klamath River fall chinook. Harvest may be further constrained to meet the National Marine Fisheries Service's Endangered Species Act requirements for listed species, including Sacramento River winter chinook, Central California Coastal and Southern Oregon/Northern California coho, and Snake River fall chinook. Since 1993, addressing Indian fishing rights in the Klamath River Basin has required significant reductions in the ocean harvest rate on Klamath River fall chinook. Because of the need to constrain ocean harvest rates on Klamath River fall chinook, commercial fisheries have not been allowed to harvest Central Valley stocks to the extent that would be permitted by the management goal for Sacramento River fall chinook alone (122,000-180,000 adult hatchery and natural spawners). Spawning escapements have been well above the goal range in recent years. A record number of adults (324,000) returned in 1997.

Two stocks in this ESU (San Joaquin and Cosumnes river stocks) have been identified as being of special concern. Even though total population abundance in this ESU is relatively high, the abundance of natural fall chinook salmon in the San Joaquin River Basin is low. Habitat problems were considered to be the most important source of ongoing risk to this ESU, although the National Marine Fisheries Service is extremely concerned about threats to genetic integrity posed by hatchery and harvest programs related to fall/late-fall-run chinook salmon. They concluded that chinook salmon in this ESU presently are not in danger of extinction but are likely to become endangered in the foreseeable future.

Critical habitat, if designated, could include all river reaches accessible to chinook salmon in the Sacramento and San Joaquin rivers and their tributaries in California. Also included are river reaches and estuarine areas of the Sacramento-San Joaquin Delta, all waters from Chipps Island westward to Carquinez Bridge, including Honker Bay, Grizzly Bay, Suisun Bay, and Carquinez Strait, all waters of San Pablo Bay westward of the Carquinez Bridge, and all waters of San Francisco Bay (north of the San Francisco/Oakland Bay Bridge from San Pablo Bay to the Golden Gate Bridge). Excluded are areas upstream of the Merced River and areas above specific dams identified in the March 9, 1998, *Federal Register* (63 *FR* 11481) or above long-standing, naturally impassable barriers (natural waterfalls in existence for at least several hundred years).

5) Puget Sound Chinook Salmon

This ESU of chinook salmon was proposed for listing as threatened on March 9, 1998 (63 *FR* 11481) and subsequently listed as threatened on May 24, 1999 (64 *FR* 14307). This ESU encompasses all naturally spawned spring-, summer-, and fall-runs of chinook salmon in the Puget Sound region from the North Fork Nooksack River to the Elwha River on the Olympic Peninsula, inclusive. Chinook salmon in this area all exhibit an ocean-type life history. Although some spring run chinook salmon populations in the Puget Sound ESU have a high proportion of yearling smolt emigrants, the proportion varies substantially from year to year and appears to be environmentally mediated rather than genetically determined. Puget Sound stocks all tend to mature at ages 3 and 4 and exhibit similar, coastally oriented, ocean migration patterns. There are substantial ocean distribution differences between Puget Sound and Washington coast stocks, with recoveries of Washington coastal chinook found in much larger proportions from Alaskan waters. The marine distribution of Elwha River chinook salmon most closely resembled other Puget Sound stocks rather than Washington coast stocks.

The boundaries of the Puget Sound ESU correspond generally with the boundaries of the Puget Lowland Ecoregion. Despite being in the rainshadow of the Olympic Mountains, the river systems in the western portion of Puget Sound maintain high flow rates due to the melting snowpack in the surrounding mountains. Temperatures tend to be moderated by the marine environment. The Elwha River, which is in the Coastal Ecoregion, is the only system in this ESU that lies outside the Puget Sound Ecoregion. In life-history and genetic attributes, the Elwha River chinook salmon appear to be transitional between populations from Puget Sound and the Washington Coast ESU.

Overall abundance of chinook salmon in this ESU has declined substantially from historical levels, and many populations are small enough that genetic and demographic risks are likely to be relatively high. Both long- and short-term trends in abundance are predominantly downward, and several populations are exhibiting severe, short-term declines. Spring chinook salmon populations throughout this ESU are all depressed.

Habitat throughout the ESU has been degraded. In general, upper tributaries have been impacted by forest practices, and lower tributaries and mainstem rivers have been impacted by agriculture and/or urbanization. Diking for flood control, draining and filling of freshwater and estuarine wetlands, and sedimentation resulting from forest practices and urban development are cited as problems throughout the ESU. Blockages by dams, water diversions, and shifts in flow regime due to hydroelectric development and flood-control projects are major habitat problems in several basins. A variety of important habitat issues have been identified for streams in this ESU, including changes in flow regime (all basins), sedimentation (all basins), high temperatures (Dungeness, Elwha, Green/Duwamish, Skagit, Snohomish, and Stillaguamish rivers), streambed instability (most basins), estuarine loss (most basins), loss of large woody debris (Elwha, Snohomish, and White rivers), loss of pool habitat (Nooksack, Snohomish, and Stillaguamish rivers), and blockage or passage problems associated with dams or other structures (Cedar, Elwha, Green/Duwamish, Snohomish, and White rivers). Reductions in habitat capacity and quality have contributed to escapement problems for Puget Sound chinook salmon, as shown by loss of tributary and mainstem habitat due to dams and loss of slough and side-channel habitat due to diking, dredging, and hydromodification.

Nearly 2 billion fish have been released into Puget Sound tributaries since the 1950's. Hatchery production throughout the ESU may mask trends in natural populations and make it difficult to determine whether they are self sustaining. This difficulty is compounded by the lack of data pertaining to the proportion of naturally spawning fish that are of hatchery origin. There also has been widespread use of a limited number of hatchery stocks, resulting in an increased risk of loss of fitness and diversity among populations. An estimated 11 out of 29 stocks in this ESU are being sustained, in part, through artificial propagation. The vast majority of these have been derived from local returning fall-run adults.

Returns to hatcheries have accounted for over half of the total spawning escapement, although the hatchery contribution to spawner escapement probably is much higher than that due to hatchery-derived strays on the spawning grounds. In the Stillaguamish River, summer chinook have been supplemented under a wild broodstock program for the last decade. In some years, returns from this program have comprised up to 30-50% of the natural spawners, suggesting that the unaided stock is not able to maintain itself. Almost all of the releases into this ESU have come from stocks within this ESU, with the majority of within-ESU transfers coming from the Green River Hatchery or hatchery broodstocks that have been derived from Green River stock. The pervasive use of Green River stock throughout much of the hatchery network that exists in this ESU may reduce the genetic diversity and fitness of naturally spawning populations.

Previous assessments of stocks within this ESU have identified several stocks as extinct or possibly extinct and several stocks as being at risk or of concern. Overall abundance of chinook salmon in this ESU has declined substantially from historical levels, and both long and short-term trends in abundance are predominantly downward. Several populations are exhibiting severe, short-term declines. Spring chinook salmon populations throughout this ESU are all depressed. The National Marine Fisheries Service concluded that chinook salmon in this ESU presently are not in danger of extinction but are likely to become endangered in the foreseeable future.

Critical habitat, if designated, could include all marine, estuarine, and river reaches accessible to chinook salmon in Puget Sound. Puget Sound marine areas include South Sound, Hood Canal, and North Sound to the international boundary at the outer extent of the Strait of Georgia, Haro Strait, and the Straits of Juan De Fuca to a straight line extending north from the west end of Freshway Bay, inclusive. Excluded are areas above specific dams identified in the March 9, 1998, *Federal Register* (63 *FR* 11481) or above long-standing, naturally impassable barriers (natural waterfalls in existence for at least several hundred years).

6) Lower Columbia River Chinook Salmon

This ESU of chinook salmon was proposed for listing as threatened on March 9, 1998 (63 FR 11481) and subsequently listed as threatened on May 24, 1999 (64 *FR* 14307). This ESU includes all naturally spawned chinook populations from the mouth of the Columbia River to the crest of the Cascade Range, excluding populations above Willamette Falls. Celilo Falls, which corresponds to the edge of the drier Columbia Basin Ecosystem and historically may have presented a migrational barrier to chinook salmon at certain times of the year, is the eastern boundary for this ESU. "Tule" fall chinook salmon in the Wind and Little White Salmon rivers is included in this ESU but not the introduced "upriver bright" fall chinook salmon populations in the Wind, White Salmon, and Klickitat rivers.

In addition to the geographic features mentioned above, genetic and life-history data were important factors in defining this ESU. Populations in this ESU are considered ocean type. Some spring-run populations have a large proportion of yearling migrants, but this trend may be biased by yearling hatchery releases. Subyearling migrants were found to contribute to the escapement. Recoveries for Lower Columbia River ESU populations indicate a northerly migration route but with little contribution to the Alaskan fishery. Populations in this ESU also tend to mature at age 3 and 4, somewhat younger than populations from the coastal, upriver, and Willamette ESU's. Ecologically, the Lower Columbia River ESU crosses several ecoregions—Coastal, Willamette Valley, Cascades, and East Cascades. Apart from the relatively large and apparently healthy fall-run population in the Lewis River, production in this ESU appears to be predominantly hatchery driven with few identifiable naturally spawned populations.

All basins are affected by habitat degradation. Major habitat problems primarily are related to blockages, forest practices, urbanization in the Portland and Vancouver areas, and agriculture in floodplains and low-gradient tributaries. Substantial chinook salmon-spawning habitat has been blocked or impaired in the Cowlitz, Lewis, Clackamas, Hood, and Sandy rivers.

Hatchery programs to enhance the abundance of chinook salmon fisheries in the lower Columbia River began in the 1870's, rapidly expanded, and have continued throughout this century. Although the majority of the stocks have come from within this ESU, more than 200 million fish from outside the ESU have been released since 1930. A particular concern at the present time is the straying by Rogue River fall chinook salmon, which are released into the lower Columbia River to augment harvest opportunities. Available evidence indicates a pervasive influence of hatchery fish on natural populations throughout this ESU, including both spring- and fall-run populations. In addition, the exchange of eggs between hatcheries in this ESU has led to the extensive genetic homogenization of hatchery stocks. The large numbers of hatchery fish in this ESU make it difficult to determine the proportion of naturally produced fish. In spite of the heavy impact of hatcheries, genetic and life-history characteristics of populations in this ESU differ from those in other ESU's. The loss of fitness and diversity within the ESU is an important concern.

Previous assessments of stocks within this ESU have identified several stocks as being at risk or of concern. One assessment identified two stocks as extinct (Lewis River spring run and Wind River fall run), four stocks as possibly extinct, and four stocks as a high risk of extinction. Another assessment considered 20 stocks within the ESU, of which only 2 (Lewis River and East Fork Lewis River fall runs) were considered to be of native origin, predominantly natural production, and healthy. There have been at least six documented extinctions of populations in this ESU, and it is possible that extirpation of other native populations has occurred but has been masked by the presence of naturally spawning hatchery fish. About half of the populations comprising this ESU are very small, increasing the likelihood that risks from genetic and demographic drift processes in small populations will be important. The National Marine Fisheries Service concluded that chinook salmon in this ESU presently are not in danger of extinction but are likely to become endangered in the foreseeable future.

Critical habitat, if designated, could include all river reaches accessible to chinook salmon in Columbia River tributaries between the Grays and White Salmon rivers in Washington and the Willamette and Hood rivers in Oregon, inclusive. Also included are river reaches and estuarine areas in the Columbia River from a straight line connecting the west end of the Clatsop jetty (south jetty, Oregon side) and the west end of the Peacock jetty (north jetty, Washington side) upstream to The Dalles Dam. Excluded are areas above specific dams identified in the March 9, 1998, *Federal Register* (63 *FR* 11481) or above long-standing, naturally impassable barriers (natural waterfalls in existence for at least several hundred years).

7) Upper Willamette River Chinook Salmon

This ESU of chinook salmon was proposed for listing as threatened on March 9, 1998 (63 *FR* 11481) and subsequently listed as threatened on May 24, 1999 (64 *FR* 14307). This ESU includes naturally spawned spring-run populations above the Willamette Falls. Fall chinook salmon above the Willamette Falls are introduced and, although they are naturally spawning, they are not considered a population for purposes of defining this ESU. Historic, naturally spawned populations in this ESU have an unusual life history that share features of both stream and ocean types. Scale analysis of returning fish indicate a predominantly yearling smolt life history and maturity at 4 years of age, but these data are primarily from hatchery fish and may not accurately reflect patterns for the natural fish. Young-of-year smolts have been found to contribute to the returning 3-year old year-class. The ocean distribution is consistent with an ocean-type life history, and considerable numbers of recoveries occur in the Alaskan and British Columbian coastal fisheries. Intrabasin transfers have contributed to the homogenization of Willamette River spring chinook salmon stocks; however, Willamette River spring chinook salmon remain one of the most genetically distinctive groups of chinook salmon in the Columbia River Basin.

While the abundance of Willamette River spring chinook salmon has been relatively stable over the long term and there is evidence of some natural production, it is apparent that the natural population is not replacing itself. Total abundance has been relatively stable at approximately 20,000-30,000 fish. However, recent natural escapement is fewer than 5,000 fish and has been declining sharply. Natural production accounts for only one-third of the natural spawning escapement, suggesting that the natural population is falling far short of replacing itself. While hatchery programs in the Willamette River Basin have maintained broodlines that are relatively free of genetic influences from outside the basin, they may have homogenized the population structure within the ESU. The introduction of fall-run chinook salmon into the basin and laddering of Willamette Falls have increased the potential for genetic introgression between wild spring-run and hatchery fall-run chinook salmon, but there is no direct evidence of hybridization (other than an overlap in spawning times and locations) between the two runs. Prolonged hatchery propagation of the majority of the production from this ESU also may have had deleterious effects on the ability of Willamette River spring chinook salmon to reproduce successfully in the wild.

Habitat blockage and degradation are significant problems in this ESU. Available habitat has been reduced by construction of dams in the Santiam, McKenzie, and Middle Fork Willamette river basins, and these dams probably have adversely affected remaining production through thermal effects. Agricultural development and urbanization are the main activities that have adversely affected habitat throughout the basin. Another concern is that commercial and recreational harvests are high relative to the apparent productivity of natural populations.

A previous assessment of risk to stocks in this ESU identified the Willamette River spring-run chinook salmon as of special concern due to its vulnerability to minor disturbances, the special character of this stock, and insufficient information on population trend. The National Marine Fisheries Service concluded that chinook salmon in this ESU are not presently in danger of extinction but are likely to become endangered in the foreseeable future.

Critical habitat, if designated, could include all river reaches accessible to chinook salmon in the Willamette River and its tributaries above the Willamette Falls. Also included are river reaches and estuarine areas in the Columbia River from a straight line connecting the west end of the Clatsop jetty (south jetty, Oregon side) and the west end of the Peacock jetty (north jetty, Washington side) upstream to and including the Willamette River in Oregon. Excluded are areas above specific dams identified in the March 9, 1998, *Federal Register* (63 *FR* 11481) or above long-standing, naturally impassable barriers (natural waterfalls in existence for at least several hundred years).

(b) Chum Salmon

Information on chum salmon was taken from the March 10, 1998, *Federal Register* (63 *FR* 11773). Chum salmon have the widest natural geographic and spawning distribution of any Pacific salmonid, primarily because its range extends farther along the shores of the Arctic Ocean than that of the other salmonids. Historically, chum salmon were distributed throughout the coastal regions of western Canada and the United States as far south as Monterey, California. Presently, major spawning populations are found only as far south as Tillamook Bay on the northern Oregon coast.

Chum salmon usually spawn in coastal areas, and juveniles outmigrate to seawater almost immediately after emerging from the gravel that covers their redds. This ocean-type migratory behavior contrasts with the stream-type behavior of some other species in the genus *Oncorhynchus* (for example, coastal cutthroat trout, steelhead, coho salmon, and most types of chinook and sockeye salmon), which usually migrate to sea at a larger size, after months or years of freshwater rearing. This means that survival and growth in juvenile chum salmon depend less on freshwater conditions (unlike stream-type salmonids, which depend heavily on freshwater habitats) than on favorable estuarine and marine conditions. Another behavioral difference between chum salmon and most species that rear extensively in freshwater is that chum salmon form schools, presumably to reduce predation.

Most chum salmon (95%) mature between 3 and 5 years of age, with 60-90% of the fish maturing at 4 years of age. However, a higher proportion of 5-year-old fish occurs in the north, and a higher proportion of 3-year-old fish occurs in the south.

Chum salmon usually spawn in the lower reaches of rivers typically within 100 kilometers of the ocean. Redds usually are dug in the mainstem or in side channels of rivers. In some areas (such as in Alaska), they typically spawn where upwelled groundwater percolates through the redds. During the spawning migration, adult chum salmon enter natal river systems from June to March, depending on characteristics of the population or geographic location. Migration timing is used to distinguish anadromous populations of chum salmon as summer versus fall or early fall versus late fall. In Washington, a variety of seasonal runs are recognized, including summer, fall, and winter populations, with fall-run fish being predominate. Summer runs are found in Hood Canal, the Strait of Juan de Fuca, and in southern Puget Sound; and winter-run fish are found in only two rivers, both in southern Puget Sound.

1) Columbia River Chum Salmon

This ESU of chum salmon was proposed for listing as threatened on March 10, 1998 (63 FR 11773) and subsequently listed as threatened on May 24, 1999 (64 *FR* 14307). Historically, chum salmon were abundant in the lower reaches of the Columbia River and may have spawned as far upstream as the Walla Walla River (more than 500 kilometers inland). Today, only remnant chum salmon populations exist, all in the lower Columbia River.

The Columbia River historically had large runs of chum salmon that supported a substantial commercial fishery in the first half of the twentieth century. There presently are neither recreational nor directed commercial fisheries for chum salmon in the Columbia River, although some chum salmon are taken incidentally in the gillnet fisheries for coho and chinook salmon and there has been some recreational harvest in some tributaries. Returns of chum salmon to three streams in the Columbia River suggest that there may be a few thousand, perhaps up to 10,000 chum salmon spawning annually in the Columbia River basin. On the Oregon side of the Columbia River, 23 spawning populations have been identified, but no estimate of the number of spawners in these populations is available. Current abundance probably is less than 1% of historical levels, and the ESU undoubtedly has lost some of its original genetic diversity. These populations may have been influenced by hatchery programs and/or by introduced stocks, but information on hatchery-wild interactions is unavailable.

A number of factors may threaten naturally reproducing chum salmon throughout its range, including destruction, modification, or curtailment of its habitat or range; overuse for commercial, recreational, scientific, or education purposes; disease or predation; inadequacy of existing regulatory mechanisms; and other natural or human-caused factors.

The present depressed condition of many populations is the result of several long-standing, human-induced factors, including habitat degradation, water diversions, harvest, and artificial propagation, that are additive to the adverse effects of natural factors, such as competition and predation, or environmental variability from such factors as drought and poor ocean conditions. Among habitat losses documented by the National Marine Fisheries Service, those with the most impact on chum salmon include:

- water withdrawal, conveyance, storage, and flood control (resulting in insufficient flows, stranding, juvenile entrainment, and instream temperature increases);
- logging and agriculture (loss of large woody debris, sedimentation, loss of riparian vegetation, habitat simplification);
- mining (especially gravel removal, dredging, pollution); and
- urbanization (stream channelization, increased runoff, pollution, habitat simplification).

Many spill dams and other small hydropower facilities were constructed in lower river areas, and the Bonneville Dam presumably continues to impede recovery of upriver populations. Substantial habitat loss in the Columbia River estuary and associated areas presumably was an important factor in the decline and also represents a significant continuing risk for this ESU. Because chum salmon generally spend only a short time relative to other salmonids in streams and rivers before migrating downstream to estuarine and nearshore marine habitats, the survival of early life-history stages depends more on the health and ecological integrity of estuaries and nearshore environments than it does for most other Pacific salmon. Habitat loss in the estuarine or nearshore marine environment is difficult to quantify, because there are few historical studies that include baseline information and these studies encompass a variety of classification methods and several time intervals to measure change.

Besides habitat degradation, other concerns include overutilization, disease, predation, existing regulatory mechanisms, and other natural or human-caused factors. Chum salmon have been targeted for commercial and recreational fisheries throughout their range. Incidental harvest in salmon fisheries in the Strait of Juan de Fuca and coho salmon fisheries in Hood Canal are considered to be a significant threat for the Hood Canal summer-run ESU. There is no clear evidence that disease poses a risk factor, but predation has been identified as a risk factor. Existing regulatory mechanisms may not provide adequate protection for this species. Climatic conditions are known to have changed recently in the Pacific Northwest. Most Pacific salmonids south of British Columbia have been affected by changes in ocean production that occurred during the 1970's. Hatcheries in the U.S. Pacific Northwest have produced chum salmon to increase harvest and rebuild depleted runs for almost 100 years. Potential problems associated with hatchery programs include genetic impacts on indigenous, naturally reproducing populations, disease transmission, predation of wild fish, difficulty in determining wild-stock status due to incomplete marking of hatchery fish, depletion of wild-stock to increase brood stock, and replacement rather than supplementation of wild stocks through competition and continued annual introduction of hatchery fish. The more hatchery fish that are released, the more likely natural populations are to be impacted by hatchery fish.

Critical habitat for this ESU, if designated, could include all river reaches accessible to listed chum salmon (including estuarine areas and tributaries) in the Columbia River downstream from the Bonneville Dam, excluding Oregon tributaries upstream of Milton Creek at river kilometer 144 near the town of St. Helens (63 *FR* 11773). The National Marine Fisheries Service determined that a final critical habitat designation is not determinable for this ESU at this time (64 *FR* 14507). Additional information can be found in the March 10, 1998, *Federal Register* (63 *FR* 11773) and the March 25, 1999 *Federal Register* (64 *FR* 14507).

2) Hood Canal Summer-Run Chum Salmon

This ESU of chum salmon was proposed for listing as threatened on March 10, 1998 (63 *FR* 11773) and subsequently listed as threatened on May 24, 1999 (64 *FR* 14507). This ESU includes summer-run chum salmon populations in Hood Canal in Puget Sound and in Discovery and Sequim bays on the Strait of Juan de Fuca. These fish spawn from mid-September to mid-October.

In general, summer-run chum salmon are most abundant in the northern part of the range, where they spawn in the mainstems of rivers. Farther south, water temperatures and stream flows during late summer and early fall become unfavorable for salmonids. These conditions do not improve until the arrival of fall rains in late October/November. Few summer chum populations are found south of northern British Columbia. Ecologically, summer-run chum salmon populations from Washington must return to freshwater and spawn during periods of peak high water temperature, suggesting an adaptation to specialized environmental conditions that allow this life history strategy to persist in an otherwise inhospitable environment.

Summer-run chum salmon in this ESU have experienced a steady decline over the past 30 years. Spawning escapement of summer-run chum salmon in Hood Canal numbered more than 40,000 fish in 1968 but was reduced to only 173 fish in 1989. In 1991, only 7 of 12 streams that historically contained spawning runs of summer chum salmon still had escapements. In 1995-1996, escapement increased to more than 21,000 fish in northern Hood Canal, the largest return in more than 20 years. These increases in escapement were observed primarily in rivers on the west side of Hood Canal, with the largest increase occurring in the Big Quilcene River where the Fish and Wildlife Service had been conducting an enhancement program starting with the 1992 brood year. Streams on the east side of Hood Canal continued to have either no returning adults or no increases in escapement. Several factors may have contributed to the dramatic increase in abundance in 1995-1996, including hatchery supplementation, reduction in harvest rate, increase in marine survival, and improvements in freshwater habitat.

A number of factors may threaten naturally reproducing chum salmon throughout its range, including destruction, modification, or curtailment of its habitat or range, overuse for commercial, recreational, scientific, or education purposes, disease or predation, inadequacy of existing regulatory mechanisms, and other natural or human-caused factors. These are discussed in the section on Columbia River chum salmon.

Critical habitat for this ESU, if designated, could include all river reaches accessible to listed chum salmon (including estuarine areas and tributaries) draining into Hood Canal as well as Olympic Peninsula rivers between Hood Canal and Sequim Bay, Washington. Also included is the Hood Canal waterway, from its southern terminus at the Union River north to its confluence with Admiralty Inlet near Port Ludlow, Washington. (63 *FR* 11773). The NMFS determined that a final critical habitat designation is not determinable for this ESU at this time (64 *FR* 14507). Additional information can be found in the March 10, 1998, *Federal Register* (63 *FR* 11773) and the March 25, 1999 *Federal Register* (64 *FR* 14507).

(c) Oregon Coast Coho Salmon

This ESU of coho salmon was listed as threatened on August 10, 1998 (63 *FR* 42587). It was initially described and proposed as threatened on July 25, 1995 (60 *FR* 38011). This ESU includes coho salmon from Oregon coastal drainages between Cape Blanco and the Columbia River. Adult run and spawn timing are similar to those along the Washington coast and in the Columbia River, but less variable.

Coho salmon on the West Coast of the contiguous United States and much of British Columbia generally exhibit a relatively simple 3-year lifecycle. Adults typically begin their freshwater spawning migration in the late summer and fall, spawn by midwinter, and then die. The run and spawning times vary between and within coastal and Columbia River Basin populations. Depending on river temperatures, eggs incubate in redds for 1.5-4 months before hatching as alevins (a larval lifestage dependent on food stored in a yolk sac). Following yolk-sac absorption, alevins emerge from the gravel as young juveniles or fry and begin actively feeding. Juveniles rear in freshwater for up to 15 months, then migrate to the ocean as smolts in the spring. Coho salmon typically spend two growing seasons in the ocean before returning to their natal stream to spawn as 3-year olds. Some precocious males, called jacks, return to spawn after only 6 months at sea.

Historically, this species probably inhabited most coastal streams in Washington, Oregon, and northern and central California. Some populations, now extinct, are believed to have migrated hundreds of miles inland to spawn in tributaries of the upper Columbia River in Washington and the Snake River in Idaho. Based on historical commercial landing statistics and estimated exploitation rates, escapement of coho salmon in coastal Oregon was estimated to be nearly 1 million fish in the early 1900's, with a harvest of nearly 400,000 fish. Recent estimates indicate an average spawning escapement of less than 30,000 adults. While the methods of estimating total escapement are not comparable between the historical and recent periods, these numbers suggest that current abundance of coho salmon on the Oregon coast may be less than 5% of that in the early part of this century. Based on the National Marine Fisheries Service's examination of the available information, it is apparent that spawning escapements for coho salmon populations in the Oregon coastal ESU have declined substantially during this century. Of the 43 Oregon coho salmon stocks north of Cape Blanco, 31 were considered as either depressed or of special concern, and only 6 stocks were considered healthy. In another assessment, two stocks were considered to be at high risk of extinction and 14 stocks at moderate risk of extinction.

The present depressed condition of this population is the result of several long-standing, human-induced factors. The major activities responsible for the decline of coho salmon in Oregon are logging, road building, agricultural activities, grazing, urbanization, stream channelization, dams, wetland loss, water withdrawals, and unscreened diversions for irrigation. Other factors include disease and predation, particularly in local areas, inadequate regulations, poor ocean conditions, and widespread use of hatchery programs. Also, coastwide abundance of many stocks appears to be very low, and there has been a complete ban of most ocean fishing for coho salmon. For these reasons, the National Marine Fisheries Service concludes that coho salmon in the Oregon coast ESU are presently threatened.

(d) Ozette Lake Sockeye Salmon

This ESU of sockeye salmon was proposed for listing as threatened on March 10, 1998 (63 *FR* 11749) and subsequently listed as threatened on May 24, 1999 (64 *FR* 14528). This ESU consists of sockeye salmon that return to Ozette Lake through the Ozette River and spawn primarily in lakeshore upwelling areas in Ozette Lake. Minor spawning may occur below Ozette Lake in the Ozette River or in Coal Creek. Sockeye salmon do not presently spawn in tributary streams to Ozette Lake, although they may have spawned there historically.

Sockeye salmon are anadromous, meaning they migrate from the ocean to spawn in freshwater. They are the third most abundant of the Pacific salmon species. Sockeye salmon exhibit a wide variety of life-history patterns that reflect varying dependency on the freshwater environment. The vast majority of sockeye salmon spawn in or near lakes, where the juveniles rear for 1-3 years before migrating to sea. They typically spawn in inlet or outlet tributaries of lakes or along the shoreline of lakes where upwelling of oxygenated water through gravel or sand occurs. For this reason, the major distribution and abundance of large sockeye salmon stocks are closely related to the location of rivers that have accessible lakes in their watersheds for juvenile rearing. On the Pacific coast, sockeye salmon inhabit riverine, marine, and lake environments from the Columbia River and its tributaries north and west to the Kuskokwim River in western Alaska.

Upon emergence from the substrate, sockeye salmon alevins exhibit a varied behavior that appears to reflect local adaptations to spawning and rearing habitat. Lake-type sockeye salmon juveniles move either downstream or upstream to rearing lakes. Periods of stream-bank holding are limited for most juvenile sockeye salmon, as emergents in streams above or between connecting lakes use the current to travel to the nursery lake. Lake residence time usually increases the farther north a nursery lake is located, ranging from 1-2 years in Washington and British Columbia to 3 or, rarely, 4 years in Alaska. Juvenile sockeye salmon in lakes are visual predators, feeding on zooplankton and insect larvae. Smolt migration typically occurs between sunset and sunrise, beginning in late April and extending through early July.

Once in the ocean, sockeye salmon feed on copepods, euphausiids, amphipods, crustacean larvae, fish larvae, squid, and pteropods. The greatest increase in length is typically in the first year of ocean life, whereas the greatest increase in weight is during the second year. Sockeye salmon spend from 1-4 years in the ocean before returning to freshwater to spawn. Adult sockeye salmon home precisely to their natal stream or lake habitat. Stream fidelity in sockeye salmon is thought to be adaptive, since this ensures that juveniles will encounter a suitable nursery lake.

The most recent (1992-1996) 5-year average annual escapement for this ESU was about 700. Historical estimates indicate run sizes of a few thousand sockeye salmon in 1926, with a peak recorded harvest of nearly 18,000 in 1949. Subsequently, commercial harvest declined steeply to only a few hundred fish in the mid-1960's and was ended in 1974. Assuming that Ozette River harvest consisted of sockeye salmon destined to spawn in this system, comparison of these estimates indicates that recent abundance is substantially below the historical abundance range for this ESU. Habitat degradation from logging and associated road building and overfishing in the 1940's and 1950's have been identified as the major causes of the decline. The National Marine Fisheries Service concluded that the Ozette Lake sockeye salmon ESU is not presently in danger of extinction but, if present conditions continue into the future, it is likely to become so in the foreseeable future.

Critical habitat, if designated, could include all lake areas and river reaches accessible to listed sockeye salmon in Ozette Lake, in Clallam County, Washington (63 *FR* 11749). Critical habitat would consist of the water, substrate, and adjacent riparian zone of estuarine, riverine, and lake areas in watersheds draining into and out of Ozette Lake. Accessible areas are those within the historical range of the ESU that can still be occupied by any lifestage of sockeye salmon. Inaccessible areas are those above long-standing, naturally impassable barriers (natural waterfalls in existence for at least several hundred years). Adjacent riparian zones are defined as those areas within a horizontal distance of 300 feet (91.4 meters) from the normal line of high water of a stream channel, adjacent off-channel habitat (600 feet or 182.8 meters, when both sides of the channel are included), or lake. Additional information can be found in the March 10, 1998, *Federal Register* (63 *FR* 11749). The National Marine Fisheries Service determined that a final critical habitat designation is not determinable for this ESU at this time (64 *FR* 14528).

(e) Steelhead

On August 9, 1996, the National Marine Fisheries Service issued a proposed rule to list five ESU's as endangered and five ESU's as threatened under the Endangered Species Act (61 *FR* 41541). On August 18, 1997, the National Marine Fisheries Service subsequently issued a Final Rule listing two ESU's (Southern California and Upper Columbia River) as endangered and three ESU's (Central California Coast, South-Central California Coast, and Snake River Basin) as threatened (62 *FR* 43937). These ESU's and steelhead life history information were discussed in a previous Endangered Species Act consultation for the Proposed Northeast National Petroleum Reserve-Alaska Integrated Activity Plan (USDOI, BLM, 1998).

Additional ESU's are addressed in this EIS. The National Marine Fisheries Service had previously extended the deadline for five other ESU's (Lower Columbia River, Oregon Coast, Klamath Mountains Province, Northern California, and California Central Valley) for 6 months to solicit, collect, and analyze additional information (62 *FR* 43974). On March 19, 1998, the final rule was issued listing steelhead in the Lower Columbia River and California Central Valley ESU's as threatened (63 *FR* 13347). On March 25, 1999, the final rule was issued listing steelhead in the Middle Columbia River and Upper Willamette River ESU's as threatened (64 *FR* 14517). These two ESU's were proposed for listing as threatened on March 10, 1998 (63 *FR* 11797). On February 11, 2000, the National Marine Fisheries Service issued a proposed rule to list steelhead in the Northern California ESU as threatened (65 *FR* 6960).

Steelhead on the west coast have experienced declines in abundance in the past several decades as a result of natural and human factors. Forestry, agriculture, mining, and urbanization have degraded, simplified, and fragmented habitat. Water diversions for agriculture, flood control, and domestic and hydropower purposes have greatly reduced or eliminated historically accessible habitat.

Lower Columbia River: This coastal steelhead ESU occupies tributaries to the Columbia River between the Cowlitz and Wind rivers in Washington and the Willamette and Hood rivers in Oregon. Excluded are steelhead in the upper Willamette River Basin above Willamette Falls and steelhead from the Little and Big White Salmon rivers in Washington. This ESU is composed of both winter- and summer-run steelhead. Genetic data show steelhead from this ESU to be distinct from steelhead from the upper Willamette River and coastal streams in Oregon and Washington.

Rivers draining into the Columbia River have their headwaters in increasingly drier areas, moving from west to east. Columbia River tributaries that drain the Cascade Mountains have proportionally higher flows in late summer and early fall than rivers on the Oregon coast. No estimates of historical (pre-1960's) abundance are available for this ESU. Total run size for the major stocks in the lower Columbia River for the early 1980's are estimated to be approximately 150,000 winter steelhead and 80,000 summer steelhead, but it was estimated that approximately 75% of the total run was of hatchery origin. Of the 18 stocks for which adequate adult escapement-trend data exist—11 have been declining and 7 increasing. The National Marine Fisheries Service concludes that the Lower Columbia River steelhead ESU presently is not in danger of extinction but is likely to become endangered in the foreseeable future (61 *FR* 41541).

California Central Valley: This coastal steelhead ESU occupies the Sacramento and San Joaquin rivers and their tributaries. In the San Joaquin Basin, however, the best available information suggests that the current range of steelhead has been limited to the Stanislaus, Tuolumne, and Merced Rivers (tributaries) and the mainstem San Joaquin River to its confluence with the Merced River by human alteration of formerly available habitat. The Sacramento and San Joaquin rivers offer the only migration route to the drainages of the Sierra Nevada and southern Cascade mountain ranges for anadromous fish.

The Central Valley is much drier than the coastal regions to the west, receiving on average only 10 to 50 cm of rainfall annually. The valley is characterized by alluvial soils, and native vegetation was dominated by oak forests and prairie grasses prior to agricultural development. Steelhead within this ESU have the longest freshwater migration of any population of winter steelhead. The distance from the Pacific Ocean to spawning streams can exceed 300 kilometers. There is essentially one continuous run of steelhead in the upper Sacramento River. River entry ranges from July through May, with peaks in September and February. Spawning begins in late December and can extend into April. Historical (pre-1960's) abundance estimates for this ESU are not available. In 1961, it was estimated that the total run size in the Sacramento River, including San Francisco Bay, was 40,000 fish. Limited data exist on recent abundance for this ESU, but it is estimated that the present total run size probably is fewer than 10,000 fish. The National Marine Fisheries Service concludes that the Central California Coast steelhead ESU presently is in danger of extinction (61 *FR* 41541).

Upper Willamette River: This coastal steelhead ESU occupies the Willamette River and its tributaries upstream from Willamette Falls. The native steelhead of this basin are late-migrating winter steelhead entering freshwater primarily in March and April, whereas most other populations of west coast winter steelhead enter freshwater beginning in November or December. No estimates of historical (pre-1960's) abundance for this ESU are available. However, over the past several decades, total abundance of natural late-migrating winter steelhead ascending the Willamette Falls fish ladder has fluctuated several times over a range of approximately 5,000-20,000 spawners. The last peak occurred in 1988 and was followed by a steep and continuing decline. Abundance in each of the last 5 years has been less than 4,300 fish (64 *FR* 14517). Hatchery fish are widespread and escape to spawn naturally throughout the region. Estimates of the proportion of hatchery fish in natural spawning escapements range from 5-25% (64 *FR* 14517). The National Marine Fisheries Service concludes that the Upper Willamette River steelhead ESU presently is not in danger of extinction, nor is it likely to become endangered in the foreseeable future (61 *FR* 41541).

Middle Columbia River Basin: This inland steelhead ESU occupies the Columbia River Basin from Mosier Creek, Oregon, upstream to the Yakima River, Washington, inclusive. Steelhead of the Snake River Basin are excluded. This region includes some of the driest areas of the Pacific Northwest, generally receiving less than 40 centimeters of rainfall annually. Vegetation is of the shrub-steppe province, reflecting the dry climate and harsh temperature extremes. All steelhead in the Columbia River Basin upstream from the Dalles Dam are summer-run, inland steelhead. Life- history information for steelhead of this ESU indicates that most steelhead smolt at 2 years and spend 1-2 years in saltwater before reentering freshwater, where they may remain up to a year before spawning. Estimates of historical (pre-1960's) abundance for this ESU indicate that the total historical run size might have been in excess of 300,000. The most recent 5-year average run size was 142,000, with a naturally produced component of 39,000. These data indicate approximately 74% hatchery fish in the total run to this ESU. Most of the hatchery strays in the Deschutes River are believed to be long-distance strays from outside the ESU (64 *FR* 14517). The National Marine Fisheries Service concludes that the Middle Columbia River steelhead ESU presently is not in danger of extinction but has reached no conclusion regarding its likelihood of becoming endangered in the foreseeable future (61 *FR* 41541).

Northern California: This coastal steelhead ESU occupies river basins from Redwood Creek in Humboldt County, California, to the Gualala River in Mendocino County, California. Dominant vegetation along the coast is redwood forest, while some interior basins are much drier than surrounding areas. Elevated stream temperatures are a factor affecting steelhead and other species in some of the larger river basins, but not to the extent that they are in river basins farther south. With the exception of major river basins such as the Eel, most rivers in this region have a short duration of peak flows. Steelhead within this ESU include both winter and summer steelhead, including what is presently considered to be the southernmost population of summer steelhead, in the Middle Fork Eel River. Half-pounder juveniles also occur in this area. As with the Rogue and Klamath rivers, some of the larger rivers in this area have migrating steelhead year-round. Entry into the river ranges from August through June and spawning from December through April, with peak spawning in January in the larger basins and late February and March in the smaller coastal basins. Historical (pre-1960's) abundance information for this ESU is available from dam counts in the upper Eel River (annual average of 4,400 adults in the 1930's), South Fork Eel River (annual average of 19,000 in the 1940's), and Mad River (annual average of 3,800 adults in the (1940's). In the mid-1960's, it was estimated that steelhead spawning populations for many rivers in this ESU totaled 198,000 fish. While no overall recent abundance estimate for this ESU exists, the substantial declines in run size from historic levels at major dams in the region indicate a probable similar overall decline in abundance from historic levels. The status of this ESU was recently reviewed in January 2000. Based on a review of updated abundance and trend information that was available, it was concluded that the current status of the ESU has not changed significantly since it was last evaluated in December 1997 (65 *FR* 6960). The National Marine Fisheries Service concludes that the Northern California steelhead ESU is not presently in danger of extinction but is likely to become endangered in the foreseeable future (61 *FR* 41541).

(f) Bull Trout

The Coastal-Puget Sound population segment of the bull trout was proposed for listing as threatened by the Fish and Wildlife Service on June 10, 1998 (63 *FR* 31693) and subsequently listed as threatened on November 1, 1999 (64 *FR* 58909). The best available information supports designating five distinct population segments of bull trout. The Coastal-Puget Sound bull trout distinct population segment encompasses all Pacific coast drainages within the coterminous United States north of the Columbia River in Washington State. This population segment is discrete, because it is geographically segregated from other sub-populations by the Pacific Ocean and the Cascade Mountain Range. The population segment is significant because it is thought to contain the only anadromous forms of bull trout in the coterminous Unites States, thus, occurring in a unique (i.e., marine) ecological setting. The loss of this population segment would significantly reduce the overall range of the taxon. No bull trout exist in coastal drainages south of the Columbia River.

Bull trout, members of the family Salmonidae, are char native to the Pacific northwest and western Canada. They are closely related to Dolly Varden and are present over part of the Dolly Varden's range, most notably in the Coastal-Puget Sound Region in Washington. The taxonomic classification between these two char has been controversial. Initially bull trout and Dolly Varden were considered as a single species but have been recognized as separate species since 1980. Bull trout exhibit both resident and migratory life history strategies. Resident populations are generally found in small headwater streams where they spend their entire lives, whereas migratory populations spawn and rear in tributary streams for one to four years before migrating downstream into a larger river or lake to mature. Although bull trout are generally not anadromous, it is thought they may migrate to saltwater to mature in some coastal areas. Some biologists believe the existence of anadromous bull trout is uncertain. However, historical accounts and collection records suggest an anadromous life history form in the species. All life-history stages of bull trout are associated with complex forms of cover, including large woody debris, undercut banks, boulders, and pools.

Bull trout become sexually mature in 4-7 years and live as long as 12 years. They typically spawn in August through October in consecutive or alternate years in low-gradient streams with clean, loosely compacted gravel, groundwater inflow, and water temperatures ranging from 4-10 degrees Celsius. Postspawning mortality, longevity, and repeat spawning frequency are not well known. Incubation of eggs normally requires from 100-145 days, depending on water temperature. Juveniles remain in the substrate after hatching, emerging in early April through May.

Bull trout are opportunistic feeders. Resident and juvenile migratory bull trout prey on terrestrial and aquatic insects, macro-zooplankton, amphipods, mysids, crayfish, and small fish. Adult migratory bull trout are primarily piscivorous, known to feed on various trout, salmon, whitefish, yellow perch, and sculpin.

The Coastal-Puget Sound population segment contains 35 subpopulations of native char (bull trout, Dolly Varden, or both species). Fifteen of these sub-populations have been analyzed, and 12 of the 15 confirmed the presence of bull trout, either as bull trout only or both bull trout and Dolly Varden. The Fish and Wildlife Service believes it is likely that bull trout will occur in the majority of the remaining 20 subpopulations also. The 35 subpopulations have been grouped into five analysis areas, Coastal, Strait of Juan de Fuca, Hood Canal, Puget Sound, and Transboundary. Ten subpopulations occur in five river basins in the Coastal analysis area, the Chehalis River-Grays Harbor, Coastal Plains-Quinault River, Queets River, Hoh River-Goodman Creek, and Quillayute River. Five sub-populations occur in three river basins in the Strait of Juan de Fuca analysis area, the Elwha River, Angeles Basin, and Dungeness River. Three sub-populations occur in the Skokomish River basin in the Hood Canal analysis area. Sixteen sub-populations occur in eight river basins in the Puget Sound analysis area, the Nisqually River, Puyallup River, Green River, Lake Washington basin, Snohomish River-Skykomish River, Stillaguamish River, Skagit River, and Nooksack River. One sub-population occurs in the Chilliwack River basin in the Transboundary analysis area. Historical accounts from the Puget Sound analysis area indicate that anadromous char entered rivers in the southern portion of the area in large numbers during the fall. However, native char are now rarely collected in the southern drainages of this area.

Bull trout in the Coastal-Puget Sound population segment have been adversely affected by flood control structures, hydroelectric projects, water diversion structures including irrigation withdrawals, forest practices, agricultural cultivation, grazing, urbanization, and industrial development. Many of these practices have resulted in increased sediment load to the streams, reduced channel stability, increased peak stream flows, and an overall loss of quality stream habitat, including reduced cover and large woody debris, loss of deep pools, increased water temperatures, and sedimentation of spawning areas. Although fishing for native char is currently closed in most of the waters within the Coastal-Puget Sound population segment, poaching is still a factor negatively affecting the population in nine drainages. Disease or predation are not thought to be a primary factor in the decline of bull trout in this population segment.

(g) Tidewater Goby

The tidewater goby was listed as an endangered species on February 4, 1994 (59 *FR* 5494). This species was discussed in a previous Endangered Species Act consultation for the Proposed Northeast National Petroleum Reserve-Alaska Integrated Activity Plan (USDOI, BLM, 1998). It is addressed in this EIS to include designation of critical habitat, which was proposed for the species on August 3, 1999 (64 *FR* 42249). A draft economic analysis was subsequently prepared and made available for comment on June 28, 2000 (65 *FR* 39850) and the comment period for proposed critical habitat determination was reopened.

In addition to the proposed rule to designate critical habitat for the tidewater goby, the Fish and Wildlife Service proposed on June 24, 2000 to remove the northern populations of the tidewater goby from the list of threatened and endangered species (64 *FR* 33816). The species is classified as endangered throughout its entire range. It was later determined that more populations of the species exist north of Orange County than were known at the time of the listing, threats to those populations are less severe than previously thought, and the species has a greater ability to recolonize former habitats than was known in 1994 when it was listed. The populations of tidewater gobies in Orange and San Diego Counties constitute a distinct population segment and would be retained as endangered species if this rule is finalized.

The following general areas are proposed as critical habitat:

- Aliso Creek (Orange County) and its associated lagoon and marsh from the Pacific Ocean to approximately 1.0 kilometer (0.6 mile) upstream.
- San Mateo Creek, its associated lagoon and marsh, from the Pacific Ocean to approximately 1.3 kilometers (0.9 mile) upstream.
- San Onofre Creek, its associated lagoon and marsh, from the Pacific Ocean to approximately 0.6 kilometer (0.4 mile) upstream.
- Approximately 1.0 kilometer (0.6 mile) of Las Flores Creek, and its associated lagoon and marsh, from the Pacific Ocean to Interstate 5.
- Approximately 0.8 kilometer (0.5 mile) of Hidden Creek, and its associated lagoon and marsh, from the Pacific Ocean to Interstate 5.
- Approximately 0.7 kilometer (0.4 mile) of Aliso Creek and its associated lagoon and marsh, from the Pacific Ocean to Interstate 5.
- Approximately 0.7 kilometer (0.4 mile) of French Creek, and its associated lagoon and marsh, from the Pacific Ocean to Interstate 5.
- Approximately 1.0 kilometer (0.6 mile) of Cockleburr Creek and its associated lagoon and marsh, from the Pacific Ocean to Interstate 5.
- Santa Margarita River, from the Pacific Ocean to a point approximately 5.0 kilometers (3.1 miles) upstream.
- Buena Vista Lagoon, its associated marsh and creek, from the Pacific Ocean to a point approximately 3.4 kilometers (2.1 miles) upstream.
- Agua Hedionda Lagoon, its associated marsh and creek, from the Pacific Ocean to a point approximately 3.7 kilometers 92.3 miles) upstream.

Each area includes the current 50-year floodplain. Although the majority of land being proposed for designation is under Federal administration and management, some estuary and riparian systems are on State, county, city, and private lands.

2. Seals and Polar Bears

The Sale 170 Final EIS, Section III.B.4 (USDOI, MMS, 1998), and BPXA (1998a) describe seals and polar bears in the proposed Liberty area, and these descriptions are summarized and incorporated here by reference. The Liberty Project could affect ringed and bearded seals and polar bears, which are common in the area. Map 2B only portrays sightings of these species and sightings of terrestrial mammals included in the Liberty Development Project Environmental Report (LGL, Woodward-Clyde, and Applied Sociocultural Research 1998). Other species that are uncommon or rare in the project area, such as beluga whales and spotted seals, are not expected to be exposed to or harmed by any of Liberty's activities and are not discussed further.

a. Ringed Seals

Widely distributed throughout the Arctic, this species is the most abundant seal in the Beaufort Sea. Its estimated population in the Alaskan Beaufort Sea is 80,000 during the summer and 40,000 during the winter (Frost and Lowry, 1981). Ringed seal densities within the Liberty area depend on food availability, water depth, ice stability, and distance from human disturbance. Seal densities reflect changes in the ecosystem's overall productivity in different areas (Stirling and Oritsland, 1995). In the zone of floating shorefast-ice of the Beaufort Sea, ringed seals range from 1.5-2.4 seals per square nautical mile (Map 2B showing the floating shorefast-ice; Frost, Lowry, and Burns, 1988). Surveys in May 1996 through 1999 recorded densities of about 0.81 seals per square kilometer in the Beaufort Sea fast-ice habitat (Frost and Lowry, 1999). Ringed seals probably are a polygamous species. When sexually mature, they establish territories during the fall and maintain them during the pupping season. Pups are born in late March and April in lairs that seals excavate in snowdrifts and pressure ridges. During the breeding and pupping season, adults on shorefast ice (floating fast-ice zone) usually move less than individuals in other habitats; they depend on a relatively small number of holes and cracks in the ice for breathing and foraging. During nursing (4-6 weeks), pups usually stay in the birth lair. This species is a major resource that subsistence hunters harvest in Alaska (see Sec. VI. B-1, Subsistence-Harvest Patterns).

b. Bearded Seals

This species occurs throughout the Arctic and usually prefers areas of less stable or broken sea ice, where breakup occurs early (Cleator and Stirling, 1990). Most of the bearded seals in Alaskan outer continental shelf areas, an estimated 300,000-450,000 seals, are found in the Bering and Chukchi seas. Estimates on the abundance of bearded seals in the Beaufort Sea and in Alaskan waters currently are unavailable. Bearded seals stay on moving ice habitat in the Beaufort Sea. Their densities in the western Beaufort Sea and in the Liberty area are greatest during the summer and lowest during the winter. Their most important habitat in winter and spring is active ice or offshore leads. Map 2B shows recent sightings in the Liberty area.

Pupping takes place on top of the ice from late March through May mainly in the Bering and Chukchi seas, although some takes place in the Beaufort Sea. These seals do not form herds but sometimes do form loose groups. Bearded seals (ugruk) are a main subsistence resource and a favorite food of subsistence hunters (residents of Barrow, as cited in S.R. Braund and Assocs. and University of Alaska, Anchorage, Institute for Social and Economic Research, 1993).

c. Polar Bears

The Southern Beaufort Sea's population (from Icy Cape to Cape Bathurst, Northwest Territories, Canada) is about 1,800 bears (Amstrup, 1995; Wiig, Born, and Garner, 1995; Gorbics, Garlich-Miller, and Schliebe, 1998). This population has increased over the past 20-30 years at 2% or more per year and is believed to be increasing slightly or stabilizing near its carrying capacity (Amstrup, 1995; USDOI, Fish and Wildlife Service, 1995b). Their seasonal distribution and local abundance vary widely in the Alaskan Beaufort Sea. Amstrup (1983) estimated their average density to be one bear every 78-130 square kilometers (30-50 square miles), with much lower densities beyond 100 miles offshore and higher densities near ice leads, where seals concentrate during the winter. Another study estimated their overall density from Point Barrow to Cape Bathurst as one bear every 141-269 square kilometers (54-103 square miles) (Amstrup, Stirling, and Lentifer, 1986). Sea ice and food are the two most important natural influences on their distributions.

Drifting pack ice off the coast of the Alaskan Beaufort Sea probably supports more polar bears than either shorefast ice or polar pack ice, probably because young seals are abundant in this habitat. Polar bears prefer rough sea ice, floe-edge ice, and moving ice over smooth ice for hunting and resting (Martin and Jonkel, 1983; Stirling, Andriashek, and Calvert, 1993). Polar bears sometimes concentrate along Alaska's coast when pack ice drifts close to the shoreline, at whale carcass locations, and when shorefast ice forms early in the fall. Polar bears can swim great distances and are very curious animals (Adams, 1986, pers. commun.).

Pregnant and lactating females with newborn cubs are the only polar bears that occupy winter dens for extended periods. Typically, dens are more sparsely distributed in the Alaskan coastal zone than in areas receiving consistent use, areas such as Wrangell Island, Russia, and in Hudson Bay and James Bay, Canada. Pregnant females come to coastal areas in late October or early November to build maternity dens. Most onshore dens are close to the seacoast, usually not more than 8-10 kilometers inland (Map 2B). Offspring are born from early December to late January, and females and cubs break out from dens in late March or early April.

Polar bear dens have been located on river banks in northeast Alaska and on shorefast ice close to islands east of the mouth of the Colville River. Dens have been found recently in the Liberty area. Topographic relief (hills, banks, and other terrain features) provides areas where enough snow accumulates for bears to build dens. Polar

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bear hunters from Nuiqsut and Kaktovik identified several of the coastal dens shown in Map 2B (USDOI, Fish and Wildlife Service, 1995b; Kalxdorff, 1997).

Female polar bears usually do not use the same den sites each year (Ramsay and Stirling, 1990; Amstrup, Garner, and Durner, 1992), but they often do use the same geographic areas (Amstrup, Garner, and Durner, 1992). Shifts in the distribution of den locations in Canada may be related to changes in sea-ice conditions (Ramsay and Stirling, 1990).

Besides being protected by the Marine Mammal Protection Act of 1972, polar bears and their habitats are covered further by the International Agreement on the Conservation of Polar Bears. This 1976 agreement among Canada, Denmark, Norway, the Union of Soviet Socialist Republics, and the United States addresses protecting of "habitat components such as denning and feeding sites and migration patterns." Also proposed is a bilateral agreement between the United States and Russia to conserve polar bears in the Chukchi/Bering seas (USDOI, Fish and Wildlife Service, 1997).

The North Slope Borough/Inuvialuit Game Council's management of polar bears for the southern Beaufort Sea includes sustainable harvest quotas based on estimated population size, sustainable harvest rates for female polar bears, and information regarding the sex ratio of the subsistence harvest.

3. Marine and Coastal Birds

About 70 species of birds are expected to occur regularly in the Liberty area (BPXA, 1995, 1998a; Johnson and Herter, 1989; USDOI, MMS, 1996a, 1998; TERA, 1993b, 1995b). Nearly all species are migratory, inhabiting Arctic Slope or Beaufort Sea habitats only from May to October. Major groups and species that may be fairly common to abundant in this area during all or part of the breeding and postbreeding periods include:

- **Loons and Waterfowl:** red-throated loon, Pacific loon, greater white-fronted goose, snow goose, Canada goose, brant, northern pintail, king eider, common eider, long-tailed duck (formerly, oldsquaw), scaup, scoters.
- **Shorebirds:** black-bellied plover, lesser golden-plover, semipalmated sandpiper, pectoral sandpiper, dunlin, stilt sandpiper, long-billed dowitcher, red-necked phalarope, red phalarope.
- **Passerines:** Lapland longspur, common redpoll.
- **Seabirds:** parasitic jaeger, glaucous gull, arctic tern.
- **Other:** rock ptarmigan.

Species that commonly use nearshore coastal waters (20-meter depths or less) include the brant, long-tailed duck, common eider, king eider, red phalarope, and glaucous gull. Species that may overwinter in the onshore development area include gyrfalcon, rock and willow ptarmigan, snowy owl, and common raven.

a. Annual Cycle

(1) Spring Migration

Waterfowl species such as the **long-tailed duck**, **king eider**, **common eider**, and **brant** migrate eastward along a broad front, which includes inland, coastal, and offshore routes from about mid-May to mid-June (Johnson and Herter, 1989; Johnson and Richardson, 1981; Richardson and Johnson, 1981). However, individuals of some species arrive earlier, such as gulls and ducks observed by Andrew Oenga in the Point Brower area of the Sagavanirktok River Delta in late April (North Slope Borough, Commission on History and Culture, 1980). The availability of open water offshore determines, in part, the routing and timing of **king eider** and **long-tailed duck** arrival, and probably other species. Open leads usually occur within 10 kilometers offshore of barrier islands but also occur farther offshore with some regularity. Spring-migrant waterbirds can be expected to land on any available water (Schamel, 1978; Richardson and Johnson, 1981). As the earliest spring migrants, male **king eiders** are particularly subject to stranding and starvation when wind and ice conditions close off traditionally used leads (Barry, 1968). During a recent spring migration, an estimated 373,000 **king eiders** and 71,000 **common eiders** passed Point Barrow (Suydam et al., 1997). **Loons** and **eiders** gather in spring runoff water in river deltas during late May and early June until local nesting areas are free of snow (Bergman et al., 1977). Likewise, most **shorebirds** and other **waterfowl** concentrate in snow-free coastal or inland areas until nest sites are available.

(2) Nesting Period

Lesser snow geese and **brant** nest on Howe and Duck islands in the Sagavanirktok River Delta (Johnson, 1994a,b; Stickney and Ritchie, 1996) and move to this and other delta areas for broodrearing from early July to late August (Maps 6 and 7). Other important broodrearing areas for **brant** include Point McIntyre and the northwest side and head of Prudhoe Bay. As many as 241 **brant** nests have been recorded on the delta and islands during the nesting season (Stickney and Ritchie, 1996). Most **brant** occupy sedge-grass meadows on tidal flats, lagoons, creek mouths, and portions of river deltas within 0.8 kilometer of the coast for broodrearing. Up to 170 adults and goslings have been recorded in the delta and 551 in areas to the east as far as Tigvariak Island, including the Kadleroshilik River delta (Stickney and Ritchie, 1996). In 1993, 455 **lesser snow goose** nests were located on Howe Island, about 3 nests per acre (Johnson, 1994b). In the Sagavanirktok River Delta area, 826 and 838 adults and goslings, respectively, were captured. Important broodrearing areas are found throughout Foggy Island Bay (Johnson, 1994b), including the eastern Sagavanirktok River Delta, Kadleroshilik River Delta, Shaviovik River Delta, to Mikkelsen Bay; approximately 31% of all captures between 1980 and 1993 were made in these areas. **Common eiders** nest on barrier islands offshore from the Liberty area (Map 7) as well as on Duck Island, abandoned exploratory islands in the Sagavanirktok River Delta, and on the Endicott causeway (Johnson, Wiggins, and Rodrigues, 1993; Johnson and Herter, 1989) (Map 8). **Loons**, **tundra swans** (Map 7), **greater white-fronted geese**, **Canada geese**, and other waterfowl nest, forage, rear their broods, and molt in wetland habitats that would be crossed by the onshore portion of the proposed pipeline that connects Liberty to the Badami pipeline. In the area between Prudhoe Bay and the Badami Prospect, nest densities for several species—including **Pacific loon**, **Canada goose**, **black-bellied plover**, **pectoral sandpiper**, **dunlin**, **stilt sandpiper**, and **red phalarope**—reach their highest levels in coastal habitats surrounding the lower Kadleroshilik River (TERA, 1995b) **Glaucous gulls** and **arctic terns** (and potentially some **black guillemots**) nest on barrier and other islands in the Liberty area.

(3) Postnesting Period

Among **phalaropes** and some **sandpipers**, the nonincubating members of pairs leave nesting areas on the tundra (from mid-June to late July), soon after the eggs are laid, and concentrate in coastal habitats. The other parent and fledged young follow in several weeks. In mid- to late August, juveniles form large flocks on coastal and barrier island beaches, foraging intensively on outer beaches, lagoon shorelines, and mudflats (Johnson and Richardson, 1981). Most have departed the area by mid-September. Male **common eiders** migrate to coastal molting areas in western Alaska, departing when incubation begins in late June and early July (Johnson and Herter, 1989). Nonbreeding and failed breeding females probably accompany the males, forming large flocks before heading west. Successful females with fledged young move from nest areas to molting sites, possibly nearby in coastal lagoons or other nearshore areas (Barry, 1968; Johnson and Herter, 1989) before moving south to wintering areas beginning in late August. Likewise, male **king eiders** undertake a migration to molting areas in Chukchi and Bering seas from early July through August (Cotter, Dickson, and Gratto, 1997). Suydam et al. (1997) observed adult males migrating past Point Barrow in September and October, indicating that some apparently molt in the Beaufort Sea. Females migrate from mid-August into September (Suydam et al., 1997), and young leave the breeding areas in September and October (Map 8). From mid-July to early September, **long-tailed ducks** gather in coastal lagoons (Map 6) and large lakes to feed and molt before migrating westward in the fall; Simpson Lagoon is a traditional important molting area (Johnson, 1985; Johnson and Richardson, 1982). Males, failed breeders, and nonbreeders are present early in this interval; females with young move to such areas following molt. Most waterfowl depart the area by the middle or end of August; but **loons**, **tundra swans**, **king eiders**, and **long-tailed ducks** may be found in remaining open-water areas until late September or October. In late August to mid-September, immature **arctic peregrine falcons** and **gyrfalcons** forage in coastal areas.

b. Habitats

(1) Offshore Marine Waters

Bird densities generally are low in offshore areas (Divoky, 1984). For example, densities of **long-tailed ducks** were less than 11 birds per square kilometer outside the barrier islands just east of Foggy Island Bay, and fewer than 3 birds per square kilometer were found farther offshore (Johnson and Gazey, 1992). During aerial surveys in 1999 (Map 8), **loons**, **glaucous gulls**, **common eiders**, **king eiders**, and **long-tailed ducks** were the most commonly recorded species in late June (Tiplady, 1999, pers. commun.). By late July, king eiders dominated the counts in offshore waters. By late August, **king eiders** still were numerous, but substantial numbers of **loons** and **long-tailed ducks** also occurred; most birds were within about 50 kilometers of the coast. There is a continual movement of eiders to the west from early July to November as fall migration proceeds (USDOI, Fish and Wildlife Service, 1999b).

(2) Nearshore Marine Waters

In the Liberty area, shallow waters in Foggy Island Bay and saltmarsh habitat along the Sagavanirktok and Kadleroshilik river deltas probably provide the most protected areas for feeding and rearing young. **Loons**, diving ducks such as the **long-tailed duck** and **common eider**, as well as **scaup** and **scoters** and **glaucous gulls** forage in nearshore waters. Lagoons formed by barrier islands provide important feeding and staging habitat for waterfowl, particularly molting and staging **long-tailed ducks** and **eiders**. Simpson Lagoon, beyond Prudhoe Bay to the west, is the closest well-defined lagoon system. However, barrier and other islands on the west side of Foggy Island Bay, the outer Sagavanirktok, Kadleroshilik, and Shaviovik River deltas, and the McClure Islands and Tigvariak Island also provide protected areas. Highest densities of **long-tailed ducks** are found in the outer portions of lagoons just inside the barrier islands (Maps 6 and 8). Lagoons become increasingly important for these species later in the season, as melting ice makes larger areas of open water available (Johnson and Richardson, 1982). Shorebird concentrations are found along lagoon shorelines, saltmarshes, river deltas, and mudflats in July and August before the fall migration.

(3) Barrier Islands

These sparsely vegetated gravel islands provide nesting habitat for **common eiders**, **glaucous gulls**, and **arctic terns**. **Common eiders** nest here almost exclusively. Small scattered groups of **black guillemots** also may nest on these islands. Many **phalaropes** come here after breeding, typically foraging along the seaward side (Johnson and Richardson, 1981), and small numbers of other shorebirds may be present. The occurrence of many species on barrier and other islands in particular has been noted by Native residents. For example, Etta Ekolook recalled aaqhaaliq (**long-tailed duck**) molting in the Tigvariak Island area, although more so at other barrier islands with other duck species. Mitqutailaq (**arctic tern)** nested at Tigvariak, and occasional niglingaq (**brant)** passed by (Ekolook, as cited in North Slope Borough, Commission on History and Culture, 1980). Also, aqargiq (**ptarmigan**) were observed on the ice out of sight of land. Further east, Mary Akootchook and Josephine Itta have seen many amauligruaq (**common eider**) and quinaluk (**king eider**) at Flaxman, Pole, and Belvedere Islands, niglingaq (**brant**) near Flaxman, and aqargiq (**ptarmigan**) and ukpik (**snowy owl**) on the island (Akootchook and Itta, as cited in North Slope Borough, Commission on History and Culture, 1980). Thomas Napageak cites Pole Island as an important nesting area for **eiders** and other waterfowl (Napageak, as cited in U.S. Army Corps of Engineers, 1999); Fenton Rexford notes that many waterfowl go through the Kaktovik area (Rexford, as cited in U.S. Army Corps of Engineers, 1996), and Jennie Ahkivak recalls accompanying her father to Cross Island each spring to hunt ducks (Ahkivak, as cited in USDOI, BLM, 1974).

(4) Tundra

Onshore habitats available to birds include moist and wet tundra, flooded tundra, ponds, and lakes. River gravel or sandbars usually are barren or sparsely vegetated and little used by birds for breeding. Although no specific information is available for the Kadleroshilik River gravel island that is the preferred gravel mine site, nonbreeding or postbreeding shorebirds or other species such as **American pipit** and **northern pintail** may occasionally forage or rest in such habitat. Only the occasional **semipalmated plover** and possibly other species such as **semipalmated sandpiper** are likely to nest there. Shrub habitat may be present along river channels and attract several songbird species. The most numerous shorebird species in the area (sandpipers, phalaropes) prefer wet tundra habitats, whereas loons use lakes, and geese prefer deeper ponds (**brant**) or wet tundra near lakes (**greater white-fronted goose**). **Long-tailed ducks** nest on small ponds with emergent sedges and grass and an open central area with deeper water. **King eiders** nest near deeper ponds that have less emergent vegetation (Larned and Balogh, 1997).

(5) Other Habitats

River deltas in the Liberty area (outer Sagavanirktok and Shaviovik) particularly the outer mud flats, are heavily used by shorebirds (Andres, as cited in Nickles et al., 1987); this probably is true of the Kadleroshilik) as well.

c. Abundance

Most of the **long-tailed ducks** nesting in western arctic North America pass through the Beaufort Sea region (Wilbor, 1999). At least 250,000 and perhaps up to four times this number are involved (USDOI, Fish and Wildlife Service, 1999b). After the breeding season, flocks of as many as 2,400 molting and postmolting **long-tailed ducks** have been recorded in the McClure Islands northeast of the Liberty area. Johnson and Gazey (1992) recorded average densities of 120-534 birds per square kilometer in Liberty area lagoons between Flaxman Island and the Jones Islands. Recent surveys (1999) in the area between West Dock and Pole Island have recorded average densities of 65 birds per square kilometer during the molt period (late July-August), and up to about 122 postmolting (late August) birds per square kilometer (Noel, Johnson, and Wainwright, 2000). The McClure Islands appear to be especially important in the Liberty area. Johnson and Richardson (1981) observed densities averaging as high as 566 birds per square kilometer in Simpson Lagoon, and densities as high as 749 birds per square kilometer off Gwydyr Bay west of the Liberty area in mid- to late July, suggesting that up to 50,000 individuals were present (Johnson and Herter, 1989; Johnson and Richardson, 1981).

Recent offshore and nearshore surveys by the Fish and Wildlife Service in the central Beaufort Sea area between Harrison and Mikkelsen Bays beginning in late June/late July and late August 1999 (Map 8) and 2000 resulted in an estimated population index for the **long-tailed duck** of 20,994 (June/July survey) to 37,792 (August survey) (Stehn and Platte, 2000). Indices for other species were: **king eider,** 19,842 (June/July) and 6,698 (August); **common eider,** 3,300 (June/July) and 1,477 (August); **Pacific loon**, 764 (June/July) and 666 (August); **red-throated loon**, 164 (June/July) and 169 (August); **yellow-billed loon,** 95 (June/July) and 17 (August); and **scoter species,** 4,814 (June/July) and 3,494 (August). Estimates of density for the **long-tailed duck** ranged as high as 73.8 birds per square kilometer (June/July) along the mainland shoreline in the eastern portion of the survey area and 58.1 birds per square kilometer in the eastern mid-lagoon area. High densities for other species were: **king eider**, 3.6 birds/square kilometer (June/July) in western offshore waters and 10.0 (August) along western mainland shoreline; **common eider**, 4.6 birds/square kilometer (June/July) in west-central barrier island pass area and 56.4 birds per square kilometer in eastern barrier island pass area. Density of **loons** and **scoters** was very low.

A study near the proposed Badami pipeline found that nest density of all species combined in the Kadleroshilik River area was 69.7 per square kilometer in 1994 (TERA, 1995b). **Lapland longspur** (25.0 per square kilometer), **pectoral sandpiper** (12.0 per square kilometer), **semipalmated sandpiper** (9.0 per square kilometer), and **red phalarope** (7.7 per square kilometer) were the most abundant nesting species (Table VI.A-1). The highest breeding-season densities for all 34 species recorded ranged from 251.7 birds per square kilometer in the second week of June to 167.0 in mid-July, and 131.7 in mid-August. Most abundant were the four species noted above plus **dunlin** and **red-necked phalarope**. The average density of all species for the entire breeding season was 185.6 birds per square kilometer; during broodrearing and postbreeding periods, the density was 88.2 and 119.2 birds per square kilometer, respectively. Troy (1982) found peak shorebird densities of 62 birds per kilometers of shoreline predominantly **semipalmated sandpiper**, **dunlin**, and **stilt sandpiper**, on the Sagavanirktok River Delta in early August. The highest nesting densities generally occur in areas of mixed wet and dry habitats, whereas birds often move to wetter areas for broodrearing. Differences in nest and bird density relative to habitat and the breeding-season period often arise due to some species foraging in different habitat than where the nest is placed, and/or that one member of the pair departs soon after eggs are laid.

d. Population Status

In the Beaufort Sea region, aerial surveys have shown most waterfowl populations have been relatively stable since 1986 or 1992 (Larned et al., 1997, 1999; Mallek and King, 2000). However, **red-throated loon** numbers observed in early June surveys have declined. Counts of birds passing Pt. Barrow in spring and aerial surveys indicate that the **common eider** population declined by as much as 50%, and **king eiders** 50% or more, in the period 1976-1994 (Suydam et al., 1999; USDOI, Fish and Wildlife Service, 1999b). **Long-tailed duck** numbers on the Arctic Coastal Plain have remained generally stable, but aerial survey counts made in late June have declined (Conant et al., 1997; Eliot, 1997; Larned and Balogh, 1997; Larned, et al., 1999, Mallek and King, 2000), while populations south of the Brooks Range and in northwestern Canada have declined significantly (Conant et al., 1997). Also, the three species of scoters, which may occur in this area, may have declined (Eliot, 1997; USDOI, Fish and Wildlife Service, 1999b). The **greater scaup** population nesting on the Arctic Coastal Plain is stable or increasing (USDOI, Fish and Wildlife Service, 1999b). The coastal plain **brant** population has remained relatively stable since the 1970’s, although numbers nesting at particular colonies varies considerably (Stickney and Ritchie, 1996). The small- to medium-sized colonies characteristic of the coastal plain nesting population makes individual colonies more vulnerable to predation than larger colonies, but dispersed distribution may decrease this effect on a regional scale (Raveling, 1989). The **lesser snow goose** population nesting on Howe Island in the Sagavanirktok River Delta area just west of Liberty has increased steadily over the past 2 decades (Johnson, 1994b; Johnson and Noel, 1996).

4. Terrestrial Mammals

Among the terrestrial mammals that occur in the Liberty area, the caribou, muskox, grizzly bear, and arctic fox are the species most likely to be affected by development. Maps 2A and B only portrays sightings of these species and sightings of marine mammals included in the Liberty Development Project Environmental Report (LGL, Woodward-Clyde, and Applied Sociocultural Research 1998). Other species, such as moose, are too sparse in the project area to be affected by development of the Liberty Project. The Final EIS for Lease Sale 170 (USDOI, MMS, 1998) and the BPXA Environmental Report (1998a) more thoroughly describe terrestrial mammals occurring across Alaska’s Arctic Coastal Plain, and these descriptions are incorporated here by reference.

a. Caribou

The Central Arctic Herd occurs immediately adjacent to the project area. Its range extends from the Itkillik River east to the Canning River and from the Beaufort coast south into the Brooks Range. Some caribou of the Porcupine Caribou Herd may frequent the coastal plain near the Liberty area, but few or none calve there and few use the area after calving (Clough et al., 1997, as cited in LGL Alaska Research Assocs. and Greenridge Sciences, 1997).

The Central Arctic Herd was estimated at 23,000 caribou in 1992 but declined to about 18,100 in 1994 (Abbott, 1993; Whitten, 1995 pers. commun.). In 1995, the herd totaled 18,100 caribou with 6,327 west of the Sagavanirktok River and 11,766 east of it. In 1997, the herd increased to 19,730 caribou, with about 12,000 west of the river and 7,730 east of it (Lenart, 1999; Whitten, 1998, pers. commun.). The differences between the 1995 and 1997 counts show considerable movement between the eastern and western segments of the herd (Lenart, 1998).

The eastern calving area for the Central Arctic Herd is shown in Map 2A. The herd usually calves within 30 kilometers of the Beaufort Sea coast. The herd separates into two segments based on the locations of the calving concentration areas, one on each side of the Sagavanirktok River. The eastern segment occurs within the Liberty area and ranges along the Arctic Coastal Plain from the Sagavanirktok River east to the Hulahula River during the summer. Only a few hundred caribou of this herd winter on the coastal plain during most years.

Calving takes place in the spring, generally from late May to late June (Hemming, 1971). During and just after calving, cows and calves are most sensitive to human disturbance. They join into increasingly larger groups, foraging mainly on the emerging buds and leaves of willow shrubs and dwarf birch (Thompson and McCourt, 1981). In the postcalving period, July through August, caribou form the largest groups.

Insect-relief areas become quite important during the insect season from late June to mid-August (Lawhead, 1997). Insect harassment reduces foraging efficiency and increases physiological stress (Reimers, 1980). Caribou use various coastal and upland habitats for relief from insect pests—typically sandbars, spits, river deltas, some barrier islands, mountain foothills, snow patches, and sand dunes. In these areas, stiff breezes keep insects from concentrating and landing on the caribou. In the Liberty Project area, caribou of the Central Arctic Herd usually congregate near the coast for insect relief. Caribou herds often move from insect-relief areas along the Arctic coast to and from green foraging areas.

b. Muskoxen

Populations of muskoxen died out in the 1800's in northern Alaska (Smith, 1989) but were reintroduced in the 1960's and 1970's. In the east, muskoxen were reintroduced to the Arctic National Wildlife Refuge in 1969 and to the Kavik River area (between Prudhoe Bay and the Refuge) in 1970. In the west, they were reintroduced near Cape Thompson on the Chukchi coast in 1970 and 1977 (Smith, 1989). The reintroductions to the east established the Refuge population, which grew rapidly and expanded both east and west of the Refuge (Garner and Reynolds, 1986). An estimated 270 muskoxen were counted between the Colville River and the Refuge, and a breeding population has been established in the area of the Itkillik-Colville rivers (Johnson et al., 1996).

Muskoxen generally do not migrate but will move in response to seasonal changes in snow cover and vegetation. They use riparian habitats along the major river drainages on the Arctic Slope year-round. Calving takes place from about April to early June (Garner and Reynolds, 1987). Distribution of muskoxen during the calving season, summer, and winter are similar, with little movement during winter (Reynolds, 1992). Only 14 muskoxen were sighted in the project area (LGL Alaska Research Assocs., Inc. and Greenridge Sciences, 1997) mostly along the Kadleroshilik River (Map 2A).

c. Grizzly Bears

The grizzly bear population on the western North Slope was considered stable or slowly increasing in 1991. Densities were highest in the foothills of the Brooks Range and lowest on the Arctic North Slope (Carroll, 1991). On the North Slope, grizzly bear densities vary from about 0.3-5.9 bears per 100 square miles, with a mean density of 1 bear per 100 square miles. The number of grizzly bears using the Prudhoe Bay and Kuparuk oil fields adjacent to the Liberty area has increased in recent years: The State of Alaska, Department of Fish and Game captured and marked 27 bears while studying the bears' use of the oil fields (Shideler and Hechtel, 1995). These bears have very large home ranges (2,600-5,200 square kilometers) and travel up to 50 kilometers a day (Shideler and Hechtel, 1995). Since 1991, 17 grizzly bears were recorded in the Liberty area (LGL Alaska Research Assocs., Inc. and Greenridge Sciences, 1997). On the North Slope, grizzly dens occur in pingos, banks of rivers and lakes, sand dunes, and steep gullies in uplands (Harding, 1976; Shideler and Hechtel, 1995).

LGL Alaska Research Assocs., Inc. and Greenridge Sciences (1997) recently located two dens in the project area (Map 2A). Grizzlies select dens mostly based on southern exposure and deep snow accumulation (LGL Alaska Research Assocs., Inc. and Greenridge Sciences, 1997). They usually enter dens in early October to late November and emerge in early April to mid-May.

Within the Liberty area, most bears forage in riparian areas (along streams and other bodies of water) Along the coast, they scavenge on the carcasses of marine mammals and prey on waterfowl eggs and young. They also feed on sedges and grasses, prey on arctic ground squirrels and rodents, and forage on plant roots and berries (BPXA, 1998a).

d. Arctic Foxes

The arctic fox population on the North Slope has increased since 1929, as the values and harvest rates of white fox pelts declined (Chesemore, 1967). Fox populations peak whenever lemmings (their main prey) are abundant. Other food sources include ringed seal pups and the carcasses of other marine mammals and caribou, which are important throughout the year (Chesemore, 1967; Hammill and Smith, 1991). Tundra-nesting birds also are a large part of their diet during the summer (Chesemore, 1967; Fay and Follmann, 1982; Quinlan and Lehnhausen, 1982; Raveling, 1989). The availability of winter food sources directly affects the foxes' abundance and productivity (Angerbjorn et al., 1991). Arctic foxes on the Prudhoe Bay oil field readily use development sites for feeding, resting, and denning; their densities are greater in the oil fields than in surrounding undeveloped areas (Eberhardt et al., 1982; Burgess et al., 1993). However, arctic foxes are particularly subject to outbreaks of rabies, and their populations tend to fluctuate with the occurrence of the disease and with changes in the availability of food. Marine mammals are an important part of the diet of arctic foxes that occur along the coast of western Alaska (Anthony, Barten, and Seiser; 2000).

5. Lower Trophic-Level Organisms

This section summarizes information described in former environmental impact statements for the Beaufort Sea (USDOI, MMS, 1998) and in the Liberty Environmental Report (BPXA, 1998a), which are incorporated here by reference. Lower-trophic-level organisms are the basis of foodwebs. The shrimp, crab, and phytoplankton "are all tied into the whale and the ugruk [bearded seal]," as explained by Fenton Rexford of Kaktovik during a Northstar hearing (Rexford, as cited in U.S. Army Corps of Engineers, 1999:Sec. 6.2.6.2). The same relationship was described by John Armstrong: "the algae, the [animal] plankton and the fish . . .all form a food chain link" (Armstrong, as cited in Dames and Moore, 1988:2). The food chain extends to human subsistence; as explained by Merlin Traynor, "much comes from the sea here for subsistence, such as birds, bearded seals, seals, fish, whitefish, char, plus the whales" (Traynor, as cited in Dames and Moore, 1988:40).

Lower trophic-level organisms in the Beaufort Sea include both plants and animals in two distinct habitats or communities: planktonic (living in the water column) and benthic/coastal (living on or in the sea bottom). We will describe first the planktonic communities, including those on the underside of the ice during the winter (epontic communities). Next, we will describe coastal and benthic communities, including the Boulder Patch kelp habitat.

Each year, the shorefast ice dominates the coastal area, and freshwater and sediment flow through after breakup. These conditions disturb the intertidal and nearshore subtidal zones of the Beaufort Sea (0-2 meters deep), which support no permanent marine organisms but many opportunistic ones that recolonize the zones during the summer.

a. Planktonic Communities

Annual primary production in the Alaskan Beaufort Sea is very low compared to that of other oceans. Recent estimates are up to 30 grams of carbon per square meter per year in the shelf and coastal environments. This is roughly the same as that produced in the central gyres (areas of lowest primary productivity) of the Atlantic and Pacific oceans (Schell, 1988; Cooney, 1988). Also, phytoplankton in the Beaufort Sea do not appear to bloom, as is common in other oceans, but increase a modest amount during and after ice breakup. In stark contrast to this, the annual plankton bloom along the Bering Sea's ice edge produces as much as 725 grams of carbon per square meter per hour (Hood and Calder, 1981).

Annual primary production in nearshore waters such as Stefansson Sound is typically 5-20 grams of carbon per square meter per year (Schell et al., 1982). The most productive areas of Alaska's Beaufort Sea are the area just east of Barrow in the west and the Barter Island area in the east. Near Barrow, this production comes from the annual springtime influx of plankton-rich waters from the northern Bering Sea, which contributes to primary production as high as 50 grams of carbon per square meter per year (Schell et al., 1982). Near Barter Island, upwelling events increase the amount of available nutrients for plankton growth (Schell, 1988). The abundance of phytoplankton appears to be greatest in nearshore waters less than 5 meters deep, with decreasing numbers farther offshore. However, they produce more grams of carbon per square meter per year in the clearer waters farther offshore, where they have more sunlight (Horner, Coyle, and Redburn, 1974). Phytoplankton are most abundant in late July and early August, when sunlight is strongest. Because primary production is low in Alaska's Beaufort Sea, the zooplankton communities are impoverished and are characterized by low diversity, low biomass, and slow growth (Cooney, 1988). Nevertheless, more than 100 species of zooplankton have been identified in the Alaskan Beaufort Sea:

- species that occur throughout the Arctic Basin,
- species that are swept into the area from the Bering and Chukchi seas,
- species that live in nearshore, less saline environments, and
- the larval forms of animals that live in the benthos (meroplankton) (USDOC, NOAA, 1978).

In a study of the eastern Beaufort Sea, Richardson (1986) found that copepods represented 87% of the individual zooplankters and 78 % of the zooplankton wet-weight biomass. Zooplankton spread out over hundreds of kilometers in the eastern Beaufort Sea. Off Kaktovik, patches of zooplankton were more abundant in nearshore and inner shelf waters, and biomass was greater than in more offshore waters (Richardson, 1986).

Epontic communities consist of plants and animals living on or in the undersurface of sea ice. Microalgae in the ice are mainly pennate diatoms and microflagellates. Although approximately 200 diatom species have been identified from Arctic Sea ice, only a few species dominate. Microalgae are found in sea ice as it forms in the fall, but their origin is unknown (Horner and Schrader, 1981). They distribute, develop, and produce variably based on available light. Ice algae in Stefansson Sound were responsible for nearly all primary production during the winter and spring (Horner and Schrader, 1982). Schell and Horner (1981) estimated that their production was only about one-twentieth of the annual total nearshore. Dunton (1984) found that ice algae beneath clear ice contributed about 25% of the carbon produced in Stefansson Sound's Boulder Patch. The production of ice algae is key during early spring. They are food for animals living in or near ice (e.g., protozoans, copepods, nematodes, amphipods), in the water column, and on the bottom (Horner and Schrader, 1981).

b. Benthic and Coastal Communities

The benthic and coastal communities in Alaska's Beaufort Sea contain macrophytic algae (large kelp), benthic microalgae and bacteria, and benthic invertebrates. Although the silty sediment in the Beaufort Sea does not suit most macrophytes, cobbles and boulders are suitable and do exist. The largest kelp community thus far described occurs in Stefansson Sound and is commonly known as the Boulder Patch (Map 1). For additional information concerning the flora and fauna of this area, see Dunton and Schonberg (1981), Dunton, Reimnitz, and Schonberg (1982), Dunton (1984), Martin and Gallaway (1994), and BPXA (1998a:4-15 to 4-20). The depended fauna include fish such as a local eelpout and *Liparis*, also known as the clingfish or leatherfin lumpsucker, but no widespread anadromous species such as salmon or the abundant arctic cisco (Dunton and Schell, 1987).

The densest part of the Boulder Patch is just west of the proposed Liberty site (Map 1 and Fig. III.C-2). Other rocky beds, although smaller in size, occur near the Stockton Islands, Flaxman Island, and Demarcation Bay (Thorsteinson, 1983). The rocky area offshore of Kayutak near Flaxman Island was known as unusual by the Natives for many years (Jacobson and Wentworth, 1982). As explained in the Liberty Environmental Report (BPXA, 1998a), these Alaskan kelp beds are separated by hundreds of kilometers from the primary range of kelp in the Canadian Arctic. With few spatially limited exceptions, Stefansson Sound is unique along the Alaskan Beaufort Sea. It provides the necessary combination of rock substrate, depth sufficient to allow a 12- to 14-foot thick layer of free water under the ice during winter and protection from extensive ice gouging by the offshore shoals and barrier islands.

The Boulder Patch was studied intensively during the late 1970's and early 1980's as part of the National Oceanic and Atmospheric Administration/Outer Continental Shelf Environmental Assessment Program. In addition, a refined delineation of the distribution for a portion of the Boulder Patch resulted from offshore oil and gas exploration in Stefansson Sound. The summer 1997 BPXA program of side-scan sonar surveys, complimented with ROV and diver observations, provided data that further refine the known distribution of this community in Stefansson Sound (Fig. III.C-1).

As explained in the Liberty Environmental Report (BPXA, 1998a), a study initiated in 1984 determined the rates and diversity of faunal and floral recolonization. Two bare Flaxman boulders were deployed at each of three locations with varying densities of kelp, and were positioned away from neighboring boulders to reduce rapid recolonization by vegetative growth from bordering communities. Recolonization in 1986 and 1987 was considered negligible, although there was early episodic colonization dominated by species of polychaetes and algae. By 1988, some encrusting bryozoans and hydroids were evident at all sites. By 1989, one study boulder was inhabited by six species and, by 1990, this same boulder was colonized by soft coral.

Another example of recolonization was described during the MMS Arctic Kelp Workshop (USDOI, MMS, Alaska OCS Region,1998a). One of the participants described the kelp that recolonized the slope-protection system at the old Northstar Island, which is several miles from the Boulder Patch. Concrete mats were placed around the island when it was constructed for exploration purposes in 1985. Small kelp plants were growing on the concrete mats near the surface within 7 or 8 years of when they were installed. However, a recent survey showed that, even though some of the mats were abandoned in place, the kelp did not survive. A recent post-abandonment survey revealed that essentially all of the mats are covered with gravel from the eroding top of the berm (Coastal Frontiers Corp., 2000). In contrast to the abandonment of the old Northstar Island, essentially all of the concrete mats were removed from Tern when it was abandoned. There have been no biological surveys of Tern, but the side slopes would probably be like the ones at Northstar--covered with eroding gravel and unsuitable for kelp. The gravel would probably be inhabited by typical fast-growing benthic organisms. Baseline studies of the Beaufort Sea coast, including Foggy Island Bay, showed that the abundant, fast-growing organisms included polychaete worms, amphipods, isopods, and bivalve mollusks (196:USDOC, NOAA, 1978).

The rocks of the Boulder Patch are widely scattered and range in size from pebbles to boulders. Boulders up to 2 meters across and 1 meter high exist, but most rocks are pebbles or cobbles. The boulders lie on the sediment surface in a layer that is apparently very thin, "no more than one boulder thick" (Dunton, Reimnitz, and Schonberg, 1982). Most of the Boulder Patch area has from no rock cover to less than 25% rock cover; however, several areas have more than 25% rock cover, and one has more than 50% (Martin and Gallaway, 1994). Water is 4-9 meters deep in the Boulder Patch. The rocks in this area have a layer of ice-free water (about 4 meters thick) that keeps ice from gouging them. This characteristic (and the presence of rocks for settlement) makes the benthic communities of the Boulder Patch much more abundant and diverse than elsewhere in Alaska's Beaufort Sea. Large kelp, soft corals, sponges, snails, hydroids, sea anemones, bryozoans, chitons, sea stars, sea squirts, crabs, clams, and polychaete worms are among those found in the benthic environment of this area. The communities usually do not grow in water less than 4 meters deep because of sediment influx during breakup and ground-fast ice in winter.

The brown alga, *Laminaria solidungula*, dominates the Boulder Patch's kelp communities. During the winter (about 8 months), kelp communities normally receive only about 10% of the sun's yearly energy input, but *L. solidungula* still completes nearly 90% of its yearly growth during this time by using food reserves stored during the summer. In years when they get more light (due to reduced ice cover), their growth can be 30-40% higher (with enough food reserves) (Dunton, 1990, as cited in Martin and Gallaway, 1994). However, more light does not necessarily increase growth during the summer, because *L. solidungula* will not grow if the light is too strong. Approximately 98% of the carbon produced annually in the Boulder Patch comes from kelp and phytoplankton. Dunton (1984) estimates that benthic microalgae contribute about 2% of the annual carbon produced in the Boulder Patch.

During the MMS Arctic Kelp Workshop (USDOI, MMS, Alaska OCS Region, 1998a), a participant explained that there are records of kelp growth and light levels from 1984-1991. The growth from year to year varied considerably. If the ice was clear and the plants received even a small amount of light during the winter, they grew a fair amount. The growth during 1990 was exceptional, but 1988 was a really bad year for photosynthetic carbon fixation by kelp. No carbon was stored during 1988. That meant that during the following year, 1989, only small blades or fronds were formed.

During the workshop there was extensive discussion about suspended sediments that might reduce light levels (USDOI, MMS, Alaska OCS Region, 1998a). One participant described a study of the BF-37 gravel island near the outer edge of the Boulder Patch. The study showed that the slope-protection system on that island successfully limited the amount of sediment in the water column. The participant also explained, in response to a question about suspended sediment from natural barrier islands, that the islands are very old geologically and that the fine sediment has pretty much been winnowed away. The following year, an additional report, *Liberty Development: Construction Effects on Boulder Patch Kelp Production* (Ban et al., 1999) was prepared for BPXA to further quantify the effects of suspended sediments. The estimates in the report, that sediment from the Liberty Project would reduce annual kelp productivity by about 6% (Ban et al., 1999), are described further in Section III.C.3.e.

Other benthic and coastal invertebrates typically are divided into epifauna and infauna, based on their relationship with the bottom substrate. A description of these organisms and the general patterns of their distribution and abundance are in the final EIS's for Sales 97, 124, and 144 (USDOI, MMS, 1987a, 1990b, and 1996a, respectively); the final EIS for Sale 109 (USDOI, MMS, Alaska OCS Region, 1987); and in Thorsteinson (1983). Because landfast ice is present in winter and freshwater and sediment flow in after breakup, relatively few species are in nearshore waters less than 2 meters deep. Biomass and diversity generally increase with depth, except in the shear zone at 15-25 meters. A lot of ice gouging occurs in this zone between the landfast ice and the moving polar pack ice, which usually disturbs the sediments where infaunal organisms live. Polychaetes, bivalves, and gammarid amphipods dominate this area. The coastal lagoons of the Beaufort Sea support a nearshore benthic environment that many vertebrates use as a feeding ground in the late summer (Thorsteinson, 1983). Dominant benthic invertebrates include amphipods, mysids, copepods, and other motile crustaceans. They are food for some fishes, birds, and marine mammals (Envirosphere Company, 1985). Other invertebrates, such as bivalves, snails, crabs, and shrimp, are food for some marine mammals (for example, walruses and bearded and ringed seals; Frost and Lowry, 1983). In general, the food habits of marine invertebrates vary depending on habitat, season, and preferences; but they typically rely on marine plants, other invertebrates, waste, and carrion.

The benthos near the Liberty site was studied during construction and monitoring of the Endicott causeway, and the results are summarized in BPXA's Environmental Report (p. 4-15:BPXA, 1998a). The report explains that these studies identified 99 taxa of marine macrobenthos within southeastern Stefansson Sound seaward of the 2-meter isobath, which would correspond with the depth range of the Liberty pipeline corridor and island site. The report also notes that the faunal diversity was low and changed annually during the 5-year study, which was considered typical for shallow, ice-stressed benthic habitats in the Arctic.

Site-specific studies of the benthos in the proposed island site and pipeline corridors were conducted for BP by LGL and Coastal Frontiers Corporation, and the results of both studies were summarized by the principal investigators during an MMS Arctic Kelp Workshop in May 1998. The principal investigators explained that there was a high degree of local variability in the benthos, as noted in the workshop Proceeding (USDOI, MMS, Alaska OCS Region, 1998a).

The effects on these resources from potential oil spills and disturbance from the proposed project are analyzed in Sections III.C.2.e and 3.e.

6. Fishes

Fishes inhabiting the Arctic must cope with harsh environmental conditions not required of their counterparts to the south (Fig. VI. A-2). For example, during the 8-10-month winter period, freezing temperatures reduce their habitat by more than 95% (Craig, 1989). Food is very scarce during this time, and most of their yearly food supply must be acquired during the brief arctic summer (Craig, 1989). As a result, fishes inhabiting the Arctic grow slowly compared to those inhabiting warmer regions. Nevertheless, several types of fishes are year-round residents in the Arctic. They include:

- freshwater fishes that spend their entire life in freshwater (some also spend brief periods in brackish coastal waters);
- marine fishes that spend their entire life in marine waters (some also spend brief periods in brackish coastal waters); and
- migratory fishes that typically move between fresh, brackish, and marine waters for various purposes (some individual fishes do not migrate).

The freshwater environment of the Arctic Coastal Plain consists of slow-moving rivers and streams as well as lakes, ponds, and a maze of interconnecting channels. Some waterbodies are completely isolated; however, most are permanently, seasonally, or sporadically connected. Seasonally connected lakes are flooded during breakup, while sporadically connected lakes are flooded only during high-water years (Parametrix, Inc., 1996). Many of these waters support freshwater and migratory fish populations. At least 20 species of fishes have been collected in or near the Colville drainage system to the west (11 freshwater and 9 migratory species) (Moulton and Carpenter, 1986; Bendock, 1997). The distribution and abundance of freshwater and migratory fishes on the Arctic Coastal Plain depend on (1) adequate overwintering areas, (2) suitable feeding and spawning areas, and (3) access to these areas (typically provided by a network of interconnecting waterways) (Parametrix, Inc., 1996). Studies on the Sagavanirktok River have shown that different fishes dominate at different times of the year:

- Summer: arctic grayling, round whitefish, Dolly Varden char (also called arctic char), broad whitefish, and slimy sculpin (Hemming, 1988; Woodward-Clyde Consultants, 1980).
- March: broad and humpback whitefish, arctic grayling, round whitefish, burbot, and slimy sculpin in the lower part of the river.
- April: broad and humpback whitefish, arctic and least cisco, arctic grayling, round whitefish, burbot, and slimy sculpin.
- May: broad whitefish, arctic and least cisco, arctic grayling, round whitefish, and burbot (Craig, 1989).

In winter, bodies of freshwater less than 6 feet deep are frozen to the bottom (Craig, 1989). In deeper waters that do not freeze to the bottom, the amount of dissolved oxygen is of critical importance. Flowing waters exceeding 7-10 feet in depth (depending on water velocity) generally are considered deep enough to support overwintering fishes. However, in standing waters the ice becomes thicker, and dissolved oxygen becomes less available as the winter progresses. In such cases, depths of up to 18 feet have been suggested as being the minimum required to support overwintering freshwater fishes (USDOI, BLM, 1990).

The marine coastal environment of the Beaufort Sea consists of inlets, lagoons, bars, and numerous mudflats (USDOI, BLM, 1978a). During the open-water season, the nearshore zone of this area is dominated by a band of relatively warm, brackish water that extends across the entire Beaufort Sea coast. The summer distribution and abundance of coastal fishes (marine and migratory species) is strongly affected by this band of brackish water. The band typically extends 1-6 miles offshore and contains more abundant food resources than waters farther offshore. It is formed after breakup by freshwater input from rivers such as the Colville and Sagavanirktok. It has its greatest extent off river delta areas, with a plume sometimes extending 15 miles offshore. During the open-water season, migratory fishes tend to concentrate in the nearshore area, which is used also by marine fishes and occasionally by some freshwater fishes. Migratory fishes acquire nearly all of their yearly food supplies during the brief open-water season. The areas of greatest species diversity within the nearshore zone are the river deltas (Bendock, 1997). Sixty-two species of fish have been collected from the coastal waters of the Alaskan Beaufort Sea (69% marine, 26% migratory, 5% freshwater). All (except salmon) are typical of fishes resident to arctic coastal waters from Siberia to Canada (Craig, 1984). Thirty-seven species were collected in the warmer nearshore brackish waters, and 40 species were collected in the colder marine waters farther offshore (some use both habitats). As the summer progresses, the amount of freshwater entering the nearshore zone decreases, and nearshore waters become colder and more saline. From late summer to fall, migratory fishes move back into rivers and lakes to overwinter and to spawn (if sexually mature). In winter, nearshore waters less than 6 feet deep freeze to the bottom. Before they freeze, marine fishes continue to use the nearshore area under the ice but eventually move into deeper offshore waters, when the ice freezes to the bottom (Craig, 1984).

Subsistence fishermen harvest freshwater, marine, and anadromous fish in the area at differing times of the year, although the majority are harvested in summer. For example, summer fishing for whitefish occurs all around the Shaviovik River Delta, and Tom cod , sculpin, ling cod, flounder, and other marine species are taken in the Foggy Island area (North Slope Borough, Commission on History and Culture, 1980). In the spring, subsistence fishermen harvest arctic char as they migrate to sea, and later in summer as the char move about in nearshore waters. In the fall, large migrations of whitefish and lake trout are fished along the Beaufort Sea shoreline in less than three feet of water. Changes in fish populations have been observed by Wilson Soplu a subsistence fisherman, who noted that fish populations in the Shaviovik River have changed from many small fish, to fewer large fish (North Slope Borough, Commission on History and Culture, 1980). For additional information concerning subsistence fishing and those harvesting fish, see Section VI.B.1.

a. Freshwater Fishes

Freshwater fishes inhabit many of the rivers, streams, lakes, and ponds landward of the Liberty area. They include lake trout, arctic grayling, Alaska blackfish, northern pike, longnose sucker, round whitefish, burbot, ninespine stickleback, slimy sculpin, arctic lamprey, and threespine stickleback (rare). Freshwater fishes are found almost exclusively in freshwater (Moulton and Carpenter, 1986). Those with access to rivers, such as the Colville and Sagavanirktok (for example, arctic grayling), are sometimes found in the nearshore band of brackish coastal water described earlier. All of the above freshwater species have been collected near the mouth of the Colville River during summer (USDOI, BLM, 1978a); however, their presence in the coastal environment is sporadic and brief, with a peak occurrence expected during or immediately following spring breakup.

Many of the streams on the Arctic Coastal Plain serve as interconnecting links to the many lakes in the area (Bendock, 1997). Some waters are used primarily as nursery areas, others for feeding, others for spawning and/or overwintering, and others as corridors linking these areas together. Juvenile fishes prefer the warmer shallow-water habitats that become available during the ice-out period (Hemming, Weber, and Winters, 1989). The most abundant freshwater fish is the ninespine stickleback (Hemming, 1996). Highest numbers are found in waters having emergent and submerged vegetation suitable for spawning and rearing, with overwintering sites nearby (Hemming, 1993). In streams, the most common freshwater fishes include arctic grayling, ninespine stickleback, and slimy sculpin (Netsch et al., 1977; Bendock and Burr, 1984). In lakes, the most common freshwater fishes include lake trout, arctic grayling, round whitefish, and burbot. Older lake fishes usually are dominant. In general, the larger, deeper, clearer lakes with outlets and suitable spawning areas are more likely to support fishes. Smaller lakes that are more shallow and turbid, without outlets or suitable spawning areas, are not likely to support fishes (Netsch et al., 1977; USDOI, BLM, 1978a). Bodies of freshwater less than 6 feet deep generally do not have resident fish populations, although some may be used during the summer for feeding, rearing, or as access corridors to other waters.

Freshwater fishes feed on terrestrial and aquatic insects and their larvae, zooplankton, clams, snails, fish eggs, and small fishes (Bendock and Burr, 1984; USDOI, BLM, 1978a; Hemming, Weber, and Winters, 1989). Lake trout and burbot are reported to forage heavily on least cisco, round whitefish, grayling, and particularly on slimy sculpin and ninespine stickleback. Lake trout also have been reported to feed on voles (USDOI, BLM, 1978b) and burbot on Arctic lamprey (Bendock and Burr, 1984). Except for burbot, which spawns under ice in late winter, freshwater fishes spawn from early spring to early fall in suitable gravel or rubble. With the onset of winter, freshwater fishes move into the deeper areas of lakes, rivers, and streams.

The Kadleroshilik River supports only small numbers of ninespine stickleback, Dolly Varden (a migratory species), and arctic grayling. Neither spawning nor overwintering are believed to occur in the river or near the proposed Kadleroshilik River mine site. Small runs of pink and chum salmon (anadromous species) sometimes occur in the Colville River, and in some of the drainages west of the Colville River; however, neither species has established populations anywhere on the North Slope (Bendock and Burr, 1984).

b. Marine Fishes

Both marine and migratory fishes inhabit coastal waters. Marine fishes include arctic cod, saffron cod, twohorn (uncommon) and fourhorn sculpins, Canadian eelpout, arctic flounder, capelin, Pacific herring (uncommon), Pacific sand lance (uncommon), and snailfish (Craig, 1984; Moulton and Carpenter, 1986). Marine fishes prefer the colder, more saline coastal water seaward of the nearshore brackish-water zone described earlier. As the summer progresses, the nearshore zone becomes more saline due to decreased freshwater input from rivers and streams. During this time, marine fishes often share this same nearshore environment with migratory fishes, primarily to feed on the abundant epibenthic fauna or to spawn (Craig, 1984). In the fall, when migratory fishes have moved out of the nearshore area and into freshwater systems to spawn and overwinter, marine fishes remain in the nearshore area to feed.

Common marine fishes in the nearshore area include fourhorn sculpin and capelin (Schmidt, McMillan, and Gallaway, 1989; Thorsteinson, Jarvela, and Hale, 1991). Saffron cod, arctic flounder, and snailfish also use the nearshore area; however, their occurrence is sporadic and variable and in much lower numbers. Common marine fishes in waters farther offshore include arctic cod and kelp snailfish (Craig, 1984; Schmidt, McMillan, and Gallaway, 1989; Thorsteinson, Jarvela, and Hale, 1991). Arctic cod have been found to be more concentrated along the interface between the warmer nearshore water and colder marine water. The warmer nearshore zone with its more moderate salinity is thought to be an essential nursery area for juvenile arctic cod (Cannon, Glass, and Prewitt, 1991). Arctic cod are abundant and contribute significantly to productivity in arctic coastal waters. Because of the significant contribution they make to the diets of marine mammals, birds, and other fishes, arctic cod have been described as a “key species in the ecosystem of the Arctic Ocean” (Craig, 1984). They are believed to be the most significant consumer of secondary production in the Alaskan Beaufort Sea (Frost and Lowry, 1983) and even to influence the distribution and movements of marine mammals and seabirds (Craig, 1984, citing Finley and Gibb, 1982).

Marine fishes in the area primarily feed on marine invertebrates. They rely heavily on epibenthic and planktonic crustacea such as amphipods, mysids, isopods, and copepods. Flounders also feed heavily on bivalve mollusks, while fourhorn sculpins supplement their diets with juvenile arctic cod. Because the feeding habits of marine fishes are similar to those of migratory fishes (amphidromous and anadromous species), some marine fishes are believed to compete with migratory fishes for the same prey resources (Craig, 1984; Fechhelm et al., 1996). Competition is most likely to occur in the nearshore brackish-water zone, particularly in or near the larger river deltas, such as the Colville and the Sagavanirktok. As the nearshore ice thickens in winter, marine fishes continue to feed under the ice but eventually leave as the ice freezes to the bottom some 6 feet thick. Seaward of the bottomfast ice, marine fishes continue to feed and reproduce in nearshore waters all winter (Craig, 1984). Most spawn during the winter, some in shallow coastal waters, and others in offshore waters. Arctic cod spawn under the ice between November and February (Craig and Haldorson, 1981). Snailfish spawn farther offshore by attaching their adhesive eggs to a rock or kelp substrate.

c. Migratory Fishes

The members of this group commonly are referred to as anadromous fishes. They are born and reared in freshwater, migrate to sea as juveniles, and return to freshwater as adults to spawn and die. Migratory fishes indigenous to the arctic environment (amphidromous species) differ substantially from migratory fishes inhabiting warmer waters to the south (anadromous species). Amphidromous fishes live much longer, grow much slower, and become sexually mature much later in life. Additionally, they do not make one far-ranging ocean migration and return years later to freshwater to spawn and die like anadromous fishes (for example, salmon). Instead, they make many migrations between freshwater and the sea for purposes other than just spawning. Unlike anadromous fishes, amphidromous fishes spend much more time in brackish coastal waters than they do in marine waters. Additionally, they return to freshwater to overwinter, not necessarily to spawn. In fact, amphidromous fishes typically return many times to freshwater before reaching spawning age. Even after reaching spawning age, spawning occurs only if their nutritional requirements were met during the brief arctic summer. When they do spawn, they do not necessarily die; some return years later to spawn again before dying. Despite these major differences, the term amphidromous is seldom used when referring to the indigenous migratory fishes of the arctic environment (Craig, 1989). For this reason and because the term anadromous is misleading, this review simply refers to this group of mostly amphidromous species as migratory fishes.

Migratory fishes inhabit many of the lakes, rivers, streams, interconnecting channels, and coastal waters. They include arctic cisco, least cisco, Bering cisco, rainbow smelt, humpback whitefish, broad whitefish, Dolly Varden char (formerly known as arctic char), and inconnu. The highest concentration and diversity of migratory fishes in the area occurs in river-delta areas, such as the Colville and the Sagavanirktok (Bendock, 1997). Small runs of pink and chum salmon (anadromous species) sometimes occur from the Colville River west; however, neither species has established populations anywhere in the area (Bendock and Burr, 1984). The most common migratory fishes in nearshore waters are arctic and least cisco (Craig, 1984). Lakes that are accessible to migratory fishes typically are inhabited by them as well as the resident freshwater fishes. Least cisco is the most abundant migratory fishes found in these lakes.

With the first signs of spring breakup (typically June 5-20), adult migratory fishes (and the juveniles of some species) move out of freshwater rivers and streams and into the brackish coastal waters nearshore. They disperse in waves parallel to shore, each wave lasting a few weeks or so. Some disperse widely from their streams of origin (for example, arctic cisco and some Dolly Varden char). Others, like broad and humpback whitefish and least cisco, do not; and they are seldom found anywhere but near the mainland shore (Craig, 1984). Most migratory fishes initiate relatively long and complex annual migrations to and from coastal waters (Bendock, 1997). However, some populations of Dolly Varden char, least cisco, and broad and humpback whitefish never leave freshwater (Craig, 1989). Many believe that arctic cisco in the Colville River area originated from spawning stocks of the Mackenzie River in Canada (Gallaway et al., 1983; Fechhelm and Fissel, 1988; Fechhelm and Griffiths, 1990). However, there are reports from fishermen that arctic cisco in spawning condition have been caught in at least the upper Colville and Chipp rivers (Moulton, Fawcett, and Carpenter, 1985, citing W. Matumeak, 1984, pers. commun.).

During the 3- to 4-month open-water season that follows spring breakup, migratory fishes accumulate energy reserves for overwintering and, if sexually mature, they spawn. They prefer the nearshore brackish-water zone, rather than the colder, more saline waters farther offshore. While their prey is concentrated in the nearshore zone, their preference for this area is believed to be more correlated with its warmer temperature (Craig, 1989; Fechhelm et al., 1993). Migratory fishes are more abundant along the mainland and island shorelines, but they also inhabit the central waters of bays and lagoons. Larger fishes of the same species are more tolerant of colder water (e.g., Dolly Varden char and arctic and least ciscoes) and range farther offshore (Moulton, Fawcett, and Carpenter, 1985; Thorsteinson, Jarvela, and Hale, 1991). Smaller fishes are more abundant in warmer, nearshore waters and the small, freshwater streams draining into the Beaufort Sea (Hemming, 1993).

Infaunal prey density in the nearshore substrate is very low and provides little to no food for migratory fishes. However, prey density in the nearshore water column is high, about five times that of freshwater habitats on the Arctic Coastal Plain. The nearshore feeding area also is much larger than that of freshwater habitats on the coastal plain (Craig, 1989). For these reasons, both marine and migratory fishes come to feed on the relatively abundant prey found in nearshore waters during summer. Migratory fishes feed on epibenthic mysids and amphipods (often greater than 90% of their diet) and on copepods, fishes, and insect larvae (Craig and Haldorson, 1981; Craig et al., 1984; Craig, 1989). In early to midsummer when migratory fishes are most abundant in nearshore waters, little dietary overlap is observed among them. However, in late summer when they are less abundant and their prey is more abundant, dietary overlap is common in nearshore waters (Moulton, Fawcett, and Carpenter, 1985). Marine birds also compete for the same food resources during this time. Migratory fishes do little to no feeding during their migration back to freshwater and when spawning, but some resume feeding during winter. Most migratory fishes return to freshwater habitats in the late summer or fall to overwinter and, if sexually mature, to spawn. Others, like cisco and whitefish, return much earlier, arriving 6-10 weeks before spawning starts, thus forfeiting about half of the nearshore-feeding period (Craig, 1989). Char, ciscoes, and whitefish spawn in streambed gravels in fall in the Sagavanirktok River. Spawning in the arctic environment can occur only where there is an ample supply of oxygenated water during winter. Because of this and the fact that few potential spawning sites can meet this requirement, spawning often occurs in or near the same area where fishes overwinter (Craig, 1989).

7. Vegetation-Wetland Habitats

Detailed information on vegetation of the central Arctic Coastal Plain, including the Prudhoe Bay oil fields and the Liberty area, is available in Walker and Acevedo (1987) (U. S. Geological Survey Beechey Point Quadrangle, vegetation and land cover series L-0211). The authors produced comprehensive vegetation maps and reports that not only describe the area's vegetation but also provide techniques to show the changes over time resulting from oil-field development.

Sedge, grasses, and shrubs dominate the vegetation classes. Water sedge (*Carex aquatilis*) is the dominant species in the wet tundra class, in both of the flooded tundra classes, and in the one aquatic class that bears its name. Pendant grass, *Arctophila fulva*, dominates the other aquatic class. *Eriophorum vaginatum*, commonly called tussock cotton grass, dominates the tussock tundra class.

Common shrub species include mountain alder (*Alnus crispa*), dwarf birch (*Betula nana*), four-angled mountain heather (*Cassiope tetragona*), crowberry (*Empetrum nigrum*), *Ledum palustre*, cloudberry (*Rubus chamaemorus*), bog blueberry (*Vaccinium uliginosum*), lingonberry (*Vaccinium vitis-idaea*), and species of the genera *Andromeda*, *Arctostaphylos*, *Dryas*, and willow (*Salix*). *Salix* and *Alnus* (to a much lesser extent) are the dominant species of the low and tall shrub classes. Except for *Betula*, all are dwarf shrubs.

The four dominant types of plant cover next to Foggy Island Bay and the Liberty area (Walker and Acevedo, 1987) are:

- Open-water and pond complexes having more than about 40% open water with aquatic grass tundra (about 70% of the land cover).
- Wet herbaceous tundra dominated by wet-sedge (*Carex*) and cotton-grass species (*Eriophorum*). It has little permanent water or up to 40% water-covered ground or 30% moist herbaceous tundra that includes wet coastal areas periodically flooded with saltwater (about 13% of the total land cover).
- Moist or dry tundra dominated by dwarf shrubs such as willow (*Salix*), lichens, and forbs.
- Barren areas along major streams composed of 60% barren peat, mineral soil, or gravel. These areas may have patches with sparse cover of forbs and dwarf shrubs.

Liberty's onshore area has large expanses of moist sedge (*Carex* and *Eriophorum* spp.) and willow dwarf shrub (*Salix* spp.) (LGL, Woodward-Clyde, and Applied Sociocultural Research, 1998). The area's coast includes eroding bluffs, sandy beaches alternating with lower tundra areas having some saltwater intrusions, sand dunes, sandy spits, and estuarine areas at the mouths of streams (LGL, Woodward-Clyde, and Applied Sociocultural Research, 1998). Deltas of the Sagavanirktok, Kadleroshilik, and Shaviovik rivers support a complex mix of wet arctic saltmarsh, dry coastal barrens, salt-killed tundra, typical moist and wet tundra, and dry, partially vegetated gravel bars.

In freshwater wetlands, high abundances of invertebrate populations correlate strongly with the presence of emerging water sedge (*Carex*) and pendant grass (*Arctophila*) (Bergman et al., 1977).

The vegetation at the proposed Liberty pipeline junction site with the Badami pipeline is primarily low polygons with *Carex aquatilis* dominant in basins, *Eriophorum angustifolium* prevalent in troughs, and *Salix planifolia spp. Pulchra domiant* dominant on rims with cover classification category wet sedge/moist sedge, dwarf shrub tundra complex present (Noel and McKendrick, 2000). The shoreline landing for the proposed Liberty pipeline is moist/wet high centered polygons with deep troughs. The vegetation is predominantly *Eriophorum angustifolium, Carex aquatilis, Salix reticulata, Salix planifolia* spp. *Pulchra*, and *Vaccimium vitis-idaea* with cover classification category moist sedge, dwarf shrub tundra present (Noel and McKendrick, 2000).

Seventy vascular plant species were found at the proposed gravel mine site on the Kadleroshilik River (Noel and McKendrick, 2000). Five wetland plant communities were identified at the gravel bar site corresponding to age of habitat since deposition, a gradation of fine soil accumulation, and soil wetness. Ten land cover classes were identified (Figure II.A-7b). The youngest habitat on the gravel bar is sparsely vegetated with *Artemisia glomerata* the dominant plant with cover classification categories river gravel and dry barren/forb complex present . The next youngest habitat was dominated by *Salix ovallifolia* with cover classification category dry dwarf shrub, crustose lichen tundra and dry barren/dwarf shrub, forb grass complex present. The vegetation cover in this community has been heavily grazed by caribou and muskoxen (Noel and McKendrick, 2000). The *Salix ovalifolia* community is replaced by *Dryas integrifolia* on the next older habitat plant with cover classification categories dry dwarf shrub, crustose lichen tundra and dry barren/dwarf shrub, forb grass complex present. *Carex aquatilis* dominates the oldest community on the gravel bar with cover classification categories wet sedge tundra, moist sedge, dwarf shrub tundra and dry dwarf, crustose lichen tundra present. Grasses dominate a community composed of *Poa arctica, Bromus pumpellianus, Agropyron macrourum, Deschampsia caespitosa, Trisetum spicatum, Artemisia tilesii, Epilobium latifolia,* and *Lupinus arcticus* which is associated with an area of wind depsited sands/silts. This community contains about 30-50% cover and is classified as dry barren/dwarf shrub, grass complex (Noel and McKendrick, 2000).

8. Essential Fish Habitat

a. Magnuson Fishery Conservation and Management Act

The Magnuson Fishery Conservation and Management Act (16 U.S.C. 1801-1882) established and delineated an area from the State's seaward boundary out 200 nautical miles as a fisheries conservation zone for the United States and its possessions. The Act established national standards for fishery conservation and management, and created eight Regional Fishery Management Councils to apply those national standards in fishery management plans. Congress amended and reauthorized the Magnuson Act through passage of the Sustainable Fisheries Act of 1996. The reauthorization implements a number of reforms and changes. The Act, as amended, requires a fishery management plan to be based on the best available scientific and economic data for each commercial species (or related group of species) of fish that is in need of conservation and management within each respective region.

Another provision requires that Fishery Management Councils identify and protect essential fish habitat for every species managed by a fishery management plan (50 CFR 600). The essential fish habitat is defined as the water and substrate necessary for fish spawning, breeding, feeding, and growth to maturity. Section 600.10 defines "waters" as aquatic areas and their associated physical, chemical, and biological properties that are used by fish and may include aquatic areas historically used by fish where appropriate. "Substrate" is the sediment, hard bottom, and structures underlying the waters and associated biological communities. The act also requires Federal Agencies to consult on activities that may adversely affect essential fish habitats designated in the fishery management plans. An adverse effect is "…any impact which reduces the quality or quantity of EFH." The activities may have direct (for example, physical disruption) or indirect (for example, loss of prey species) effects on essential fish habitats and be site-specific or habitatwide. Loss of prey is considered an adverse effect on essential fish habitat, because one component of the essential fish habitat is that it be necessary for feeding. The adverse effects must be evaluated individually and cumulatively.

b. Essential Fish Habitat

Five fishery management plans exist for fisheries in Alaska. They cover groundfish in the Gulf of Alaska, groundfish and crabs in the Bering Sea and Aleutian Islands, and salmon and scallops Statewide. Five species of salmon are covered under the fishery management plan for salmon in Alaskan waters, including king (chinook) salmon, red (sockeye) salmon, silver (coho) salmon, chum (dog) salmon, and pink (humpbacked) salmon. Of the fishery management plans for Alaskan fisheries, only the plan for salmon designates essential fish habitat in the Beaufort Sea (Amendment 5). Essential fish habitat for salmon was defined as "…the aquatic habitat, both freshwater and marine, necessary to allow for salmon production needed to support a long-term sustainable salmon fishery and salmon contributions to healthy ecosystems." In Alaska, essential fish habitat for salmon was defined as: (1) "…all streams, lakes, ponds, wetlands, and other water bodies currently or historically accessible to salmon…" and (2) "…all estuarine and marine areas utilized by Pacific salmon of Alaska origin, extending from the influence of tidewater and tidally submerged habitats to the limits of the U.S. EEZ."

Essential fish habitat for salmon in marine areas was limited to include only the subset of habitat to a depth of 500 meters. Essential fish habitat was defined for six stages of salmon life history:

- eggs and larvae,
- juveniles in freshwater,

- juveniles in the estuary,
- juveniles before their first winter in the marine environment,
- immature and maturing adults in the marine environment, and
- adults in freshwater.

Habitat Areas of Particular Concern have been recognized for salmon in Alaska. These include, all anadromous streams, lakes and other freshwater areas used by salmon, and nearshore marine and estuarine habitats such as eel grass beds, submerged aquatic vegetation, emergent vegetated wetlands, and certain intertidal zones. Although it is possible that all five species of salmon that live in Alaskan waters could be found in the Beaufort Sea, there are no commercial salmon fisheries there. Only pink salmon appear to be present in the Liberty area in sufficient numbers to permit small (0-1.5 kilograms/year/person) subsistence fisheries for residents of Nuiqsut and Kaktovik (State of Alaska, Dept. of Fish and Game, 1998). Although chum salmon are believed to be present in the Liberty area, in recent years, they appear to be little used for subsistence purposes by those villages.

c. Analysis of Possible Effects

The proposed action is the development of the Liberty Prospect by BPXA for purposes of producing oil with associated transportation to U.S. and world markets. The project is fully described in Sections I and II.

Analyses of the effects, including cumulative effects, of the proposed action and its alternatives on salmon, salmon habitat, and associated species, including potential prey species, is given in various sections of this document; see also Table I-2.

We note that in any evaluation of the effect of an action on the condition of an important resource, it is critical to have some standard against which to judge the effect of the action on the resource in question. In this sense, the analysis of essential fish habitat for salmon in the Beaufort Sea appears to lead to a contradiction. In Amendment 5 to the Fishery Management Plan for the Salmon Fisheries in the Exclusive Economic Zone off the Coast of Alaska, essential fish habitat is said to consist of "…the aquatic habitat … necessary to allow for salmon production needed to support a long-term sustainable fishery and salmon contributions to healthy ecosystems." An adverse effect, as defined by 50 CFR 600.910, is "any impact which reduces the quality or quantity of EFH." Because of this linkage, confusion could exist when judging if a development could have an adverse affect on essential fish habitat (essential fish habitat constituting the habitat necessary to support viable populations and sustained commercial fisheries), when there are no commercial fisheries and salmon are rare and do not reproduce in the area affected by the development.

Therefore, for purposes of evaluating the effects of Liberty-related development on essential fish habitat, to be judged an adverse effect, the effect need only have the potential to be adverse, in the sense that the quality or quantity of potential habitat, including potential prey, for salmon could be diminished, assuming that salmon actually occupied the habitat under consideration (which they do not).

d. Mitigation of Impacts to Salmon Essential Fish Habitat

In Amendment 5 to the Fishery Management Plan for the Salmon Fisheries in the Exclusive Economic Zone off the Coast of Alaska, recommendations are listed for mitigation to be undertaken during development activities to minimize adverse effects on essential fish habitat. The recommendations relevant to Liberty include: (1) assess cumulative effects of oil and gas production, (2) minimize disposal or dumping of dredge spoils and drilling muds, and (3) minimize deposition of fill in wetlands. Liberty's contribution to the cumulative effects of development in the Beaufort Sea area is discussed in Section IV.B. Implementation of measures to minimize these and other actions is discussed in Section I.H.6 and summarized in Tables I-2 and I-3. Potential alternatives would not substantially change the effect of the proposed action on essential fish habitat. These alternatives are described in Section II.C and are analyzed in Section IV.

B. SOCIAL ENVIRONMENT

There are six categories that describe the existing social environment and past MMS leasing:

- Subsistence-Harvest Patterns
- Sociocultural Systems
- Archaeological Resources
- Economy
- Land Use Plans and Coastal Management Programs
- Brief History of Leasing and Drilling in the Area

1. Subsistence-Harvest Patterns

a. Subsistence-Harvest Areas

(1) A Definition of Subsistence

Generally, subsistence is considered hunting, fishing, and gathering for the primary purpose of acquiring food. The Alaska National Interest Land Conservation Act defines subsistence as the customary and traditional uses by rural Alaska residents of wild, renewable resources for direct personal or family consumption as food, shelter, fuel, clothing, tools, or transportation; for the making and selling of handicraft articles out of nonedible byproducts of fish and wildlife resources taken for personal or family consumption; for barter, or sharing for personal or family consumption; and for customary trade (16 U.S.C. § 3113). The North Slope Borough Municipal Code defines subsistence as an activity performed in support of the basic beliefs and nutritional needs of the residents of the borough and includes hunting, whaling, fishing, trapping, camping, food gathering, and other traditional and cultural activities (North Slope Borough Municipal Code 19.20.020 (67)). As a lifeway for Native Alaskans, subsistence is more than the harvesting, processing, sharing, and trading of marine and land mammals, fish, and plants. Subsistence should be understood to embody cultural, social, and spiritual values that are the essence of Alaskan Native cultures (Bryner, 1995; State of Alaska, Dept. of Natural Resources, 1997).

(2) Nuiqsut Harvest Areas

Specific harvest areas for wildfowl, caribou, moose, fish, whales, and seals for Nuiqsut are shown in Map 9. The Inupiat community of Nuiqsut has subsistence-harvest areas in and adjacent to the Liberty Project area. However, most sources indicate that the project area is not visited regularly by Nuiqsut subsistence hunters primarily because of its distance from the community. Seaward of the project area, at Cross Island, is a crucially important region for Nuiqsut subsistence bowhead whale hunting. Cross Island, Nuiqsut's principal staging area for subsistence whale hunting, is a barrier island 20 miles northwest of the gravel island proposed for Liberty development in Foggy Island Bay. Before oil development at Prudhoe Bay, the onshore area from the Colville River Delta in the west to Flaxman Island in the east and inland to the foothills of the Brooks Range (especially up the drainages of the Colville, Itkillik, and Kuparuk rivers) was historically important to Nuiqsut for the subsistence harvests of caribou, waterfowl, furbearers, fish, and polar bears. Offshore, in addition to bowhead whale hunting, seals historically were hunted as far east as Flaxman Island. Commercial whaling near and within the barrier islands during the late 1800's has been documented (Thomas P. Brower, as cited in North Slope Borough, Commission on History and Culture,1980). Bowheads also have been observed inshore of the barrier islands, and recent mention has been made of the area being used as a whale feeding area (V. Nauwigewauk, as cited in Shapiro, Metzner, and Toovak, 1979; Isaac Akootchook, as cited in USDOI, MMS, 1979a; Thomas P. Brower, as cited in North Slope Borough, Commission on History and Culture, 1980; Frank Long, Jr., as cited in Dames and Moore, 1996c; Burton Rexford, as cited in USDOI, MMS, 1996d; and Isaac Nukapigak, as cited in USDOI, MMS, Alaska OCS Region, 1998b).

(3) Kaktovik Subsistence Areas

In the past, Kaktovik's area for subsistence harvests extended onshore as far west as Prudhoe Bay and offshore as far west as Tigvariak Island. Recent Kaktovik subsistence activity does not take place this far west, but some of the preferred species—bearded seal (ugruk) and, to a lesser extent, beluga whale—pass through the area potentially affected by Liberty development.

(4) Barrow Subsistence Areas

Historically, Barrow's subsistence harvest areas do not extend this far east, ending for the most part at the Colville River Delta. More extensive descriptions of community harvest patterns for these communities can be found in the Beaufort Sea Sale 144 Final EIS (USDOI, MMS, 1996a), the Beaufort Sea Planning Area Oil and Gas Lease Sale 170 Final EIS (USDOI, MMS, 1998), the Northeast National Petroleum Reserve-Alaska Draft Integrated Activity Plan/EIS (USDOI, BLM and MMS, 1997), and the Beaufort Sea Oil and Gas Development/ Northstar Project Draft EIS (U.S. Army Corps of Engineers, 1998).

b. General Discussion of Subsistence and Harvest Patterns

(1) The Cultural Importance of Subsistence

Subsistence activities are assigned the highest cultural values by the Inupiat and provide a sense of identity as well as being an important economic pursuit. Many species are important for the role they play in the annual cycle of subsistence-resource harvests, yet effects on subsistence can be serious, even if the net quantity of available food does not decline. Subsistence resources provide more than dietary benefits. They also provides materials for personal and family use, and the sharing of resources helps maintain traditional Inupiat family organization. Subsistence resources also provide special foods for religious and social occasions; the most important ceremony, Nalukataq, celebrates the bowhead whale harvest. The sharing, trading, and bartering of subsistence foods structures relationships among communities, while at the same time the giving of such foods helps maintain ties with family members elsewhere in Alaska.

(2) Annual Cycle of Harvest Activities

Annual subsistence cycles for Nuiqsut are described in Figure VI.B-1. Full-time wage employment has affected the subsistence hunt positively by providing cash for snowmachines, boats, motors, and fuel—important tools for the hunt. On the other hand, full-time employment limits the time a subsistence hunter can spend hunting to after work hours. During winter, this time window is further limited by waning daylight. In summer, extensive hunting and fishing activities can be pursued after work without any light limitation.

(3) Community Subsistence-Harvest Patterns

Two major subsistence-resource categories occur on the North Slope: the coastal/marine and the terrestrial/aquatic. In the coastal/marine group, the food resources harvested are whales, seals, walrus, waterfowl, and fish. In the terrestrial/aquatic group, the resources sought are caribou, freshwater fish, moose, Dall sheep, grizzly bear, edible roots and berries, and furbearers. Generally, communities harvest resources most available to them, and harvests tend to be concentrated near communities, along rivers and coastlines, and at particularly productive sites. The distribution, migration, and the seasonal and more extended cyclical variation of animal populations make determining what, where, and when a subsistence resource will be harvested a complex choice. Many areas might be used infrequently, but they can be quite important harvest areas when they are used (USDOI, BLM, 1978c).

Use by a village of any particular species can vary greatly over time, and data from short-term harvest surveys often can lead to a misinterpretation of use/harvest trends. For example, if a particular village did not harvest any bowhead whales in one year, obviously their use of whales would go down; consequently, consumption and use of caribou and other species likely would go up—in absolute and percent terms. If caribou was not available one winter, other terrestrial species could be hunted with greater intensity. The subsistence harvest of vegetation by communities adjacent to the project area is limited, while the harvest of faunal resources, such as marine and terrestrial mammals and fish, is heavily emphasized. The total spectrum of available resources in the arctic region is limited when compared with more southerly regions.

While subsistence-resource harvests differ from community to community, the resource combination of caribou, bowhead whales, and fish was identified as being the primary grouping of resources harvested. Caribou is the most important overall subsistence resource in terms of effort spent hunting, quantity of meat harvested, and quantity of meat consumed. The bowhead whale is the preferred meat and the subsistence resource of primary importance, because it provides a unique and powerful cultural basis for sharing and community cooperation (Stoker, 1984, as cited by Alaska Consultants, Inc. [ACI], Courtnage, and Braund, 1984). In fact, the bowhead could be said to be the foundation of the sociocultural system. Depending on the community, fish is the second or third most important resource after caribou and bowhead whales. Bearded seals and various types of birds also are considered primary subsistence species. Waterfowl are particularly important during the spring, when they provide variety to the subsistence diet. In the late 1970’s, when bowhead whale quotas were low and the Western Arctic Herd (caribou) crashed (and the Alaska Board of Game placed bag limits on them), hunters turned to bearded seals (ugruk), ducks, geese, and fish to supplant the subsistence diet. Seal oil from bearded seals is an important staple and a necessary complement to other subsistence foods.

The subsistence pursuit of bowhead whales has major importance to the communities of Barrow, Nuiqsut, and Kaktovik and continues today to be the most valued activity in the subsistence economy of these communities. This is true even in light of harvest constraints imposed by quotas of the International Whaling Commission; relatively plentiful supplies of other resources such as caribou, fish, and other subsistence foods; and supplies of retail grocery foods. Whaling traditions include kinship-based crews, use of skin boats (only in Barrow for their spring whale-hunting season), distribution of the meat, and total community participation and sharing. In spite of the rising cash income, these traditions remain as central values and activities for all Inupiat in these North Slope communities. Bowhead whale hunting strengthens family and community ties and the sense of a common Inupiaq heritage, culture, and way of life. In this way, whale-hunting activities provide strength, purpose, and unity in the face of rapid change. In terms of the whale harvest, Barrow is the only community within the area that harvests whales in both the spring and the fall. Nuiqsut and Kaktovik residents hunt bowheads only during the fall whaling season.

An important shift in subsistence-harvest patterns occurred in the late 1960’s, when the substitution of snowmachines for dogsleds decreased the importance of ringed seals and walruses as key sources of dogfood and increased the relative importance of waterfowl. This shift illustrates that technological or social change can lead to the modifications of subsistence practices. Because of technological and harvest-pattern changes, the dietary importance of waterfowl also may continue to increase; however, these changes would not affect the central and specialized dietary roles that bowhead whales, caribou, and fish—the three most important subsistence-food resources to North Slope communities—play in the subsistence harvests of Alaska’s Inupiat, and for which there are no practical substitutes.

Subsistence resources used by Nuiqsut, Barrow, and Kaktovik are listed in Table VI.B-1 by common species name, Inupiaq name, and scientific name. For a comparison of the proportion of Inupiaq household foods obtained from subsistence in the years 1977, 1988, and 1993, see Table VI.B-2. Table VI.B-3 shows the percentage of households that participated in successful harvests of subsistence resources in the three communities being discussed, and Table VI.B-4 shows individual species’ percentages of the total average subsistence harvest for each community.

c. Nuiqsut Subsistence-Harvest Seasons and Harvest Success Profile

Nuiqsut's population stood at 354 in 1990 and rose to 410 by 1995 (USDOC, Bureau of the Census, 1991; State of Alaska, Dept. of Labor figures as cited in State of Alaska, Dept. of Fish and Game, 1995a). Nuiqsut is located near the mouth of the Colville River, which drains into the Beaufort Sea. For Nuiqsut, important subsistence resources include bowhead whale, caribou, fish, waterfowl, ptarmigan and, to a lesser extent, seals, muskoxen, and Dall sheep. Polar bears, beluga whales, and walruses are seldom hunted but can be taken opportunistically while in pursuit of other subsistence species. A 1993 Department of Fish and Game subsistence study showed that nearly two-thirds of all Nuiqsut households received more than half of their meat, fish, and birds from local subsistence activity (Pedersen et al., 1995, as cited in Fall and Utermohle, 1995). Nuiqsut's marine and terrestrial subsistence-harvest areas can be seen in Map 9. The preferred harvest periods for Nuiqsut are indicated in Figure VI.B-1. A summary of subsistence resources harvested in the 1993 and 1994-1995 seasons can be seen in Tables VI.B-5 and VI.B-6, respectively.

(1) Bowhead Whales

Even though Nuiqsut is not located on the coast (it is approximately 25 miles inland with river access to the Beaufort Sea), bowhead whales are a major subsistence resource. Bowhead whale hunting usually occurs between late August and early October, with the exact timing depending on ice and weather conditions. Ice conditions can dramatically extend the season up to 2 months or contract it to less than 2 weeks. Unlike the Barrow spring whale hunt, staged from the edge of ice leads using skin boats, Nuiqsut whalers use aluminum skiffs with outboard motors to hunt bowheads in open water in the fall. Generally, bowhead whales are harvested by Nuiqsut residents within 10 miles of Cross Island, but hunters may at times travel 20 miles or more from the island. Historically, the entire coastal area from Nuiqsut east to Flaxman Island and the Canning River Delta has been used, but whale hunting to the west of Cross Island has never been as productive and whale hunting too far to the east requires long tows of the whales back to Cross Island for butchering, creating the potential for meat spoilage (Impact Assessment, Inc., 1990a).

In the past, Nuiqsut has not harvested many bowhead whales (20 whales from 1972-1995); however, their success has improved in the past few years. Unsuccessful harvests were more common in the 1980's, with no whales taken in 1983, 1984, 1985, and 1988; but in the 1990's, the only unsuccessful years have been 1990 and 1994 (USDOI, MMS, 1996a; U.S. Army Corps of Engineers, 1998). A 1993 Alaska Department of Fish and Game subsistence survey in Nuiqsut indicated that 31.8% of the total subsistence harvest was marine mammals, and 28.7% of the total harvest was bowhead whales (State of Alaska, Dept. of Fish and Game, 1995a; Tables VI.B-5 and VI.B-6). The harvest of bowhead whales at Nuiqsut greatly affects the percentage of total harvest estimates, because in years when whales are taken, other important subsistence species are underrepresented due to the great mass of the total pounds of whale harvested.

Although in Nuiqsut bowheads are not the main subsistence resource in terms of edible pounds harvested per capita, they remain, as in other North Slope communities, the most culturally prominent to the Inupiat. The bowhead is shared extensively with other North Slope communities and often with Inupiat residents in communities as far away as Fairbanks and Anchorage. Nuiqsut Whaling Captains Association President, Frank Long, Jr., presented a history of Nuiqsut bowhead whaling and summarized major issues of concern in the Proceedings of the 1995 Arctic Synthesis Meeting (USDOI, MMS 1996d).

(2) Caribou

Nuiqsut harvests several large land mammals, including caribou and moose; of these, caribou is the most important subsistence resource. Caribou may be the most preferred mammal in Nuiqsut's diet and, during periods of high availability, it provides a source of fresh meat throughout the year. Data gathered in 1976 show caribou provided an estimated 90.2% of the total subsistence harvest (S.R. Braund and Assocs. and University of Alaska, Anchorage, Institute of Social and Economic Research, 1993). More recent subsistence caribou-harvest data are shown in Tables V.B-5 and V.B-6 (State of Alaska, Dept. of Fish and Game, 1995a). Caribou are harvested throughout the year. Caribou-harvest statistics for 1976 show that 400 caribou provided approximately 47,000 pounds of meat (Stoker, 1983, as cited in ACI, Courtnage, and Braund, 1984). In 1985, an estimated 513 caribou were harvested, providing an estimated 60,000 edible pounds of meat (37.5% of the total subsistence harvest; State of Alaska, Dept. of Fish and Game, 1993). A 1993 Alaska Department of Fish and Game subsistence study estimated a harvest of 674 caribou, providing about 82,000 edible pounds of meat (30.6% of the total subsistence harvest; State of Alaska, Dept. of Fish and Game, 1995a). In 1993, 74% of Nuiqsut's households harvested caribou, 98% used caribou, 79% shared caribou with other households, and 79% received caribou shares. Harvests occurred at 16 locations with the highest harvest, 111 caribou, at Fish Creek (Pedersen et al., 1995, as cited in Fall and Utermohle, 1995). A subsistence-harvest survey conducted by the North Slope Borough, Division of Wildlife Management covering the period from July 1994 to June 1995 reported 249 caribou harvested by Nuiqsut hunters, or 58% of the subsistence harvest in edible pounds. The report noted this as quite a low number of caribou when compared to reported harvests for earlier years. Explanations offered by local hunters were: (1) the need to travel longer distances to harvest caribou than in the past;

(2) the increasing numbers of muskox that hunters believe keep caribou away from traditional hunting areas; and (3) restricted access to traditional subsistence hunting areas due to oil exploration and development in these areas (Brower and Opie, 1997; Brower and Hepa, 1998).

Because of the unpredictable movements of the Central Arctic and Teshekpuk Lake caribou herds, and because of ice conditions and hunting techniques that depend on the weather, Nuiqsut's annual caribou harvest can fluctuate markedly; but when herds are available and when weather permits, caribou are harvested year-round. Elders Samuel and Sarah Kunaknana related that caribou hunters in the past had to go inland to hunt caribou, because they never came down to the coast as they do now (Shapiro, Metzner, and Toovak, 1979).

(3) Fish

Fish provide the most edible pounds per capita of any subsistence resource harvested by Nuiqsut (see Tables VI.B-5 and VI.B-6; State of Alaska, Dept. of Fish and Game, 1993, 1995a). The harvests of most subsistence resources, such as caribou, can fluctuate widely from year to year because of variable migration patterns and because harvesting techniques depend on ice and weather conditions—much the same as the conditions surrounding the bowhead whale hunt. Even though fish-harvest rates (and total catch) vary from year to year, the harvest of fish is perhaps more consistent than the harvest of land animals. The harvesting of fish is not subject to seasonal limitations, a situation that adds to their importance in the community's subsistence round. Nuiqsut has been shown to have the largest documented subsistence fish harvest on the Beaufort Sea coast (Moulton, 1997; Moulton, Field, and Brotherton, 1986). Moreover, in October and November, fish may provide the only source of fresh subsistence foods.

Fishing is an important activity for Nuiqsut residents because of the community's location on the Nechelik Channel of the Colville River, which has large resident fish populations. The river supports 20 species of fish, and approximately half of these are taken by Nuiqsut residents (George and Nageak, 1986). Local residents generally harvest fish during the summer and fall, but the fishing season basically runs from January through May and from late July through mid-December. The summer, open-water harvest lasts from breakup to freezeup (early June to mid-September). The summer harvest covers a greater area, is longer than the fall/winter harvest, and a greater number of species are caught. Broad whitefish, the primary species harvested during the summer, is the only anadromous species harvested in July. Thomas Napageak relates that "in the summer when it is time to fish for large, round-nosed whitefish the place called Tirragruag gets filled with them as well as the entrance to Itqiliq. Nigliq River gets filled with nets all the way to the point where it begins. We do not go to Kuukpiluk in the summer months. Then we enter Fish Creek...another place where they fish for whitefish is Nuiqsagruaq" (Thomas Napageak [USDOI, BLM, 1998]). In July, lake trout, northern pike, broad whitefish, and humpback whitefish are harvested south of Nuiqsut. Traditionally, coastal areas were fished in June and July, when rotting ice created enough open water for seining. Nuiqsut elder Sarah Kunaknana, interviewed in 1979, said: "...in the little bays along the coast we start seining for fish (iqalukpik). After just seining 1 or 2 times, there would be so many fish we would have a hard time putting them all away" (Shapiro, Metzner, and Toovak, 1979). Salmon species reportedly have been caught in August but not in large numbers. Pink and chum salmon are the most commonly caught, although there reportedly has not been a great interest in harvesting them (George and Nageak, 1986). Arctic char is found in the main channel of the Colville River but does not appear to be a major subsistence species because, although apparently liked, it is not abundantly caught (George and Nageak, 1986; George and Kovalsky, 1986; State of Alaska, Dept. of Fish and Game, 1993, 1995a).

The fall/winter under-ice harvest of fishes begins after freezeup, when the ice is safe for snowmachine travel. Local families can fish approximately 1 month after freezeup. The Kuukpigruaq Channel is the most important fall fishing area in the Colville region, and the primary species harvested are Arctic and least cisco. Even after freezeup, people continue to fish for whitefish (Thomas Napageak [USDOI, BLM, 1998]). Nuiqsut resident Ruth Nukapigak recounts a recent winter fishing trip in December 1997: "I, myself, took my net out in December right before Christmas Day. I was catching whitefish in my net" (USDOI, BLM, 1998). Arctic and least cisco amounted to 88 and 99% of the harvest in 1984 and 1985, respectively; however, this percentage varied greatly depending on the net-mesh size. Humpback and broad whitefish, sculpin, and some large rainbow smelt also are harvested, but only in low numbers (George and Kovalsky, 1986; George and Nageak, 1986). A fish identified as "spotted least cisco" also has been harvested. This fish is not identified by Morrow (1980) but may be a resident form of least cisco (George and Kovalsky, 1986). Weekend fishing for burbot and grayling occurs at Itkillikpaat, 6 miles from Nuiqsut (George and Nageak, 1986; ADF&G, 1995a).

The summer catch in 1985 totaled about 19,000 pounds of mostly broad whitefish; in the fall, approximately 50,000 pounds of fish were caught, for an annual per capita catch of 244 pounds; some of this catch was shipped to Barrow (Craig, 1987). A 1985 Alaska Department of Fish and Game subsistence survey estimated the edible pounds of all fish harvested at 176.13 pounds per capita (44.1% of the total subsistence harvest; State o Alaska, Department of Fish and Game, 1993). In 1986, there was a reduced fishing effort in Nuiqsut; and the fall harvest was only 59% of that taken in 1985 (Craig, 1987). In 1992, 34% of the edible pounds of the total subsistence harvest was fish and, by 1993, the estimate for edible pounds of all fish harvested had risen to 250.62 pounds per capita (33.7% of the total subsistence harvest; George and Fuller, In prep.; State of Alaska, Dept. of Fish and Game, 1995a). A subsistence-harvest survey conducted by the North Slope Borough Division of Wildlife Management covering the period from July 1994-June 1995 reported that the subsistence fishing provided 30% of the total subsistence harvest (see Table V.B-6; Brower and Opie, 1997; Brower and Hepa, 1998). A recent survey shows that 80% of all Nuiqsut households participate in some fishing activity (State of Alaska, Dept. of Fish and Game, 1995a).

(4) Other Marine Mammals

(a) Seals

Seals are hunted year-round, but the bulk of the seal harvest occurs during the open-water season, with breakup usually occurring in June. In the spring, seals can be hunted once the landfast ice goes out. Present-day sealing is most commonly done at the mouth of the Colville when it begins flooding in June. According to Thomas Napageak:

> …when the river floods, it starts flowing out into the ocean in front of our village affecting the seals that include the bearded seals in the spring month of June…. When the river floods, near the mouth of Nigliq River it becomes filled with a hole or thin spot in [the] sea ice that has melted as the river breaks up. When it reaches the sea, that is the time that they begin to hunt for seals, through the thin spot in the sea ice that has melted. They hunt for bearded seals and other types of seals (USDOI, BLM, 1998).

Nuiqsut resident Ruth Nukapigak recounts past trips to this same sealing area: "I love to follow my son Jonah every year just when the ice begins moving down there and it takes us one hour travel time to get there. That is where we go to hunt for seals" (USDOI, BLM, 1998). Nuiqsut elder Samuel Kunaknana, when interviewed in 1979, noted that when the ice is nearshore in the summer, it is considered to be good for seal hunting (S. Kunaknana, as cited in Shapiro, Metzner, and Toovak, 1979). While seal meat is eaten, the dietary significance of seals primarily comes from seal oil, served with almost every meal that includes subsistence foods. Seal oil also is used as a preservative for meats, greens, and berries. Seal skins are important in the manufacture of clothing and, because of their beauty, spotted seal skins often are preferred for making boots, slippers, mitts, and parka trim. In practice, however, ringed seal skins are used more often in the making of clothing because the harvest of this species is more abundant. A 1993 Department of Fish and Game subsistence survey in Nuiqsut indicates that 31.8% of the total subsistence harvest was marine mammals, and 3.1% of the total harvest was seals (State of Alaska, Dept. of Fish and Game, 1995a). George and Fuller (In prep.) estimated 24 ringed seals, 6 spotted seals, and 16 bearded seals were harvested in 1992, and the overall marine mammal contribution (including bowhead whales) to the total subsistence harvest was estimated at 36%. A subsistence-harvest survey conducted by the North Slope Borough Division of Wildlife Management covering the period from July 1994-June 1995 reported a harvest of 23 ringed seals and a contribution of marine mammals of only 2% to the total subsistence harvest, because no bowhead whales were harvested that season (Brower and Opie, 1997; Brower and Hepa 1998).

(b) Polar Bears

The harvest of polar bears by Nuiqsut hunters begins in mid-September and extends into late winter. Polar bear meat is eaten, although little harvest data are available. One documented bear was harvested in the 1962-1982 period; for the period 1983-1995 Nuiqsut harvested 20 polar bears (Schliebe, 1995; State of Alaska, Dept. of Fish and Game, 1993, 1995a; Brower and Opie, 1997; Brower and Hepa, 1998). According to whaling captain Thomas Napageak's statement at the Beaufort Sea Sale 144 Public Hearings in Nuiqsut, the taking of polar bear is not very important now because Federal regulations prevent the selling of the hide: "...as valuable as it is, [it] goes to waste when we kill a polar bear" (USDOI, MMS, 1995b).

(c) Beluga Whales

Some sources have mentioned beluga whales being taken incidentally during the bowhead harvest, but Thomas Napageak, President of the Native Village of Nuiqsut, in recent testimony stressed that the village of Nuiqsut has never hunted beluga whales: "I don't recall a time when I went hunting for beluga whales. I've never seen a beluga whale here" (USDOI, BLM, 1998).

(d) Walrus

The Alaska Department of Fish and Game subsistence-survey data indicate that two walruses were harvested in the 1985/1986 harvest season, but no new walrus data for the community have been gathered since then (State of Alaska, Department of Fish and Game, 1993, 1995a). Walruses probably are incidentally taken during seal hunting.

(5) Moose

Moose normally are harvested from August-October by boat on the Colville (upriver from Nuiqsut), Chandler, and Itkillik rivers, but the timing of harvest varies, depending on the current hunting regulations. Harvest data show that moose have been harvested during the winter months by snowmachine (Brower and Opie, 1997). In 1985, hunters from 40 households out of a total 76 households surveyed reported a harvest of seven moose (State of Alaska, Dept. of Fish and Game, 1993). In 1993, 62 households out of a total 91 households surveyed managed to harvest nine moose (State of Alaska, Dept. of Fish and Game, 1995a). A subsistence-harvest survey conducted by the North Slope

Borough Division of Wildlife Management covering the period from July 1994-June 1995 reported five moose harvested, or 5% of the total edible pounds harvested that season (Brower and Opie, 1997; Brower and Hepa, 1998). In 1992, caribou and moose accounted for 27% of the total subsistence harvest (George and Fuller, In prep.); in 1993, moose and caribou accounted for 33% (Pedersen, 1996); and in the period covered by the North Slope Borough subsistence survey (July 1994-June 1995), caribou and moose accounted for 63% of the edible pounds of subsistence resources harvested by Nuiqsut hunters (Brower and Opie, 1997; Brower and Hepa, 1998). This jump to a much higher percentage for terrestrial mammals is likely explained by an unsuccessful bowhead whale harvest during the study period (Suydam et al., 1994).

(6) Wildfowl

Waterfowl and coastal birds are a subsistence resource that has been growing in importance since the mid-1960's. Birds are harvested year-round, with peak harvests in May-June and September-October. The most important species for Nuiqsut hunters are the Canada and white-fronted goose and brant; eiders are harvested in low numbers. Ruth Nukapigak relates that "...when the white-fronted goose come, they do hunt them. When the thin ice near the mouth of the river breaks up, that is when they start duck hunting. We, the residents of Nuiqsut, go there to hunt for ducks when they arrive" (USDOI, BLM, 1998). The only upland bird hunted extensively is the ptarmigan (State of Alaska, Dept. of Fish and Game, 1993, 1995a; Brower and Opie, 1997). Recent data indicated the subsistence bird harvest provided 5% of the total subsistence harvest (Brower and Opie, 1997; Brower and Hepa, 1998). Waterfowl hunting occurs mostly in the spring, beginning in May, and continues throughout the summer. In the summer and early fall, such hunting usually occurs as an adjunct to other subsistence activities, such as checking fish nets.

2. Sociocultural Systems

The topic of sociocultural systems encompasses the social organization and cultural values of a society. This section provides a profile of the sociocultural systems that characterize the North Slope communities of Barrow, Nuiqsut, and Kaktovik. The ethnic, sociocultural, and socioeconomic makeup of the communities on the North Slope is primarily Inupiaq. Nuiqsut is the closest Inupiat community to the Liberty Project area.

The communities of Barrow, Nuiqsut, and Kaktovik potentially could be affected by development in the project area. Their populations and current socioeconomic conditions are discussed before the important variables in a sociocultural analysis—social organization, cultural values, institutional organization, and other ongoing issues—are considered.

The following summarizes and incorporates by reference detailed descriptions of sociocultural systems found in the Beaufort Sea Sale 144 Final EIS (USDOI, MMS, 1996a), the Northeast National Petroleum Reserve-Alaska Draft Integrated Activity Plan/EIS (USDOI, BLM and MMS, 1997), the Beaufort Sea Sale 170 Final EIS (USDOI, MMS, 1998), and the Beaufort Sea Oil and Gas Development Project/ Northstar Draft EIS (U.S. Army Corps of Engineers, 1998). The summary is augmented by additional material, as cited.

a. Characteristics of the Population

The North Slope has a fairly homogeneous population of Inupiat, approximately 72% in 1990. This is an approximation, because the 1990 Census did not distinguish between Inupiat and other Alaskan Natives and American Indians, although there were only 110 individuals (1.8% of the total North Slope Borough population) in the North Slope Borough that fell into these latter two classifications. The percentage in 1990 ranged from 92.7% Inupiat in Nuiqsut to 61.8% Inupiat in Barrow (USDOC, Bureau of the Census, 1991). In 1999, Alaska Department of Labor population estimates were 4,438 for Barrow, 486 for Nuiqsut, and 259 for Kaktovik (State of Alaska, Dept. of Labor, 1998).

North Slope society responded to early contacts with outsiders by successfully changing and adjusting to new demands and opportunities (Burch, 1975a, b; Worl, 1978; North Slope Borough Contract Staff, 1979). Since the 1960's, the North Slope has witnessed a period of "super change," a pace of change quickened by the area's oil developments (Lowenstein, 1981). In the Prudhoe Bay/Kuparuk industrial complex, oil-related work camps have altered the seascape and landscape, making some areas off limits to traditional subsistence hunting. In addition, large North Slope Borough Capital Improvement Projects have dramatically changed the physical appearance of North Slope Borough communities.

Social services have increased dramatically since 1970, with increased Borough budgets and grants acquired early on by the Inupiat Community of the Arctic Slope, and later by the Arctic Slope Native Association and other borough nonprofits. In 1970 and 1977, residents of North Slope villages were asked about their state of well-being in a survey conducted by the University of Alaska, Anchorage, Institute of Social and Economic Research (Kruse et al., 1983). The survey noted significant increases in complaints about alcohol and drug use in all villages between 1970 and 1977. Health and social-services programs have attempted to address these problems with treatment programs and shelters for wives and families of abusive spouses and with greater emphasis on recreational programs and services. In the last decade, all communities in the North Slope Borough have struggled with banning the sale, use, and possession of alcohol, and the issue of whether a community will become “dry” or stay “wet” is constantly being brought before local voters.

The introduction of modern technology has tied the Inupiat subsistence economy increasingly to a cash economy (Kruse, 1982). Nevertheless, oil-supported revenues have been able to support a lifestyle that still is distinctly Inupiaq, and outside pressures and opportunities have sparked what may be viewed as a cultural revival (Lantis, 1973). What exists in the communities of the North Slope is “a unique lifestyle in which a modern cash economy and traditional subsistence are interwoven and interdependent” (USDOI, BLM, 1979). North Slope residents exhibit an increasing commitment to areawide political representation, local and regional tribal governments, and the cultural preservation of such institutions as whaling crews and dancing organizations as well as the revival of traditional seasonal celebrations. People continue to hunt and fish, but aluminum boats, outboards, snow machines, and all-terrain vehicles now blend these pursuits with wage work. Inupiat whale hunting remains a proud tradition that involves ceremonies, dancing, singing, visiting, cooperation between communities, and the sharing of foods. Effects from ongoing and proposed oil development on subsistence have been, are, and will continue to be a major issue for residents of North Slope communities (Kruse et al., 1983; ACI and Braund, 1984; USDOI, MMS, 1994, 1995b, 1996a; Stephen R. Braund, In prep.; USDOI, BLM, 1997c; USDOI, MMS, 1998).

b. Socioeconomic Conditions

(1) Barrow

On the North Slope, Barrow is the largest community and the regional center Barrow’s estimated population in 1999 was 4,438 (State of Alaska, Dept. of Labor, 1999). Barrow already has experienced dramatic population changes as a result of increased revenues from onshore oil development and production in Prudhoe Bay and other smaller oil fields; these revenues early on served to stimulate the North Slope Borough Capitol Improvement Program. In 1970, the Inupiat population of Barrow represented 91% of the total population (USDOC, Bureau of the Census, 1971). In 1985, non-Natives outnumbered Natives between the ages of 26 and 59 (North Slope Borough, Dept. of Planning and Community Services, 1989). By 1990, Inupiat representation had dropped to 63.9% (USDOC, Bureau of the Census, 1991; Harcharek, 1992). Barrow’s entire terrestrial and marine subsistence-harvest area lies well to the west of the Liberty area.

In the period from 1975-1985, Barrow experienced extensive social and economic transformations. The North Slope Borough Capital Improvement Program stimulated a boom in the Barrow economy and an influx of non-Natives to the community; between 1980 and 1985, Barrow’s population grew by 35.6% (Kevin Waring Associates, 1989). Inupiat women entered the labor force in the largest numbers ever and achieved positions of political leadership in newly formed institutions. The proportion of Inupiat women raising families without husbands also increased during this period, a noticeable alteration in a culture where the extended family, operating through interrelated households, is salient in community social organization (Worl and Smythe, 1986). During this same period, the social organization of the community became increasingly diversified with the proliferation of formal institutions and the large increase in the number of different ethnic groups. Socioeconomic differentiation is not new in Barrow. During the commercial-whaling period and the reindeer-herding period, there were influxes of outsiders and significant shifts in the economy. Other fluctuations have occurred during different economic cycles: fur trapping, U.S. Navy and arctic contractors’ employment, the Capital Investments Program boom, and periods of downturn (Worl and Smythe, 1986). As a consequence of the changes it already has sustained, Barrow may be more capable of absorbing additional changes as a result of development than would smaller, homogeneous Inupiat communities such as Nuiqsut and Kaktovik.

(2) Nuiqsut

Nuiqsut is located on the west bank of the Nechelik Channel of the Colville River Delta, about 25 miles from the Arctic Ocean and approximately 150 miles southeast of Barrow. The population was 354 (92.7% Inupiat) in 1990 (USDOC, Bureau of the Census, 1991) and was estimated at 486 in 1999 (State of Alaska, Dept. of Labor, 1999). Nuiqsut, one of three abandoned Inupiat villages in the North Slope region identified in the Alaska Native Claims Settlement Act, was resettled in 1973 by 27 families from Barrow. Nuiqsut’s important bowhead whale hunting area at Cross Island is northwest of the Liberty Project area. Today, Nuiqsut is experiencing rapid social and economic change with the building of a new hotel, the influx of non-Inupiat oil workers, and the potential development of oil in the National Petroleum Reserve-Alaska and the Alpine field adjacent to the community.

(3) Kaktovik

Kaktovik, incorporated in 1971, is the easternmost village in the NSB. In 1990, it had a population of 224 (83% Inupiat) and an estimated population of 259 in 1999 (USDOC, Bureau of the Census, 1991; State of Alaska, Department of Fish and Game, 1995b; Kevin Waring Associates, 1989; State of Alaska, Dept. of Labor, 1999). Kaktovik is located on the north shore of Barter Island, situated between the Okpilak and Jago rivers on the Beaufort Sea coast. Barter Island is one of the largest of a series of barrier islands along the north coast and is about 300 miles east of Barrow. Kaktovik’s subsistence-harvest areas are well to the east of the Liberty area, but some species migrating eastward, seaward of the project area, potentially could be affected by activities there.

c. Social Organization

The social organization of these Inupiat communities is strongly kinship oriented. Kinship forms "the axis on which the whole social world turn[s]" (Burch, 1975a,b). Historically, households were composed of large, extended families, and communities were kinship units. Today, there is a trend away from the extended-family household because of increases in mobility, availability of housing, and changes in traditional kinship patterns. However, kinship ties in Inupiat society continue to be important and remain a central focus of social organization.

The social organization of North Slope Inupiat encompasses not only households and families but also wider networks of kinspeople and friends. These various types of networks are related through various overlapping memberships and are embedded, as well, in those groups that are responsible for hunting, distributing, and consuming subsistence resources (Burch, 1970). An Inupiat household on the North Slope may contain a single individual or group of individuals who are related by marriage or ancestry. The interdependencies that exist among Inupiat households differ markedly from those found in the United States as a whole. In the larger non-Inupiat society, the demands of wage work emphasize a mobile and prompt workforce. While modern transportation and communication technologies allow for contact between parents, children, brothers, sisters, and other extended-family members, more often than not, independent nuclear households (father, mother, and children) or conjugal pairs (childless couples) form independent "production" units that do not depend on extended-family members for the day-to-day support of food, labor, or income. A key contrast between non-Native and Inupiat cultures occurs in their differing expectations of families—the Inupiat expect and need support from extended-family members on a day-to-day basis.

Associated with these differences, the Inupiat hold unique norms and expectations about sharing. Households are not necessarily viewed as independent economic units; and giving, especially by successful hunters in the community, is regarded as an end in itself, although community status and esteem accrue to the generous. Kinship ties are strengthened through the sharing and exchanging of subsistence resources (Nelson, 1969; Burch, 1971; Worl, 1979; ACI, Courtnage, and Braund, 1984; Luton, 1985; Chance, 1990).

d. Cultural Values

Traditionally, Inupiat values focused on the Inupiat's close relationship with natural resources, specifically game animals. The Inupiat also had a close relationship to the supernatural with specific beliefs in animal souls and beings who control the movements of animals. Other values included an emphasis on the community, its needs, and its support of other individuals. The Inupiat respect persons who are generous, cooperative, hospitable, humorous, patient, modest, and industrious (Lantis, 1959; Milan, 1964; Chance, 1966, 1990). Although there have been substantial social, economic, and technological changes in Inupiat lifestyle, subsistence continues to be the central organizing value of Inupiat sociocultural systems. The Inupiat remain socially, economically, and ideologically loyal to their subsistence heritage. Indeed, "most Inupiat still consider themselves primarily hunters and fishermen" (Nelson, 1969). This refrain is repeated again and again by the residents of the North Slope (Kruse et al., 1983; ACI, Courtnage, and Braund, 1984; Impact Assessment, Inc., 1990a,b; USDOI, MMS, 1994). Task groups still are organized to hunt, gather, and process subsistence foods. Cooperation in hunting and fishing activities also remains an integral part of Inupiat life, and who one cooperates with is a major component of the definition of significant kin ties (Heinrich, 1963). Large amounts of subsistence foods are shared within the community, and who one gives to and receives from are also major components of what makes up significant kin ties (Heinrich, 1963; ACI, Courtnage, and Braund, 1984).

On the North Slope, "subsistence" is much more than an economic system; the hunt, the sharing of the products of the hunt, and the beliefs surrounding the hunt tie families and communities together, connect people to their social and ecological surroundings, link them to their past, and provide meaning for the present. Generous hunters are considered good men, and good hunters are often respected leaders. Good health comes from a diet of products from the subsistence hunt, and young hunters still give their first game to the community elders. To be generous brings future success. These are some of the essential ways that subsistence and beliefs about subsistence join with sociocultural systems.

The cultural value placed on kinship and family relationships is apparent in the sharing, cooperation, and subsistence activities that occur in Inupiat society; however, cultural value also is apparent in the patterns of residence, reciprocal activities, social interaction, adoption, political affiliations (some families will dominate one type of government administration, for example, the village corporation), employment, sports activities, and membership in voluntary organizations (Mother's Club, Search and Rescue, etc.) (ACI, Courtnage, and Braund, 1984).

Bowhead whale hunting remains at the center of Inupiat spiritual and emotional life; it embodies the values of sharing, association, leadership, kinship, arctic survival, and hunting prowess (see Bockstoce et al., 1979; ACI, Courtnage, and Braund, 1984). Barrow resident Beverly Hugo, testifying at public hearings for MMS' Beaufort Sea Sale 124, summed up Inupiaq cultural values this way:

> …these are values that are real important to us, to me; this is what makes me who I am…the knowledge of the language, our Inupiat language, is a real high one; sharing with others, respect for others…and cooperation; and respect for elders; love for children; hard work; knowledge of our family tree; avoiding conflict; respect for nature; spirituality; humor; our family roles. Hunter success is a big one, and domestic skills, responsibility to our tribe, humility….These are some of the values…that we have…that make us who we are, and these values have coexisted for thousands of years, and they are good values…(USDOI, MMS, 1990c).

The importance of the whale hunt is more than emotional and spiritual. The organization of the crews does much to delineate important social and kin ties within communities and to define community leadership patterns as well. The structured sharing of the whale helps determine social relations both within and between communities (Worl, 1979; ACI, Courtnage, and Braund, 1984; Impact Assessment, Inc., 1990a). Structured sharing also holds true for caribou hunting, fishing, and other subsistence pursuits. In these communities, the giving of meat to elders does more than feed old people; it bonds giver and receiver, joins them to a living tradition, and draws the community together.

Today, this close relationship between the spirit of a people, their social organization, and the cultural value of subsistence hunting may be unparalleled when compared with other areas in America where energy-development is taking place. The Inupiat's continuing strong dependence on subsistence foods, particularly marine mammals and caribou, creates a unique set of potential effects from onshore and offshore oil development on the social and cultural system. Barrow resident Daniel Leavitt articulated these concerns during the 1990 public hearing for Beaufort Sea Sale 124: "…as I have lived in my Inupiat way of livelihood, that's the only…thing that drives me on is to get something for my family to fill up their stomachs from what I catch" (USDOI, MMS, 1990c).

Another great concern that North Slope Borough Inupiat communities express is the lack of traditional knowledge and testimony appearing in government documents, particularly MMS's oil lease-sale EIS's. Mayor George N. Ahmaogak, Sr., of the North Slope Borough said in a 1990 letter to MMS: "The elders who spoke particularly deserve a response to their concerns…. You should respect the fact that no one knows this environment better than Inupiat residents…" (Ahmaogak, 1990, pers. commun.). In public testimony in 1993 concerning a Letter of Authorization for bowhead whale monitoring at the Kuvlum Prospect, the late Burton Rexford, Chairman of the Alaska Eskimo Whaling Commission, stated that the most important environmental information would come from whaling captains, crew members, and whaling captains' wives. "We know our environment—our land and resources—at a deep level" (USDOC, NOAA, NMFS, 1993). These same concerns were unanimously echoed by those testifying for Barrow, Kaktovik, and Nuiqsut in hearings and scoping meetings for Beaufort Sea Sales 144 and 170, for National Petroleum Reserve-Alaska management, and for the Northstar and Liberty projects (Public Hearing Transcripts, Beaufort Sea Sale 144 [USDOI, MMS, 1995a, b, c], Beaufort Sea Sale 170 [USDOI, MMS, 1997b], National Petroleum Reserve-Alaska Integrated Activity Plan Draft EIS [USDOI, BLM and MMS, 1997], Beaufort Sea Oil and Gas Development Project/Northstar [U.S. Army Corps of Engineers, 1996], and the Liberty Project [USDOI, MMS, Alaska OCS Region, 1998b]).

e. Institutional Organization of the Communities

The North Slope Borough provides most government services for the communities of Barrow, Nuiqsut, Kaktovik as well as other communities in the Borough. These services include public safety, public utilities, fire protection, and some public-health services. Future fiscal and institutional growth is expected to slow because of economic constraints on direct Inupiat participation in oil-industry employment and growing constraints on the Statewide budget, although North Slope Borough revenues have remained healthy and its own permanent fund account continues to grow as does its role as primary employer in the region (Kruse et al., 1983; Harcharek, 1992, 1995). The Arctic Slope Regional Corporation, formed under the Alaska Native Claims Settlement Act, runs several subsidiary corporations. Most of the communities also have a village corporation, a Traditional Village or Indian Reorganization Act Village Council, and a city government. The Indian Reorganization Acts and village governments have not provided much in the way of services, but village corporations have made many service contributions. The Inupiat Community of the Arctic Slope, the regional tribal government, has recently taken on a more active and visible role in regional governance.

f. Other Ongoing Issues

Other issues important to an analysis of sociocultural systems are those that will affect or are already affecting Inupiat society (i.e., cumulative impacts). The EIS's for

MMS Sales 97, 124, 144, and 170 and for the National Petroleum Reserve-Alaska detail issues about changes in employment, increases in income, decreases in Inupiaq fluency, rising crime rates, and substance abuse (Sec. III.C.1 in USDOI, MMS, 1987a, 1990b, 1996a, 1998, and USDOI, BLM and MMS, 1998) and also discuss the fiscal and institutional growth of the North Slope Borough. These discussions are incorporated by reference and summarized briefly below. In addition, Smythe and Worl (1985) and Impact Assessment, Inc. (1990a) detail the growth and responsibilities of local governments.

The baseline of the present sociocultural system includes change and strain. The very livelihood and culture of North Slope residents come under increasingly close scrutiny, regulation, and incremental alteration. Increased stresses on social well-being and on cultural integrity and cohesion come at a time of relative economic well-being. The expected challenges on the culture by the decline in Capital Improvement Project funding from the State of Alaska have not been as significant as once expected. The buffer effect has come mostly through the dramatic growth of the Borough's own permanent fund, the North Slope Borough taking on more of the burden of its own capital improvement, and its emergence as the largest employer of local residents. Yet funding challenges (and subsequent challenges to the culture) continue as the Alaska State Legislature experiments with new formulas that would reduce funding for rural school districts and as revenues from oil development at Prudhoe Bay decline.

3. Archaeological Resources

The following analyses represent the Prehistoric Resource Analysis and Shipwreck Update Analysis required in the MMS Handbook for Archaeological Resource Protection (620.1-H). See also the Liberty Development Project, Environmental Report (BPXA, 1998a:4-50 to 4-53), for a more complete discussion on these resources.

a. Prehistoric Resources

Prehistoric resources "pertain to that period of time before written history. In North America, 'prehistoric' usually refers to the period before European contact" (MMS Manual 620.1-H).

(1) Onshore

The Alaska Heritage Resources Survey site files show sites where prehistoric components have been recorded in the Beaufort Sea Planning Area. They consist of habitation sites, lithic scatters, and isolated finds (Dale, 1996, pers. commun.). No prehistoric sites have been found within the proposed Liberty Project area (Lobdell, 1998a:12).

(2) Offshore

We evaluated geophysical/geological and archaeological data to determine whether the Liberty Project area may have submerged prehistoric sites. The prehistoric archaeological site potential was analyzed with respect to the distribution and survivability of potential preserved terrestrial sediments and submerged landforms. The project area includes lease OCS-Y 1650 and neighboring Federal and State lands on the outer continental shelf within the project area and the pipeline corridor.

We incorporate by reference the archaeological analyses prepared for previous Beaufort Sea lease sales and previous works concerning the geologic processes that affect the survivability of potential prehistoric sites. Wherever appropriate, these sources have been updated with current reports, surveys, and information.

(3) Review of the Baseline Study

No new baseline studies exist for archaeological resources in the Beaufort Sea. The analysis for Lease Sale 170 is the most current and was referred to while we prepared this report.

(4) Review of Reports on Geology and Cultural Resources

We reviewed the following geohazards and geotechnical reports to prepare this analysis:

- The Preliminary Liberty Cultural Resources Report (Watson Company [1999]).
- The Liberty High Resolution Geophysical Survey, Foggy Island Bay in Stefansson Sound, Alaska (Watson Company [1998]).
- Liberty Pipeline Route Survey, Foggy Island Bay in Stefansson Sound (Watson Company [1998]).
- Geotechnical Exploration Liberty Development Project, Foggy Island Bay, Alaska (Duane Miller & Assocs. [1997]).
- Geotechnical Exploration Liberty Development North Slope, Alaska (Duane Miller & Assocs. [1998]).

BPXA provided these studies to support the Liberty Project.

We also reviewed the following geohazards and geotechnical reports prepared to support exploration in the Liberty area:

- Beaufort Sea Shallow Hazards Synthesis Liberty #1 Well (Arctic Geoscience, Inc. [1997]).
- Geophysical and Geotechnical Site Evaluation, Karluk Prospect, Beaufort Sea Alaska (Harding Lawson Associates [1981a]), in support of Chevron USA's Karluk OCS-Y 0194 Well #1.
- Geotechnical Investigation Tract 42 Well Site, Beaufort Sea, Alaska, (Harding-Lawson Associates [1981b]), for Shell Oil Company's Tern Prospect.
- Geologic Hazards Report for Shell Oil Company's Tern Prospect (Harding-Lawson Associates [1981c])

- The Warthog No. 1 Camden Bay, Beaufort Sea, Shallow Hazards Survey Results (Fairweather E&P Services Inc. [1997]). This was reviewed because of its relevance to potential archaeological resources in the shallow Beaufort Sea.

A sediment core southwest of the Liberty Prospect contained a 10-foot-thick layer of Holocene sediments. It consisted of a 3-foot-thick basal layer of gray, silty sand with a trace of shell fragments overlain by a layer of soft, saturated, fibrous peat. Many sediment cores collected in Foggy Island Bay, Stefansson Sound area have contained an organic-rich silt with fibrous material at the base of the Holocene section. Core B-7, collected by Duane Miller in 1997, contains a peat layer at the base of the 18-foot-thick Holocene section, about 3.5 miles southwest of the proposed Liberty Island. This core indicates the presence of an intact sequence of Holocene-age terrestrial and nearshore sediments close to the Liberty Prospect.

Subbottom profiler data collected in the area indicate well-preserved paleochannel features in the Liberty area, but the Liberty Island site appears to have no paleochannel features. At the Warthog Prospect, the subbottom profiler data also show well-preserved channel-edge features, such as levees and terraces. These channel features all occur just below the seafloor, suggesting that they date from a recent low stand of sea level that occurred during the late Wisconsinan glaciation (about 19,000-6,000 Y.B.P. [Years Before Present]); however, their absolute age is uncertain. If the features in the Warthog area are late Wisconsinan in age, they would represent areas where prehistoric archaeological resources may occur. A sediment core collected about 5 kilometers southwest of the Warthog Prospect contained a layer composed of 40% organics at a depth of about 15 feet subbottom. However, woody fragments from a sediment layer higher in the same core and shell fragments from other cores in nearby shallow-water State lands were radiocarbon age-dated by ARCO and yielded dates older than 20,000 Y.B.P. These organics are probably reworked older material.

(5) Review of Sea-Level History

Because Liberty is within the shallow Beaufort Sea, which was exposed as dry land and available for people to live on until the sea level rose and flooded the project area sometime around 5,000 to 6,000 Y. B.P., it may contain archaeological resources. Relative sea level in the Beaufort Sea was approximately 50 meters below present at 13,000 Y. B.P. (Hopkins, 1967), which is just before the general timeframe for the arrival of people in the Arctic.

(6) Review of Geological/Geophysical Data to Determine the Potential for Survival of Archaeological Sites

The geohazards and geotechnical reports and surveys collected in the Liberty Project area suggest there may be potential for archaeological resources to have survived the destructive erosional processes that operated on the coast as sea level rose and sculpted the seafloor. Sediment core(s) collected in Foggy Island Bay, Stefansson Sound contained a peat layer in the Holocene section. Peat does not prove the existence of archaeological resources but only shows that there is the potential for Holocene-age sedimentary sequences, including archaeological sequences, in the Liberty area. It also shows that erosion from ice gouging, thermokarst erosion, etc., was not significant enough to thoroughly rework the Holocene section.

The subbottom profiler data show the presence of well-preserved late Pleistocene/Holocene-age fluvial channels within the project area. The subbottom profiler data also show a buried lake or lagoon along the western pipeline route with underlying peat beds approximately 12 feet below the seafloor. The age of the peat is unknown. Adjacent to this buried depression is a seafloor shoal that may represent a drowned island. The buried edge of this island terminates in a possible buried paleoterrace at the edge of the paleolagoon or paleolake. The banks, terraces, and point bars of these channels and lagoons, and areas on paleoislands, are places that would have been chosen by prehistoric people for campsites and subsistence activity. Because these features appear to be well preserved, any archaeological sites that are present also would be well preserved. Also, because the channels and lagoon terraces are buried by only a few meters of Holocene sediments, any sites would be detectable with physical sampling techniques such as sediment coring.

The analysis of prehistoric resources for Beaufort Sea Sale 144 concluded that destructive geologic processes such as ice gouging, thermokarst erosion, and storm surges had strongly reworked the near-surface shelf sediments in the Beaufort Sea Planning Area. Therefore, it was concluded that prehistoric archaeological sites had a very low potential for survival. The geophysical data from the Liberty Project area and the Warthog Project contradict this previous conclusion. Information from the side-scan sonar and underwater video images of the seafloor show that ice gouging is sparse to nonexistent at these two locations. Evidence shows that locations beneath floating shorefast ice and landward of the barrier islands get more protection from ice gouging and other destructive geologic processes that operate on the open shelf and perhaps were sheltered from some of the erosional effects of rising sea level.

Thus, after reviewing geophysical high-resolution data and geotechnical core data from the Liberty Project area, we conclude that prehistoric archaeological sites potentially may exist and may have survived the destructive geologic processes of the Holocene sea transgression and those that operate at the modern seafloor.

b. Historic Resources

Historic resources pertain "to the period of time for which written history exists" (MMS Manual 620.1-H) including, but not limited to, shipwrecks.

(1) Onshore

A review of the Alaska Heritage Resource Survey site files shows sites with historic components in the Beaufort Sea Planning Area. They consist of a Distant Early Warning line station and its research equipment and habitation, cemetery, military debris, camp, hunting, reindeer-herding, trapping, ice cellar, and lookout-tower site types (Dale, 1996, pers. commun.).

Lobdell (1998a) surveyed the proposed project area in August 1997 and recorded two Historic Period sites: Foggy Island Bay Site #2 (49-XBP-024) and Foggy Island Bay Site #3 (49-XBP-026). Both are ruins of historic sod houses. Foggy Island Bay Site #2 is 0.2 miles northwest of the proposed onshore pipeline route (Alternative I) and undergoes active thermokarst erosion (Lobdell, 1998a:8). Foggy Island Bay Site #3 is 1 mile southeast of the proposed onshore pipeline route under Alternative III. Besides ruins of sod houses, this site also contains a grave 70 meters from the house ruins. Thermokarst erosion has not affected the site, because a substantial fronting strand flat protects it from geological processes (Lobdell, 1998a:11).

The State Historic Preservation Officer accepted the report of the onshore survey on May 2, 1998. The historian concurred that the preferred mitigation of the two recorded historic sites was avoidance (Bittner, 1998).

(2) Offshore

Our computerized list of shipwrecks for the project area shows two known shipwrecks. In 1894, the *Reindeer*, a 340-ton whaling bark, wrecked near Reindeer Island in the Midway Islands, probably 25-30 miles west of the proposed project location. In 1907, the *Duchess of Bedford*, a 60-ton expedition schooner, wrecked near Flaxman Island some 40-45 miles east of the proposed location (Burwell, 1998, pers. commun.; Tornfelt and Burwell, 1992). The final distribution of a shipwreck on the seafloor depends on such factors as sediment depth and composition, sea currents, water depth, size and type of ship, and geologic processes. To date, no surveys have been done to find these wrecks, and the information we have is not enough to assign them to specific locations.

Rates of sedimentation sufficient to bury shipwrecks within recent history have not been identified for the Liberty Project area. There are no indications in the side-scan sonar or subbottom profiler records of any seafloor anomalies. Therefore, it is unlikely that either of these shipwrecks is located within the project area.

(3) Assessment Procedures

Archaeological resource means any material remains of human life or activities that are at least 50 years of age and that are of archaeological interest. *Of archaeological interest* means capable of providing scientific or humanistic understandings of past human behavior, cultural adaptation, and related topics through the application of scientific or scholarly techniques such as controlled observations, contextual measurement, controlled collection, analysis, interpretation and explanation. *Material remains* means physical evidence of human habitation, occupation, use, or activity, including the site, location, or context in which such evidence is situated. Our policy is to consider the effects on archaeological resources in all decisions on planning, leasing, permitting, and regulatory actions. To do this, we must assess whether the proposed action may affect archaeological resources within the area (MMS Manual Part 620.1.1).

Properties may be eligible for the National Register of Historic Places if they contain or are likely to contain information to contribute to our understanding of human history or prehistory. This national inventory of sites has certain criteria for listing. Most archaeological sites listed on or eligible for the National Register meet Criterion D, Information Potential. With rare exception, properties must be 50 or more years old to be considered eligible for the National Register (USDOI, National Park Service, 1991).

Nominating a site is time consuming. One must detail specific information, measurements, location, and historical background. Consequently, properties officially listed on the Register are only a fraction of those sites that would be eligible after assessment. All sites are given initial equal protection in the process. Checking the Register for a list of sites is a start. However, most of the Beaufort Sea Planning Area has not been surveyed for archaeological sites, and the National Register lists no sites on the outer continental shelf. As a result, we must identify archaeological resources or potential resources within the planning area using regional baseline studies as predictive models, geophysical and geological data, historical accounts of shipwreck disasters, and marine remote-sensing data compiled from required shallow-hazards surveys.

4. Economy

a. Employment

(1) History of Employment in the North Slope Borough

Employment as a whole and by sector in the North Slope Borough, including the oil-industry workers at Prudhoe Bay between 1990 and 1998, is shown in Table VI.B-7. Mining

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employment is the petroleum employment at Prudhoe Bay and nearby facilities. Nearly all of these workers commute to Southcentral Alaska and Fairbanks. The total employment less mining reflects workers who reside permanently in the North Slope Borough.

For details on employment, see the Final EIS for Sale 170 (USDOI, MMS, 1998, Sec. III.C.1), which is incorporated here by reference.

Nuiqsut had 193 people in their labor force in 1993-1994. Of these, 125 were permanent full time, 42 temporary or seasonal, 16 part time, and 10 unemployed. Others were underemployed. The Borough employed 46%, the Borough School District employed 17%, and the Village Corporation employed 20% of those employed in 1993 (North Slope Borough, 1995).

(2) The North Slope Borough is the Largest Employer of Permanent Residents in the Borough

The Borough's government employs many people directly and finances construction projects under its Capital Improvement Program, which employs even more. For details, see the Final EIS for Sale 170 (USDOI, MMS, 1998, Sec. III.C.1).

(3) Unemployment in the North Slope Borough

According to State figures, unemployment in the North Slope Borough was 3.5-5.5% from 1975-1998. However, according to the 1993 North Slope Borough Census, 24% of the Borough's resident labor force believe themselves to be underemployed (North Slope Borough, 1995). For details, see the Final EIS for Sale 170 (USDOI, MMS, 1998, Sec. III.C.1).

(4) North Slope Oil-Industry Employment of North Slope Borough Resident Natives

One of the North Slope Borough's main goals has been to create employment for Native residents. It has been successful in hiring many Native people for the Borough's construction projects and operations. Only a few permanent residents hold jobs at the industrial enclaves at Prudhoe Bay.

The North Slope Borough has tried to facilitate employment of Native people in the oil industry at Prudhoe Bay. They are concerned that the oil industry has not done enough to train unskilled laborers or to allow them to participate in subsistence hunting. The Borough also is concerned that the oil industry recruits using methods common to western industry. The Borough would like to see serious efforts by industry to hire the Borough's residents (Nageak, 1998). For further information, see the Final EIS for Sale 170 (USDOI, MMS, 1998a, Sec. III.C.1).

The purpose of BPXA's Itqanaiyagvik Program is to increase North Slope Borough Native employment. It is a joint venture with the Arctic Slope Regional Corporation and its oil-field subsidiaries and is being coordinated with the Borough and the Borough's School District (BPXA, 1998b).

(5) Most North Slope Oil-Industry Workers Reside in Southcentral Alaska and Fairbanks

In the past, most workers at oil operations centered at Prudhoe Bay commuted between worker enclaves on the North Slope and permanent residences in other parts of the State. Most of these workers reside in Southcentral Alaska and the Fairbanks area. Some workers have commuted between the enclaves and permanent residences outside Alaska. As explained above, mining employment on Table VI.B-7 indicates workers at and near Prudhoe Bay, but most of these workers reside in Southcentral Alaska and Fairbanks.

Employment in the Anchorage-Matsu Region, the Kenai Peninsula Borough, and Fairbanks North Star Borough is shown in Table VI.B-8.

b. Revenues

(1) Federal Revenues

Federal outer continental shelf revenues in the Beaufort Sea include sales volume, sales value, royalties, rents and other; annual revenues for these are: 1995, $1.0 million; 1996, $1.6 million; 1997, $1.0 million, and 1998, $2.0 million. Bonuses in the 1995-98 period are $14.4 million for Lease Sale 144 in 1996 and $5.3 million for Lease Sale 170 in 1998. Total revenues are: 1995 $1.1 million; 1996 $16.5 million; 1997 $1.1 million; and 1998 $7.4 million.

Federal income tax collected from outer continental shelf workers is estimated to be $1.1 million for drilling and related activity on Warthog and Liberty Island in 1997. There was no income tax in 1995, 1996, or 1998 because there was no worker activity on the outer continental shelf.

(2) State Revenues

The Federal government distributed outer continental shelf revenues to the State of Alaska for rents, bonuses, royalties, escrow funds and settlement payments as follows: 1995 $9.4 million; 1996 $9.5 million; 1997 $17.3 million; and 1998 $13.6 million.

State income tax and state spill and conservation tax related to the Beaufort outer continental shelf 1995 to 1998 is zero.

(3) North Slope Borough Revenues

The North Slope Borough received no outer continental shelf revenues for the period 1995-1998.

The tax base in the Borough since the 1980's has consisted mainly of high-value property owned or leased by the oil industry in the Prudhoe Bay area. In Fiscal Year 1995, more than 95% of revenues came from property taxes, according to the Final EIS for Sale 144 (USDOI, MMS, 1996a, Sec. III.C.1).

North Slope Borough revenues were $224-$235 million between 1992 and 1997. In 1997, the assessed value of all property was $11.7 billion and in 1998, $11.4 billion. The North Slope Borough projects total assessed value will decline steadily from $11.1 billion in 1999 to $8.0 billion in 2005 (Nageak, 1998).

In Fiscal Year 1994, the North Slope Borough applied a rate of 18.5 mills to assessed property—4.78 mills for operations and 13.72 mills for debt service. Although the mill rate for operations is at the limit allowed by State statutes, the Borough's mill rate to repay bonded indebtedness is unlimited. Therefore, the Borough can raise the mill rate to repay bonds without legal restraints, and limits on short-term revenues do not drive current capital expenditures. The State perceives a limit of 20 mills on the rate for oil and gas property; thus, self limitation at an 18.5-mill rate leaves the North Slope Borough a buffer to increase revenues, if assessed values fall unexpectedly (Nageak, 1998).

(4) Net Present Value to the Government

The net present value of receipts to Federal and State governments for projects on the Beaufort outer continental shelf in 2000 is zero.

c. Subsistence as a Part of the North Slope Borough's Economy

The predominately Inupiat residents of the North Slope Borough traditionally have relied on subsistence activities. Although not part of the cash economy, subsistence hunting is important to the Borough's whole economy and even more important to the culture (see Secs. VI.B.1 and 2).

d. Additional Information on the Economy

See *Liberty Development Project* (Northern Economics, Inc., 1998) for additional information on the economy.

5. Land Use Plans and Coastal Management Programs

Most of the land in the North Slope Borough is held by a few major landowners:

- The Federal Government. More than half of the 20 million hectares in the region is contained in the NPR-A and the Arctic National Wildlife Refuge.
- The State of Alaska (1.4 million hectares).
- Eight Native village corporations and the Arctic Slope Regional Corporation (totaling 1.9 million hectares).

Complex land-ownership patterns result from the Alaska Native Claims Settlement Act, which requires conveying only surface-estate rights to Native village corporations but allows subsurface-estate rights to be conveyed to Native regional corporations. In selected Federal holdings, such as the Arctic National Wildlife Refuge and the National Petroleum Reserve-Alaska, the act restricts village corporations to surface-estate rights and reserves the subsurface estate for the Federal Government; the Arctic Slope Regional Corporation had to select its subsurface estate outside these holdings.

Major land uses on the North Slope are divided between traditional subsistence uses of the land and hydrocarbon-development operations. The extent and location of hydrocarbon exploration, development, and production on the North Slope and offshore areas are described under major projects for the cumulative case (Sec. V.B).

a. Federal Lands

Federal lands are mainly associated with offshore oil and gas leases and coastal management. In addition, onshore Federal lands on the North Slope consist of small Distant Early Warning line sites, the Arctic National Wildlife Refuge, and the National Petroleum Reserve-Alaska.

Of the seven Distant Early Warning-line sites on Alaska's northern coast, three were decommissioned and converted entirely to North Warning System sites. One of these, the Bullen site, is about 20 miles from the proposed activity.

The Arctic National Wildlife Refuge is located about 110 miles east of the project area, and the National Petroleum Reserve-Alaska is about 90 miles west (Map 3a).

b. State Lands and Coastal Management Standards

The State of Alaska's lands cover most of the arctic coast between the National Petroleum Reserve-Alaska and the Arctic National Wildlife Refuge. This jurisdiction extends to submerged lands within 3 miles of the coastline (Map 1).

The Federal Coastal Zone Management Act and the Alaska Coastal Management Act were enacted in 1972 and 1977, respectively. Through these acts, development and land uses in coastal areas are managed to balance using coastal areas and protecting valuable coastal resources. The Federal Coastal Zone Management Act is administered by the Office of Ocean and Coastal Resource Management within the National Oceanic and Atmospheric Administration's National Ocean Service. The Act requires that direct and indirect Federal activities be consistent with a State's federally approved coastal management program. Indirect activities are those that require Federal permits, such as activities described in development and production plans. The Federal consistency requirement is an important mechanism to address coastal effects, to ensure adequate Federal consideration of State coastal management programs, and to avoid conflicts between States and Federal Agencies. The provisions and policies of the Federal and State coastal management programs are described in MMS Reference Paper 83-1 (McCrea, 1983). We summarize this paper in the following paragraphs and incorporate it by reference.

Statewide standards of Alaska's Coastal Management Program may be refined through local coastal programs prepared by coastal districts. Coastal districts are encouraged to prepare local programs to supplement the Statewide standards. Alaska's Coastal Policy Council and the Secretary of the U.S. Department of Commerce must approve these district programs through the Office of Ocean and Coastal Resource Management before they can go into Alaska's Coastal Management Program. The North Slope Borough is the only coastal district near the sale area, and its coastal management program is part of Alaska's program. We describe the Borough's program after discussing the Statewide standards.

The Alaska Coastal Management Program, as initially approved by the Office of Ocean and Coastal Resource Management, includes:

- The Alaska Coastal Management Act
- Guidelines and standards developed by the Coastal Policy Council
- Maps depicting the interim boundaries of the State's coastal zone

The Federal Coastal Zone Management Act, as amended, requires lessees to certify that activities in their development and production plans comply with the State's coastal program, if they affect any land or water use in the coastal zone. The State must concur with, or object to, the lessees' certification.

The type of Federal activity we evaluate in this EIS is approval of a Federal license or permit detailed in an outer continental shelf Plan. The State reviews these activities to determine whether they will be consistent with its plan. This review authority applies to the proposed development and production activities in the Liberty Project area. The Federal Government cannot permit these activities unless the State concurs, or is conclusively presumed to have concurred, that the plan follows its management program for the coastal zone (43 U.S.C. 1340(c) and 1351(d); 16 U.S.C. 1456(c)(3)). If we receive the State's concurrence, we may approve permits for activities described in the plan under 15 CFR 930.63(c). We may require changes to the plan if the operator has agreed to the State's requirements.

If we get a written consistency objection from the State before the review period expires, we will not permit an activity described in the plan unless the following occurs:

- The operator amends the plan to meet the objection under 15 CFR 930.83 and we then receive, conclusively presumed, concurrence.
- On appeal, the Secretary of Commerce, under 15 CFR 930.120, finds the plan consistent with the objectives of the Federal Coastal Zone Management Act or necessary in the interest of national security.
- Courts declare the original objection invalid.

The State must determine within 6 months that a proposed activity is not consistent with its approved program and must notify the applicant. The State objection must describe the following:

- how the proposed activity will be inconsistent with specific elements of the management program and
- alternatives that the applicant could adopt that would allow the proposed activity to be consistent with the management program.

The State also must tell applicants they can appeal to the Secretary of Commerce under 15 CFR 930 Subpart H. Applicants have 30 days from receipt of the objection to file a notice of appeal with the Secretary of Commerce. They may appeal if the activity either furthers the purposes or objectives of the Federal Coastal Zone Management Act or is necessary in the interest of national security.

c. North Slope Borough

The North Slope Borough is a home-rule municipality governed by State law and a municipally adopted charter. Their land-management regulations are codified in Title 19 of the Borough's Municipal Code and are applied to all lands within the Borough not owned by the Federal Government. Municipal powers include platting (control over the subdivision of land) and regulations of land use, which must be based on a comprehensive plan. Platting regulations and land use controls within the municipal boundary, which extends to the limit of State waters in the Alaskan Beaufort Sea, are under Borough control.

(1) The North Slope Borough's Comprehensive Plan and Land Management Regulations

These were first adopted in December 1982. The Land Management Regulations were revised on April 12, 1990. The revisions simplified the regulatory process but did not alter the basic premise of the comprehensive plan—to preserve and protect the land and water habitats essential to subsistence living and the Inupiat way of life. The plan identifies important issues and directs how to handle them within the Borough. It is the basis for the Borough's Land Management regulations, which establish zoning districts and performance-based policies for using land. Areawide

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policies in the Land Management regulations are, for the most part, the same as those for the Borough's coastal management. The main differences are how they carry out these policies. Coastal management policies cover only activities within the coastal zone, or activities that affect uses of this zone.

(2) The North Slope Borough District's Coastal Management Program

This program was adopted in 1984 and approved by Alaska's Coastal Policy Council in April 1985 and the Federal Office of Ocean and Coastal Resource Management in May 1988. The coastal management boundary adopted for the Borough's program varies slightly from the interim boundary of Alaska's Coastal Management Program. In the mid-Beaufort sector, the boundary was extended inland on several waterways to include habitats that support spawning and overwintering of anadromous fishes. Along the Chukchi Sea coast, it was extended inland to include the Kukpuk River and a 1.6-kilometers corridor along each bank.

The Borough's program was developed to balance exploring, developing, and extracting nonliving natural resources against maintaining and accessing the living resources vital to the Inupiat people's traditional cultural values and way of life.

d. Native Allotments

These allotments are important uses of land near the Liberty project and are considered Indian trust resources (lands). They are small land parcels (up to 160 acres) given to families for private use under the Alaska Native Allotment Act (1906). The use or lease of these allotments requires consensus of all family heirs and the approval of the Bureau of Indian Affairs. Map 1 shows Native allotments near the Liberty Project area.

6. Brief History of Leasing and Drilling in the Area

a. Previous Lease Sales in the Beaufort Sea

Sale BF, December 11, 1979
Sale 71, October 13, 1982
Sale 87, August 22, 1984
Sale 97, March 16, 1988
Sale 124, June 26, 1991
Sale 144, September 18, 1996
Sale 170, August 5, 1998

These sales resulted in 686 issued leases, which generated more than $3.5 billion in bonus revenues for the State and Federal treasuries. All Beaufort Sea leases have a primary term of 10 years. Companies owning them may choose to relinquish them at any time before the primary term expires. Of the 686 original leases, 592 have been relinquished or have expired. Ninety-six leases remain active as of October 31, 1998.

b. Drilling History

During 20 years in the Beaufort Sea, industry has drilled 30 exploratory wells, and 10 leases have been determined capable of producing. BPXA considers the Northstar and Liberty Prospects producible and proposes to develop them.

C. PHYSICAL ENVIRONMENT

There are five categories that describe the physical environment of the area:

- Geology
- Marine Water Quality
- Air Quality
- Climate and Meteorology
- Oceanography of Foggy Island Bay

1. Geology

Shallow geological and geophysical data provide the initial, and sometimes only, information about marine archaeology, engineering considerations, and critical biological habitats on the outer continental shelf. The term "shallow" is relative but usually means a depth of about 1,000 feet (300 meters) or less beneath the seafloor, which normally includes Pleistocene strata and Recent sediments. In the following discussion, shallow geological data include maps, diagrams of cross-sections and boreholes, and data from rock or sediment samples; the geophysical data are mainly high-resolution seismic-reflection data from high-resolution instruments, such as side-scan sonars (aerial views), fathometers, subbottom profilers, boomers, mini-sparkers, and air- or waterguns (all cross-sectional records with variable power, penetration, and resolution).

Shallow geology of the Liberty area is described in published information on regional geology (Dinter, Carter, and Brigham-Grette, 1990; Craig, Sherwood, and Johnson, 1985) combined with site-specific geological and geophysical data.

a. Regional Setting

Foggy Island Bay, located east of Prudhoe Bay between the deltas of the Sagavanirktok and Canning rivers, opens to

Stefansson Sound on the central Beaufort Sea coast. The bay and sound are sheltered from the Arctic Ocean by the McClure group of barrier islands (Fig. VI.C-1). The coastal and inland physiography is typical of the Arctic Coastal Plain, a vast, low-angle, sloping plain that extends north from the Brooks Range to the Beaufort Sea. This tundra-covered, frozen plain has many permafrost features such as pingos, ice wedges, thaw lakes, and patterned ground. Rivers dissect the plain and form deltas along the coast. Four rivers empty into the Beaufort Sea and form modern deltas south of the proposed Liberty Island location: from west to east, the Sagavanirktok, Kadleroshilik, Shaviovik, and Canning rivers (Maps 1 and 2). The deltas contain features such as distributary channels, small islands, barrier bars, spits, and lagoons. Typical coastal features include bluffs, terraces, wave-cut cliffs, and beach ridges. The coast erodes (Fig. VI.C-2) on the order of 6-9 feet (2-3 meters) a year (Hopkins and Hartz, 1978), but these rates vary greatly depending on coastal geomorphology, sediment composition, and exposure to storm and tidal forces. Rates generally are higher on bluffs, headlands, and coastal segments consisting of fine-grained and permafrost material. River deltas do not show any erosion.

The barrier islands of the McClure Island group lie northeast, relatively far offshore compared to other barrier islands—about 9.5 miles (15.5 kilometers) from the coast and 7 miles (11 kilometers) from the proposed production island. Individual islands and shoals have a core that remains from the paleo-Arctic Coastal Plain. These island cores consist mainly of deposits from the Pleistocene Gubik Formation, which mantle the onshore Arctic Coastal Plain. The islands apparently are eroding and building up, gradually moving sediment to the south and west, as suggested in a comparison of ocean charts from 1952 and 1990 (Fig. VI.C-3).

Foggy Island Bay overlies the northern flank of the eastern end of the Barrow Arch geologic structure and lies about 40 miles (64 kilometers) south of the Hinge Line Fault Zone. The Barrow Arch and associated structures, combined with Paleozoic and Mesozoic rocks, form the prolific oil fields of the North Slope. These structural features typically are not geologically active, and there is no evidence of recent seismic activity in the area west of the Canning River and south of the Hinge Line Fault Zone. However, the island site is 60-70 miles (96-112 kilometers) west of the geologically and seismically active Camden Bay region, which has had earthquakes, including a magnitude 5.3 in 1968. The proximity of the active seismic zone to the Foggy Island Bay brings the Liberty location potentially within the area of ground-shaking during large Camden Bay earthquakes.

b. Quaternary Geological History

The Quaternary geological history of Alaska generally reflects glacial advances and retreats and the effects of glacial processes. In the Beaufort Sea area, glaciers played only a small or indirect role in shaping the physical environment. Glaciation generally was limited to alpine and mountain-front glaciers. Glacial and eustatic sea-level fluctuations, however, have dominated the Quaternary history and geomorphology of the area.

The Arctic Coastal Plain and its seaward continuation contains interfingering wedges of marine and nonmarine sediments of the Gubik Formation. These sediments were deposited during higher and lower Pleistocene sea-level stands starting at approximately 70,000 years ago. When the sea went down, streams and rivers deposited sediments as alluvial layers and deltas and wedges that thin towards the sea. When the sea rose, it deposited silts and clays, with some boulders carried by ice, to form wedges that thin towards land.

Since the late Pliocene era (approximately 3.5 million years ago), the sea rose at least five times, reaching heights of 200 feet (60 meters) above present-day levels. Table VI.C-1 shows the major Quaternary episodes of increases in sea level.

Since the late Pleistocene, sea level has fluctuated from 21-30 feet (7-10 meters) higher than today (about 70,000 years ago), to 270 feet (90 meters) or more lower than today (18,000 years ago), resulting in the overlapping marine and nonmarine sediment wedges described earlier. At the lowstand 18,000 years ago, the paleo-shoreline was seaward of the present-day barrier islands. When the sea rose, it drowned onshore features such as river channels, lagoons, paleo-shorelines and associated coastal features, permafrost and related features, and organic deposits. Sea level generally has risen from 18,000 years ago (Table VI.C-2) until today, with a few notable times when it leveled off or retreated. About 13,000 years ago, the sea level stood at -50 meters, corresponding to the late Wisconsin glacial advance. The shoreline during this period was seaward of the McClure Islands. Near the beginning of the Holocene 11,000 years ago, the sea level began to rise to its present position, reached about 5,000 years ago.

c. Offshore Geology

The Liberty Island site lies in Federal waters in outer Foggy Island Bay, between Foggy Island on the Sagavanirktok River Delta 5.5 miles (8.5 kilometers) to the west and Karluk Island in the McClure group 6.5 miles (10.5 kilometers) to the northeast (Fig. VI.C-1). Water depths are shallow, less than 23 feet (7 meters).

It is commonly assumed that the Holocene marine transgression extensively eroded and “planed off” terrestrial landforms as they progressively were drowned by the rising water. However, evidence from high-resolution seismic-profiling systems have indicated that many recognizable landform features and terrestrial strata exist offshore and, therefore, have survived the rise in sea level (17h). These landforms have been modified somewhat by marine processes such as ice gouging, wave erosion, current and strudel scouring, and sedimentation.

(1) Stratigraphy

(a) Pleistocene Deposits

Offshore, Pleistocene strata have the same interfingering wedges of the Gubik Formation as the Arctic Coastal Plain. These deposits underlie the seafloor across the Beaufort shelf and, where Holocene sediments are absent, they crop out and become exposed at the seafloor.

Pleistocene strata on the shelf generally thicken seaward away from the Brooks Range. Based on shallow seismic data (17f), the thickness of the Gubik Formation is hundreds to several hundreds of feet ((17b) Dinter, Carter, and Brigham-Grette, 1990). The base of the Gubik Formation offshore is not well defined on seismic data, because it is similar to the marine and deltaic strata of the underlying Tertiary Brookian sequence and displays similar acoustic reflection properties (17f). Craig, Sherwood, and Johnson (1985) have seen a possible regional unconformity on seismic data (17f) between the Gubik Formation and underlying Pliocene and older strata. In the study area, a strong reflector on seismic profiles (representing an unconformity) that occurs about 300 feet (90 meters) below the seafloor may represent this boundary. Above this layer, two broad seismic-stratigraphic (17f) units of the Gubik Formation are in the study area, separated by another prominent seismic reflector (upper and lower seismic-stratigraphic units in Fig. VI.C-4). Dinter, Carter, and Brigham-Grette (1990) mapped a regional seismic reflector that they believe represents the base of Pelukian-age deposits, which are roughly time-equivalent to the Gubik Formation (17f) (Fig. VI.C-5). This probably is the reflector that separates the upper and lower Pleistocene seismic stratigraphic (17f) units in the study area.

The lower Pleistocene unit rests on older Plio-Pleistocene rocks of the Brookian sequence and is about 200 feet (60 meters) thick. It has an uneven upper surface, which is characteristic of subareal erosion from streams or glaciers. The unit is crudely stratified and includes many internal layers and discontinuous sedimentary bodies. It correlates with strata encountered in shallow cores that consist mainly of terrestrial beach, lagoon, delta, and alluvial deposits, plus sands, sandy gravels, and silty sands. This unit predominantly is a nonmarine member of the Gubik Formation.

The upper Pleistocene unit unconformably overlies the lower unit and is 100-110 feet (30-34 meters) thick. In the western study area, a unit of the Gubik Formation laden with boulders and cobbles crops out at the seafloor (Figs. VI.C-6 and -7) and forms part of the Boulder Patch biological habitat. This unit consists of marine silts, clays, sands, and isolated organic-rich silts and peat. It contains occasional boulders and cobble erratics. The upper Pleistocene unit probably correlates with the Pelukian-age strata mapped in Figure VI.C-5 (Dinter, Carter, and Brigham-Grette, 1990).

Their similarity to onshore deposits and evidence from core-hole data (Dinter, Carter, and Brigham-Grette, 1990) suggest that the seafloor exposures of boulders and cobbles are likely outcrops of the marine Flaxman Member of the Gubik Formation. Erosion of the Flaxman sediments left a lag made of gravel, cobbles, and boulders (Fig. VI.C-7) called the Boulder Patch. The Flaxman Member is a marine deposit containing a lot of ice-rafted sediments whose unique composition suggests they came from the Canadian Arctic islands about 70,000 years ago. Winnowing of fine-grained parts of this unit left the lag behind.

(b) Holocene (Recent)

Holocene sediments are usually thin throughout the shallow Beaufort shelf (Fig. VI.C-2) and cover the eastern part of the study area. Geotechnical borings collected in the Liberty area show that Holocene sediments are mainly soft, reworked marine silts, clays, and fine-grained sands. The geological report for Liberty shows Holocene sediments, where present, are more of a mixture of sands and silts typical of nearshore deposits. Holocene marine sediments thicken from nothing to about 9 feet (2.6 meters) on a line running generally north-to-south through the central part of the area. Correlation of seismic with geotechnical data suggests that Holocene sediments are slightly thicker than seismic profiles show.

The source of Holocene marine strata is stream sediment and fine-grained marine sediments carried by coastal currents. Seasonal storms and offshore currents rework and redistribute fine-grained sediments. This reworked Holocene veneer covers older Holocene and Pleistocene features such as drowned lagoons, stream channels, and more recent features like ice gouges and strudel scoured depressions. Borings in older Holocene and Pleistocene strata have recovered medium-stiff to stiff silts, sands with local organic-rich silts and stiff clays, and peat. These materials support the idea of rapid drowning of the Arctic coast and preservation of coastal features.

(2) Seafloor Features

Permafrost: Permafrost exists in the study area (Fig. VI.C-8). By strict definition, permafrost is soil that remains below 32 degrees Fahrenheit (0 degrees Celsius [32 degrees Fahrenheit]) for 2 or more years. Recorded bottom temperatures at the Liberty area are below 32 degrees Fahrenheit (0 degrees Celsius), thereby making all sediments permafrost. Bonded permafrost is soil cemented with visible ice. Unbonded permafrost is loose soil or sediments below freezing. Geotechnical data indicate that bonded permafrost is encountered in sediments at or very near the surface onshore (Dinter, Carter, and Brigham-Grette, 1990). Exposure to temperatures below freezing during lower sea-level stands created several thousand feet of permafrost. Offshore, the bonded permafrost drops off rapidly but rises again in some areas and near barrier islands.

Geotechnical studies found bonded permafrost within 20 feet (6 meters) of the seafloor at several locations in Stefansson Sound and Foggy Island Bay. The occurrence and extent of permafrost offshore still is not well known. Bonded permafrost offshore appears to be related to the presence of overconsolidated, low-permeability silts and clays of the Flaxman Member of the Gubik Formation. These silts and clays form a barrier to the infusion of salt water that would lower the thaw point and cause ice to melt (Duane Miller and Assocs., 1997).

(3) Seafloor Sediment

(a) Boulders and Gravel

The seafloor in the extreme western part of the study area is mantled with coarse-grained sediments—gravel, cobbles, and boulders (Figs. VI.C-6 and -7). The Boulder Patch, an area containing more than 25% boulders, forms a critical biological habitat for kelp and associated benthic marine organisms. Figure VI.C-7 shows concentrations of sediment coarser than 2 millimeters in diameter in the central Beaufort Sea, including the study area. Boulder deposits are common in the North Slope and are part of the Flaxman Member of the Pleistocene Gubik Formation. Boulder deposits on the seafloor show the area is probably a remnant of the Arctic Coastal Plain. The barrier islands from Camden Bay to Reindeer Island in the west are remnants of the Arctic Coastal Plain; their cores consist of sediments from sources outside the Brooks Range.

(b) Holocene Soft Bottom

Muds consisting of Holocene marine clays, silts, and sands cover the seafloor in the eastern part of the study area. On side-scan sonar records, these deposits exhibit fresh small-scale ice gouging and some hard targets, possibly representing erratic boulders (Fig. VI.C-6).

(c) Ice Gouges

Ice gouging is intense and almost pervasive on the shallow Beaufort Sea shelf (less than 164 feet [50 meters]) (Fig. VI.C-9). However, ice gouging is sparse in the study area of Foggy Island Bay. Modern ice gouging is confined to discontinuous, sparse, narrow, and shallow features (Fig. VI.C-6). Foggy Island Bay is protected from the large ice masses responsible for major ice gouging in other parts of the Beaufort Sea by the outlying barrier islands and by floating shorefast ice, which blocks most drift ice from entering the bay. The presence of biological habitats in the Boulder Patch is due to the protection from ice gouging.

There are large ice gouges in the study area, but they appear to be old (Fig. VI.C-6). They are partly or completely filled with marine sediments. Side-scan sonar images show they have little or no relief and that their expression is due to textural differences between the infill sediments and the surrounding seafloor. These older gouges are even in the Boulder Patch, but do not seem to have recently affected the distribution or texture of these seafloor deposits. The gouges may be many hundreds, if not thousands, of years old and are preserved because there are no modern large-scale ice-gouging events and sedimentation rates are low.

(4) Subsurface Features

(a) Buried Channels

In the extreme eastern part of the study area, channels underlie the Holocene marine unit. These channels are cut into the Pleistocene unit and exhibit infill and overbank features (Fig. VI.C-10). The channels trend generally north and may be extensions of the Canning or Sagavanirktok rivers onto the paleo-Arctic Coastal Plain.

(b) Lagoons

Possible lagoon features are present in the eastern part of the study area and are expressed on seismic profiles as slight, filled-in depressions with a higher-amplitude reflector at their base. This reflector is discontinuous and may represent buried organic material within the lagoon. Cores in the area suggest such deposits are present (Dinter, Carter, and Brigham-Grette, 1990).

(c) Permafrost

Diffractions in seismic reflection data may originate from ice-bonded sediments or ice lenses in the deeper (more than 1,000 feet [300 meters]) stratigraphic section.

(d) Other Features

Possible ice/sand-wedge, strudel-scour, ice-gouge, and small stream-cut features are visible on some records, usually more toward shore. These relict features are covered over or filled in by Holocene deposits and they are usually no more than 3-6 feet (1-2 meters) below the seafloor.

2. Marine Water Quality

Foggy Island Bay is located off the central part of the Alaskan Beaufort Sea coast between the deltas of the Sagavanirktok and Shaviovik rivers (Map 1); these deltas are located west and east of the bay, respectively. The Kadleroshilik River flows into the central part of the bay. Coastal waters, consisting of a mixture of sea- and freshwaters, may be transported through Foggy Island Bay in a westerly direction, when winds are blowing from the east and through the bay in an easterly direction, when winds come the west (Sec.VI.C.5); during the open-water season, the winds are mainly from the east. The winds also influence the amount of mixing between the different watermasses along the coast—strong, sustained winds are more effective in mixing than light, variable winds. The characteristics of the coastal waters vary with the year, season, location (bay, delta), wind (direction, speed, persistence), river discharge, amount of solar heating, and characteristics of the terrestrial and marine coastal environment.

The quality of the marine aquatic environment is determined by water's physical and chemical characteristics. The constituents of the waters mainly are composed of naturally occurring substances but may include manmade substances—pollutants. The naturally occurring substances are derived from the atmospheric, terrestrial, and other aquatic (freshwater and marine) environments. The waterborne and airborne substances entering the marine environment may include pollutants.

Because of little or no industrial activity, most contaminants occur at low levels in the Beaufort Sea. However, sediment particles (fine enough to be suspended), trace metals, and hydrocarbons are introduced into the marine environment through river runoff, coastal erosion, atmospheric deposition, and natural seeps. The rivers (Colville, Kuparuk, Sagavanirktok, and Canning) that flow into the Alaskan Beaufort Sea remain relatively unpolluted by human activities.

a. Pollutants

The principal sources of pollutants entering the marine environment include discharges from industrial activities (petroleum industry) and accidental spills or discharges of crude or refined petroleum and other substances.

Pollutants may be classified as physical, chemical, and biological. Physical pollutants include suspended solids. Suspended solids may inhibit photosynthesis, decrease benthic activity, and interfere with fish respiration.

The chemical pollutants include organic and inorganic substances. The decomposition of organic substances uses oxygen and, if enough organics are present, the concentration of oxygen could be reduced to levels that would threaten or harm oxygen-using inhabitants of the water column. The measure of oxygen-depleting substances is the biochemical oxygen demand. Some of the organic substances, such as oil (crude or refined), can have a wide variety of sublethal and lethal effects on marine organisms; these effects can impair subsistence, recreational, or commercial uses of the marine biological resources. The discharge of soluble inorganic substances may change the pH or the concentration of trace metals in the water, and these changes may be toxic to some marine plants and animals.

Biological pollution may cause (1) waterborne diseases by adding viruses, protozoa, or bacteria to the receiving waters or (2) excessive biological growth—eutrophication—by increasing the concentration of nutrients, nitrogen and/or phosphorus, in the waters; eutrophication also occurs naturally. The presence of coliform bacteria in the water is considered an indication of fecal contamination.

b. Regulatory Control of Pollutants

The principal method for controlling pollutant discharges is through Section 402 (33 U.S.C. § 1342) of the Federal Water Pollution Control Act (commonly referred to as the Clean Water Act of 1972, which establishes a National Pollution Discharge Elimination System (Laws, 1987). Under Section 402, the U.S. Environmental Protection Agency or authorized States can issue permits for pollutant discharges, or they can refuse to issue such permits if the discharge would create conditions that violate the water-quality standards developed under Section 303 (33 U.S.C. § 1313) of the Clean Water Act. The Clean Water Act, Section 403 (33 U.S.C. § 1343), states that no National Pollution Discharge Elimination System permit shall be issued for a discharge into marine waters except in compliance with established guidelines.

The guidelines require a determination that the permitted discharge will not cause unreasonable degradation to the marine environment (40 CFR 125.122). Unreasonable degradation of the marine environment means (1) significant adverse changes in ecosystem diversity, productivity, and stability of the biological community within the area of discharge and surrounding biological communities; (2) threat to human health through direct exposure to pollutants or through consumption of exposed aquatic organisms; or (3) loss of aesthetic, recreational, scientific, or economic values, which is unreasonable in relation to the benefit derived from the discharge.

(1) Turbidity

Satellite imagery and suspended-particulate-matter data suggest that in general, turbid waters are confined to waters less than 16 feet (5 meters) deep and do not extend seaward of the barrier islands. Turbidity is caused by fine-grained particles suspended in the water column. These particles come from rivers discharging into the marine environment, coastal erosion, and resuspension by wave action of particles deposited on the seafloor.

In mid-June through early July, the shallow inshore waters generally carry more suspended material, because runoff from the rivers produces very high turbidity adjacent to the river mouths. Deltas at the mouths of rivers indicate deposition of fine-grained sediment. The turbidity resulting from the floods, along with other factors, blocks light and measurably reduces primary productivity of waters shallower than about 40 feet (12 meters). Total suspended solids in the Sagavanirktok River channels in 1985 (mid July through mid September) ranged from 0.2-30.0 milligrams per liter (U.S. Army Corps of Engineers, 1987). Maximum values corresponded to midseason river discharge peaks following large rainfall events in the Brooks Range. The highest levels of suspended particles in the Sagavanirktok River discharge occur during breakup: values ranged from 63-314 milligrams per liter for 1971-1976 (U.S. Army Corps of Engineers, 1993).

Coastal erosion rates vary annually and seasonally. In Foggy Island Bay, the coast is eroding at a rate of about 4-10 feet (1.2-3 meters) per year (Grantz and Mullen, 1992, as reported in BPXA, 1998a).

Wave action resulting from prevailing winds and storms during the open-water season resuspends unconsolidated river-delta and seafloor sediment, which increases the turbidity in shallow inshore areas. Any ice cover in summer limits wave action and decreases turbidity. Seafloor sediments in Foggy Island Bay consist of fine sand-, silt-, and clay-size particles—particles less than 0.250 millimeter (0.01 inch) in diameter.

In the winter, the amount of suspended sediments under the sea ice ranged from 2.5-76.5 milligrams per liter along the pipeline route for the proposed Liberty Project (Montgomery Watson, 1997 and 1998). Total suspended solids in the water from beneath the ice in Gwydyr Bay ranged from 7,480-26,920 milligrams per liter and from off Stump Island ranged from nondetectable to 885 milligrams per liter (Montgomery Watson, 1996; as reported in US. Army Corps of Engineers, 1998)

(2) Dissolved Oxygen

Dissolved-oxygen levels in the Beaufort Sea usually are at or near saturation. Cold climate waters, such as those in the Beaufort Sea, generally contain more oxygen than warmer climate waters because of the greater solubility of oxygen in colder waters. Oxygen can be added to the sea in the upper layers by adsorption of air and in the layer where light penetrates by photosynthesis. Oxygen can be lost from the sea at the surface by exchanges with the atmosphere and in all depths during respiration of plants and animals and the decomposition of organic matter by bacteria.

During the open-water period, dissolved-oxygen levels in the Beaufort Sea range from about 8-12 milligrams per liter (Woodward-Clyde Consultants, 1981).

Under winter-ice cover, respiration of oxygen continues, but atmospheric exchange and photosynthetic production of oxygen cease. During ice formation, dissolved oxygen is excluded from the ice into the water column. Dissolved-oxygen concentrations in the water under the ice (1) around West Dock ranged from 9-12 milligrams per liter during February-May, (2) off Oliktok Point ranged from 11.8-13.1 milligrams per liter during April 1987 (U.S. Army Corps of Engineers, 1998), and (3) along the proposed Liberty pipeline route ranged from 7.6-13.2 milligrams per liter during March 1997 (Montgomery Watson, 1997, as reported in BPXA, 1998a).

Over the ice-covered period, areas with unrestricted circulation seldom drop below 6 milliliters of oxygen per liter (URS Greiner Woodward Clyde, 1998a). In areas of reduced circulation or high respiration, further depletion occurs. Such basins sometimes turn anoxic before spring breakup. Brine drainage during ice formation generates some vertical circulation.

Biological oxygen demand measured under the ice in March 1998 along the proposed Liberty Development Project pipeline route was less than 1 milligram per liter (detection limit) (Montgomery Watson, 1998). The colder water temperatures limit decomposition and consequent oxygen demand throughout the water column in winter. Chemical oxygen demand would be minimized because of the low water temperatures which reduces chemical reaction and the high, near or above saturation, levels of oxygen in the water.

(3) Hydrogen Ion Concentration (pH)/Acidity/Alkalinity

The acidity/alkalinity of the waters is determined by the concentration of hydrogen ions and is expressed as the pH. Possible pH values range from 1-14. A pH value of 7 indicates a neutral water, values less than 7 indicate acidity, and values greater than 7 indicate alkalinity. The pH of seawater generally ranges from 7.8-8.2 and freshwater from 6-7. Some pH values from waters in the central part of the Beaufort Sea are shown in the following:

Area	Open Water	Under Ice
Prudhoe Bay[1]	7.8-8.2	6.8-7.9
Oliktok Point[2]	7.5-7.7	7.6-8.0
West Dock[1]	8.0-8.2	7.9-8.1

[1] U.S. Army Corps of Engineers (1998)
[2] KLI (1987), as reported in U.S. Army Corps of Engineers (1998)

(4) Trace Metals

Trace-metal concentrations in the Beaufort Sea sediments and waters are shown in Table VI.C-3. The amounts are considerably lower than Environmental Protection Agency criteria and show no indication of pollution (USDOI, MMS, 1996a).

Studies to date have not found any evidence of trace-metal contamination of sediments. Observed geographic variations in the trace-metal concentration were attributed to grain-size distribution and organic content, with higher trace-metal concentrations in finer sediments. The major rivers—Canning (except for mercury), Sagavanirktok, Kuparuk, and Colville—are thought to be major natural sources for the trace metals in the Beaufort Sea coastal sediments.

(5) Hydrocarbons

Background water hydrocarbon concentrations are low, generally equal to or less than 1 part per billion (parts per billion ≈ nanogram/gram), and appear to be biogenic (USDOI, MMS, 1996a). Sediment aliphatic and aromatic hydrocarbon levels are relatively high in comparison with other undeveloped outer continental shelf areas. The hydrocarbon composition differs from that of most other areas, because it is largely derived from fossils. The primary hydrocarbon sources are onshore coal and shale outcrops and natural petroleum seeps that are drained by rivers into the Beaufort Sea.

Most of the aliphatic hydrocarbons—80-85%—found in Harrison Bay are higher molecular-weight alkanes (n-C21 to n-C34) characterized by odd-carbon dominance, indicating a biogenic source from terrestrial plant materials. The presence of significant quantities of lower molecular-weight alkanes, 0.3-1.2 parts per million (15-20% of the total aliphatic hydrocarbons), also suggests a widespread presence of petroleum hydrocarbons in the sediments. The highest concentrations were found offshore of the Colville River (Harrison Bay) and offshore of the Kuparuk River.

The total aromatic hydrocarbons range between 8 and 16 parts per million and appear to be derived mostly from nonindustrial, abiotic source materials. The subportion of total aromatic hydrocarbons constituting two-to-five-ring polynuclear aromatic hydrocarbons (PAH) ranges from 0.2 parts per million in Camden Bay and the Endicott Field area to 0.65 parts per million in the Kuparuk River Delta and 1.0 parts per million in Harrison Bay. The predominance of two-to-three-ring PAH over most four-to-five-ring PAH (with the exception of perylene) indicates that the PAH is derived from petrogenic (e.g., crude oil or coal) rather than pyrolytic sources. This derivation requires local marine or local terrestrial sources rather than a long-distance, atmospheric source. The rivers, particularly the Colville and Kuparuk, appear to be important sources of PAH; however, marine-sediment concentrations range higher than riverine-sediment concentrations, suggesting the possibility of additional contributions from marine seeps.

There is no evidence that the hydrocarbon concentrations in Beaufort Sea sediments are derived from oil-industry activities.

3. Air Quality

The existing air quality of the entire North Slope of Alaska is superior to that set by the National Ambient Air Quality Standards and Alaska air-quality laws and regulations. Concentrations of regulated air pollutants are far less than the maxima allowed. The Environmental Protection Agency calls this an attainment area, because it meets the standards of the Clean Air Act. The Prevention of Significant Deterioration program of that Act places additional limitations on nitrogen dioxide, sulfur dioxide, and total suspended particulate matter. Table VI.C-4 lists the ambient air-quality standards for the Liberty Project, and Table VI.C-5 lists measured air pollutants at Prudhoe Bay.

Over most of the onshore area adjacent to the Liberty Project, there are only a few small, scattered emissions from widely scattered sources. The only major local sources of industrial emissions are in the Prudhoe Bay/Kuparuk/Endicott oil-production complex. This area was the subject of monitoring programs during 1986-1987 (ERT Company, 1987; Environmental Science and Engineering, Inc., 1987) and from 1990 through 1996 (ENSR, 1996, as cited in U.S. Army Corps of Engineers, 1999). Five monitoring sites were selected—three deemed subject to maximum air-pollutant concentrations and two deemed more representative of the air quality of the general Prudhoe Bay area. The more recent observations are summarized in Table VI.C-5. All the values meet the State and Federal ambient-air-quality standards. The results demonstrate that most ambient pollutant concentrations, even for sites subject to maximum concentrations, generally meet the ambient-air-pollution standards. This is true even if we assume the baseline Prevention of Significant Deterioration program concentrations (determined on a site-specific basis) to be zero, limiting the allowable increase in concentrations.

Although the measurements do indicate that the air quality standards are being met, some pollution nevertheless has occurred. Hattie Long stated. “ We get a lot of yellow haze out of Prudhoe all year long…since the time that the haze started hovering over Nuiqsut” (U.S. Army Corps of Engineers, 1996).

During the winter and spring, winds transport pollutants to arctic Alaska across the Arctic Ocean from industrial Europe and Asia (Rahn, 1982). These pollutants cause a phenomenon known as arctic haze. Pollutant sulfate due to arctic haze in the air in Barrow—that in excess of natural background—averages 1.5 micrograms per cubic meter. The concentration of vanadium, a combustion product of fossil fuels, averages up to 20 times the background levels in the air and snowpack. Recent observations of the chemistry of the snowpack in the Canadian Arctic also provide evidence of long-range transport of small concentrations of organochlorine pesticides (Gregor and Gummer, 1989). Concentrations of arctic haze during winter and spring at Barrow are similar to those over large portions of the continental United States, but they are considerably higher than levels south of the Brooks Range in Alaska. Any ground-level effects of arctic haze on the concentrations of regulated air pollutants in the Prudhoe Bay area are included in the monitoring data given in Table VI.C-5. Model calculations indicate that less than 10% of the pollutants emitted in the major source regions is deposited in the Arctic (Pacyna, 1995). Maximum concentrations of some pollutants, sulfates and fine particles, were observed during the early 1980's; observers measured decreases at select stations at the end of the 1980's (Pacyna, 1995). Despite this seasonal, long-distance transport of pollutants into the Arctic, regional air quality still is far better than standards require.

4. Climate and Meteorology

Meteorological conditions primarily control the characteristics of Foggy Island Bay. Air temperature, precipitation, and wind speed and direction are the most important. Air temperature controls when river ice breaks up and how much heat transfers between the atmosphere and the water. Precipitation controls the timing and amount of freshwater input. Winds control the mixing and distribution of the water's physical properties by moving the water.

The onshore area next to the Liberty Project is within the Arctic Coastal Zone (Zhang, Osterkamp, and Stamnes, 1996). The Arctic Coastal Zone has cool summers and relatively warm winters because it's near the ocean. Precipitation is lowest in this region, and more than 50% falls as snow. Table VI.C-6 summarizes the climatic conditions for the Arctic Coastal Zone.

a. Air Temperature

Monthly average air temperatures for the Liberty area rise above freezing only in June, July, and August. Even during these months, air temperature on any day may vary from near 0-20 degrees Celsius. July typically is the warmest, with an average air temperature onshore of about 7-9 degrees Celsius and offshore of 4-6 degrees Celsius. December through March usually are the coldest months. Table VI.C-7 shows air temperatures at Tern Island for February through May 1987. Average temperatures for February and March are -30 and -28 degrees Celsius, respectively.

b. Precipitation

Summer rainfall is infrequent and averages less than 30 millimeters per month (Hummer, 1990,1991). Occasional late-summer rainstorms can increase the amount of seasonal and annual rainfall. Although rainfall usually is light during the short summers, heavier rainstorms occasionally occur, most commonly in the foothills. Summer precipitation, generally greatest in July and August, is 114 millimeters at Sagwon (U.S. Department of Agriculture, 1996).

Snow cover on the North Slope begins from late September to early October and disappears from late May through the middle of June (Zhang, 1993; Zhang, Stamnes, and Bowling, 1996). The timing of snowmelt varies mainly with changes in the incoming longwave radiation (Zhang, Bowling, and Stamnes, 1997).

c. Winds

Wind speed and direction control coastal oceanographic conditions. Winds affect ice distribution, current speed and direction, vertical and horizontal mixing of watermasses, and wave action. The dominant wind direction in the open-water season is easterly to northeasterly. Easterly winds typically are more persistent in the early season (June and July). As the open-water season progresses, westerly winds are more frequent. Average wind speeds during the open-water season are near 5 meters per second in Stefansson Sound. Wind speeds above 8 meters per second fully mix the vertical column of water in Stefansson Sound.

Meteorological data from Tern Island during February through May show wind speeds ranging from 0-14 meters per second, with an average of 4-6 meters per second (Table VI.C-7). The dominant wind direction during the ice-covered season is westerly.

Vincent Nageak stated: "It is difficult to find a leeward side among any of those three groups of islands…so we usually go to Foggy Island for protection (V. Nageak, as cited in Shapiro and Metzner, 1979).

For More Information on Meteorology: The EIS's for MMS Sales 124, Sale 144, and the Northstar Project discuss the regional meteorology of the Beaufort Sea (USDOI, MMS, 1990a, 1996a; U.S. Army Corps of Engineers, 1998). BPXA discusses meteorology in the Environmental Report for the Liberty Development Project (BPXA, 1998a). The Endicott Environmental Monitoring Reports from 1986 through 1990 discuss meteorology at Endicott (Hummer, 1990, 1991; Cover, 1991; and Walter, Horgan, and Cover, 1991 and 1992).

5. Oceanography of Foggy Island Bay

Foggy Island Bay is within Stefansson Sound. A series of offshore barrier islands separate Stefansson Sound from the offshore Beaufort Sea.

a. Seasonal Generalities

In the early summer, the ice melts and rivers break up and overflow the sea ice. Open water occurs next to the Sag, Kadleroshilik and Shaviovik river deltas and is largely river water and ice meltwater. This water is brackish, meaning a mixture of fresh- and saltwater. Cold marine water lies adjacent to or below this surface layer (Colonell and Niedoroda, 1988).

By midsummer, the open-water area becomes large enough for wind to mix and circulate the water. The nearshore brackish water mixes to form a coastal watermass with a range of intermediate temperatures and salinity whose distribution is determined primarily by the wind.

By late summer, freshwater discharge generally is low, and air temperatures fall. The water becomes marine and fairly uniform throughout the nearshore and offshore regions. By November, sea ice covers most of the area. Through the winter, water temperatures decrease and ice continues to form. Joseph Nukapigak stated, "...In the Arctic, nine months out of the year...we have sea ice" (Nukapigak as cited in USDOI, MMS, 1995a).

b. Circulation

The open-water circulation in Foggy Island Bay depends mostly on the wind, and the wind's direction is more important than its speed (Short et al., 1990). The wind's direction and how often it changes direction control the direction of surface currents, how long watermasses remain, and the amount of mixing between different watermasses. Thomas Napageak stated: "… they both work together, the current and the wind" (Napageak, as cited in Dames and Moore, 1996c:7. Other controls include river discharge, ice melt, bathymetry, and the configuration of the coastline.

The two dominant wind directions are northeast and southwest (Morehead et al., 1992b). Under easterly winds, water moves to the west. Under westerly winds, common in the fall and winter, surface water moves to the east. The mean surface-current direction year-round is to the west. Vincent Nageak stated: "Foggy Island is always the place to go when strong winds start from the west because the water is shallow there. The current is always to the east" (Nageak. as cited in Shapiro and Metzner, 1979).

In addition to the water's easterly or westerly motion, water also moves toward the shore or away from the shore. Under easterly winds, some water moves from offshore to onshore. This circulation pattern causes the gradual removal of warm, brackish water from the nearshore and replaces it with colder, more salty (marine) water. Under westerly winds, some water moves from onshore to offshore. This circulation pattern causes the accumulation of warm, less saline water along the coast and the removal of cold, saline marine water.

Brine rejection and the tide's motion control circulation under the ice. In Stefansson Sound near Foggy Island Bay, it is generally perpendicular to the shoreline to the north-northeast near the bottom. Matthews (1981) estimates a return flow to the south-southwest in the surface layer.

c. Currents

Currents near the Liberty Project range from 0 to more than 68 centimeters per second during the open-water season (Woodward-Clyde Consultants, 1998). Drifter studies by Matthews (1979) show surface current speeds in open water up to 40-50 centimeters per second when storms pass. After January, under-ice currents are generally less than 2 centimeters per second. In November and December, maximum current speeds under ice are slightly less than 10 centimeters per second (Table VI.C-8) and mean speeds are 1-2 centimeters per second.

Matthews' (1980) under-ice observations show that salt rejection and brine formation occur as sea ice is forming. Brine forms as the season progresses from November, when only about 0.6 meters of ice is present until March, when 2 meters of ice is present. Data from a current meter indicate a pulsating density-induced current in the waters 1-2 meters above the bottom. The current flows offshore with peak current speeds about 10 centimeters per second.

d. Temperature and Salinity

Temperature and salinity data for open water in Foggy Island Bay show that the Sag River influences nearshore water. After breakup, the bay has a freshwater layer that mixes to form a brackish nearshore zone. The freshwater layer has salinities of 10 to 15 parts per thousand. The freshwater mixes with marine water to form a coastal watermass with salinities of 15-25 parts per thousand and temperatures of 0-9 degrees Celsius. As the summer progresses, water within the bay becomes colder and saltier (more marine) and relatively well mixed. Marine water has salinities greater than 25 parts per thousand and temperatures of 0-2 degrees Celsius.

Temperature and salinity in February 1997 under ice near the pipeline routes to the Liberty Project range from -2-0 degrees Celsius (28-32 degrees Fahrenheit) and from 21-30 parts per thousand, respectively (Montgomery Watson, 1997, 1998).

e. Tides and Storm Surges

The semidiurnal tidal range is 6-10 centimeters near the Liberty gravel island (Matthews, 1980; Kowalik and Matthews, 1982; Morehead et al., 1992b). The level of the water changes constantly in response to the wind. Positive tidal surges occur with strong westerly winds, while negative surges occur with strong easterly winds. Roxy Ekowana stated: "Such a strong west wind…and I found out that it was also high tide" (Ekowana as cited in North Slope Borough, Commission on History and Culture, 1980:115). In a Northstar public meeting, Thomas Napageak relayed knowledge of the interaction between wind and water levels: "...you don't get...high tides [storm surges] on a northeast wind.... But when we've got the southwesterly wind, that's when the tide [water level] comes up." (Napageak, as cited in Dames and Moore, 1996c:7). Frank Long, Jr. described how a rising tide or storm surge can force water over the top of sea ice and flood river drainages: "If there's enough water that comes in, it'll bring the ice up, plus water will be flowing...up over the edge." (Long, as cited in Dames and Moore, 1996c:8). An example of a negative storm surge also was observed by Nuiqsut whaling captains who reported that, in 1977, the water drained out of a bay near Oliktok Point and then came back in (Dames and Moore, 1996c:3). Under the ice, tidal surges (up or down) can be ten-times larger than the tidal range and can flush up to 40% of the volume of Foggy Island Bay (Matthews, 1980).

During open water, the storm surge can be a 4-foot rise and fall at the gravel island. BPXA estimates a 100-year storm surge of 6.7-foot rise at the coastline (BPXA, 2000a). Shell Oil Company estimates a 3-foot rise at Tern Island (Woodward-Clyde Consultants, 1981).

f. River Discharge

Three rivers drain into Foggy Island Bay—the east channel of the Sagavanirktok River, the Kadleroshilik River, and the western distributaries of the Shaviovik River.

River water is a major source of fresh, warm water to the nearshore environment and drives the circulation near the coast. River water contributes to the breakup of coastal ice in the spring. Etta Ekolook noted: "…we knew that when the Sagvagniqtuuq River breaks, it travels far out onto the sea ice" (Ekolook, as cited in North Slope Borough, Committee on History and Culture, 1980). Andrew Oenga comments: "When the flooding begins from the river ice break-up, it all happens very suddenly (Oenga, as cited in North Slope Borough, Commission on History and Culture, 1980). During most of the summer, the river water is warm (10-17 degrees Celsius). These temperatures are several degrees higher than coastal water. Only in late summer (September) does the river's water temperature fall to or below coastal water. Table VI.C-9 shows the characteristics of these three rivers.

g. Sea Ice

Sea ice covers Foggy Island Bay for three-quarters of the year. There are wide-ranging spatial and temporal variations, but the following is a generalization:

- September: shore ice forms, the river deltas freeze, and frazil, brash, and grease ice form within Foggy Island Bay.
- Mid-October: smooth first-year ice forms within Foggy Island Bay. Thomas Napageak remarked: "...The critical months [for ice formation] are October, November, and December." (Napageak, as cited in Dames and Moore, 1996c:7).
- November through May: the fast ice covers more than 97% of the Liberty area.
- Late May: the Sag, Kadleroshilik and Shaviovik Rivers flood over the nearshore sea ice.
- Early June: floodwaters drain Sarah Kunaknana stated: "In June and July when the ice is rotting in the little bays along the coast… (Kunaknana, as cited in Shapiro and Metzner,1979).
- Early to mid-July: floating and grounded landfast ice break up. The areas of open water with few icefloes expand along the coast and away from the shore, and pack-ice migrates seaward. Vincent Nageak states: " The ice all along the coast on the mainland side of these islands rots early …" (Nageak, as cited in North Slope Borough, Commission on History and Culture, 1980). Samuel Kunaknana stated: "The ice goes completely out after July 4 around the Colville (Kunaknana, as cited in Shapiro and Metzner, 1979).

The Liberty gravel island and its associated pipeline lie within the landfast-ice zone, which extends from shore to the zone of grounded ridges or shear zone.

(1) Shear Zone

Grounded ridges first form just outside the barrier islands in about 8-15 meters of water. By late winter, they may extend beyond the 20-meter isobath. Sara Kunaknana, Elijah Kakinya, Henry Nashanknik, and Bruce Nukapigak all mention a tendency for the shear zone to form running from Cross Island to Barter Island on the seaward side of the barrier islands (Shapiro and Metzner, 1979). Henry Nashanknik stated: "These Islands [McClure and Stockton Islands] have always had ice piled around them. Sometimes in the fall, the ice would pile all around these islands and at times just the ocean side would have pressure ridges" (Nashanknik, as cited in Shapiro and Metzner, 1979). Walter Akpik remembers the ice conditions on Narwhal Island: "During our first winter at Narwhal Island the ice was moving and piling up so high that some of the ice broke off the top and almost hit our house. Our house was in the middle of the island and Narwhal isn't that wide"(Akpik, as cited in North Slope Borough, Commission on History and Culture, 1980). Jeannie Ahkivgak stated: "Where the pressure ridge's large is out beyond the barrier islands"

(Ahkivgak, as cited in North Slope Borough, Committee on History and Culture, 1980).

(2) Landfast Ice

The landfast ice in Foggy Island Bay is general considered smooth. Etta Ekolook stated " The ice inside the barrier islands is smooth and remains so until it thaws out in the spring time" (Ekolook, as cited in North Slope Borough, Commission on History and Culture, 1980).

The landfast ice around Liberty may move several hundred meters during early winter. Shapiro and Metzner (1979), in an article on extending the observations through oral histories, reference ice motion between Narwhal Island and the coast during a storm in November or December of 1924. Bruce Nukapigak stated: " At the same time these westerly winds cause movements in the ice between the barrier island and the mainland. But this is in the fall before it gets really thick" (Nukapigak, as cited in Shapiro and Metzner, 1979). Otis Akivgak recalled: "Even the shoreside ice piled up so high [on Pole Island] that it was hard to drive our dog team on it" (Akivgak, as cited in North Slope Borough, Commission on History and Culture, 1980).

Fast ice in later winter usually moves tens of meters, but may move up to several hundred meters. Deformations take the form of pileups and rideups on the coastal and island beaches and rubble fields and small ridges offshore. As the winter progresses, extensive deformation within the landfast-ice zone decreases, as the ice in the landfast zone thickens, strengthens, and becomes more resistant to deformation. Elija Kakinya stated: "Right around Flaxman Island, on the lagoon side, that is behind the barrier islands, inward to the inland, after the ice formed and freezed it never moved or any disturbance that I can recall in that area" (Kakinya, as cited in Shapiro and Metzner, 1979). Jeannie Ahkivgak stated: "The ice between the barrier islands and the mainland doesn't pile up too much. Sometimes there would be small pressure ridges in there" (Ahkivgak, as cited in North Slope Borough, Commission on History and Culture, 1980).

By late winter, first-year sea ice in the landfast-ice zone is about 2 meters thick; out to a depth of about 2 meters, it is frozen to the bottom, forming the bottomfast-ice subzone. The remaining ice in the landfast zone is floating, forming the floating fast-ice subzone.

Bruce Nukapigak states: "When it's high tide these cracks [tidal crack] usually widen and close or even jam up when the tide goes down…There is this type of crack on both sides of McClure Islands out from the mainland to the ocean." (Nukapigak, as cited by Shapiro and Metzner, 1979).

The onshore movement of sea ice in the landfast-ice zone is a relatively common event that generates pileups and rideups along the coast and on offshore barrier islands. The onshore pileups often extend up to 20 meters inland from the shoreline over both gently sloping terrain and up onto steep coastal bluffs. Ice rideups, in which the whole ice sheet slides relatively unbroken over the ground surface for more than 50 meters, do not happen often; rideups beyond 100 meters are rare.

(3)Open-Water Icefloes

By the middle of July, much of the fast ice inside the 10-meter isobath has melted; and some movement of the ice has occurred. After the first openings and ice movement in late June to early June, the areas of open water with few icefloes expand along the coast and away from the shore, and there is a seaward migration of the pack ice. The concentration of icefloes generally increases seaward. During summer, winds from the east and northeast are common. These winds drive the ice offshore; westerly winds move the ice onshore. Elijah Kakinya noted: "In some years when the ice goes out in spring, it isn't visible in summer. Some years the ice goes out and comes back and is visible, and hangs around all summer months" (Kakinya, as cited in North Slope Borough, Commission on History and Culture, 1980). Elijah Kakinya stated: "In summer months, when there is a westerly wind, you can see ice from shore. But when the wind is blowing from northeasterly, the ice always goes out...you can't see any ice from shore" (Kakinya, as cited in North Slope Borough, Commission on History and Culture, 1980:152). Vincent Nageak stated "…but in summer, huge ice chunks can pass the islands into Prudhoe Bay when the wind is from the west" (Nageak, as cited in North Slope Borough, Commission on History and Culture, 1980).

For More Information: From 1985-1990, the U.S. Army Corps of Engineers collected measurements of temperature, salinity, and current speeds during open water in western Foggy Island Bay as part of the Endicott Environmental Monitoring Program. The cites for these reports are: Hachmeister et al., 1987; Short et al., 1990; Short et al, 1991; Morehead et al., 1992a; Morehead et al., 1992b; and Morehead, Dewey and Horgan, 1993. The Northstar EIS nicely summarizes traditional knowledge on currents and sea ice throughout the Beaufort Sea region from Barrow to Kaktovik. The cite for this report is U.S. Army Corps of Engineers, 1999.

SECTION VII

REVIEW

AND

ANALYSIS

OF

COMMENTS

RECEIVED

(Reserved for the Final EIS)

SECTION VIII

COORDINATION

AND

CONSULTATION

CONTENTS OF SECTION VIII

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VIII. Coordination and Consultation

A. DEVELOPMENT OF THE PROPOSAL

On September 8, 1996, at the Outer Continental Shelf Lease Sale 144, British Petroleum Exploration and Oil, Inc., was the high bidder for Lease Number OCS-Y-01650 (Fig. II.A-18) in the Beaufort Sea. The lease is composed of parts of four outer continental shelf blocks, with the largest block being Official Protraction Diagram NR 06-03, block 6820. On October 3, 1996, BP Exploration, Alaska (BPXA) became the designated operator. They began exploration activities the winter of 1996-7, and on March 31, 1997, British Petroleum completed the exploration well. After announcing a successful discovery, BPXA began planning for the next step, development and production. In January 1998, BPXA submitted a Development and Production Plan to the Minerals Management Service (MMS).

On February 23, 1998, the MMS initiated the scoping process by publishing (63 FR 9015) a Notice of Intent to Prepare an Environmental Impact Statement (EIS) for the proposed Liberty Plan. The MMS deemed the Plan submitted under 30 CFR 250.34(f) on February 19, 1998.

The MMS received written scoping comments from the following organizations and individual:

- U.S. Department of Energy
- State of Alaska, Division of Governmental Coordination
- Greenpeace, et al.
- U.S. Department of the Interior, Office of the Secretary, Office of Environmental Policy and Compliance
- Alaska Public Campaigns and Media Center
- David von den Berg
- Petersburg Energy LLC

Scoping meetings were held in Nuiqsut (March 18, 1998), Barrow (March 19, 1998), Anchorage (March 25, 1998 and April 8, 1998), Kaktovik (March 31, 1998), and Fairbanks (April 1, 1998). Comments were received from 82 individuals who attended one or more of the scoping meetings.

In October and November 1999, MMS held a series of information update meetings in the same communities where we held scoping meetings in early 1998. The purpose of these meetings was to provide information on the status of the EIS and to gather additional information about environmental issues and concerns. The minutes of those meetings and a list of attendees at the meetings can be found in Appendix E.

B. DEVELOPMENT OF THE EIS

During preparation of this production and development EIS, the public, Federal, State, and local agencies; and industry were consulted to obtain descriptive information, to identify significant effects and issues, and to identify effective mitigation measures and reasonable alternatives. We also incorporated information such as traditional knowledge from past pre-sale EIS's for the Beaufort Sea Planning Area. All of the information received has been considered in preparing this EIS. Scoping and public hearing information can be found in Section I.G and Appendix E.

A Liberty Interagency Team was created in spring 1998 to discuss a broad range of issues related to the development and content of the Liberty EIS. The Liberty Interagency Team has participation from five Federal Agencies (Minerals Management Service, Fish and Wildlife Service, U.S. Army Corp of Engineers, National Marine Fisheries Service, Environmental Protection Agency); two State of Alaska Agencies (State Pipeline Coordinator's Office and the Division of Governmental Coordination), and the North Slope Borough. The Interagency Team met periodically during the EIS preparation process. A description of the various agencies roles and permitting authority is provided in Section I.A. Scoping and EIS alternatives were major issues of discussion for the Liberty Interagency Team.

C. LIST OF CONTACTS FOR THE EIS

The following are the major Federal, State, and local government agencies; academic institutions; members of the oil and gas industry; special-interest groups; other organizations; and private citizens who were contacted during the preparation of this EIS or past Beaufort Sea EIS's and were sent copies of the draft EIS for review.

Federal - Executive Branch - Departments
Department of Commerce
    National Marine Fisheries Service
Department of Defense
    Corps of Engineers
Department of Energy
Department of the Interior
    Alaska Resource Library
    Fish & Wildlife Service, Fairbanks Ecological Services

Federal - Administrative Agencies and Other Agencies
Environmental Protection Agency
    Region 10

State of Alaska
Department of Environmental Conservation
    Division of Air & Water Quality
    Division of Spill Prevention & Response
Department of Fish & Game
Department of Natural Resources
    Division of Oil and Gas
    Joint Pipeline Office
Office of the Governor
    Division of Governmental Coordination

Local Governments, Native Organizations, and Libraries
Alaska Eskimo Whaling Commission
Alaska Resource Library
City of Barrow
City of Kaktovik
City of Nuiqsut
North Slope Borough
    Office of the Mayor
    Planning Commission
    Planning Department
    Wildlife Management

Special-Interest Groups
Alaska Center for the Environment
Greenpeace
National Resources Defense Council
Northern Alaska Environmental Center

Petroleum Industry
BP Exploration (Alaska), Inc., Health, Safety, and Environment Department

Associations, Companies, and Other Groups
Alaska Public Radio
Alaska Cable Network - Fairbanks
Anchorage Daily News
Arctic Sounder
Barrow Cable
Fairbanks Daily News-Miner
KBRW Radio
Petroleum News Alaska
Prime Cable - Anchorage

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Akootchook, George
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SECTION IX

LOW PROBABILITY
VERY LARGE
OIL-SPILL EVENT

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IX. Low-Probability, Very Large Oil Spill

A very large oil spill is an issue of concern to everyone. We define a very large oil spill as greater than or equal to 150,000 barrels of oil. A very large oil spill is a low-probability event with the potential for very high effects. In this section, we analyze the potential effects to resources of an oil spill from a blowout at the proposed Liberty gravel island in the Beaufort Sea and from a potential tanker accident in the Gulf of Alaska. Very large spills happen infrequently, and we have limited data for use in our statistical models and predictive efforts.

The largest spill from a blowout in Federal waters is 80,000 barrels. One other spill greater than 50,000 barrels has happened since offshore drilling began in the United States. Because there are no spills greater than 150,000 barrels in U.S. waters, we must look elsewhere for data on spills of that size. Therefore, we use worldwide data to estimate the chance of very large spills occurring. The spill information we use is based on spills from other countries that do not have the regulatory standards that are enforced on the outer continental shelf. In addition, some drilling practices used elsewhere either are not practiced here or are against outer continental shelf regulations.

Internationally from 1979 through 1996, five oil-well blowouts greater than or equal to 10 million gallons (238,000 barrels) have occurred (*Oil Spill Intelligence Report, International Oil Spill Statistics, 1996*, Cutter Information Corp., 1997). Five of the blowouts greater than 10 million gallons were mostly the result of either war or drilling practices that oil companies do not now use and may not use under MMS regulations in the United States. During this same time period, there were roughly 470 billion barrels of oil produced worldwide (*BP Statistical Review of World Energy, 1997*, and earlier issues). These data provide a rate of about 0.01 blowouts greater than or equal to 10 million gallons per billion barrels produced. If this rate is applied to the Liberty Project, the estimated probability of one or more oil spills of 10 million gallons (238,000 barrels) is 0.001, or 0.1%.

S.L. Ross Environmental Research Ltd. (1998) calculated the chance of an extremely large oil spill (greater than 150,0000 barrels) from a blowout for an average of the Northstar and Liberty projects using worldwide spill frequencies. Using only Liberty information, the estimated frequency of spills greater than 150,000 barrels from blowouts during a drilling operation, based on an exposure of wells drilled (14) is 4.62×10^{4} , or a 0.05% chance over the 2-year drilling period. Using only Liberty information, the estimated frequency of spills greater than 150,000 barrels from production/workover wells based on exposure of well-years (210) is 2.10×10^{3}, or 0.21% over the lifetime of Liberty.

The other type of very large oil spill we analyze is a tanker spill. Two very large tanker spills have occurred in U.S. waters, the *Burma Agate* near Galveston (247,500 barrels) and the *Exxon Valdez* in Prince William Sound (258,000 barrels) (Anderson, 1994, pers. commun.; Wolfe et al., 1994).

We also evaluate the potential effects associated with BPXA’s Oil Discharge Prevention and Contingency Plan (BPXA, 2000b) for cleaning up a blowout spill (see Appendix K). That Plan is described in Section II.A.4 and in Section III.C.2. This section evaluates the two following scenarios.

For a **blowout in open-water**, containment and recovery involves using ocean boom for containment and both weir and oleophilic (oil-attracting) skimming devices for recovery. The tactics discussed also require using minibarges for storage, support vessels, tugs, and workboats.

This scenario calls for one barge skimmer system and three skimmer systems deployed from bay-class workboats. These four systems would have a combined estimated recovery capacity of 12,950 barrels of oil per shift (10 hours). These systems could be deployed and operational at the Liberty site within 12 hours of the spill. Shoreline recovery of oil would be initiated on day two of the spill, and daily recovery capacity would be increased to 26,700 barrels per day (20 hours).

For a **blowout in broken-ice during freezeup**, containment and recovery involves using ocean boom for containment and oleophilic (oil-attracting) skimming devices for recovery. The tactics discussed also require using minibarges for storage, support vessels, tugs, and workboats.

This scenario calls for two barge skimming systems and four skimming systems deployed from bay-class workboats. These four systems would have a combined estimated recovery capacity of 18,060 barrels of oil per shift (10 hours). These recovery rates would decrease, depending on the ice concentrations in the area being worked. The actual effectiveness of the cleanup effort would be constrained by the weather, wind, wave, and ice conditions at the time of the spill.

These scenarios are based on an examination of the actual environmental conditions found at the site and represent a reasonable effort to consider the average conditions that can occur during cleanup activities. The effects from oil-spill-cleanup activities are evaluated in Sections III and IV.

As ice coverage increases, tactics would be modified to maintain a safe operation. Specifically, small boats would be placed on ice-reinforced barges for transportation. As ice concentrations increase, the oil spill would be tracked using buoys. Operations would continue using in situ burning, when oil concentrations are adequate to support burning, or when ice conditions allow over-ice or open-water recovery to start. Oil entrained in the ice during freezeup conditions would be collected or burned when the oil migrated up through the brine channels in the ice during breakup conditions in the spring.

In Sections IX.A and B, we analyze the potential effects to resources from a very large blowout spill in the Beaufort Sea and a very large oil tanker spill in the Gulf of Alaska.

A. EFFECTS TO RESOURCES FROM A 180,000-BARREL BLOWOUT OIL SPILL

We analyze the potential effects of a spill of 180,000 barrels from the Liberty gravel island on sensitive resources in the Beaufort Sea region. We derive this spill size from BPXA's estimate of greatest possible discharge.

BPXA estimates a 15,000-barrel flow rate per day for 15 days, totaling 225,000 barrels. Computer model runs simulating a blowout by S.L. Ross Environmental Research Ltd., Dickens and Associates, and Vaudrey and Associates (1998) estimate that 20% of the oil would evaporate in the air. This amount equals 45,000 barrels. An additional 3,400 barrels remain on the gravel island (BPXA, 1999). A total of 176,600 barrels reaches the water or ice. For purposes of analysis, we round this number to 180,000 barrels.

BPXA provided an estimate of the greatest possible discharge that could occur from a blowout in the *Oil Discharge Prevention and Contingency Plan, Liberty Development Area, North Slope, Alaska* (BPXA, 2000b). The State of Alaska requires this estimate for a response planning standard under 18 AAC.75.430.

1. Blowout Assumptions

We assume a blowout would occur from the Liberty gravel island and release crude oil into the environment for 15 days. The three general environments into which the oil would discharge are solid ice, broken ice, and open water.

The following blowout assumptions are from modeling (S.L. Ross Environmental Research Ltd., Dickens and Associates, and Vaudrey and Associates, 1998). A blowout spill rises into the air at an average rate of 500 barrels per hour (BPXA, 2000b). Oil droplets fall to the gravel island and surrounding area. Approximately 20% of the 225,000 barrels evaporates into the air, leaving 180,000 barrels on the island's surface and surrounding area (Tables IX-1 and IX-2).

Within 15 days from the start of the spill:

- 3,400 barrels remain on the gravel island,
- 86,600 barrels drain from the island into the environment, and
- 90,000 barrels fall to the surrounding environment at a rate of 10,000-12,000 barrels a day.

Of the oil falling to the surrounding environment:

- 84% of the oil falls out approximately 4,500 feet from the source within a 975-foot wide area, and
- 16% of the oil falls out approximately 13,000 feet from the source within a 2,000-foot wide area.

2. Behavior of a Blowout Oil Spill in Solid Ice

Oil would drain from the gravel island to the solid sea ice and would fall to the solid sea ice in a scattered pattern. No oil would enter open water. Alaska Clean Seas estimates it would take 122 days to recover the oil from the blowout after the flow is stopped (Alaska Clean Seas, 1998).

There would be little or no change in the oil's physical properties at very low temperatures and when buried under a snow cover. Blowing snow would tend to combine with pooled oil, until the oil is effectively saturated with snow crystals. The oil would not penetrate the ice surface.

3. Behavior of a Spill in Broken Ice

Broken ice occurs in the Beaufort Sea during fall freezeup and spring breakup. This scenario assumes that oil would drain from the gravel island into broken ice and would fall

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to the broken ice in a scattered pattern. The ice would contain the oil somewhat and reduce spreading. Unless the oil is frozen into the ice, the evaporation rate would not change. Dispersion and emulsification rates are lower in broken ice than in open water.

a. Fall Freezeup

During fall freezeup, the oil would freeze into the grease ice and slush before ice sheeting occurs. Winds and storms could break up and disperse the ice and oil until the next freezing cycle. These freezing cycles can be hours or days. Before freezeup, the oil could move at rates of 5 nautical miles per day (S.L. Ross Environmental Research Ltd., Dickens and Associates, and Vaudrey and Associates, 1998).

In late spring and summer, the unweathered oil would melt out of the ice at different rates, depending on whether it is encapsulated in multiyear or first-year ice and when the oil was frozen into the ice. In first-year ice, most of the oil spilled at any one time would percolate up to the ice surface over about a 10-day period. About mid-July, the oil pools would drain into the water among the floes of the opening ice pack. Thus, in first-year ice, oil would be pooled on the ice surface for up to 30 days before being discharged from the ice surface to the water surface. The pools on the ice surface would concentrate the oil, but only to about 2 millimeters thick, allowing evaporation of 15% of the oil, the part of the oil composed of the lighter, more toxic components of the crude. By the time the oil is released from the melt pools on the ice surface, evaporation has almost stopped, with only an additional 4% of the spilled oil evaporating during an additional 30 days on the water. Tables IX-3a and IX-3b show specific estimates of the fate of a spill into broken ice. Table IX-4 shows our estimate of the length of coastline oiled.

b. Spring Breakup

For purposes of analysis, we assume that a spill during spring breakup would have the same effects as an open-water spill. At spring breakup, the ice concentrations are variable. With high concentrations of ice, oil would spread between icefloes. As the ice concentrations eventually decrease to less than three-tenths, the oil on the water behaves as an open-water spill, with local oil patches temporarily trapped by the wind against floes. Oil that is on the icefloes would move with the ice as it responds to nearshore currents (S.L. Ross Environmental Research Ltd., 1998).

4. Behavior of Spills in Open Water

This scenario assumes oil would drain from the gravel island into open water. Oil also would fall to open water adjacent to the gravel island. The oil would move with the currents and the winds. The fate of an open-water spill is shown in Tables IX-5a and IX-5b. Table IX-4 shows our estimate of the length of coastline oiled.

5. The Chance of an Oil Spill Contacting Resources of Concern

We estimate how much oil would reach specific shorelines or other environmental resources from the conditional probabilities for a spill from the Liberty gravel island. For a full discussion of the Oil-Spill-Risk Analysis model and how we derive the oil-spill modeling simulations and supporting tables, see Appendix A.

Table IX-6 summarizes the conditional probabilities that a spill starting at the gravel island would contact individual land segments or environmental resources within 1, 3, 10, 30, and 360 days during summer or winter.

a. Summer Open-Water Spill

For spills starting in the summer months (July through September) after 30 days, the general transport of oil from Liberty Island would be in a radius outward. Generally, higher chances of oil contact would be to the west and north of the Liberty gravel island. Generally, environmental resource areas outside a 30-mile radius from the Liberty gravel island have less than a 10% chance of contact.

b. Winter Broken-Ice Spill

For spills starting in the winter months (October through June) and melting out into open water ,after 360 days, the general transport of oil would be to the west and north from the Liberty gravel island, similar to the summer pattern. The pattern of contact to the east has lower percentages, with most of the area contacted having a 1% chance or less outside a 30-mile radius of Liberty.

6. Analysis of Impacts to Each Resource from a 180,000-Barrel Blowout Oil Spill

a. Threatened and Endangered Species

(1) Bowhead Whales

(a) Summary and Conclusion for Bowhead Whales

Most individual bowhead whales exposed to spilled oil are expected to experience temporary, nonlethal effects. Whales may suffer baleen fouling or irritated skin or sensitive tissues, or they may ingest oil or oil-contaminated prey. Exposure of bowhead whales to a very large oil spill may kill a few individuals. However, few bowhead whales are expected to die, because oil weathers very quickly and exists on the sea surface primarily as tarballs, which would be widely dispersed.

If a large oil spill occurred during September and October, oil-spill-cleanup activities could disturb bowhead whales during their fall migration. There is no information available regarding bowhead disturbance from oil-spill-cleanup operations, but noise disturbance to bowheads from vessel and aircraft traffic involved with cleanup activities likely would be similar to that already described in Section III.C.3. Most oil-spill-cleanup work probably would occur inside the barrier islands, because the spill model indicates that spilled oil has a relatively low probability of reaching areas outside of the barrier islands. Some whales may be disturbed by vessel or aircraft traffic and displaced seaward, if cleanup activities occurred outside the barrier islands or in the channels between the barrier islands during the whale migration. Oil-spill-cleanup activities likely would be ongoing for several seasons and likely for more than 1 year.

(b) Details on How an Oil Spill from a Blowout Might Affect Bowhead Whales

A 180,000-barrel oil spill resulting from a blowout is assumed to occur at Liberty Island (Table IX-2). We estimate that one or more blowouts of this size would have a 0.1% chance of occurring over the lifetime of the Liberty Project. For a winter spill, about 87,000 barrels would remain in the slick after 30 days (Table IX-3a). For a spill in the open water, about 60,000 barrels would remain in the slick after 30 days (Table IX-5a).

Probabilities in the following discussion are conditional probabilities estimated by the Oil-Spill-Risk Analysis model (expressed as percent chance) of a large spill contacting environmental resource areas where bowhead whales may be present in areas outside the barrier islands within 30-360 days (Table IX-6). The model estimates less than a 0.5-16% chance of a spill starting at Liberty Island contacting important bowhead whale habitat (environmental resource areas or ice/sea segments) within 30 days and within 360 days during the summer season. Ice/Sea Segment 11 has the highest chance (8%) of total contact over both a 30-day period and a 360-day period during the summer. The model estimates a 15% chance that this oil would contact important bowhead whale habitat (Environmental Resource Area 39) within a 30-day period and a 16% chance of contact within a 360-day period during the summer. During the winter, the chance of contact to Ice/Sea Segment 10 ranges from a 2% chance of contact over a 30-day period to a 5% chance of contact over a 360-day period, respectively. Environmental Resource Area 39 has a 3% chance of contact over a 30-day period and a 15% chance of contact over a 360-day period. Environmental Resource Area 40 has a 2% chance of contact over a 30-day period and a 16% chance of contact over a 360-day period. Environmental Resource Areas 39 and 40 have the highest chance of contact in this group. There is less than a 0.5% chance of an oil spill from the Liberty Island contacting the spring lead system (SPL 1-5) over both a 30-day period and a 360-day period during either the summer or winter. The chance of an oil spill from the offshore portion of the pipeline (PP1) and the nearshore portion of the pipeline (PP2) contacting ice/sea segments, environmental resource areas, and spring lead systems referenced above is the same as or less than from Liberty Island and, therefore, is not analyzed here.

An oil spill in the spring ice-lead system is a major concern for bowhead whales. In this spill scenario, such a spill is not likely to occur. The fall migration through the Beaufort Sea generally occurs in relatively open water, and the spill would not be continuous over the entire area. It is unlikely that the spill would impede the migration. Migrating whales could contact oil, but this contact likely would be brief. Before the fall migration, some of the spill would weather and some toxic hydrocarbons would evaporate and not cause potential breathing problems to bowheads. Remaining oil would be dispersed tarballs. Bowheads have been observed feeding north of Flaxman Island (near Ice/Sea Segment 6) in some years. If tarballs are present, bowheads could ingest them. The effects of oil contacting bowheads would be the same as for the Proposal (Alternative I), with most individuals experiencing temporary, nonlethal effects. Whales may suffer baleen fouling or irritated skin or sensitive tissues, or they may ingest oil or oil-contaminated prey. Exposure of bowhead whales to a very large oil spill may kill a few individuals. However, few, if any, bowhead whales are expected to die, because oil would be weathered and be primarily in the form of fairly widely dispersed tarballs on the sea surface.

(c) Effects of Oil-Spill Prevention and Response

Lessees are advised by the MMS that they must be prepared to respond to oil spills that could occur as a result of offshore oil and gas exploration and development activities. BPXA submitted an Oil Discharge Prevention and Contingency Plan (BPXA, 2000b) to the MMS for approval when they submitted the Liberty development and production plan. The contingency plan was developed for site-specific operations at Liberty based on the type, timing, and location of the proposed activity. General aspects of oil-spill prevention and response, an inventory of available equipment, and containment/cleanup methods for four seasonal scenarios are summarized in Section II.A.4. Oil-spill prevention and response strategies and methods would be used to mitigate significant oil-spill impacts, but specific methods would not be used if it was determined they could cause additional harm to the species.

The contingency plan includes detailed scenarios that outline the equipment, response tactics, and logistics necessary to clean up these volumes of oil under different environmental conditions—open water, solid ice, and broken ice. The scenarios describe a set of specific response tactics (a description of how oil would be contained and recovered) that would be used. Each tactic is based on a specific type and number of systems that include containment boom(s), oil skimmers, and vessels needed to contain and recover a specific volume of oil. These tactics include open water, solid ice (both over and under), broken ice (freezeup and breakup), the shoreline, and onshore cleanup and recovery. The tactics also address the storage, tracking and surveillance, in situ burning of oil, shoreline cleanup, wildlife and sensitive area response, disposal, and logistics.

Bowhead whales would be migrating through the Beaufort Sea offshore of the Liberty Project during the fall. If a blowout occurred during the open-water period or the broken-ice period in the fall, some bowheads may be displaced temporarily from an area due to the large numbers of personnel, equipment, vessels, and aircraft conducting oil-spill-cleanup operations. Containment and recovery involves ocean-containment booms, storage barges, weir and oleophilic skimming devices, and support tugs and boats. The capability of this equipment to clean up spilled oil and estimated recovery rates are discussed in Section II.A.4. The estimated recovery rates are based on the estimated capacity of the equipment under optimum conditions. It is not likely this rate of recovery would be realized. The actual effectiveness of the cleanup effort would be constrained by the weather; wind, wave, and ice conditions; equipment failure; and human error.

Various response tactics could be beneficial in protecting bowhead whales during a large oil spill. For example, one of the tactics proposed for the containment and recovery of higher concentrations of oil near the source of the release during open water (Tactic R-19 in the Alaska Clean Seas Manual [Alaska Clean Seas, 1998]) would use two weir-type skimmers, and two 1,500-foot sections of open-ocean boom deployed from the surface of a deck barge. Two workboats would be used to establish the necessary boom configuration, and a tug would be used to maneuver the barge. This tactic is estimated to achieve a combined recovery rate of 427 barrels per hour (8,540 barrels of oil per day, based on two 10-hour shifts). Using a combination of tactics identified in Table 1-6 of BPXA's contingency plan (BPXA, 2000b), the combined estimated recovery capacity is 12,950 barrels of oil per 10-hour shift. As noted earlier, this estimated recovery is based on the estimated capacity of the equipment under ideal conditions, and it is not likely that this rate of recovery would be realized.

To address broken-ice conditions, the preceding tactic would be modified to include using an ice-reinforced barge and two additional boom/skimmer systems (Tactic R-19A). These systems would be deployed either from behind the deck barge or to either side of the barge, depending on the ice concentrations. These two systems can add an estimated additional 434 barrels/hour to the original 427 barrels indicated above. This system is sensitive to the amount of ice found in the recovery area. Efficiencies for containment are decreased by 30%, 60%, and 80% as ice concentration increases by 30%, 50%, and 70%, respectively. This system has the added advantage that, in the event conditions become unsafe due to ice concentrations, the boats could be loaded on the deck barge for safe passage through the ice. Using a combination of tactics identified in Table 1-6 of BPXA's contingency plan (BPXA, 2000b), the combined estimated recovery capacity is 18,060 barrels of oil per 10-hour shift.

It is difficult to assess the effectiveness of these cleanup and response tactics in protecting bowhead whales. Response efforts to preclude oil from getting through entrances between the barrier islands and reaching the bowhead's main migration corridor would be very effective at protecting bowheads. If cleanup and response efforts were successful, no oil would reach bowhead habitat outside the barrier islands. If cleanup and response efforts were not successful and little or no oil was cleaned up, the chance of oil contacting bowhead habitat outside the barrier islands would be the same as described above without any cleanup response. If cleanup and response efforts were partially successful, the most likely scenario, the amount of oil on the water would be reduced and likely would cover a smaller area. If oil passed through the entrances and reached the main migration corridor, some bowheads would be affected. It is likely that fewer bowheads would be exposed to oil as a result of cleanup operations than without cleanup operations. Oil-spill-cleanup activities likely would be ongoing for several seasons and likely for more than 1 year. The effects of oil on bowhead whales would be as described in Section III.C.2.a(1).

Oil-spill-cleanup activities during September and October could disturb bowhead whales during their fall migration. There is no information available regarding bowhead disturbance from oil-spill-cleanup operations, but noise disturbance to bowheads from vessel and aircraft traffic involved with cleanup activities likely would be similar to that already described in Section III.C.3.a(1). Most oil-spill-cleanup work probably would occur inside the barrier islands, because the spill model indicates that spilled oil has a relatively low probability to reach areas outside of the

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barrier islands. Some whales might be disturbed by vessel or aircraft traffic and displaced seaward, if cleanup activities occurred outside the barrier islands or in the channels between the barrier islands during the whale migration. Oil-spill-cleanup activities likely would be ongoing for several seasons and likely for more than 1 year. The icebreaking barge, the *Endeavor*, could be used if a spill occurred during broken ice conditions in October. Information regarding how far noise could be heard from this vessel conducting icebreaking operations is not available. If this vessel were to be used before the end of the bowhead whale fall migration, it is possible some migrating whales could hear the noise. It is likely the shallow water with ice cover and the presence of the barrier islands greatly would reduce the amount of noise reaching migrating whales. Considering this likely reduction in noise levels, the low chance of an oil spill, the very narrow window of time in October that the use of an icebreaking vessel might affect whales, and the relatively low chance that oil would reach bowhead habitat outside the barrier islands, there is a low probability that whales would be affected by cleanup activities.

(2) Eiders

(a) Summary and Conclusions for Eiders

The 180,000-barrel blowout oil spill in open water assumed for this analysis is expected to cause spectacled eider mortality if females with recently fledged young contact stranded oil in coastal habitats along the extensive shoreline that may be oiled, or flocks of adult eiders or females with young feeding in lagoons and offshore waters are contacted by a spill sweeping over thousands of square kilometers. Substantial mortality would represent a significant loss for the relatively small Arctic Coastal Plain spectacled eider population, requiring many generations for recovery. Recovery is not likely to occur if the regional population is declining.

A winter spill released from the ice in spring could contact eiders concentrated in open water near the Sagavanirktok or other river deltas. Death of food organisms from oiling could adversely affect the ability of juvenile eiders to develop as rapidly as they would normally or might delay the accumulation of fat reserves for migration in any individuals. Any mortality from such indirect effects would be additive to the loss of oiled individuals. Although Fish and Wildlife Service survey data do not show a significant decline in the coastal plain spectacled eider population, the potential exists for a significant adverse effect from an oil spill on this population, particularly that segment nesting in the eastern portion of the range.

Steller's eiders are not expected to be in the Liberty Project area.

(b) Details on How an Oil Spill from a Blowout Might Affect Spectacled Eiders

If a 180,000-barrel oil spill occurred at Liberty Island and entered offshore waters (the volume falling on the island and surrounding area after about 20% of the 225,000-barrel blowout evaporates), it could contact 322 kilometers (200 miles) of coastline within 30 days (Table IX-4). This distance is equivalent approximately to the coastline from Camden Bay to western Harrison Bay. About 36,000 barrels of oil are expected to go ashore within 30 days, and the discontinuous slick could sweep over an area of 5,700 square kilometers (Table IX-5b). An estimated 4,100 barrels of the spill would become mixed with bottom sediments. We estimate that one or more blowouts of this size would have a 0.1% chance of occurring over the lifetime of the Liberty Prospect development.

1) Probable Effects on Eiders

From early June to early July (males) and late June to early September (females or females with young), flocks of eiders may be present in coastal lagoons and offshore waters (TERA, 1995b, 1999), or females with young have moved through coastal habitats to the open sea after the young have fledged. Realistic values currently are unavailable for densities of spectacled eiders present in this area during any given period that would allow the estimation of potential mortality from oil-spill contact. However, if a spill sweeping over the large area indicated above contacted some of these flocks, or broodrearing females with young came into contact with oil along the 322 kilometers (200 miles) of coast where oil is likely to contact or become stranded, mortality is expected to occur. A spill occurring in winter and released from the ice in spring could contact concentrations of eiders in open water near the Sagavanirktok and other river deltas. For the spectacled eider, with a relatively small regional population and low productivity, the loss that could result from such a spill of perhaps tens of locally nesting individuals plus an unknown number of migrants would represent a significant loss. Because there is no clear population trend in the coastal plain population, and there is a lack of certain data required to model population fluctuations, an estimate of recovery time from such a loss currently would be too speculative to be meaningful. Also, losses may be difficult to separate from natural variation in population numbers (see the discussion in Sec. III.C.2.a(2), Threatened and Endangered Species, Eiders, Population Effects).

Oil contacting or mixed into bottom sediments and mudflat areas, or affecting species-rich foraging areas such as boulder patches, is expected to kill substantial numbers of the eider's food organisms. It is difficult to determine the actual effect that such indirect effects as a decline in food organisms would have on bird populations. Decreased food availability might adversely affect the ability of juvenile birds to develop as rapidly as they would normally or might delay the accumulation of fat reserves for migration in any individuals. Any mortality from such indirect effects would be additive to the loss of oiled individuals.

2) Effects of Oil-Spill-Prevention and Response

General aspects of oil-spill prevention and response are summarized in Section II.A.4, and effects are discussed in Section III.C.2.a(2).

a) A Blowout During Open-Water Conditions

Despite the potential for effective spill containment, recovery, and cleanup under ideal weather conditions, these may not exist during a spill incident, and some eider habitats in the Liberty area and to the west are likely to be contacted by oil. Most detections of satellite-tagged spectacled eiders have been in or offshore of Harrison Bay, or outside or offshore of western Simpson Lagoon where the Oil-Spill-Risk Analysis model estimates the chance of contact by spilled oil within 30 days in summer is less than 5% (Environmental Resource Areas 14-20, and 48-50). However, despite the low probability of contact, these areas would need to be surveyed for eider presence to plan a response strategy. If the spill is not contained before reaching these areas, the most effective response may involve hazing.

Although spectacled eiders apparently spend little time in nearshore coastal habitats, females with broods may occupy them briefly before moving to offshore staging areas. Containment, recovery, and cleanup activities for a large spill are expected to involve hundreds of workers and numerous boats, aircraft, and onshore vehicles operating over an extensive area for more than 1 year. The presence of such a workforce is likely to act as a general hazing factor, displacing any eiders from the immediate area of activity, perhaps within a few kilometers, which potentially might be viewed as a positive result, given birds' extreme vulnerability to oil in the environment. If a reliable system of locating eiders in a specific area can be devised, specific birds or groups in danger of oil contact could be targeted with specific hazing tactics.

Currently, no important specific foraging areas for eiders are identified in the Liberty area, and displacement away from the area is not expected to significantly affect their development (juveniles) or ability to accumulate fat to fuel migration. Displacement by cleanup activity of females with broods from coastal habitats may have a negative effect, if it prematurely forces them into the offshore marine environment where the high salinity could increase stress on the ducklings, which have relatively low salt tolerance (USDOI, Fish and Wildlife Service, 1996). Disturbance of nesting spectacled eiders by onshore cleanup activities is not expected to significantly affect eider productivity. There appears to be little tendency for this species to nest near the coast (TERA, 1999), where there is the highest probability of disturbance by cleanup activity. Because of low nesting density, few nesting birds are likely to be displaced and potentially lose their clutches or broods to predators as a result of disturbance by cleanup operations. Helicopter support traffic and human presence probably would be the most disturbing factors associated with oil-spill-cleanup activity. If their presence forces eiders from a marine area where oil contact is imminent, it may be considered a positive factor. However, overland flights and off-road personnel activity during the nesting season may displace females from their nests or broods and result in egg or duckling losses. During the nesting season in early June to early September, an effort should be made to route air traffic over areas where there is a low probability of eider nesting, and spill-cleanup personnel should not enter inland areas except on established roads.

Prompt containment and removal of oil from offshore areas, accompanied by hazing tactics targeting high-use areas, is likely to result in a substantial reduction of spectacled eider mortality from a large oil spill. Cleanup also would decrease the amount of oil available for uptake by bottom-dwelling organisms that are the principal food of eiders. This could reduce the potential for oil uptake by eiders and associated adverse physiological side effects, although the benefit of this indirect effect on the eider population is likely to be minor.

b) A Blowout During Broken-Ice Conditions

Containment and oil recovery following a blowout spill that enters the marine environment under broken-ice conditions at meltout or freezeup is expected to be less effective than for an open-water spill. Although under these conditions the area covered by the spill would be smaller (3,200 square kilometers, Table IX-3b), spectacled eiders are not expected to occupy areas of broken ice in either period, unless substantial areas of open water are available. Even after spring melting provides areas of open water, most arriving spring migrants likely would occupy overflow areas off river mouths. Those are available earlier and are near nesting areas; the greatest benefits may result from containment and cleanup in such areas. In this season, the hazing effect of cleanup activity or actively hazing birds out of areas that oil is expected to enter may be counterproductive, because there are few alternative habitats that flushed birds can occupy. If most spectacled eiders arrive in the area via overland routes (TERA, 1999), the benefit of spill containment and cleanup would be minimal, until they begin reentering the marine environment following breeding. By this time, the oil would have weathered and probably become a minor hazard. In fall, spectacled eiders are not likely to be present in numbers beyond late September, and oil present in broken ice at this time is not expected to contact eiders. Likewise, cleanup activity at this time is not expected to disturb eiders.

b. Seals and Polar Bears

(1) Summary and Conclusion for Seals and Polar Bears

A 180,000-barrel blowout oil spill could result in the oiling of several hundred to a few thousand ringed seals and a number of bearded seals and polar bears. The recovery of seals and polar bears could take perhaps 3-4 years and about 6-10 years, respectively.

(2) General Description on How an Oil Spill from a Blowout Might Affect Seals and Polar Bears

The potential effect of a 180,000-barrel oil spill on ringed and bearded seals and polar bears could be severe (see the discussion of the general effects of oil on these marine mammals in Sec. III.C.2.b). Within 30 days of the oil's release from sea ice, about 20% (36,000 barrels) of the oil would contact coastline from the Endicott Causeway east to Bullen Point in the Badami area (Table IX-3a). A substantial portion of the ringed seal pupping habitat in the shorefast ice off Foggy Island Bay could be exposed at least partially to an oil spill at the end of the pupping season in June.

An estimated 0.81 ringed seals per square kilometer could be contaminated by the spill (average overall seal density for central Beaufort Sea-Liberty area in 1998 as reported by Frost and Lowry [1999]). With the spill sweeping over 3,200 square kilometers within 30 days, an estimated 2,600 ringed seals (0.81 x 3,200) could be exposed to the spill. This exposure could result in the death of up to perhaps a few thousand ringed seals through inhalation and absorption of toxic hydrocarbons in the oil, fouling the seals' fur. This loss of ringed seals could take at least 3-4 years for an estimated resident population of about 40,000 to recover (about 6.5% of the population lost to the spill and assuming an annual recruitment of about 2%).

About 1-2% of the oil spill is estimated to contact seal and polar bear ice-front habitats offshore from the Endicott Causeway east to Bullen Point during winter (represented by Ice/Sea Segments shown in Maps A-2 and A-3 and in Table IX-6). Several thousand ringed and bearded seals and perhaps 60-100 polar bears could be exposed to the oil spill (assuming a bear density of 1 bear per 78-130 square kilometers and a total surface area of 7,900 square kilometers is swept by the discontinuous oil slick within 60 days; Table IX-3b).

Assuming that all ringed and bearded seals, and all polar bears exposed to the oil died because of absorption (through the skin), inhalation, and/or ingestion of toxic hydrocarbons in the oil, these losses could take seal populations about 3-4 years and polar bears perhaps 6-10 years to fully recover. The estimated recovery of polar bears assumes an annual sustainable biological removal of 76 bears per year and a subsistence harvest of 58.8 bears per year. If the population increases by 18 bears per year, 100 bears could be replaced within 5-6 years. However, if more females than males are lost to the spill, or other factors such as food availability were affected, the recovery could take longer, possibly 10 years.

(3) General Effects of Oil-Spill Prevention and Response

(a) A Blowout During Open-Water Conditions

The response plan (BPXA, 2000b) assumes an optimum oil-recovery capacity of 12,950 barrels per 10 hours using one barge skimmer system and three skimmer systems deployed from bay-class workboats. Daily oil-recovery capacity could increase to 26,700 barrels per day. However, the effectiveness of oil recovery is expected to drop dramatically under poor weather conditions.

Some of the 180,000-barrel oil spill is likely to oil seal and polar bear habitats in the Foggy Island Bay area. Hundreds of workers, many boats, and several aircraft operating in the area for cleanup probably would displace some seals and polar bears from oiled areas and temporarily stress others. These effects may occur during 1 or 2 years of cleanup; however, we do not expect it to greatly affect seal and polar bear behavior and movement beyond the area oiled by the spill or after cleanup.

Cleanup efforts should include the removal of all oiled animal carcasses to prevent polar bears from scavenging on them. Oil-spill-contingency measures that include the hazing by aircraft of wildlife away from the oil spill could reduce the chances of polar bears entering coastal waters where there is an oil slick. However, such hazing may have to be repeated to prevent polar bears from entering the oiled water or oiled shoreline area after the aircraft has left. Poor weather conditions would prevent this contingency measure from being effective.

The tactics for responding to spills in broken ice and pack ice could help, including the strategies for tracking of oil in pack ice and the in-situ burning of oil on ice. However, poor weather conditions would prevent this contingency measure from being effective. The response plan discusses the importance of timely salvage of oiled carcasses and the required State and Federal permits. Poor weather and remote locations would lessen the effective removal of oiled carcasses.

The effectiveness of the oil-spill response plan in preventing or reducing oil effects on seals and polar bears will be determined by efforts to prevent the oil from reaching open leads in the ice and coastal habitats. In situ burning of oil could help to reduce the risk of oil contact to these habitats. However, the effectiveness of in-situ burning of the oil is determined by weather conditions at the time of the spill. Poor weather would prevent burning of the oil and could drive the oil into coastal areas. The cleanup of oiled shoreline in Prince William Sound had very mixed results.

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Cleanup operations often contributed to the oil damage to shoreline habitats and intertidal feeding areas.

(b) A Blowout During Broken-Ice/Freezeup Conditions

The response plan assumes an optimum oil-recovery capacity of 18,060-barrels per 10 hours using two barge skimmer systems and four skimmer systems deployed from bay-class workboats. However, the effectiveness of oil recovery is expected to drop dramatically under poor weather conditions. Some of the 180,000-barrel oil spill is likely to oil seal and polar bear habitats as described above under the open-water blowout scenario and have about the same level of cleanup effectiveness. The formation of shorefast ice during freezeup conditions is expected to reduce the amount of oil reaching coastal habitats compared to the amount of habitat oiled under the open water scenario.

c. Marine and Coastal Birds

(1) Summary and Conclusion for Marine and Coastal Birds

A 180,000-barrel oil spill, assumed for analysis, occurring in the open-water season is likely to result in the loss of thousands of broodrearing and young waterfowl and shorebirds, if they contact stranded oil along a substantial proportion of the 322 kilometers (200 miles) of affected shoreline. In lagoon habitats, observed high densities of long-tailed ducks suggest that tens of thousands of molting individuals could be contacted by a spill sweeping over thousands of square kilometers, representing a significant loss from the regional population. Likewise, contact of substantial numbers of postbreeding common eiders in the vicinity of barrier islands would result in significant losses.

A winter spill entering the environment after the ice melts in the spring could contact loons and other migrant waterfowl concentrated in open water near river deltas. Mortality of prey organisms could decrease the availability of food and adversely affect the ability of young waterfowl and shorebirds to develop as rapidly as they would normally or the ability of individuals to accumulate fat reserves for migration; this would be additive to the population effects of losses of oiled individuals.

(2) Details on How an Oil Spill from a Blowout Might Affect Marine and Coastal Birds

The 180,000-barrel oil spill at Liberty Island, assumed for analysis, entered offshore waters, 322 kilometers (200 miles) of coastline are expected to be contacted within 30 days (Table IX-4). This distance is equivalent approximately to the coastline from Camden Bay to western Harrison Bay. Within 30 days, about 36,000 barrels of oil is expected to come ashore, and the discontinuous slick could sweep over an area of 5,700 square kilometers (Table IX-5). There would be a 9% chance of contact at the Howe Island snow goose colony and an 11% chance of contact by a winter spill after 6 months. An estimated 4,100 barrels of the spill would become entrained in bottom sediments. We estimate that one or more blowouts of this size would have a 0.1% chance of occurring over the lifetime of the Liberty Project.

(a) Probable Effects of a Large Spill

In mid- to late summer, up to 3,200 broodrearing/young brant, 2,000 broodrearing/young lesser snow geese, tens of tundra swans, and thousands of shorebirds are present in Beaufort Sea shoreline habitats, and many tens of thousands of long-tailed ducks and large numbers of king and common eiders are present in coastal lagoons and offshore waters (Johnson, 1994a,b; Johnson and Gazey, 1992; Johnson and Noel, 1996; Noel, Johnson, and Wainwright, 2000; Noel and Johnson, 1996; Stickney and Ritchie, 1996; Stickney et al., 1994; Troy, 1995). A spill during this period could result in mortality exceeding a few thousand individuals, if broodrearing waterfowl or shorebirds contact stranded oil along a substantial proportion of the 322 kilometers (200 miles) of affected shoreline. In lagoon habitats, oldsquaw densities averaging 40-275 birds per square kilometer (Noel, Johnson, and Wainwright, 2000) suggest that when large concentrations of molting long-tailed ducks are present, tens of thousands could be contacted by a spill sweeping over the large area indicated above, representing a significant loss proportion of the regional population. Significant losses also would be experienced by postbreeding common eiders concentrated near barrier islands and in lagoons.

A spill occurring in winter and released in spring could contact loons and other migrant waterfowl concentrated in open water near river deltas. For species such as the yellow-billed loon, with relatively small populations and low productivity, this could represent a significant loss. Because there is no clear population trend in the coastal plain population, and there is a lack of certain data required to model population fluctuations, an estimate of recovery time from such a loss currently would be too speculative to be meaningful. Also, losses may be difficult to separate from natural variation in population numbers (see the discussion in Sec. III.C.2.a(2), Threatened and Endangered Species, Eiders, Population Effects).

Oil entrained in bottom sediments and mudflat areas, or affecting species-rich foraging areas such as boulder patches, is expected to result in mortality of potential prey organisms of waterfowl and shorebirds. The actual effect on bird populations of such indirect effects on food organisms is difficult to determine. Presumably, decreased food availability would adversely affect the ability of young to develop as rapidly as they would normally or the ability of individuals to accumulate fat reserves for migration; this would be additive to the population effects of losses of oiled individuals.

(b) Effects of Oil-Spill Prevention and Response

General aspects of oil-spill prevention and response, an inventory of available equipment, and containment/cleanup methods for four seasonal scenarios are summarized in Section II.A.4. Most spill-response equipment is stored in Deadhorse (Alaska Clean Seas), but some is kept on Egg Island outside Gwydyr Bay. Oil-spill prevention and response strategies would be used to mitigate significant oil-spill impacts, but specific methods would not be used if it was determined they could cause additional harm to bird species.

1) A Blowout During Open-Water Conditions

Despite the potential for effective spill containment, recovery, and cleanup under ideal weather conditions, these may not exist during a spill incident and some loon, waterfowl, shorebird, and seabird habitats in the Liberty area and to the west are likely to be contacted by oil. Recent aerial surveys (Tiplady, 1999, pers. commun.) recorded substantial numbers of loons, waterfowl, and seabirds from Mikkelsen Bay west to Harrison Bay. In this area, the probability of contact by spilled oil varies from 60% near Liberty Island to less than 5% in Harrison Bay and Simpson Lagoon, where some of the most substantial concentrations of these species were recorded. Although some species exhibited concentrations in Harrison Bay and Simpson and other lagoons, as a group, this suite of species was surprisingly widespread in its offshore distribution, ranging from the coastal shoreline to 50 kilometers offshore. If a large spill is not contained before reaching these areas, the most effective response may involve hazing; however, this tactic is expected to meet with variable success, depending on the particular species occupying a given area.

Containment, recovery, and cleanup activities for a large spill are expected to involve hundreds of workers and numerous boats, aircraft and onshore vehicles operating over an extensive area for more than 1 year. The presence of such a workforce is likely to act as a general hazing factor, displacing birds from the immediate area of activity, perhaps within a few kilometers, which potentially may be viewed as a positive result given birds' extreme vulnerability to oil in the environment. If a reliable system of locating bird concentrations in a specific area can be devised, specific birds or groups in danger of oil contact could be targeted with specific hazing tactics.

Species occurring in the Liberty area vary considerably in their use of marine habitats, resulting in varying vulnerability to cleanup activities. For example, molting long-tailed ducks primarily occupy protected lagoons where they could be severely disturbed, if these areas became the focus of intensive cleanup efforts. Because there are relatively few comparable alternative habitats in which to molt, there could be an adverse effect on their ability to complete the molt on a normal schedule if they were displaced to less favorable habitats. However, displacement of molting birds away from an area of potential oil contact may be considered a positive effect of cleanup activity that could offset the adverse effects of displacement to a lower quality area. Displacement of loons, king and common eiders, postmolt long-tailed and other sea ducks, and glaucous gulls occupying offshore waters is not expected to significantly affect their ability to accumulate fat to fuel migration, because there is abundant similar habitat they may occupy, although the availability of high quality foraging habitat in the Beaufort Sea currently remains unknown. Likewise, displacement of shorebirds from oiled coastline is expected to have a similar effect. Displacement by cleanup activity of female waterfowl with broods from coastal habitats may have a negative effect if it prematurely forces them into the offshore marine environment where foraging may be more difficult for the ducklings, and other stresses may increase. Disturbance of nesting sea ducks by onshore cleanup activities is not expected to significantly affect their productivity. There appears to be little tendency for most of these species to nest near the coast, where there is the highest probability of disturbance by cleanup activity. Because of low nesting density, few nesting birds are likely to be displaced and potentially lose their clutches or broods to predators as a result of disturbance by cleanup operations. Helicopter support traffic and human presence probably would be the most disturbing factors associated with oil-spill-cleanup activity. If their presence forces ducks from a marine area where oil contact is imminent, it may be considered a positive factor. However, overland flights and off-road personnel activity during the nesting season may displace females from their nests or broods and result in egg or duckling losses. During the nesting season, early June to early September, an effort should be made to route air traffic over areas where there is a low probability of waterfowl nesting, and spill-cleanup personnel should not enter inland areas except on established roads. Lesser snow geese nesting on Howe Island, brant nesting colonies along the coast, and both species broodrearing in coastal habitats are likely to be disturbed by summer cleanup activity in nearby areas.

Prompt containment and removal of oil from offshore areas, accompanied by hazing tactics targeting high-use areas, is likely to result in a substantial reduction of sea duck and shorebird mortality from a large oil spill. Cleanup also would decrease the amount of oil available for uptake by bottom-dwelling organisms that are the principal food of sea ducks and shorebirds. This could reduce the potential for oil uptake by these species, and associated adverse physiological side effects, although the benefit of this indirect effect on their populations is likely to be minor. Removal of oiled bird carcasses from beaches would eliminate a source of oiling for scavengers such as glaucous gulls and common ravens.

2) A Blowout During Broken-Ice Conditions:

Containment and oil recovery following a blowout spill that enters the marine environment under broken-ice conditions at meltout or freezeup is expected to be less effective than for an open-water spill. Although under these conditions the area covered by the spill would be smaller (3,200 square kilometers, Table IX-3b), most bird species are not expected to occupy areas of broken ice in either period unless substantial areas of open water are available. Even after spring melting provides areas of open water, most arriving spring migrants likely would occupy overflow areas off river mouths, because those are available earlier and are near nesting areas. The greatest benefits may result from containment and cleanup in such areas. In this season, the hazing effect of cleanup activity or actively hazing birds out of areas that oil is expected to enter may be counterproductive, because there are few alternative habitats that flushed birds can occupy. For sea ducks arriving via overland routes, the benefit of spill containment and cleanup would be minimal until they begin reentering the marine environment following breeding. By this time, the oil would have weathered and probably become a minor hazard. In fall, beyond late September, most sea ducks and other waterfowl and shorebirds are not likely to be present in great numbers, and oil present in broken ice at this time is not expected to represent a hazard. Long-tailed ducks are more at risk until later in the fall than most other species. Likewise, cleanup activity at this time is not expected to disturb these species.

d. Terrestrial Mammals

(1) Summary and Conclusion for Terrestrial Mammals

A 180,000-barrel blowout oil spill, assumed for analysis, would oil coastal habitats used by caribou, muskoxen, grizzly bears, and arctic foxes. Central Arctic Herd caribou are the most likely to encounter oil from this spill. Caribou would be most exposed to the oil when some of them enter coastal waters to seek relief from insects. Several hundred caribou and small numbers of muskoxen, grizzly bears, and arctic foxes could come in direct contact with the spill and suffer injury or death. However, recovery of these populations is expected within 1 or 2 years.

(2) General Description on How an Oil Spill from a Blowout Might Affect Terrestrial Mammals

If this large spill occurred during the summer, when Central Arctic Herd caribou were in the marine waters seeking relief from mosquitoes, several hundred caribou could be oiled and suffer injury or death from the spill. However, the population is expected recover within 1 or 2 years.

If this spill contacted shorelines used by grizzly bears, arctic foxes, and muskoxen, small numbers of these species could ingest oiled food items and suffer injury or death. However, probably only a small number of animals would be harmed. There probably would be no effect to grizzly bear, fox, and muskoxen populations.

If a 180,000-barrel spill occurred during winter, shorefast ice would prevent the oil from reaching the shore. During late spring and summer, some of the oil would melt out of the ice as fresh oil and could oil the shore. Caribou in the area could be oiled if they are in the water. The effects on caribou, muskoxen, grizzly bears, and arctic foxes would be similar to those from a summer spill.

The potential effect of a 180,000-barrel pipeline oil spill on caribou likely would be limited to caribou groups occurring during the spring and during the insect-relief periods in coastal waters near shorelines with extensive oil contamination. Although the oil spill would contact shoreline from Bullen Point west to the Endicott Causeway, the majority of the coastline contamination would occur between the causeway and Tigvariak Island (Land Segments 25-28; Map A-1 and Table IX-6).

Heavily oiled caribou might die from absorption and/or inhalation of toxic hydrocarbons. Several hundred Central Arctic Herd caribou could die from the oil spill. This loss would represent a short-term effect, with population recovery likely to take place within 1 or 2 years.

Caribou and muskoxen that ingest contaminated vegetation could suffer anorexia (significant weight loss) and aspiration pneumonia, leading to the death of affected mammals. The spill could harm a small number of grizzly bears and arctic foxes through ingestion of contaminated prey or carrion that they find along the shoreline. However, such losses are not expected to affect populations on the Arctic Slope. Oil-spill-cleanup activities are likely to scare many of these animals away from the spill area, reducing the number of animals coming in contact with the oil.

(3) General Effects of Oil-Spill Prevention and Response

(a) A Blowout During Open-Water Conditions

The response plan (BPXA, 2000b) assumes an optimum oil recovery capacity of 12,950 barrels per 10 hours using one barge skimmer system and three skimmer systems deployed from bay-class workboats. Daily oil-recovery capacity could increase to 26,700 barrels per day. However, the effectiveness of oil recovery is expected to drop dramatically under poor weather conditions.

Some of the 180,000-barrel oil spill is likely to oil coastal habitats occupied by herds or bands of caribou and muskoxen during the insect season. Hundreds of workers, many boats, and several aircraft probably would displace some caribou, muskoxen, grizzly bears, and foxes during cleanup operations in the spill area. These activities are not expected to affect the behavior and overall movements of these populations. Oil-spill response measures that include the hazing of wildlife away from the oil spill could reduce the chances of caribou entering coastal waters where there is an oil slick. However, such hazing may have to be repeated to prevent caribou from entering the oiled water during the insect season. The response plan discusses the importance of timely salvage of oiled carcasses and the required State and Federal permits (Alaska Clean Seas Tactics W-1 and -4). However, poor weather may prevent the timely removal of oiled carcasses. These carcasses are likely to be scavenged by arctic foxes, grizzly bears, and possibly polar bears, resulting in the loss of some foxes and bears due to ingestion of oil with the carcasses.

The effectiveness of the oil-spill response plan in preventing or reducing oil effects on terrestrial mammals will be determined by efforts to prevent the oil from reaching coastal habitats. In situ burning of oil could help to reduce the risk of oil contact to coastal habitats. However, the effectiveness of in situ burning is determined by weather conditions at the time of the spill. Poor weather would prevent the burning of the oil and could drive the oil into coastal areas and on to the shoreline. The cleanup of oiled shoreline in Prince William Sound had very mixed results. Cleanup operations often contributed to the oil damage to shorelines and intertidal areas.

(b) A Blowout During Broken-Ice/Freezeup Conditions

The response plan assumes an optimum oil recovery capacity of 18,060-barrels/10 hours using two barge skimmer systems and four skimmer systems deployed from bay-class workboats. However, the effectiveness of oil recovery is expected to drop dramatically under poor weather conditions. Some of the 180,000-barrel oil spill is likely to oil coastal habitats of terrestrial mammals as described above under the open-water blowout scenario and have about the same level of cleanup effectiveness. The formation of shorefast ice during freezeup conditions is expected to reduce the amount of oil reaching coastal habitats compared to the amount of habitat oiled under the open-water scenario.

e. Lower Trophic-Level Organisms

(1) Summary and Conclusion for Lower Trophic-Level Organisms

This very large oil spill, assumed for analysis, is estimated to contact 65% of the shoreline in the Stefansson Sound area. It could have lethal and sublethal effects on coastal and benthic communities within the affected area. The recovery of seasonal invertebrates would be expected within 2 months, but fractions of the oil might remain in shoreline sediments for up to 10 years.

(2) Details on How an Oil Spill from a Blowout Might Affect Lower Trophic-Level Organisms

This analysis considers the effects of an assumed 180,000-barrel oil spill at Liberty Island and entering offshore waters on lower trophic-level organisms during the summer and winter months. The specific effects of petroleum on lower trophic-level organisms are discussed under the Proposal (Sec. III.C.2.e). The oil spill is assumed to last for 15 days following a blowout on Liberty Island. The spill would adversely affect some lower trophic-level organisms by exposing them to petroleum-based hydrocarbons. To stay in perspective, the estimated effects of the oil spill are compared to those estimated for the 125-2,956-barrel oil spill assumed for the Proposal.

(a) Kelp and Other Marine Plants

Large-scale effects on marine plants from oil spills have been observed in the intertidal and subtidal zones of other regions. Due to the predominance of shorefast ice in the affected area, there is no resident marine flora in waters less than 6 feet deep. Therefore, no effects are expected on marine plants in these waters. The oil spill also is not expected to have any measurable effect on subtidal marine plants (such as those of the Boulder Patch area), because they live below the zone where toxic concentrations of oil can reach them.

(b) Coastal and Benthic Marine Invertebrates

Large-scale effects on marine invertebrates from oil spills have been observed in the intertidal and subtidal zones of other regions. There are limited intertidal and nearshore subtidal zones in the Beaufort Sea. Instead, it is a highly disturbed area that is seasonally recolonized by a small number of opportunistic fauna during the summer (about 3 months). The nearshore area does support a few resident and many nonresident benthic invertebrates (amphipods, mysids, copepods, clams, snails, crab, and shrimp), which are fed upon by vertebrate consumers during the summer. If contacted by surface oil, these invertebrates are likely to die or be sublethally effected.

Table IX-5a indicates that 26,000 barrels of oil would contact the shoreline within 10 days, or roughly 20 times that of the spill assumed for the Proposal (1,313 barrels). If oil contacts shoreline segments that have a 1% or greater chance of contact, about 3.5 times as much shoreline would be affected as with the spill assumed for the Proposal, or about 209 kilometers of shoreline (approximately 65% of the Stefansson Sound coastline). Based on the above, the oil spill is estimated to contact about 65% of the shoreline in the Stefansson Sound area.

The recovery of seasonal benthic invertebrates would be expected within 2 months, after water quality in the nearshore water column returns to prespill conditions and other opportunistic marine invertebrates move into the area. Oil incorporated by wave action into shoreline bottom sediments is expected to remain there for several years. In the areas where bottom sediments are heavily oiled, some lethal and sublethal effects could occur each summer, when seasonal benthic invertebrates return to those areas. However, this is not expected to affect a measurable percentage of the seasonal benthic invertebrate population in Stefansson Sound. The recovery of resident benthic invertebrates would be expected within 5 years, but could require up to 10 years in areas where water circulation is significantly reduced. Oil mixed into shoreline bottom sediments would have the greatest effect on resident benthic fauna, because they are not seasonally restocked from deeper waters as are seasonal fauna. Subtidal marine organisms deeper than 2 meters (including those of the Boulder Patch area) are not likely to be affected, because they live below the zone where toxic hydrocarbon concentrations can reach them.

The only other marine invertebrates likely to be contacted by surface oil or dispersed oil in the water column are those closer to the surface. These include zooplankton (copepods, euphausiids, mysids, and amphipods) and the larval stages of marine invertebrates such as annelids, mollusks, and crustaceans. Because of similarities in habitat use and distribution, the percentage of marine invertebrate larva contacted by floating or dispersed oil is likely to be similar to that expected for plankton (about 26%). Because of their wide distribution, large numbers, and rapid rate of regeneration, the recovery of marine invertebrate larva is expected to take about 1 or 2 weeks (the estimated flushing time for Stefansson Sound). Recovery in embayments with reduced circulation would be expected within 2 months.

(3) Oil-Spill Prevention and Response

The Alaska Clean Seas technical manual identifies sensitive sections of the Beaufort Sea coastline on which oil might persist for a decade, including some within the project area (Alaska Clean Seas, 1998: Index Sheets 1 and 2). The most sensitive types of shoreline, such as river deltas and sheltered lagoons, are listed clearly in the manual as “areas of major concern” (Alaska Clean Seas Tactic W-6). The manual also describes several tactics for protecting sensitive sections of the coastline. Intertidal and exclusion booms would be used along the shoreline in marshes and inlets. Deflection booms would be used to divert oil to sections of the coastline that are less sensitive or more suitable for recovery; the oil would be collected by booms and pumped by skimmers to local storage tanks. The shorelines that might be contaminated, as a result of diversionary booming, would be flushed to remove oil from the shore zone.

Some lower trophic-level organisms on the shorelines would be adversely affected by these and other response tactics. Spill responses that would use mechanical tilling for aeration and remediation of shoreline sediments might effect these organisms, and spill responses that use chemicals on oiled shorelines would affect the organisms, as acknowledged by Tactics SH-8 and 11. Spill responses that involve in-situ burning would affect the organisms on shorelines especially on relatively dry shorelines. The tactics for chemical treatments include warnings to avoid chemical use on cobble shorelines where there could be deep penetration, which would help to mitigate impacts. Further, all of the shoreline tactics note that Unified Command approval would be required for any shoreline cleanup, which would avoid unnecessary affects on lower trophic-level organisms.

Use of dispersants on a spill near the Boulder Patch would mix the oil farther down into the water column and could affect the kelp community. However, the use of dispersants is not essential to the Liberty Development and Production Plan and Oil-Discharge Prevention and Contingency Plan; their use would require further approval by the Coast Guard.

f. Fishes and Essential Fish Habitat

(1) Fishes

(a) Summary and Conclusion for Fishes

The likely effects on fishes due to a 180,000-barrel oil spill, assumed for analysis, primarily would depend on the season and location of the spill, the lifestage of the fishes (adult, juvenile, larval, or egg), and the duration of the oil contact. Due to their very low numbers, no measurable effects are expected on fishes in winter. Effects would be more likely to occur from an offshore spill moving into nearshore waters in summer, where fishes concentrate to feed and migrate. The probability of an offshore oil spill occurring and contacting nearshore waters is low. If an offshore oil spill did occur and contacted the nearshore area, some marine and migratory fish might be harmed or killed. However, it would not be expected to have a measurable effect on fish populations, and recovery of the number of fish harmed or killed would be expected within 5 years

(b) Details on How an Oil Spill from a Blowout Might Affect Fishes

A Very Large Blowout Oil Spill is More Likely to Affect Fishes in Summer. Due to their very low numbers and wide area of distribution, no measurable effects are expected on fishes in winter. Effects would be more likely to occur from an oil spill moving into nearshore waters in summer, where fishes concentrate to feed and migrate. Based on the Oil-Spill-Risk Analysis model (Table IX-6), the nearshore areas of highest oil-spill risk include Land Segments 25-27 (an 11-13% chance of contact).

The probability of a 180,000-barrel oil spill occurring at Liberty Island, entering offshore waters, and contacting the nearshore area is low. However, if it did occur, some marine and migratory fish might be harmed or killed. The number affected would depend on the size of the area affected, the concentration of petroleum present, the time of exposure, and the stage of fish development involved (eggs, larva, and juveniles are most sensitive). If lethal concentrations were encountered, or sublethal concentrations were encountered over a long enough period, fish mortality would be likely to occur. However, mortality due to petroleum-related spills is seldom observed outside of the laboratory environment. This is because the zone of lethal toxicity is very small and short lived under a spill, and fishes in the immediate area typically avoid that zone. Mortality would only be expected in cases where fishes were somehow trapped in a lethal concentration and could not escape. Because this would be very unlikely outside of the laboratory environment, little to no mortality due to lethal concentrations would be expected. For these reasons, a 180,000-barrel oil spill is expected to have mostly sublethal effects (for example, changes in growth, feeding, fecundity, and temporary displacement) on the marine and migratory fish that are affected by it. Juvenile fish (for example, arctic cod), which are common in the nearshore area during summer, or nearshore spawners (for example, capelin) are among those most likely to be adversely affected. Some fish in the immediate area of a spill may be killed; however, it is not expected to have a measurable effect on marine and migratory fish populations. Recovery of the number of fish harmed or killed would be expected within 5 years. Oil-spill cleanup activities are not expected to affect fish populations.

(c) Effects of Oil-Spill Prevention and Response

Oil-spill-cleanup activities, whether on ice or for oil entrained in the ice, are not expected to adversely affect fish populations. It is possible that a containment boom could trap some oil in a shoreline area and temporarily contaminate that area long enough to affect fishes or their food resources. In general however, reducing the amount of oil in the marine environment is expected to have a beneficial effect on fishes, because it reduces the possibility of hydrocarbons contacting them and their food resources. The extent of that benefit would depend on the actual reduction in the amount of oil contacting fish and their food resources, as compared to that of not reducing the amount of contact.

(2) Essential Fish Habitat

(a) Summary and Conclusion for Essential Fish Habitat

Essential fish habitat for salmon in Alaska could be adversely affected by a 180,000-barrel oil spill in a variety of ways. However, oil is not likely to come in contact with salmon spawning habitat or measurably affect individual salmon in the Liberty area following an oil spill caused by a blowout. If spilled oil concentrated along the coastline at the mouths of streams or rivers to which salmon seek access, the potential movements of a small number of salmon could be disrupted during migrations. Potential prey could be adversely affected. About 26% of the zooplankton that contact an oil-spill plume that resulted from a blowout would be adversely affected, but zooplankton populations would be expected to recover within months. If oil from an offshore spill moved into nearshore waters where potential prey fish concentrate, some individuals might be killed or experience sublethal effects including changes in growth, feeding behavior, fecundity, movements, and displacement from preferred habitat. Potential habitat could be adversely affected. Saltmarshes in the Liberty area could be inundated with oil that would kill both plants and associated invertebrates and small fishes. Complete recovery of the saltmarshes would be expected to take decades. The quality of water in essential fish habitat for salmon is likely to be degraded to hydrocarbon levels above State and Federal criteria at a Regional (greater than 1,000 square kilometers) level, but effects are not expected to persist for longer than a year. Salmon prey and prey habitat could be further adversely affected by oil-spill-response and cleanup activities.

(b) Details on How an Oil Spill from a Blowout Might Affect Essential Fish Habitat

The specific effects of petroleum on components of essential fish habitat are described elsewhere in sections discussing the effects of spilled oil on specific resources, including lower trophic-level organisms (i.e., zooplankton and marine algae, Sec. III.C.2.e); fish (Sec. III.C.2.f); wetlands (Sec. III.C.2.g); and water quality (Sec. III.C.2.l).

In the event of a very large offshore oil spill, it is possible that much of the coastline of Stefansson Sound could be oiled, with probabilities of oil contact on individual beach segments ranging from 0.01-0.27 (Table IX-6). Although Stefansson Sound is classified as essential fish habitat for salmon in Alaska, salmon are not believed to be present in significant numbers and are not known to spawn in any of its streams or rivers. Although located about 100 kilometers west of Liberty Island, shoreline adjacent to the numerous channels of the Colville River, which apparently hosts small, intermittent runs of chum and pink salmon, has a slight possibility of being oiled: 2% within 360 days of a summer spill and 1% within 360 days of a winter spill.

The most likely potential threat to individual salmon would be if spilled oil came in contact with spawning areas or concentrated in migratory pathways. However, salmon are not believed to spawn in the intertidal areas or the mouths of streams or rivers anywhere in the Beaufort Sea. Therefore, contact between spilled oil and spawning areas is very unlikely. If spilled oil concentrated along the coastline at the mouths of streams or rivers to which salmon seek access, the potential movements of a small number of salmon could be disrupted during migrations. If a very large offshore oil spill occurred, large areas of potential offshore salmon habitat are likely to underlie the resulting oil slick. Salmon are not expected to be present in the immediate vicinity of the Liberty development, where hydrocarbon concentrations in the water column may exceed the acute criterion for several days after the oil is spilled (Sec. IX.A.6.l). Small numbers of salmon may swim through the oil-spill plume in the more western portion of the affected area, near the Colville River. However, they are not likely to be measurably affected since oil penetrating the water column would likely be weathered and dispersed due to wave action and thus, have relatively little toxicity.

The potential prey of salmon in the Beaufort Sea include zooplankton and small fish. Individuals of these species could be affected by oil from a very large spill directly (lethally or sublethally) or indirectly. Zooplankton (copepods, euphausiids, mysids, and amphipods) may be contacted by surface or dispersed oil if the oil spill plume passes through their habitat. We have estimated that under those circumstances, about 26% of the individuals might be affected. Because of their wide distribution, large numbers, and rapid rate of regeneration, the recovery of plankton would be expected to take a few weeks to 2 months (see Sec. IX.A.6.e). If oil from an offshore spill moves into nearshore waters where potential prey fish concentrate, some individuals might be killed or experience sublethal effects including changes in growth, feeding behavior, fecundity, movements, and displacement from preferred habitat. Juvenile fish that are common in the nearshore area during summer (for example, arctic cod), or nearshore spawners (for example, capelin) are those most likely to be affected. Recovery of affected fish populations would be expected to take a few years (see Sec. IX.A.6.f).

Vegetation potentially important to salmon and their prey primarily includes the benthic algae community and that in estuarine and wetland habitat. Due to the predominance of shorefast ice in the Liberty area, there is no resident marine flora in waters less than 6 feet deep. Therefore, no effects are expected on marine plants in those waters. Crude oil likely to reach benthic marine plants, such as macro-algae inhabiting the Boulder Patch, likely would be weathered and dispersed due to wave action and, thus, have little toxicity; and little effect would be expected on those organisms (see Sec. IX.A.6.e). Estuarine and wetland habitat potentially are important to salmon and their prey. A 180,000-barrel oil spill likely would extensively oil shorelines from the Endicott Causeway east along the shore of Foggy Island Bay. Saltmarshes in this and adjacent areas could be inundated with oil that would kill both plants and associated invertebrates and small fishes. Complete recovery of the saltmarshes would be expected to take decades (see Sec. IX.A.6.g).

The quality of water in the essential fish habitat for salmon is likely to be degraded to hydrocarbon levels above State and Federal criteria at a regional (greater than 1,000 square kilometers) level, but effects are not expected to persist for longer than a year (see Sec. IX.A.6.l).

(c) Effects of Oil-Spill Cleanup Activities on Water Quality

The Alaska Clean Seas technical manual identifies sensitive sections of the Beaufort Sea coastline, such as marshes and inlets, where oil might persist for a decade or longer, including some within the project area (Alaska Clean Seas, 1998: Index Sheets 1 and 2). Deflection booms would be used to attempt to divert oil to sections of the coastline that have been classified as being less sensitive for collection and recovery. Contaminated shorelines would be flushed to remove oil from the shore zone. Some organisms that are potential salmon prey, or prey habitat, would be killed or otherwise adversely affected by this and other response actions. Other potential response actions that could adversely affect salmon prey and prey habitat during beach cleanup include the use of mechanical tilling for aeration and remediation of sediments; application of chemical dispersants or fertilizers, especially those containing surfactants; and in situ burning. Using dispersants on a spill near the Boulder Patch would mix the oil farther down into the water column and could affect local kelp and fish.

g. Vegetation-Wetland Habitats

(1) Summary and Conclusion for Vegetation-Wetland Habitats

The 180,000-barrel oil spill would extensively oil shorelines from the Endicott Causeway east along the shore of Foggy Island Bay. Saltmarshes in this area could be inundated with oil that would kill both plants and invertebrate species in the marshes. Complete recovery of the saltmarshes could take several decades.

(2) General Description on How an Oil Spill from a Blowout Might Affect Vegetation-Wetland Habitats

Coastal wetland from the Sagavanirktok River Delta east to about Flaxman Island could be contaminated with oil. Within 30 days of release of the spill from the sea ice, about 20% (45,000 barrels) of the oil would contact coastline from the Endicott Causeway east to Bullen Point in the Badami area (Table IX-5a). Most of the oiled shorelines would be within Foggy Island Bay and along the Endicott causeway. Coastal saltmarshes located between the Kadleroshilik River and the eastern part of the Sagavanirktok River Delta would be the most oiled by the spill. Saltmarsh habitat on Tigvariak Island and coastal marshes near the mouth of Shaviovik River east along the coast of Mikkelsen Bay also would be oiled to some extent.

(3) General Effects of Oil Spill Contingency and Response

(a) A Blowout During Open-Water Conditions

The response plan assumes an optimum oil recovery capacity of 12,950-barrels per 10 hours using one barge skimmer system and three skimmer systems deployed from bay-class workboats. Daily oil-recovery capacity could increase to 26,700 barrels per day. However, the effectiveness of oil recovery is expected to drop dramatically under poor weather conditions.

Some of the 180,000-barrel oil spill is likely to oil wetland saltmarsh habitats along the coast of Foggy Island during the summer open-water season. Cleanup operations would remove some of the oil from the shoreline, particularly on gravel shorelines such as the Endicott causeway, where absorption booms could be effective in oil recovery. However, the cleanup of contaminated/oiled saltmarshes would be difficult. Oil removal by mechanical means would alter or destroy vegetation, and flushing techniques could drive some of the oil into marsh sediments and soils.

The tactics that rely on the use of mechanical equipment on marshes might cause significant adverse impacts. Spill responses that use mechanical tilling for aeration and remediation of shoreline sediments might lead to erosion/accretion and effects on biota. Spill responses that use chemicals on oiled shorelines would affect biota. Spill responses that involve in situ burning would affect shoreline biota, especially relatively dry shoreline biota.

The effectiveness of the oil-spill contingency and response plans in preventing or reducing oil effects on vegetation-wetlands will be determined by efforts to prevent the oil from reaching coastal habitats. In situ burning of oil could help to reduce the risk of oil contact to vegetation-wetland habitats. However, the effectiveness of in situ burning of the oil is determined by weather conditions at the time of the spill. Poor weather would prevent burning of the oil and could drive the oil into coastal areas and on to the shoreline. The cleanup of oiled shoreline in Prince William Sound had very mixed results. Cleanup operations often contributed to the oil damage to shorelines and intertidal areas.

The use of fertilizers or other additives to oiled marshes may enhance biodegradation of the oil, but cold temperatures in the Arctic would lessen the effectiveness of these techniques. Oil contamination of saltmarshes is likely to persist for several years after cleanup activities have ended.

(b) A Blowout During Broken-Ice/Freezeup Conditions

The response plan assumes an optimum oil recovery capacity of 18,060 barrels/10 hours using two barge skimmer systems and four skimmer systems deployed from bay-class workboats. However, the effectiveness of oil recovery is expected to drop dramatically under poor weather conditions. Some of the 180,000-barrel oil spill is likely to oil wetland saltmarsh habitats as described above under the open-water blowout scenario and have about the same level of cleanup effectiveness. The formation of shorefast ice during freezeup conditions is expected to reduce the amount of oil reaching coastal wetland saltmarshes compared to the amount of wetlands oiled under the open-water scenario.

h. Subsistence-Harvest Patterns

(1) Summary and Conclusion for Subsistence-Harvest Patterns

Overall effects from a very large oil spill on subsistence-harvest patterns in the area around the communities of Nuiqsut and Kaktovik would be significant, because one or more important subsistence resources could become unavailable. This would result from their

- displacement,
- undesirability for use from contamination or perceived tainting,
- reduced numbers or their pursuit becoming more difficult because of increased hunter effort, and
- increased risk or cost for a period of 1-2 years.

Biological effects to subsistence resources might not affect species distributions or populations, but disturbance could extend the subsistence hunt in terms of miles to be covered, making more frequent and longer trips necessary to harvest enough resources in a harvest season. The loss of waterfowl populations to oil spills would cause harvest disruptions that would be significant to subsistence hunters who regard the spring waterfowl hunt to be of primary importance. In the event of a large spill contacting and extensively oiling habitats, the presence of hundreds of humans, boats, and aircraft would increase the displacement of subsistence species and alter or reduce access to subsistence species by subsistence hunters.

(2) Details on How an Oil Spill from a Blowout Might Affect Subsistence-Harvest Patterns

(a) Bowhead Whales

Exposure of bowhead whales to a very large oil spill may result in lethal effects to a few individuals, with the population recovering to prespill population levels within 1-3 years. However, because oil would become weathered, primarily in the form of tarballs on the sea surface, and the tarballs would be fairly widely dispersed, mortalities of bowhead whales are not expected.

(b) Seals and Polar Bears

The very large oil spill could result in the oiling of several hundred to a few thousand ringed seals along with a number of bearded seals and polar bears. The recovery of seals and polar bears could take perhaps 3-4 years and about 6-10 years, respectively.

(c) Caribou and Other Terrestrial Mammals

The very large oil spill would oil coastal habitats used by caribou, muskoxen, grizzly bears, and arctic foxes. Caribou would be most exposed to the oil when some of them enter coastal waters to seek relief from insects. Several hundred caribou and small numbers of muskoxen, grizzly bears, and foxes could come in direct contact with the spill and suffer injury or death. However, recovery of the populations is likely to occur with in 1 or 2 years.

(d) Fishes

The likely effects on fishes due to a 180,000-barrel oil spill primarily would depend on the season and location of the spill, the lifestage of the fishes (adult, juvenile, larval, or egg), and the duration of the oil contact. Due to their very low numbers, no measurable effects are expected on fishes in winter. Effects would be more likely to occur from an offshore spill moving into nearshore waters in summer, where fishes concentrate to feed and migrate. The probability of an offshore oil spill occurring and contacting nearshore waters is low. If an offshore oil spill did occur and contacted the nearshore area, some marine and migratory fish might be harmed or killed. However, it would not be expected to have a measurable effect on fish populations, and recovery of the number of fish harmed or killed would be expected within 5 years.

(e) Birds

In mid- to late summer, up to 3,200 broodrearing/young brant, 2,000 broodrearing/young lesser snow geese, tens of tundra swans, and thousands of shorebirds are present in shoreline habitats, and many tens of thousands of oldsquaw and large numbers of eiders are present in coastal lagoons and offshore waters. A spill during this period could result in heavy mortality involving thousands of individuals, if broodrearing waterfowl or shorebirds contact stranded oil along a substantial proportion of the 200-mile affected shoreline. In lagoon habitats, oldsquaw densities averaging 134 birds per square kilometer suggest that when large concentrations of molting birds are present, tens of thousands could be contacted by a spill sweeping over the large areas indicated above, representing a substantial proportion of the regional population. A spill that occurred in winter and released in spring could come in contact with loons and other migrant waterfowl concentrated in open water near river deltas. For species such as the yellow-billed loon with relatively small populations and low productivity, this could represent a significant loss requiring many generations for recovery.

(3) Analysis of Effects of an Oil Spill from a Blowout

Based on conditional probabilities, a very large blowout oil spill could threaten subsistence-harvest patterns, because the oil spill could contact subsistence-resource and harvest areas important to Nuiqsut and Kaktovik. How much oil reaches specific shorelines or other environmental resources is estimated from the conditional probabilities. A very important consideration is that this spill is both very large and of a very long duration. In such cases, the interpretation of conditional probabilities must change. The probabilities in Table IX-6 should be taken as representing what percentage of the spill would contact an individual land segment or environmental resource area rather than how likely that contact would be.

For the purpose of analysis, we analyze a 180,000-barrel oil spill resulting from a platform blowout. Approximately 20% of the oil volume evaporates into the air, leaving 180,000 barrels in the water (Tables IX-1 and IX-2). This size spill is considered to be a high-effect, low-probability event and is estimated to have a 0.1% chance of one or more blowouts of this magnitude occurring over the lifetime of the Liberty Project. For a winter spill, approximately 63,000 barrels would remain in the slick after 60 days (Table IX-3a). For a spill in the open water, approximately 39,000 barrels would remain in the slick after 60 days (Table IX-5a).

Oil-spill contact in winter could affect polar bear hunting and sealing. Bird hunting, sealing, and whaling, and the ocean netting of fish could be affected by a spill during the open-water season. The conditional probabilities express the percent chance of an oil spill starting at the Liberty gravel island contacting a particular resource area within 3, 10, 30, 60, and 180 days. The Oil-Spill-Risk Analysis model estimates a 3-26% chance that a very large oil spill in summer would contact subsistence resource and whaling areas within 60 days. The 26% chance of contact occurs in the Stockton Islands (Environmental Resource Area 60), with a 16% chance in the whaling area offshore Cross Island (Environmental Resource Area 29), 15% at Narwhal Island (Environmental Resource Area 58), 15% in the Narwhal/McClure Islands whaling area (Environmental Resource Area 58), 14% in the Maguire Islands (Environmental Resource Area 61), 12% at Tigvariak Island (Environmental Resource Area 59), 8% at Cross Island (Environmental Resource Area 56), 5% in the Kaktovik Whaling Area (Environmental Resource Area 47), and 3% at Flaxman Island (Environmental Resource Area 62). The model estimates a 0-5% chance that a very large oil spill in winter will contact subsistence resource and whaling areas within 180 days. The 5% chance of contact occurs at Midway Island (Environmental Resource Area 55), with 4% at the Narwhal/McClure Islands whaling area (Environmental Resource Area 58), 3% in the whaling area offshore Cross Island (Environmental Resource Area 29), and 1% in the Stockton Islands (Environmental Resource

Area 60), and the Maguire Islands (Environmental Resource Area 61) (see Table IX-6 and Maps A-2 and A-3).

Land segments 18 through 27 (from Oliktok Point to Tigvariak Island; see Map A-1) historically included subsistence harvest areas used by Nuiqsut subsistence hunters to harvest caribou, waterfowl, marine fishes, polar bears, and small furbearers; however, more recently, hunting appears to take place nearer to the community. Land segments 32 through 35 contain Kaktovik harvest areas for caribou, waterfowl, fishes, and seals. Conditional probabilities of a spill in summer originating at the Liberty gravel island and contacting these land segments range from 0-18%. The 18% chance occurs to Land Segment 26, directly onshore of the Liberty Island, with 9% in Land Segment 25, 4% in Land Segment 27, 2% in Land Segments 33 and 34, and 1% in Land Segments 32 and 35. The majority of the coastline contamination would occur between the Endicott causeway and Tigvariak Island (Land Segments 25-28, Table IX-6). In summer, the chances of oiling are generally higher to the east and north of the Liberty gravel island; in winter the general movement of oil is to the west of the gravel island with the highest chances of contact over boulder patch areas and on the Endicott causeway.

Because bowheads migrate through the Beaufort Sea during June, biological effects on bowhead whales from the exposure to massive amounts of spilled oil could result in lethal effects to a few individuals, with the population recovering in 1-3 years. By this time, spilled oil will have weathered and would appear in the form of tarballs that are widely dispersed on the sea surface. It is possible, although not very likely, that Nuiqsut and Kaktovik would not be allowed to harvest the bowhead whale as the bowhead migration moved east through the Beaufort Sea the following fall. It is also possible that while the bowhead whale harvest might not be curtailed, the quota could be reduced for less than 2 years, resulting in significant effects on the bowhead whale harvests of Barrow, Nuiqsut, and Kaktovik by making the bowhead less available for use or undesirable for an extended period.

Lethal biological effects on seals, polar bears, and fishes would result from a very large oil spill. Population changes in abundance and/or distribution of many of these species would require up to one or two generations for recovery to their former status. Bearded seal harvests at Nuiqsut and at Kaktovik are not likely to occur at all for that season, because the oil would be spilled during the primary harvest period. In following years, harvests would be expected to occur in greatly reduced numbers. Marine and coastal birds would have been harvested during the spring, but Nuiqsut and Kaktovik fall harvests could be reduced. Nuiqsut and Kaktovik fish harvests, particularly in river delta areas and along the coast, would be expected to be available but in reduced numbers for 1 year. It also is likely that for all subsistence resources, there could be reluctance to harvest any marine resources because of perceived tainting from oil.

(4) Effects of Cleanup Activities on Subsistence Resources and Harvests

Disturbance to bowhead whales, seals, polar bears, caribou, fish, and birds could potentially increase from oil-spill cleanup activities. Offshore, skimmers, workboats, barges, aircraft overflights. and in situ burning during cleanup could temporarily cause whales to alter their swimming direction. Such displacement could cause some animals, including seals in ice-covered or broken-ice conditions, to avoid areas where they are normally harvested or to become more wary and difficult to harvest. Nearshore, workers and boats, and onshore, workers, support vehicles, heavy equipment, and the intentional hazing and capture of animals could disturb coastal resource habitat, displace subsistence species, alter or reduce subsistence hunter access to these species, and alter or extend the normal subsistence hunt.

BPXA’s Oil Discharge Prevention and Contingency Plan (BPXA, 2000b) includes a series of four scenarios for cleaning up oil in open water, solid ice, and broken ice. These scenarios identify logistics, equipment, and tactics for the various cleanup responses. Spill cleanup would reduce the amount of spilled oil in the environment and tend to mitigate spill effects. In the case of a winter spill, when few important subsistence resources are present, cleanup is likely to be fairly effective in dealing with a spill before migrating whales and other species return to the area during breakup and the open-water season. The response plan includes specific provisions for not only the communication of information about spill responses to local communities, but also the input of community considerations through an Incident Management System. The inclusion of information on community considerations is described on the Situation Status Summary. Before production begins, BPXA must provide MMS with the contact and description of the process through which claimants (particularly Native subsistence users) would file a claim for costs and damages from oil-spill removal (pursuant to 30 CFR 253 Subpart F). BPXA also must provide MMS, the North Slope Borough, the Alaska Eskimo Whaling Commission, and the Native villages and tribal governments of Nuiqsut, Kaktovik, and Barrow, and Inupiat Communities of the Arctic Slope with a plan for long-term coordination with local communities and subsistence users.

Far from providing mitigation, oil-spill-cleanup activities more likely should be viewed as an additional impact, potentially causing displacement of subsistence resources and subsistence hunters (see Impact Assessment, Inc., 1998).

i. Sociocultural Systems

(1) Summary and Conclusion for Sociocultural Systems

The effects of a very large oil spill on sociocultural systems would cause chronic disruption to sociocultural systems for a period of 1-2 years, with a tendency for additional stress on the sociocultural systems but without a tendency toward the displacement of existing institutions.

(2) Details on How an Oil Spill from a Blowout Might Affect Sociocultural Systems

A very large oil spill would affect sociocultural systems in a number of ways. First, overall effects on subsistence-harvest patterns could be significant because of one or more important subsistence resources could become unavailable, undesirable for use, or available only in greatly reduced numbers for a period of 1-2 years. Any perceived disruption of the bowhead whale harvest from oil spills or from actual or perceived tainting of the meat anywhere during the bowhead inmigration, summer feeding, and outmigration could disrupt the bowhead hunt for an entire season, even though whales would not be rendered unavailable. In the event of a large spill contacting and extensively oiling habitats, the presence of hundreds of humans, boats, and aircraft present for oil-spill cleanup activities would increase the displacement of subsistence species and alter or reduce access to subsistence species by subsistence hunters. High effects levels on subsistence-harvest patterns could cause disruptions that could lead to a breakdown of kinship networks and sharing patterns and increased social stress in the community. Participating in the oil-spill cleanup, as local residents did in the *Exxon Valdez* oil spill in 1989, could cause residents to (1) not participate in subsistence activities, (2) have a surplus of cash to spend on material goods as well as drugs and alcohol, and (3) not seek or continue employment in other jobs in the community (as oil-spill-cleanup wages are higher than average). Indications are that the sudden, dramatic increase in income earned from working on cleaning up the *Exxon Valdez* spill and being unable to pursue subsistence harvests because of the spill caused a tremendous amount of social upheaval. This was particularly revealed with increases in depression, violence, and substance abuse (Picou et al., 1992; Cohen, 1993; Picou and Gill, 1993; Fall, 1992; Impact Assessment, Inc., 1990c; Fall and Utermohle, 1995; Human Relations Area Files, Inc., 1994).

A disruption of the kinship networks (i.e., social organization) could lead to a decreased emphasis on the importance of the family, cooperation, and sharing. Multiyear disruptions of subsistence-harvest patterns, especially to the bowhead whale, an important species to the Inupiat culture, could disrupt sharing networks, subsistence-task groups, and crew structures and could cause disruptions of the central Inupiat cultural value: subsistence as a way of life. These disruptions also could cause a breakdown in sharing patterns, family ties, and the community's sense of well-being and could damage sharing linkages with other communities. Other effects might be a decreasing emphasis on subsistence as a livelihood, with an increased emphasis on wage employment, individualism, and entrepreneurism. Effects on the sociocultural system, such as increased drug and alcohol abuse, breakdown in family ties, and a weakening of social well-being, could lead to additional stresses on the health and social services available. Effects on the sociocultural systems described above would be for 1-2 years, with a tendency for additional stress on the sociocultural systems but without tendencies toward displacement of existing institutions.

(3) Effects of Cleanup Activities on Sociocultural Systems

If a large oil spill occurred, employment for oil-spill response and cleanup could disrupt subsistence-harvest activities for at least 1-2 harvest seasons and disrupt some institutions and sociocultural systems. Most likely, it would not displace institutions. If a large spill contacted and extensively oiled coastal habitats, the presence of hundreds of humans, boats, and aircraft would displace subsistence species and alter or reduce access to these species by subsistence hunters. Cleanup of a 180,000-barrel spill could generate approximately 3,000 jobs for 1-2 years, declining to zero by the third year following a spill (see Economy, Sec. IX.A.6). This dramatic employment increase could have sudden and significant effects, including inflation and displacement of Native residents from their normal subsistence-harvest activities by employing them as spill workers. Cleanup is unlikely to add population to the communities because administrators and workers would live in separate enclaves, but cleanup employment of local Inupiat could alter normal subsistence practices and put stresses on local village infrastructures by drawing local workers away from village service jobs.

BPXA's Oil Discharge Prevention and Contingency Plan (BPXA, 2000b) includes a series of four scenarios for cleaning up oil in open water, solid ice, and broken ice. These scenarios identify logistics, equipment, and tactics for the various cleanup responses. Spill cleanup would reduce the amount of spilled oil in the environment and tend to mitigate spill effects. The response plan includes specific provisions for not only the communication of information about spill responses to local communities, but also the input of community considerations through an Incident Management System. The inclusion of information on community considerations is described on the Situation Status Summary. Before production begins, BPXA must provide the MMS with the contact and description of the process through which claimants (particularly Native subsistence users) would file a claim for costs and damages from oil-spill removal (pursuant to 30 CFR 253 Subpart F). BPXA also must provide MMS, the North Slope Borough,

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the Alaska Eskimo Whaling Commission, and the Native villages and tribal governments of Nuiqsut, Kaktovik, and Barrow, and Inupiat Communities of the Arctic Slope with a plan for long-term coordination with local communities and subsistence users.

Far from providing mitigation, oil-spill-cleanup activities more likely should be viewed as an additional impact, causing displacement of subsistence resources and subsistence hunters and employment disruptions (see Impact Assessment, Inc., 1998).

j. Archaeological Resources

(1) Summary and Conclusion for Archaeological Resources

The greatest effects to onshore archaeological sites would be from cleanup activities resulting from accidental oil spills. The most important understanding from past cleanups of large oil spills is that the spilled oil usually did not directly affect archaeological resources (Bittner, 1993). The State University of New York at Binghamton evaluated the extent of petrochemical contamination of archaeological sites as a result of the *Exxon Valdez* oil spill (Dekin, 1993). Researchers concluded that the three main types of damage to archaeological deposits were oiling, vandalism, and erosion, but fewer than 3% of the resources would suffer significant effects.

(2) Details on How an Oil Spill from a Blowout Might Affect Archaeological Resources

Following the *Exxon Valdez* spill, the greatest effects came from vandalism because more people knew about the locations of the resources and were present at the sites. Known and previously undiscovered archaeological sites in the Liberty Project area also would be vulnerable to vandalism. This type of damage increases with added population and activities during cleanup. Some workers directly disturbed archaeological sites during cleanup. However, effects from the *Exxon Valdez* cleanup were slight because the work plan and techniques changed as needed to protect archaeological and cultural resources (Bittner, 1993). To help protect archaeological sites during oil-spill cleanup, we can use various mitigating measures including avoidance (preferred), consulting on and inspecting the site, onsite monitoring, site mapping, scientifically collecting artifacts, and promoting awareness of cultural resources (Haggarty et al., 1991).

Two studies of the numbers of archaeological sites damaged by the *Exxon Valdez* spill had similar findings. In the first study by Mobley et al. (1990), of 1,000 archaeological sites in the area affected by the *Exxon Valdez* oil spill, about 24 sites (less than 3%) were damaged. In the second study by Wooley and Haggarty (1993), of 609 sites studied, 14 sites (or 2-3%) suffered major effects.

The significance of an archaeological site is more important than numbers of sites disturbed. Disturbing 20 archaeological sites that contain no significant or unique information may not be as harmful as disturbing one very significant site. However, after the *Exxon Valdez* spill, the Advisory Council on Historic Preservation declared all archaeological sites were to be treated as if they were significant and eligible for the *National Register of Historic Places* (Mobley et al., 1990).

k. Economy

(1) Summary and Conclusion for the Economy

In the event a very large oil spill occurred (180,000-barrels), the subsequent cleanup would generate approximately 3,000 jobs for 1-2 years, declining to zero by the third year following the spill. Disruptions to the harvest of subsistence resources would affect the economic well-being of North Slope Borough residents primarily through the direct loss of subsistence resources. See Section IX.A.6.h above for the effects on subsistence-harvest patterns.

(2) Details on How an Oil Spill from a Blowout Might Affect the Economy

In the event a very large oil spill occurred (180,000 barrels), it would generate approximately 3,000 cleanup jobs for 1-2 years, declining to zero by the third year following the spill. The 180,000-barrel spill is about two-thirds the size of the 240,000-barrel *Exxon Valdez* oil spill in Prince William Sound. That spill generated 10,000 cleanup-related jobs for 1 or 2 seasons that declined to zero by the fourth year following the spill. Two thirds of 10,000 is approximately 6,500 jobs. However the Beaufort Sea, its shoreline, the characteristics of a potential spill from Liberty, and current cleanup capabilities on the North Slope are different from the *Exxon Valdez* oil spill in Prince William Sound in 1989. These differences, explained below, would approximately reduce the 6,500 figure by more than half, resulting in 3,000 jobs.

A blowout release occurs over an extended period of time, 15 days or more. The volume released is 15,000 barrels a day. Equipment staged on the North Slope has sufficient capacity to contain, control, and recover this amount of oil on a daily basis as required by Alaska Statue 18 ACC 430. Personnel also are readily available on the Slope to respond almost immediately (within the first 12 hours) and begin recovery operations. The location of the spill is known. Spill-response equipment, such as exclusion boom and other response supplies, already have been positioned at key locations around the North Slope. Responders would go immediately to those locations and deploy the equipment to protect sensitive environments from contamination.

The shoreline along the Liberty development area is vastly different from that of Prince William Sound. Shorelines are

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composed primarily of sand and mud, which can readily be removed with heavy equipment, low-pressure washing, or in situ burning. Fewer personnel are required to go out and wipe down rocks. There is a huge industrial infrastructure in place to process and dispose of collected oil and wastes as generated, thereby reducing personnel required for waste management.

The *Exxon Valdez* release essentially was an instantaneous release of over 240,000 barrels of oil into the environment. There was considerable delay before a response was mounted, which allowed the oil to come in contact with the shore more rapidly than it would on the North Slope. Cleanup of a shoreline, especially one where there are heavily cobbled beaches, is very labor intensive.

A very large oil spill could adversely impact the subsistence lifestyle of the North Slope Borough economy. Because a significant segment of the Borough's economy depends on subsistence resources, a loss of those resources would translate into a substantial decline in noncash household income. Because there are limited job opportunities in the North Slope Borough, substitution of market activities for nonmarket activities would be limited. The exception to this would be jobs in cleanup activities, as described above. Some residents might find work cleaning up the spilled oil.

I. Water Quality

(1) Summary and Conclusion for Water Quality

During open water in the summer, petroleum hydrocarbons from 180,000 barrels of oil entering the waters of Foggy Island Bay could exceed the 1.5-parts per million acute-toxic criterion during the first several days of a spill in an area less than 290 square kilometers (112 square miles) and the 0.015-parts per million chronic criterion for several months in an area of about 14,000 square kilometers (5,405 square miles). This amount of oil in the water when broken sea ice is present could exceed the 1.5-parts per million acute-toxic criterion for more than 3 days in an area greater than 160 square kilometers (62 square miles) and the 0.015-parts per million chronic criterion for several months in an area of about 7,900 square kilometers (3,050 square miles).

A large spill of crude oil would significantly affect water quality by increasing the concentration of hydrocarbons in the water column to levels that greatly exceed background concentrations. However, the chance of such a large spill occurring is low. Also, regional (more than 1,000 square kilometers [386 square miles]), long-term (more than 1 year) degradation of water quality to levels above State and Federal criteria because of hydrocarbon contamination is very unlikely.

(2) Details on How an Oil Spill from a Blowout Might Affect Water Quality

Assumptions associated with a 180,000-barrel blowout on Liberty Island are noted in Section IX.A. The analysis of the effects of this spill on water quality does not consider the effects that oil-spill-cleanup measures could have in reducing the volume of oil that has been released into the water column.

The characteristics of a 180,000-barrel oil spill during broken-ice and open-water conditions are shown in Tables IX-3 and IX-5, respectively. Based on these characteristics, the estimated concentration of oil dispersed in the water column for broken ice

- after 3 days is estimated to be 3.89 parts per million (assuming a 3.0-meter [10-foot] dispersal depth),
- after 10 days is estimated to be 0.47 parts per million) (assuming a 6.1-meter [20-foot]dispersal depth),
- after 30 days is estimated to be 0.14 parts per million) (assuming a 10-meter [33-foot] dispersal depth), and
- after 60 days is estimated to be 0.06 parts per million) (assuming a 15-meter [50-foot] dispersal depth.

The estimated concentration of oil dispersed in the water column for a summer spill

- after 3 days is estimated to be 1.77 parts per million (assuming a 3.0-meter [10-foot] dispersal depth),
- after 10 days is estimated to be 0.58 parts per million) (assuming a 6.1-meter {[20-foot]dispersal depth),
- after 30 days is estimated to be 0.11 parts per million) (assuming a 10-meter [33-foot] dispersal depth), and
- after 60 days is estimated to be 0.04 parts per million) (assuming a 15-meter [50-foot] dispersal depth.

The high concentrations of oil associated with estimating dispersal in the water column may represent an upper range of dispersed-oil concentrations reached during the first several days following a large spill. The hydrocarbon concentration in the water column under broken-ice conditions during the first 3 days is greater than the 1.50 parts per million that was assumed to be the acute criterion (Sec. III.C.2.l). After day 10, the concentrations would be less than the acute criterion but greater than the chronic criterion, 0.015 parts per million (Sec. III.C.2.l), even after 60 days. In open water, the hydrocarbon concentrations would be less than the acute criterion after 3 days but would remain greater than the chronic criterion for more than 60 days. Both the summer and broken-ice concentrations of oil that are estimated to be dispersed in the water column after 30 days, 0.11 and 0.14 parts per million, respectively, are greater than petroleum hydrocarbons concentrations of 0.001-0.006 parts per million that were observed in Prince William Sound 21-41 days after the *Exxon Valdez* oil spill. The estimated concentration of dispersed oil in the water 30 days after both the summer and broken-ice/meltout spills is greater than 0.015 parts per million and indicates a relatively long period of time, perhaps several months or more, before dilution of the dispersed oil reduces the concentrations below the chronic criterion. Applicable ambient-water-quality standards for marine waters of the State of Alaska are noted in Section III.C.2.l.

The effect water depth has on dispersion of hydrocarbons is shown in Tables III.C-5. The circulation in Foggy Island Bay is primarily wind driven. The circulation patterns generally transport water out of the bay though the opening between the barrier islands. This water is replaced by water coming in from the Beaufort Sea. The travel times shown in Table II.C-7 indicate a watermass containing spilled oil could begin leaving Foggy Island Bay a day or two after a spill. The timing mainly depends on the wind velocity, persistence, and direction. Seaward of the barrier island, water depths increase with distance from the islands and water depth becomes less of a factor in limiting dispersion than it was in Foggy Island Bay.

As the watermass containing the spilled oil passes through the barrier islands and into the Beaufort Sea, the rate of dispersion will probably increase because of greater water depths and the effect the wind has on the water because of the greater fetch--the distance over which the wind blows. The time for the concentration of dispersed oil to go below the chronic criterion, 0.015 parts per million, will be less in the Beaufort Sea than in Foggy Island Bay.

(3) Effects of Oil-Spill-Cleanup Activities on Water Quality

Oil-spill-cleanup activities are not expected to effect water quality by adding any new or additional substances to the water. Removing oil from the environment would help reduce the amount of oil that gets dispersed into the water. However, the amount of oil removed depends on environmental conditions during cleanup operations. As the oil is removed, the amount contributing oil to dispersion decreases, and as the oil is dispersed, the concentration decreases. The effect of removing oil would be to reduce the concentration in the water relative to the amounts estimated in the above analysis for a given time interval or given area.

m. Air Quality

(1) Summary and Conclusion for Air Quality

A very large oil spill could cause an increase in the concentrations of gaseous hydrocarbons (volatile organic components) due to evaporation from the spill. The effects would be low.

(2) Details on How an Oil Spill from a Blowout Might Affect Air Quality

Sources of air pollutants related to outer continental shelf operations are accidental emissions resulting from gas or oil blowouts, evaporation of spilled oil, and burning of spilled oil. Typical emissions from outer continental shelf accidents consist of hydrocarbons (volatile organic compounds; only fires associated with blowouts or oil spills produce other pollutants, such as nitrogen oxides, carbon monoxide, sulphur dioxide, and particulate matter. (See supporting materials and discussions in Sec. IX.B.3.m. That section discusses the effects of a very large spill from a tanker, but the effects of a spill from a blowout would be essentially the same as those from a tanker spill.)

(3) How Cleanup of a Very Large Blowout Oil-Spill Event from the Liberty Project Might Affect Air Quality

BPXA's *Oil Discharge Prevention and Contingency Plan, Liberty Development Area* (BPXA, 2000b), emphasizes that they will mechanically contain and clean up oil spills to the maximum extent possible. This cleanup of a very large oil spill would require the operation of some equipment, such as boats and vehicles. Emissions from their operation would include nitrogen oxides, carbon monoxide, and sulphur dioxide. BPXA also discusses in that contingency plan their decision process for in-situ burning. They have requested an Alaska Department of Environmental Conservation open burn permit to conduct in-situ burning of potential spills of crude oil. If some spilled oil should be burned, the burning would release pollutants. Please see the discussion in Sec. VIII.B.3.m for further details.

(4) Effects of Accidental Emissions

A discussion of the effects of a gas blowout or oil fire associated with an accidental spill is contained in Section IV.B.12(3) of the Final EIS for Sale 144 (USDOI, MMS, 1996a), which we incorporate here by reference. Soot is the major contributor to pollution from a fire. This soot, which would cling to plants near the fire, would tend to slump and wash off vegetation in subsequent rains, limiting any health effects. We expect accidental emissions to have little effect on onshore air quality.

B. EFFECTS TO RESOURCES FROM A 200,000-BARREL TANKER OIL SPILL

1. Assumptions

We analyzed the environmental impacts of a low-probability, high effects, very large tanker spill along the Trans-Alaska Pipeline System Tanker Route in the Gulf of Alaska/Yakutat Planning Area Oil and Gas Lease Sale 158 (USDOI, MMS, Alaska OCS Region, 1995). We use that information to analyze a very large tanker spill that we estimate might occur from cumulative oil production on the

North Slope of Alaska. We estimate the mean number of tanker spills from Liberty is 0.12. For estimates of the chance of one or more tanker spills occurring from oil production at Liberty, please see Table A-35 in Appendix A.

We analyze the potential effects of a catastrophic spill of 200,000 barrels on representative areas of sensitive environmental, social, and economic resources in the Gulf of Alaska. For purposes of analysis, this very large oil spill is assumed to occur along the tanker route in the Gulf of Alaska. The offshore area between Dry Bay and Lituya Bay was chosen as a spill point for this analysis based on the diversity of exposed sensitive environmental resources from an oil spill in this area (Fig. IX-1a). The selected area is affected by a 200,000-barrel hypothetical spill with characteristics identified in the following scenario.

2. Tanker-Spill Scenario

A hypothetical tanker spill occurs along Tanker Segment T6 with onshore winds in summer (Fig. IX-1a and b). The 70,000-dead-weight-ton tanker releases 200,000 barrels of Alaska North Slope-like crude oil. Weather conditions hamper cleanup activities in the first 10 days and the oil is washed ashore, contacting the coastline within 10 days and affecting the exposed portion of the area within 30 days after its release.

Figures IX-2a and b graphically present the estimated conditional probabilities (expressed as percent chance) that an oil spill starting at Tanker Segment T6 in the summer season would contact individual land segments, sea segments, and environmental resource areas within 3, 10, and 30 days, assuming that a spill equal to or greater than 1,000 barrels occurs along Tanker Segment T6 (USDOI, MMS, Alaska OCS Region, 1995).

The hypothetical 200,000-barrel spill occurs approximately 60 kilometers due east of the coast between Dry Bay and Lituya Bay along Tanker Segment T6. The current regime in the vicinity of this hypothetical 200,000-barrel spill is characterized by the flow of the Alaska Current and the Alaska Coastal Current. These currents move the oil spill to the north and west along the Gulf of Alaska.

3. Analysis of Impacts to Each Resource from a 200,000-Barrel Tanker Oil Spill

Within 10 days during summer, the Oil-Spill-Risk Analysis from Sale 158 estimates oil-spill contact to Kayak Island, Cape Suckling, the area adjacent to Bering Glacier and Kaliakh River (Land Segments 68, 69, 70, and 71), and the area from the Yahtse River to Yakutat Bay (Land Segments 74, 75, and 76) from a spill occurring along Tanker Segment T6 (Figs. IX-1b and 2b). By the end of day 30, the Oil-Spill-Risk Analysis estimates contact to Gore Point and the Pye Islands (Land Segments 56 and 58) and from Elrington and Latouche Island to Cape Fairweather (Land Segments 61 through 80) from a spill occurring along Tanker Segment T6 (Figs. IX-1b and 2b).

During summer by the end of day 10, the Oil-Spill-Risk Analysis estimates oil-spill contact to Environmental Resource Areas 5 through 8 from a spill occurring along Tanker Segment T6 (Figs. IX-1a and 2a). By the end of day 30, the Oil-Spill-Risk Analysis estimates oil-spill contact to Environmental Resource Areas 5 through 15 and 18 and to Sea Segments 1 and 2 from a spill occurring along Tanker Segment T6 (Figs. IX-1a and 2a).

Using the oil-weathering model of Kirstein, Payne, and Redding (1983), the mass balance estimates from the *Amoco Cadiz* oil spill (Gundlach et al., 1983) and the *Exxon Valdez* oil spill (Wolfe et al., 1993), and Table IX-7, a qualitative mass balance for a hypothetical oil spill of 200,000 barrels is presented in Table IX-8. Approximately 30% of the oil is dispersed into the water column. A large component, approximately 28%, comes ashore. Approximately 30% of the oil is lost to the atmosphere due to evaporation. After 60 days, the oil (7,000 barrels) represented by the slick is no longer visible as a coherent slick and is in the form of tarballs and tar particles suspended in the water column.

As stated in the mass balance, approximately 55,000 barrels would be onshore after 60 days. The approximately 55,000 barrels of oil is estimated to landfall portions of the shores of the northern Gulf of Alaska and Prince William Sound, based on the Oil-Spill-Risk Analysis results discussed above from a spill along Tanker Segment T6.

Theoretical calculations of slick size from a hypothetical spill of 200,000 barrels were investigated using the equations of Ford (1985) and Kirstein, Payne, and Redding (1983). Table IX-7 shows the estimated areal extent of a continuous thick slick and a discontinuous slick through time.

a. Endangered and Threatened Species

(1) Endangered Whales

(a) Summary and Conclusion for Endangered Whales

The overall effects on endangered whales from exposure to a very large oil spill are expected to be low. Some whales could experience temporary, nonlethal effects, but no mortalities are expected.

(b) Details on How a Large Tanker Spill in the Gulf of Alaska Might Affect Endangered Whales

It is assumed that a 200,000-barrel tanker spill occurs offshore approximately 60 kilometers due east of the coast between Dry Bay and Lituya Bay along Tanker Segment T6 (Figs.IX-1a and 1b) in the summer. Exposure of endangered whales to spilled oil is not expected to occur. Only small numbers of endangered whales are expected to be present in the area adjacent to the hypothetical spill or in areas contacted by the hypothetical oil spill. There is a slightly higher potential that humpback whales would be exposed to spilled oil, because humpback whales may be present in the Kayak and Middleton islands (Environmental Resource Areas) area. No effects on the humpback whale population from the *Exxon Valdez* oil spill were documented (Dahlheim and Loughlin, 1990). In related studies, Loughlin (1994) did necropsies on three gray whales, one minke whale, and three harbor porpoises (none of which are endangered) after the *Exxon Valdez* oil spill. He found no indication of the cause of death and could not link the cause of death directly to the spill. He observed the carcasses of 26 gray whales, but attributed this large number to the search efforts coinciding with the whales' northern migration and focusing on the area near the spill. Few fin, sei, blue, right, or sperm whales are expected to be exposed to spilled oil. The estimated conditional probability (expressed as percent chance) of spilled oil contacting sea segment 1 (16%) is relatively low. For whales that may be in the vicinity of Environmental Resource Area 8 (Kayak Island) or 11 (Middleton Island) (Fig. IX-1a), the chances of contact are slightly higher (19-20%) (Fig. IX-2a). A few whales may be exposed to spilled oil, resulting in temporary nonlethal effects; but no mortalities are expected. The overall effects of exposure of endangered whales to a very large oil spill are expected to be low.

(2) Steller's Sea-Lion

(a) Summary and Conclusion for the Steller's Sea-Lion

Steller's sea-lions exposed to a large oil spill most likely would experience temporary, nonlethal effects, but exposure could result in lethal effects on some animals, particularly if haulouts on Kayak and Middleton islands were heavily oiled. No major rookeries are located in the hypothetical spill area.

(b) Details on How a Large Tanker Spill in the Gulf of Alaska Might Affect Steller's Sea-Lions

The very large oil spill discussed in this analysis could contact Steller's sea-lion haulouts on Kayak and Middleton Islands but is not likely to contact any major rookeries. There are no major rookeries in the hypothetical spill area, and the estimated chance of spilled oil contacting a major rookery adjacent to the spill area is low (0.5-5% or lower). The highest estimated probabilities (expressed as percent chance) for Environmental Resource Areas (Figs. IX-1a and 2a) are a 20% chance of spilled oil contacting Environmental Resource Area 8 (Kayak Island) and 11 (Middleton Island) within 30 days in the summer. If such a spill occurred, several hundred or more adult and subadult sea lions could be exposed to spilled oil and could experience various degrees of oiling. Heavily oiled individuals may experience physiological problems and elevated stress that could intensify any other debilitating problems, potentially causing death. Even if the spill stays at sea, oil is expected to contact some adults in pelagic waters, resulting in nonlethal effects.

No changes in sea lion distribution, abundance, mortality, pup production, or other potential effects were attributed to the *Exxon Valdez* oil spill (Calkins and Becker, 1990), although the population's continuing decline may have masked some effects. Calkins et al. (1994) tried to measure effects of the *Exxon Valdez* oil spill on sea lions. Sea lions were seen swimming in or near oil slicks, oil was seen near numerous haulout sites, and oil-fouled rookeries were observed at Seal Rocks and Sugarloaf Island in the Gulf of Alaska. The authors tried to detect effects both at the individual level and at the population level. Sixteen sea lions were collected and 12 were found dead during response and cleanup efforts. Tissues taken from some of these animals were tested for toxicological effects. Toxicant levels were not consistently high enough to confirm contamination. The study showed that some sea lions that were exposed to oil were metabolizing and excreting metabolites of aromatic hydrocarbons into the bile. At the population level, data collected on premature pupping showed significantly higher premature pupping ratios at a haulout site nearer the oil spill compared to a haulout site farther away. However, overall pup abundance was not shown to have been significantly affected by the spill. None of the data presented or analyzed in this study provided conclusive evidence of an effect of the *Exxon Valdez* oil spill on Steller's sea-lions. Zimmerman, Gorbics, and Lowry (1994) flew aerial and photographic surveys on the days following the *Exxon Valdez* spill. They estimated that 5-10% of the animals at oiled sites appeared to be oiled and none appeared to be debilitated. The number of animals at oiled sites did not appear to decrease relative to unoiled sites. Based on these observations, the preliminary conclusion was that Steller's sea-lions were not being acutely affected by the oil spill. Later, during collection and disposal of dead animals, cleanup crews found only small numbers of dead sea lions. An estimated six aborted sea lion fetuses were found, but it is not known if this is abnormally high because there were no baseline data. During the first 4 months following the spill, 14 more dead sea lions were found, but several of these were judged to have died before the spill. These studies suggest relatively low effects of an oil spill on sea lions.

Overall, Steller's sea-lions exposed to a very large oil spill most likely would experience temporary, nonlethal effects; but exposure could result in lethal effects on some individuals, particularly if haulouts on Kayak and Middleton islands were heavily oiled. No major rookeries are located in the hypothetical spill area.

(3) Short-Tailed Albatross

(a) Summary and Conclusion for the Short-Tailed Albatross

Mortality of short-tailed albatrosses would be very low, but any losses could require a lengthy period for recovery.

(b) Details on How a Large Tanker Spill in the Gulf of Alaska Might Affect Short-Tailed Albatross

Only a few short-tailed albatrosses would be likely to occur in the northeast Gulf of Alaska area over the 15-year Liberty production period. Because of the expected rare occurrence of this species in the area and the relatively low probability of spilled oil contacting their habitat, it is expected that exposure to spilled oil would not occur. The effects of a large oil spill are expected to be negligible.

(4) Steller's Eider

(a) Summary and Conclusion for the Steller's Eider

Mortality of Steller's eiders resulting from a tanker spill in the Gulf of Alaska would be very low, but any losses could require a lengthy period for recovery.

(b) Details on How a Large Tanker Spill in the Gulf of Alaska Might Affect Steller's Eiders

The several thousand Steller's eiders that overwinter in the Kodiak Island area are at low risk of contact if a large oil spill occurred in the Gulf of Alaska. The probability of contacting eider habitats in most of this area within 30 days is less than 5%. It is likely that only small numbers of this eider would be killed, but even small losses could require a lengthy recovery period as a result of factors that have caused this species' threatened status.

b. Sea Otters, Fur Seals, Harbor Seals, and Cetaceans in the Gulf of Alaska

(1) Summary and Conclusion for Sea Otters, Fur Seals, Harbor Seals, and Cetaceans

The potential total loss of sea otters to the 200,000-barrel tanker oil spill (perhaps 1,500-2,000 individuals) likely would take more than 5-10 years for total recovery, while the potential loss of harbor seals (perhaps about 200 individuals) likely would take perhaps 2-5 years for recovery, depending on the population status at the time of the loss and other unrelated factors adversely affecting the regional population. Potential loss of northern fur seals to the spill (perhaps 2,000-3,000 individuals) is expected to take less than one generation (probably 1 year) for recovery. The potential loss of cetaceans (10-20 individuals in a family group, such as a killer whale pod) could take perhaps 10 years or more; but such a loss to a population of whales or porpoises is expected to take about 1 year for the population to recover.

(2) General Description on How a Tanker Oil Spill Might Affect Sea Otters, Fur Seals, Harbor Seals, and Cetaceans

This analysis assumes that a 200,000-barrel tanker spill occurs offshore Cape Fairweather along the Tanker route from Valdez (Tanker Segment T6) during the summer with onshore winds (Fig. IX-1). Within 10 days, the spill is estimated to have swept over a discontinuous area of 1,737.5 kilometers (Table IX-9); and a portion of the spill is estimated to have contacted sea otter, harbor seal, and nonendangered cetacean habitats within Yakutat and Icy Bays (Environmental Resource Areas 6 and 7, respectively); sea otter and harbor seal habitats near Kayak Island (Environmental Resource Area 8); and northern fur seal habitat in the Fairweather Ground (Environmental Resource Area 5), as shown in Figures IX-1a and 2a. Sea otters within Yakutat Bay and near Kayak Island are expected to be exposed to the spill and to suffer substantial losses (perhaps several hundred animals) to the local populations from hypothermia, oil inhalation, and ingestion. Total recovery is estimated to take 5-10 years or more, based on *Exxon Valdez* oil spill studies.

Assemblages of harbor seals in Yakutat and Icy bays and near Kayak Island are expected to be exposed to the spill, and a number (perhaps several hundred or more) of them are likely to become oiled and absorb petroleum hydrocarbons through their skin and suffer physiological/toxic stress that might lead to the death of a number of oiled seals (perhaps 100-200 animals). Recovery from this loss would take place within perhaps 2-5 years, depending on the population status at the time of the loss and other unrelated factors adversely affecting the regional population. Groups of northern fur seals (perhaps a few hundred to a few thousand) migrating through the northern gulf in the Fairweather Ground are likely to be exposed to the spill in this offshore habitat. Several hundred to a few thousand fur seals are likely to become oiled and to suffer hypothermia due to oiling of their fur, and many or most of the oiled fur seals are assumed would be killed by this exposure to the spill. Recovery of the Pribilof Islands northern fur seal population (more than 800,000 seals) is expected to take place within 1 year through population recruitment.

Within 30 days after the spill, more of the oil is expected to contact Kayak Island habitats of sea otters and harbor seals as well as Yakutat and Icy bays. Some of the oil is estimated to contact sea otter and harbor seal habitats near Montague and Hinchinbrook islands (Environmental Resource Areas 12 and 10, respectively) and along the lower Kenai Peninsula (Environmental Resource Areas 13 and 14), and to contact offshore habitats of northern fur seals and cetaceans southwest of Kayak Island (Sea Segment 1) westward to Portlock Bank (Sea Segment 2 and Environmental Resource Area 18), as shown in Figures IX-

2a and 2b. Rafts of sea otters and assemblages of harbor seals along the gulf coast side of Montague and Hinchinbrook islands and along the lower Kenai Peninsula are likely to be exposed to part of the 200,000-barrel spill and to suffer some losses (such as several hundred sea otters and perhaps 100 or fewer harbor seals). At 30 days, the spilled oil is expected to be very dispersed and at least partly weathered, with much of the toxic components lost; thus, the losses of harbor seals and perhaps sea otters to oil contact at this stage of the spill are expected to be less than losses during the first 10 days of the spill.

Groups of northern furs seals migrating and feeding in offshore habitats southwest of Kayak Island and in Portlock Bank are likely to have some exposure to the spill within 30 days. This exposure is expected to result in the oiling of some fur seals (perhaps a few hundred to a few thousand animals). The assumed loss of most, if not all, of these fur seals would be due to hypothermia from the oiling and reduced thermal insulation.

Cetaceans within Yakutat Bay, such as the harbor porpoise, Dall's porpoise, and killer and gray whales migrating along the coast between Yakutat Bay and Kayak Island at the time the spill contacts these habitats, might encounter oil on the surface of the water when breathing and resting. These encounters are not expected to result in mortalities unless the cetaceans encounter a very large, continuous oil slick of fresh, highly toxic oil from the spill and consequently inhale lethal amounts of toxic fumes. This would result in the death of highly exposed whales or porpoises. The number of cetaceans lost to such possible encounters is expected to be few (probably fewer than 10 animals). If such losses occurred in a family group of killer whales, recovery could take 10 years or more. However, overall populations of killer whales, porpoises, and other cetaceans in the gulf are likely to replace the loss of 10-20 individuals within 1 year.

Cetaceans that might encounter oil from the spill within offshore habitats, such as Fairweather Ground or Portlock Bank, are not expected to suffer any lethal exposure to the spill, because the oil is expected to be highly dispersed in these offshore habitats and quite weathered when encountered in the Portlock Bank area.

c. Marine and Coastal Birds

(1) Summary and Conclusions for Marine and Coastal Birds

The effect of exposure of marine and coastal birds to a 200,000-barrel oil spill in the Gulf of Alaska between April and September is expected to seasonally affect the yellow-billed loon, pelagic cormorant, harlequin duck, Aleutian tern, Kittlitz's murrelet, and bald eagle most severely, causing mortality of many hundreds of these marine birds and tens of eagles. A spill approaching Middleton Island could contact 10,000 or more murres, kittiwakes, and auklets. Recovery from either of these scenarios could require multiple generations, and species that are declining are not expected to recover while that situation continues.

(2) Details on How a Large Tanker Spill in the Gulf of Alaska Might Affect Marine and Coastal Birds

Within 10 days a 200,000-barrel tanker spill off Cape Fairweather along Tanker Segment T6 (Fig. IX-1a) is estimated to have swept over a discontinuous area of 1,737.5 square kilometers (Table IX-9). After 60 days, the area of continuous slick is estimated to be 21 square kilometers. A portion of the spill, which is assumed to occur between April and September, is expected to contact habitats that are used during spring and early fall migration periods by a variety of marine and coastal birds and in summer by murres, murrelets, auklets, gulls, terns, and waterfowl. These lie within Yakutat and Icy bays and near Kayak Island (Environmental Resource Areas 6, 7, and 8) and in the Fairweather Ground and Middleton Island areas (Environmental Resource Areas 5 and 11), as shown in Figure IX-1a.

Oil-spill mortality in coastal areas adjacent to the spill area is likely to involve overwintering loons and grebes, cormorants, sea ducks, marbled and Kittlitz's murrelets, pigeon guillemots, gulls, and bald eagles. Based on proportional estimates from *Exxon Valdez* spill data (Ford et al., 1991; Piatt et al., 1990) and season of occurrence, and assuming equal contact in all habitats, the following approximate carcass recoveries would be expected from a spill in winter/early spring: 337 loons, 382 grebes, 674 cormorants, 1,190 sea ducks, 494 murrelets, 494 guillemots, 539 gulls, and 25 bald eagles. For any of these estimates, actual mortality may be three- to tenfold greater because of failure to recover most carcasses. Effects are expected to be most severe in species such as the yellow-billed loon, pelagic cormorant, harlequin duck, Kittlitz's murrelet, and bald eagle, where even modest losses represent a large proportion of the local, or in some cases, Alaskan populations. Greater mortality in species such as the marbled murrelet and pigeon guillemot, while locally serious in terms of loss to slowly reproducing species, is not expected to represent as severe a loss because of their substantial Alaskan populations. Recovery from this level of mortality for species whose populations are stable or increasing could require multiple generations, and species that are declining are not expected to recover while that situation continues.

Mortality in late spring is expected to include larger numbers of migrant waterfowl and shorebirds. Northwest of the spill area the Copper River Delta in particular, while not as likely to be contacted, could suffer catastrophic losses to several populations (potentially 10,000-50,000 individuals of western sandpiper, dunlin, dusky Canada goose are present) during the spring-migration period, requiring lengthy periods for recovery. Offshore seabird densities in spring average about 88 birds per square kilometer, with the potential for tens of thousands of fatalities if the spill swept an area of several hundred square kilometers or more. Recovery from such losses is expected to require multiple generations.

After departure of overwintering and southern-latitude migrants, spill mortality in summer is expected to include cormorants, arctic and Aleutian terns, murrelets, guillemot, puffins, and bald eagles in these coastal areas; recovery periods are not likely to change greatly, but substantial mortality at the large Aleutian tern colony near Yakutat would be expected and could represent a serious loss for this species with its relatively small world population. Offshore, a spill occurring and contacting primarily the Middleton Island area in summer is expected to cause substantial murre mortality and losses of kittiwakes and rhinoceros auklets (potentially 10,000 or more individuals; Gould, Forsell, and Lensink, 1982). Recovery here also is expected to require multiple generations. A spill moving into offshore areas could contact many tens of thousands of southern-hemisphere shearwaters present in large flocks during summer, but recovery of this abundant seabird probably would occur rapidly.

Summer density of the marbled murrelet in the immediate vicinity of Yakutat Bay ranges from 0.65-1.36 birds per square kilometer, declining to less than 0.31 per square kilometer beyond 50 kilometers offshore and most of the area northwest of the bay. The potential spill associated with Trans-Alaska Pipeline traffic is expected to cover a discontinuous area of 7,211 square kilometers after 30 days (Table IX-9), suggesting that murrelet mortality could total up to many hundreds of individuals. Supporting estimates of potential mortality of this magnitude, murrelets retrieved following the *Exxon Valdez* oil spill totaled about 780 (includes natural mortality), probably representing 10-30% of the total murrelet deaths during this period (Piatt et al., 1990); potential mortality values must be decreased somewhat because the size of this potential spill is 77% of the *Exxon Valdez* spill. Although murrelets have a low productivity, the large size of the eastern gulf population suggests that such mortality would be recovered within relatively few generations. Offshore average seabird densities in summer are somewhat less than in spring (69 birds/square kilometer), but mortality would not be expected to be less because of the loss of some eggs and/or young through contact with oiled adults.

d. Terrestrial Mammals

(1) Summary and Conclusion for Terrestrial Mammals

The potential loss of river otters (perhaps 50-100 individuals) and contamination of intertidal habitats from the 200,000-barrel tanker spill is estimated would take more than 1 year to recover (probably 3 years or more), while the potential loss of brown and black bears (perhaps 40 individuals) is estimated would take 1-2 years. Neither moose nor Sitka black-tailed deer are likely to suffer mortalities or other effects from the 200,000-barrel oil spill, assuming that it occurs during the summer.

(2) General Description on How a Large Tanker Spill in the Gulf of Alaska Might Affect Terrestrial Mammals

This analysis assumes that a 200,000-barrel tanker oil spill occurs offshore Cape Fairweather along Tanker route from Valdez (Tanker Segment T6 during the summer with onshore winds; Fig. IX-1b). Within 10 days, the spill is estimated to have swept over a discontinuous area of 1,738 square kilometers (Table IX-9), and a portion of the spill is estimated to have contacted coastline habitats of terrestrial mammals from Yakutat Bay westward to Kayak Island (Land Segments 68-71 and 74-76), as shown in Figures IX-1b and 2b. River otters and brown and black bears frequenting the shoreline of Yakutat Bay westward to Point Manby/Cape Sitkagi to near Icy Bay, and frequenting shoreline habitats from Cape Yakataga/Cape Suckling to Kayak Island, are expected to encounter oil from the spill along the beach and in intertidal habitats. Some river otters (perhaps more than 50) are likely to be oiled by the spill or to ingest oil from consuming oiled prey and oiled carrion. A number of river otters (perhaps more than 50) are likely to be killed by the spill, with total recovery of the local population and intertidal habitats taking more than 1 year (perhaps 3 years or more).

Brown and black bears that frequent the above oiled shoreline habitats are likely to ingest oiled prey and oiled carrion, with perhaps 20-30 bears affected. Assuming that all the bears that ingest oiled food items are killed, total recovery of brown and black bear populations and local habitats is expected to take more than 1 year (perhaps more than 3 years). Although moose that occur along the shoreline of oiled shoreline habitats (Yakutat Bay/Kayak Island) may encounter oil on the beaches and mudflats while foraging on willow and other browse, they are not likely to ingest oiled intertidal vegetation during this time of the year and, thus, are not expected to ingest oil-contaminated vegetation and suffer mortalities or other adverse effects.

Within 30 days the 200,000-barrel oil spill is estimated to contact terrestrial mammal coastal habitats from Cape Fairweather westward to Montague Island and coastline areas on the lower Kenai Peninsula (Land Segments 56, 58, and 80-61, respectively), as shown in Figures IX-1b and 2b. More oil from the spill is expected to contact river otter and brown and black bear coastal habitats from Yakutat Bay to Kayak Island, and the spill is estimated to oil other habitats along the coast of the Copper River Delta, on Hinchinbrook and Montague islands, and along the southern coast of the Kenai Peninsula. Some additional river otters (perhaps 100-200 individuals) and black and brown bears (perhaps 10 individuals) are likely to come in contact with oil on the beaches and intertidal mudflats and to ingest oiled prey or carrion. By 30 days, however, the beached oil is expected to be quite weathered and far less toxic than the oil that reaches the coast within 10 days; thus, fewer bears and river otters (perhaps 10 bears and fewer than 50 otters) are expected to suffer lethal doses of oil from ingestion of contaminated food sources. These additional losses of river otters and bears and contamination of habitats are estimated to recover within about 1-2 years.

Although the coastal habitats of Sitka black-tailed deer on Montague and Hinchinbrook islands are expected to be oiled by the 200,000-barrel oil spill, black-tailed deer are not likely to be directly exposed to the oil, because they generally do not forage on kelp and other intertidal vegetation during the summer season, when the spill is assumed to occur. Thus, Sitka black-tailed deer are not expected to suffer mortalities from the spill.

e. Lower Trophic-Level Organisms

(1) Summary and Conclusion for Lower Trophic-Level Organisms

The 200,000-barrel oil spill is estimated to harm 1-10% of the plankton in the proposed area. Recovery is expected to take 1 or 2 days for phytoplankton and up to 1 week for zooplankton. The spill also is estimated to harm about 40-50% of the intertidal and shallow subtidal marine plants and invertebrates in the area. Recovery of these communities is expected to take 2-3 years in high-energy habitats and up to 7 years in lower energy habitats. Less than 5% of the subtidal benthic populations in the area are expected to be affected.

(2) Details on How a Large Tanker Spill in the Gulf of Alaska Might Affect Lower Trophic-Level Organisms

The 200,000-barrel oil spill would expose some lower trophic-level organisms to petroleum-based hydrocarbons.

The effect of petroleum-based hydrocarbons on phytoplankton, zooplankton, and benthic organisms ranges from sublethal to lethal. Where flushing times are longer and water circulation is reduced (for example, bays, estuaries, and mudflats), adverse effects are expected to be greater; and the recovery of the affected communities is expected to take longer. Large-scale effects on plankton due to petroleum-based hydrocarbons have not been reported. Assuming that a large number of phytoplankton were contacted by an oil spill, the rapid replacement of cells from adjacent waters and their rapid regeneration time (9-12 hours) would preclude any major effect on phytoplankton communities. Observations in oiled environments show that zooplankton communities experience short-lived effects due to oil. Affected communities appear to recover rapidly from such effects because of their wide distribution, large numbers, rapid rate of regeneration, and high fecundity. Large-scale effects on marine plants and invertebrates due to petroleum-based hydrocarbons have not been reported. The sublethal effects of oil on marine plants include reduced growth and photosynthetic and reproductive activity. The sublethal effects of oil on marine invertebrates include adverse effects on reproduction, recruitment, physiology, growth, development, and behavior (feeding, mating, and habitat selection).

The 200,000-barrel spill is assumed to occur offshore. It is also assumed that a portion of it (an estimated 30,000 barrels) will contact the shore within 10 days and cover a discontinuous surface area on the water of about 1,737 square kilometers. Hence, the 200,000-barrel spill would substantially increase the amount of oil contacting the gulf shoreline and surface waters. For this reason, oil from the 200,000-barrel spill is likely to remain in the affected shoreline sediments longer.

Regarding the shoreline most likely to be contacted, the Oil-Spill-Risk Analysis estimates that the conditional probability (expressed as percent chance) of an oil spill contacting the shore within 10 days ranges from 1-4% for 9 eastern land segments (Land Segments 68-76). Conditional probabilities (expressed as percent chance) west of this are less than 0.5%. The Oil-Spill-Risk Analysis estimates that the conditional probability (expressed as percent chance) of contact within 30 days ranges from 1-8% for 27 land segments (Land Segments 7-76). However, the 30-day conditional probability (expressed as percent chance) of oil contacting the shore is generally lowest west of Resurrection Bay (1-3%) and highest east of Cape Saint Elias (2-8%). Hence, a majority of the oil from the 200,000-barrel spill that would be washed ashore is expected to contact shoreline areas from Cape Saint Elias east to Icy Bay. A much smaller amount of extremely weathered oil is expected to contact some shoreline areas to the west of Cape Saint Elias.

Based on the above, this analysis has assumed that the 200,000-barrel spill would contact about 40% more gulf shoreline, and 300% more surface water, with about three times as much oil. Within the area, all of the above differences are estimated to increase effects on marine plants and invertebrates in the intertidal area by about 40%, and to increase effects on plankton in open-water areas by about 300%. However, these increases are expected to have little effect on recovery times in the Gulf of Alaska. This is due primarily to the high rate of hydrologic exchange in open-water areas and the amount of heavy wave action in most intertidal areas.

Based on these estimates and assumptions, the 200,000-barrel oil spill is estimated to have sublethal and lethal effects on 1-5% of the phytoplankton and zooplankton populations in the area. Recovery is expected to take 1 or 2 days for phytoplankton and up to 1 week for zooplankton. The total percentage of plankton affected could increase to about 10% if many embayments were contacted by the spill. Recovery within the affected embayments is expected to take 1-2 weeks. Most marine plants and invertebrates in subtidal areas are not likely to be contacted by an oil spill (contact estimated at less than 5%). The 200,000-barrel oil spill is estimated to harm about 40-50% of the intertidal and shallow subtidal marine plants and invertebrates in the area. Recovery of these communities is expected to take 2-3 years in high-energy habitats and up to 7 years in lower-energy habitats.

f. Fishes

(1) Summary and Conclusion for Fish

The effects on fishes from a 200,000-barrel oil spill are not expected to cause population-level changes. The assumed 200,000-barrel oil spill is estimated to affect less than 0.3% of the offshore marine fisheries resources and less than 5% of the adult salmon resources in the area. However, these conservatively estimated losses would not be detectable using standard fisheries-population-assessment methods.

(2) Details on How a Large Tanker Spill in the Gulf of Alaska Might Affect Fishes

The assumed 200,000-barrel oil spill from a tanker accident that occurs in the southern portion of the area during the summer would adversely affect pelagic, semidemersal, and demersal fish that inhabit these waters. The adverse effects, ranging from sublethal to lethal in the event of contact by oil, would not, however, reach any appreciable number of fishes. The 200,000-barrel oil spill would not reach any large ocean area with persistent toxicity (Malins, 1977). These factors, when compared with the large regional fish populations, the seasonal migratory behavior of many species, the low densities within a given habitat, and the wide distribution of the populations over this region and within the area, would cause only a very small percentage of a population to be contacted by the assumed 200,000-barrel spill.

Salmon smolt and fry would be at risk during summer. Salmon have economic importance and are abundant over much of Alaska. Salmon smolt and fry would be transiting the coastal area during this time. As revealed by the studies of the *Exxon Valdez* oil spill in Prince William Sound, pink salmon fry would suffer reduced growth due to the metabolic cost of depurating a spill-related hydrocarbon burden (Wertheimer et al., 1993; Carls et al., 1993), and the slower growth of juvenile pinks may have caused an incremental reduction in survival to adulthood. Small numbers of smolt from other salmon species would also be contacted. The coastal areas that are oiled, however, do not represent a large segment of the salmon-spawning habitat or migration routes; for example, in Prince William Sound, a relatively small segment of pink salmon streams was oiled by the *Exxon Valdez* spill. In three salmon-management districts with 209 identified spawning streams, 29 (14%) actually were on oiled shorelines (Maki et al., 1993). A 200,000-barrel oil spill in offshore waters would have the potential to contact fewer of the larger number of pink salmon-spawning streams and, given the depth at which salmon fry and other salmon usually migrate, perhaps less than 1% of the migrants would be at risk from a 200,000-barrel oil spill.

Pacific herring would also be adversely affected by a 200,000-barrel oil spill because their eggs are laid within the littoral zone, and the resulting larvae and fry spend their first summer in shallow coastal waters before moving offshore in the fall. The number of herring larvae and juveniles that would be affected is indeterminate. However, given the size and distribution of herring populations in the Gulf of Alaska and the limited coastal area contacted, there probably would not be a large-scale loss of herring from a 200,000-barrel oil spill.

Some semidemersal fishes might be injured by contact with a large oil spill; but given their usual habitat in deeper waters, only the limited, low-concentration water-soluble fractions of the oil would reach these depths where it is no longer at concentrations toxic to semidemersal fishes (Kineman, 1980). During summer, some pelagic larvae and juveniles of semidemersal fishes might be at the surface but at comparatively low densities because the pelagic zone where they occur extends to 50 meters in deeper waters. Larvae and juveniles are also widely distributed. For these reasons, no appreciable number of larvae or juveniles of semidemersal fishes would be adversely affected by the spill.

Demersal fishes, well offshore and at depth, are not likely to be contacted or affected by the oil spill. Those demersal species with pelagic larvae and juveniles might be affected in the immediate zone of the oil spill, but the numbers so affected would not comprise large numbers of the total populations. This is because densities per square meter of seawater do not range above units of tens, while egg complements of most demersal species range in the thousands (Bakkala, 1975).

Laevastu et al. (1985) assessed the potential effects of a 240,000-barrel oil spill on eastern Bering Sea fishes. They estimated that less than 0.3% of yellowfin sole eggs and larvae would be killed (yellowfin sole were used as an indicator species for all demersal and semidemersal fishes in the study). Laevastu et al. also estimated that a *maximum* 13% mortality of outmigrating smolt could occur and that this could translate into a 5% loss in returning adults. Because these estimated losses are significantly lower than measurement errors (20-90%) associated with assessing changes in stock size, the authors concluded that a "…tanker accident would have no quantifiable effect on the offshore fishery resources in the eastern Bering Sea." While the eastern Bering Sea and the Gulf of Alaska are physiographically different, they support similar biotic (fish) communities that would be affected by spilled oil in similar fashions. While the Laevastu et al. (1985) results are not directly transferable to the Gulf of Alaska, they provide a conservative estimate of the level of effects that can be expected.

g. Coastal Vegetation-Wetland Habitats

(1) Summary and Conclusion for Vegetation-Wetland Habitats

The main potential effects on vegetation and wetland habitats include oil-fouling, smothering, asphyxiation, and poisoning of plants and associated insects and other small animals. In this case, complete recovery of moderately oiled wetlands of the Yakutat Bay area west to Kayak Island would take perhaps 10 years or longer. A second main effect is the disturbance of wetlands from cleanup activities. Complete recovery of heavily oiled coastal wetlands from these disturbances and oil could take several decades.

(2) General Description on How a Large Tanker Spill in the Gulf of Alaska Might Affect Coastal Vegetation-Wetland Habitats

This analysis assumes that a 200,000-barrel tanker oil spill occurs offshore Cape Fairweather along Tanker route from Valdez (Tanker Segment T6 during the summer with onshore winds; Fig. IX-1b). Within 10 days, the spill is estimated to have swept over a discontinuous area of 1,738 square kilometers (Table IX-9), and a portion of the spill is estimated to have contacted coastline habitats including some wetlands from Yakutat Bay westward to Kayak Island (Land Segments 68-71 and 74-76), as shown in Figures IX-1b and 2b. Some wetland habitat located along shoreline of Yakutat Bay westward to Point Manby/Cape Sitkagi to near Icy Bay, and along shoreline from Cape Yakataga/Cape Suckling to Kayak Island, is expected to be oiled from the spill.

h. Subsistence-Harvest Patterns

(1) Summary and Conclusions for Subsistence-Harvest Patterns

Subsistence harvests in the 200,000-barrel-spill case would be reduced or substantially altered by as much as 80% in Cordova for at least 1 year and, to a lesser extent, for selected subsistence resources 3-4 years beyond. Lesser effects could be experienced in Yakutat because of its greater distance from the offshore tanker route.

(2) Details on How a Large Tanker Spill in the Gulf of Alaska Might Affect Subsistence-Harvest Patterns

The effects on subsistence-harvest patterns would be comparable to the effects from the *Exxon Valdez* oil spill of 1989, because both tanker spills would have occurred at similar times and would be of approximately the same size. The primary difference between the two incidents is in the geography of the spills, which makes Yakutat more instantaneously subject to contact. The annual round of harvest activities for Yakutat indicates that some harvests, such as for harbor seal, salmon, and marine invertebrates, could have begun. The instantaneous nature of the event would not permit opportunistic “stocking up” of available resources. Using experience from the *Exxon Valdez* spill as a gauge, effects on subsistence-harvest patterns for the residents of Yakutat and Cordova—especially for intertidal resources and some fish species—would be expected to last for at least 4 years.

This analysis assumes that a 200,000-barrel tanker oil spill occurs offshore Cape Fairweather along Tanker Segment T6 during the summer with onshore winds (Fig.IX-1b). Within 10 days, the spill is estimated to have swept over a discontinuous area of 1,738 square kilometers (Table IX-9), and a portion of the spill is estimated to have contacted coastline habitats from Yakutat Bay westward to Kayak Island, as shown in Figures IX-1b and 2b. Within 30 days, the 200,000-barrel oil spill is estimated to contact the entire coastline associated with the Yakutat and Cordova subsistence-harvest areas.

i. Sociocultural Systems

(1) Summary and Conclusions for Subsistence-Harvest Patterns

The community of Cordova is expected to undergo severe individual, social, and institutional stress and disruption in the year of the 200,000-barrel spill that would last at least 4 years thereafter. Lesser effects could be experienced in Yakutat because of its greater distance from the offshore tanker route.

(2) Details on How a Large Tanker Spill in the Gulf of Alaska Might Affect Sociocultural Systems

The location of the 200,000-barrel spill off Cape Fairweather suggests that spill effects on Yakutat would be instantaneous, with little time to prepare, and could be expected to last at least 4 years. Individuals and communities that depend on income from commercial fisheries would experience stress and anxiety from debt burden, income shortfalls, litigation, and fear for the future should the fisheries they participate in or depend on in other capacities be shortened or terminated due to the accidental spill.

Considerable stress and anxiety also would be expected over the loss of subsistence resources, contamination of habitat, fear of the health effects of eating contaminated wild foods, and the need to depend on the knowledge of others about environmental contamination (Fall, 1992; McMullen, 1993). Individuals and the communities of Yakutat and Cordova would be increasingly stressed during the time needed to modify subsistence-harvest patterns by selectively changing harvest areas, if available. Associated culturally significant activities, such as the organization of subsistence activities among kinship and friendship groups and the relationships among those that customarily process and share subsistence harvests, would be modified or would decline as well.

The 200,000-barrel-spill case also would be expected to affect individuals and institutions in ways similar to the experience from the *Exxon Valdez* spill. As shown by that spill, some individuals found a new arena for pre-existing personal and political conflict, especially over the dispensation of money and contracts. In the smaller communities, cleanup work produced a redistribution of resources, creating new schisms in the community (Richards, No date). Many members of small communities were on the road to sobriety prior to the spill; but after the spill some people began drinking again, producing the re-emergence of numerous alcohol-related problems, such as child abuse, domestic violence, and accidents, that were there before (Richards, No date).

Institutional effects included additional burdens being placed on local government, disruption of existing community plans and programs, strain on local officials, difficulties dealing with the spiller, community conflict, disruptions of customary habits and patterns of behavior, emotional effects and stress-related disorders, confronting environmental degradation and death, and violation of community values (Endter-Wada, 1992). Postspill stress resulted from this seeming loss of control over individual and institutional environments as well as from secondary episodes such as litigation, which produced secrecy over information, uncertainty over outcomes, and community segmentation (Smythe, 1990; Picou and Gill, 1993). Attempts to mitigate effects met with a higher priority placed on concerns over litigation and a reluctance to intervene with people for fear it might benefit adversaries in legal battles (Richards, No date).

This analysis assumes that a 200,000-barrel tanker oil spill occurs offshore Cape Fairweather along Tanker Segment T6 during the summer with onshore winds (b. IX-1). Within 10 days, the spill is estimated to have swept over a discontinuous area of 1,738 square kilometers (Table IX-9), and a portion of the spill is estimated to have contacted coastline habitats from Yakutat Bay westward to Kayak Island, as shown in Figures IX-1b and 2b. Within 30 days the 200,000-barrel oil spill is estimated to contact the entire coastline associated with the Yakutat and Cordova subsistence-harvest areas.

j. Archaeological Resources

(1) Summary and Conclusion for Archaeological Resources

The expected effect on onshore archaeological resources from a large oil spill is uncertain, but data from the *Exxon Valdez* oil spill indicate that less than 3% of the resources within a spill area would be significantly affected.

(2) Details on How a Large Tanker Spill in the Gulf of Alaska Might Affect Archaeological Resources

The 200,000-barrel oil spill would affect archaeological resources by creating surface-disturbing activities resulting from emergency shoreline treatment. Following the *Exxon Valdez* oil spill, Exxon developed and funded a Cultural Resource Program to ensure that potential effects on archaeological sites were minimized during shoreline treatment (Betts et al., 1991). This program involved a team of archaeologists who performed reconnaissance surveys of the affected beach segments, reviewed proposed oil-spill treatment, and monitored treatment. As a result of the coastline surveys, hundreds of archaeological sites were discovered, recorded, and verified. This resulted in the most comprehensive archaeological record of Alaskan coastline ever documented.

Although a number of sites in the *Exxon Valdez* spill area were vandalized during the 1989 cleanup season, the large number of Exxon and government-agency archaeologists visible in the field may have lessened the amount of site vandalism that may have occurred (Mobley et al., 1990).

The Dekin study (1993) found that small amounts of petroleum hydrocarbons may occur in most archaeological sites within the study area. This suggests a low-level petroleum contamination that had not previously been suspected. Since the researchers found no evidence of extensive soil contamination from a single definable source (i.e., the oil spilled from the *Exxon Valdez*), they "…now add the continuing contamination of soils from small and large petroleum spills in areas where present and past land use coincide" (Dekin, 1993). Vandalism was found to have a significant effect on archaeological site integrity but could not be tied directly to the oil spill (Dekin, 1993).

(3) Oil-Spill Cleanup

Effects to archaeological sites as a result of oil-spill cleanup would be the same as those discussed in Section III.C.2.j.

k. Economy

(1) Summary and Conclusion for the Economy

A very large spill of 200,000 barrels would create effects similar to those experienced with the *Exxon Valdez* spill.

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Short-term employment could reach or exceed 10,000 people, along with price inflation above 25% during the first 6 months of the cleanup operation. Long-term economic effects would be minimal.

(2) Details on How a Large Tanker Spill in the Gulf of Alaska Might Affect the Economy

The most relevant historical experience of a tanker spill in Alaskan waters is the *Exxon Valdez* oil spill of 1989, which spilled 258,000 barrels. This spill generated enormous employment that rose to the level of 10,000 workers directly doing cleanup work in relatively remote locations. Smaller numbers of cleanup workers returned in the warmer months each year following 1989 until 1992. Numerous local residents quit their jobs to work on the cleanup at often significantly higher wages, which generated a sudden and significant inflation in the local economy (Cohen, 1993). Anecdotal information indicates that housing rents in Valdez in 1989 increased from 25% in some cases to sixfold in others, and inflated rents continued into 1990. Prices of food and other goods increased only slightly, because people could drive to Anchorage to purchase them (Henning, 1993, pers. commun.). Research shows that no data on inflation were gathered in a systematic way during the *Exxon Valdez* oil spill, although most observers agree that there was temporary inflation.

The number of cleanup workers actually used for a very large oil spill of 200,000 barrels would depend to a great extent on what procedures are called for in the oil-spill-contingency plan, how well prepared with equipment and training the entities responsible for cleanup were, how efficiently the cleanup was executed, and how well the coordination of cleanup was executed among numerous responsible entities. A very large oil spill of 200,000 barrels resulting from activity associated with the Liberty Project could generate about the same number of workers associated with the *Exxon Valdez* spill—or 10,000 cleanup workers at the peak of the cleanup effort. Housing for cleanup workers would likely be located outside of Yakutat in some type of temporary enclave, such as those developed during the *Exxon Valdez* spill. Based on experience from the *Exxon Valdez* oil spill, all communities proximate to the oil-spill-cleanup effort could experience temporary increases in wage rates and a shortage of housing, which could cause significant housing-rent increases.

The same economic effects would occur whether the spill was in the Gulf of Alaska or further south along the Canadian or U.S. west coast bordering on the Pacific Ocean.

I. Water Quality

(1) Summary and Conclusion for Water Quality

The water quality would be reduced from good (unpolluted) to polluted by the presence of hydrocarbons from a large (200,000-barrel) spill. This type of spill would significantly affect water quality by increasing the concentration of hydrocarbons in the water column to levels that greatly exceed background concentrations. However, such an oil spill has a relatively low probability of occurring. Contamination (the presence of hydrocarbons in amounts greater than 15 micrograms per liter) would be temporary (last for about 2 months or more) and affect an area between 10,000 and 20,000 square kilometers.(2) Details on How a Large Tanker Spill in the Gulf of Alaska Might Affect Water Quality

Accidental oil spills would add substances that may be foreign to or increase the concentration of constituents already present in the water column of the northeastern Gulf of Alaska. In general, the added substances may cause sublethal effects in some marine organisms if concentrations are greater than the chronic criteria and lethal effects if concentrations are greater than acute criteria. This analysis considers 15 micrograms per liter to be a chronic criterion and 1,500 micrograms per liter—a hundredfold higher level—to be an acute criterion for total hydrocarbons.

The effects of a very large, 200,000-barrel oil spill on water quality are based on the amount of oil dispersed into the water column; the characteristics of the oil spill are noted in Tables IX-7, 8, and 9. The concentrations are simply estimated from the amount of oil dispersed into the water column for each time interval by assuming that (1) the extent of the discontinuous area estimated for the surface extends into the water column; (2) the depth of mixing is 2 meters after 3 days, 7.5 meters after 10 days, and 15 meters after 30 days; (3) the concentration of the dispersed oil is uniform in the “mixed” watermass; (4) other processes, except sedimentation, affecting degradation of oil or removal of oil from the water column are neglected; and (5) the weight of a barrel of oil is 314.26 pounds.

The waters of the northeastern gulf are stratified in the summer; vertical mixing in the surface layer may be limited to the upper 20-25 meters. For depth-of-mixing estimates, it is assumed that the oil will be dispersed into the water column to a depth equivalent to the mean monthly significant wave height of 2 meters. At the end of 10 days, the oil is assumed to have dispersed to a depth of 7.5 meters. At the end of 30 days, the oil is assumed to have dispersed to a depth of 30 meters. The depth of mixing during the first day is assumed to be 1 meter. Table IX-8 shows the estimates of the amount of oil remaining in the water and removed by sedimentation and evaporation for time intervals from 1-60 days.

For a 200,000-barrel spill, the estimated concentrations of oil dispersed into the water column are shown in Table IX-9. The high concentrations of oil associated with estimating dispersal in the water column may represent an upper range of dispersed-oil concentrations reached during the first several days following a large spill; these concentrations are greater than the total hydrocarbon acute criterion of 1,500 micrograms per liter that was used to evaluate the effects of a 29,000-barrel spill and smaller spills. Between 10 and 30 days after the spill, concentrations of dispersed oil are within the range of concentrations reported for tanker spills of 0.18 and 1.6 million barrels of oil (National Research Council, 1985; Gundlach et al., 1983). The amount of dispersed oil in the water after 30-60 days emphasizes the time it would take before the oil is reduced to concentrations that are below the total hydrocarbon chronic criteria—15 micrograms per liter—and eventually disappears from the water. Dilution rates associated with permitted discharges suggest that the dispersion rates of oil droplets in the water column may be greater than those estimated for this spill.

m. Air Quality

(1) Summary and Conclusion for Air Quality

Concentrations of criteria pollutants would remain well below Federal air-quality standards.

(2) Details on How a Large Tanker Spill in the Gulf of Alaska Might Affect Air Quality

Under this analysis, a 200,000-barrel oil spill would affect onshore air quality. Emissions would result from evaporation and burning of the spilled oil.

Evaporation of spilled oil is a source of gaseous emissions. Modeling predictions of hydrocarbon evaporation (Payne et al., 1984a,b; Payne, 1987) from a 200,000-barrel slick over 30-day periods estimate that 56,000 barrels, or 7,817 tons, of hydrocarbons would evaporate. Because approximately 10% of gaseous hydrocarbons are nonmethane volatile organic compounds, 781.7 tons of volatile organic compounds would be lost to the atmosphere. The movement of the oil slick during this time would result in lower concentrations and dispersal of emissions over an area several orders of magnitude larger than the slick itself.

In situ burning is a preferred technique for cleanup and disposal of spilled oil in oil-spill-contingency plans. For catastrophic oil spills, in situ burning may be the only effective technique for spill control.

Burning could affect air quality in two important ways. Burning would reduce emissions of gaseous hydrocarbons by 99.98% and slightly increase emissions, relative to quantities in other oil and gas industrial operations, of other pollutants. If the oil spill were ignited immediately after spillage, the burn would combust 33-67% of the crude oil or higher amounts of fuel oil that otherwise would evaporate. On the other hand, incomplete combustion of oil would inject about 10% of the burned crude oil as oily soot, plus minor quantities of other pollutants, into the air. For a 200,000-barrel spill, setting fire at the source could burn up to 85% of the oil, with 5% remaining as residue or droplets in the smoke plume, in addition to the 10% soot injection (Evans et al., 1987). Clouds of black smoke from a 360,000-barrel oil-spill tanker fire 75 kilometers off the coast of Africa locally deposited oily residue in a rainfall 50-80 kilometers inland. Later the same day, clean rain washed away most of the residue and allayed fears of permanent damage.

Coating portions of the ecosystem in oily residue is the major, but not the only, potential air-quality risk. Recent examination of polycyclic aromatic hydrocarbons (PAH) in crude oil and smoke from burning crude oil indicate that the overall amounts of PAH change little during combustion, but the kinds of PAH compounds present do change. Benzo(a)pyrene, which is often used as an indicator of the presence of carcinogenic varieties of PAH, is present in crude-oil smoke in quantities approximately three times larger than in the unburned oil. However, the amount of PAH is very small (Evans, 1988). Investigators have found that overall, the oily residue in smoke plumes from crude oil is mutagenic but not highly so (Sheppard and Georghiou, 1981; Evans et al., 1987). The Expert Committee of the World Health Organization considers daily average smoke concentrations of more than 250 micrograms per cubic meter to be a health hazard for bronchitis.

Large fires create their own local circulating winds—toward the fire at ground level—that affect plume motion. In any event, soot produced from burning oil spills tends to slump and wash off vegetation in subsequent rains, limiting any health effects in the very short term. Accidental emissions are, therefore, expected to have a low effect on onshore air quality.

n. Commercial Fisheries

(1) Summary and Conclusion for Commercial Fisheries

Based on the assumptions discussed in the text, adjusted *Exxon Valdez* spill loss estimates, and the average annual value of the Gulf of Alaska commercial fishery, the 200,000-barrel oil spill is estimated to result in economic losses to the gulf commercial-fishing industry ranging from 37-64% per year for 2 years following the spill.

(2) Details on How a Large Tanker Spill in the Gulf of Alaska Might Affect Commercial Fisheries

The 200,000-barrel oil spill would affect the Gulf of Alaska commercial-fishing industry by exposing it to petroleum-based hydrocarbons. The 200,000-barrel spill would substantially increase the amount of oil contacting shoreline and open-water commercial fishing grounds. Because more shoreline would be contacted with more oil, oil from the 200,000-barrel spill likely would remain for a longer period in shoreline sediments. Within the Gulf of Alaska area this is not expected to result in additional closures because any large spill is large enough by itself to close northeastern gulf commercial fisheries. However, once the spill was northwest of the Trans-Alaska Pipeline System tanker route (the predominate direction of ocean currents), there would be substantially more oil moving out of the area from the 200,000-barrel spill. Hence, the oil from the 200,000-barrel spill is likely to enter and more strongly affect the commercial fishing grounds within portions of Prince William Sound and farther west toward Resurrection Bay. Due to the greater presence of oil in these areas, more fishery closures are expected with a 200,000-barrel spill that moves outside of the tanker route.

The estimated economic effect of a 200,000-barrel oil spill on the gulf commercial-fishing industry is based on what occurred during the larger (258,000 barrels) *Exxon Valdez* oil spill and a smaller (4,000 barrels) spill, and depends primarily on the highly variable *Exxon Valdez* spill cost estimates (ranging from $9-43 million/year for 2 years). The value of the gulf commercial fishery (Prince William Sound to Cape Fairweather) is estimated at $75-$200 million per year, depending on the price per year and numbers caught. Hence, in any 2-year period when the value of the northeastern gulf commercial fishery is estimated to be about $75 million per year, a 2-year loss of about $9 million per year represents a 12%-per-year loss for 2 years. A 2-year loss of about $43 million per year represents a 57%-per-year loss for 2 years. In a 2-year period when the annual value of the northeastern gulf commercial fishery is estimated to be closer to $200 million, a 2-year loss of about $9 million per year represents a 5%-per-year loss for 2 years, whereas a 2-year loss of $43 million per year represents a 22%-per-year loss for 2 years.

Because the occurrence of a large oil spill (200,000 barrels) would preclude any knowledge of what the commercial fishery would have been worth (due to closures), the value of the commercial fishery at the time of the 200,000-barrel oil spill is assumed to be the estimated average annual value of the gulf commercial fishery. In terms of the estimated average annual value (about $125 million), a 2-year loss of about $9 million per year represents a 7%-per-year loss for 2 years, whereas a 2-year loss of about $43 million per year represents a 34%-per-year loss for 2 years. These estimates are the same as for large spill because, as indicated above, any large oil spill is large enough to close the same amount of commercial fishery within the area. However, if it is assumed that the oil from the 200,000-barrel oil spill also moves outside and northwest of the area, additional closures are expected from Prince William Sound to Resurrection Bay. It is estimated that these additional closures would further reduce the value of gulf commercial fisheries (excluding Kodiak and Cook Inlet) by about 30% for 2 years. Hence, estimated gulf commercial fishing losses due to the 200,000-barrel oil spill are estimated to range between $45 million (7+30 = 37%) and $80 million (34+30 = 64%) per year for 2 years following the spill.

Thus, based on loss estimates from the *Exxon Valdez* spill and the estimated annual value of the northeastern gulf commercial fishery, the 200,000-barrel oil spill could result in an economic loss to the northeastern gulf commercial fishing industry of 12-57%-per year for 2 years. However, in terms of the estimated average annual value of the northeastern gulf commercial fishery, the 200,000-barrel oil spill is more likely to result in a loss of about 7-34% per year for 2 years within the area. Additional closures northwest of the area are estimated to increase this loss to between 37% and 64% per year for 2 years following the spill. Compensation to the commercial-fishing industry for participating in the cleanup of an oil spill is likely to exceed these economic losses by several orders of magnitude.

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The Department of the Interior Mission
As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering sound use of our land and water resources; protecting our fish, wildlife, and biological diversity; preserving the environmental and cultural values of our national parks and historical places; and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to ensure that their development is in the best interests of all our people by encouraging stewardship and citizen participation in their care. The Department also has a major responsibility for American Indian reservation communities and for people who live in island territories under U.S. administration.

The Minerals Management Service Mission
As a bureau of the Department of the Interior, the Minerals Management Service's (MMS) primary responsibilities are to manage the mineral resources located on the Nation's Outer Continental Shelf (OCS), collect revenue from the Federal OCS and onshore Federal and Indian lands, and distribute those revenues.

Moreover, in working to meet its responsibilities, the **Offshore Minerals Management Program** administers the OCS competitive leasing program and oversees the safe and environmentally sound exploration and production of our Nation's offshore natural gas, oil and other mineral resources. The MMS **Royalty Management Program** meets its responsibilities by ensuring the efficient, timely and accurate collection and disbursement of revenue from mineral leasing and production due to Indian tribes and allottees, States and the U.S. Treasury.

The MMS strives to fulfill its responsibilities through the general guiding principles of: (1) being responsive to the public's concerns and interests by maintaining a dialogue with all potentially affected parties and (2) carrying out its programs with an emphasis on working to enhance the quality of life for all Americans by lending MMS assistance and expertise to economic development and environmental protection.