Specifications for Use of NRDAM/CME Version 2.4 to Generate Compensation Formulas

Guidance Document for Natural Resource Damage Assessment Under the Oil Pollution Act of 1990

Damage Assessment
and Restoration Program

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NOAA
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SPECIFICATIONS FOR USE OF NRDAM/CME VERSION 2.4 TO GENERATE COMPENSATION FORMULAS

GUIDANCE DOCUMENT FOR NATURAL RESOURCE DAMAGE ASSESSMENT UNDER THE OIL POLLUTION ACT OF 1990

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DISCLAIMER

This guidance document is intended to be used as a tool to estimate injuries and damages likely to result from small discharges of oil under the Oil Pollution Act of 1990 (OPA). This document is not regulatory in nature. Trustees are not required to use this document in order to receive a rebuttable presumption for natural resource damage assessments under OPA.

NOAA would appreciate any suggestions on how this document could be made more practical and useful. Readers are encouraged to send comments and recommendations to:

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LIST OF EXHIBITS

LIST OF ACRONYMS

CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980, as amended
ISMCS	International Station Meteorological Climate Summary
NCDC	National Climate Data Center
NDBC	National Data Buoy Center
NOAA	National Oceanic and Atmospheric Administration
NRDA/CME	Natural Resource Damage Assessment Model for Coastal and Marine Environments
OPA	Oil Pollution Act of 1990

INTRODUCTION CHAPTER 1

1.1 Background

A major goal of the Oil Pollution Act of 1990 (OPA)[1] is to make the environment and public whole for injury to or loss of natural resources and services as a result of a discharge or substantial threat of a discharge of oil (referred to as an *incident*). This goal is achieved through returning injured natural resources and services to the condition they would have been in if the incident had not occurred (otherwise referred to as *baseline* conditions), and compensating for interim losses from the date of the incident until recovery of such natural resources and services through the restoration, rehabilitation, replacement, or acquisition of equivalent natural resources and/or services.

The U.S. Department of Commerce, acting through the National Oceanic and Atmospheric Administration (NOAA), issued final regulations providing an approach that public officials (trustees) may use when conducting Natural Resource Damage Assessments (NRDA) under OPA.[2] These NRDA regulations (the OPA regulations) describe a process by which trustees may:

- Identify injuries to natural resources and services resulting from an incident;

- Provide for the return of injured natural resources and services to baseline conditions and compensation for interim lost services; and

- Encourage and facilitate public involvement in the restoration process.

The OPA regulations are included in Appendix A of this document for reference. The preamble discussion of the OPA regulations, along with a summary of and response to public comments received on the proposed regulations, is published at 61 Fed. Reg. 440 (January 5, 1996).

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1 33 U.S.C. §§ 2701 *et seq.*

2 The OPA regulations are codified at 15 CFR part 990 and became effective February 5, 1996.

1.2 Purpose and Scope of this Document

NOAA first proposed the OPA regulations on January 7, 1994 (59 Fed. Reg. 1062). The 1994 proposed OPA regulations offered a range of natural resource damage assessment procedures varying in levels of complexity and degree of site-specific application. Those proposed regulations included a compensation formula that could be used for small oil spills in estuarine and marine environments. The compensation formula was the simplest of a series of assessment procedures in the 1994 proposed OPA regulations. The purpose of the formula was for trustees to be able to readily estimate damages based on the amount of oil spilled and several simple data inputs.

The 1994 compensation formula was developed using a computer model promulgated by the Department of the Interior (DOI) under the Comprehensive Environmental Response, Compensation, and Liability Act of 1980, as amended (CERCLA). One simplified procedure currently codified in the CERCLA rule is the Natural Resource Damage Assessment Model for Coastal and Marine Environments (NRDAM/CME), Version 2.4, which gives an estimate of *average* damages expected to result from minor discharges of oil and releases of hazardous substances occurring in the coastal and marine environment (61 Federal Register 20560, May 7, 1996). Also, DOI has developed a simplified assessment procedure for use in the Great Lakes known as the Natural Resource Damage Assessment Model for Great Lakes Environments (NRDAM/GLE), Version 1.4 (61 Federal Register 20560, May 7, 1996).

This document outlines the matrix of model runs used to derive the January 1994 compensation formula. The purpose is to allow these runs to be made using Version 2.4 of the NRDAM/CME. This will allow evaluation of how the compensation formula would change from that proposed in January 1994 and provide approximate estimates of damages for hypothetical spills based on the formula. This document does <u>not</u> include consideration of the freshwater environments.

Using the guidance and data in this document, trustees will have a simplified, cost-effective tool to use in estimating expected impacts of most discharges of oil. In order to use this guidance, trustees must have the final computer model developed by DOI. The NRDAM/CME, Version 2.4, is available from the National Technical Information Service, 5285 Port Royal Rd., Springfield, VA 22161; PB96-501788; (703) 487-4650.

The technical documentation for Version 2.4 of the current NRDAM/CME provides a full description of the model algorithms, assumptions, and underlying databases. This document lists only those data required as user inputs for runs that represent those used in the 1994 compensation formula. Reference will be made below to the NRDAM/CME, Version 2.4, documentation as to where data and sources may be found that are relevant to runs usable for the compensation formula. Refer to Appendix B for a listing of other related guidance documents in support of the OPA regulations.

1.3 Intended Audience

This document was prepared primarily to provide guidance to natural resource trustees using the OPA regulations. However, other interested persons may also find the information contained in this document useful and are encouraged to use this information as appropriate.

1.4 The NRDA Process

The NRDA process shown in Exhibit 1.1 in the OPA regulations includes three phases outlined below: Preassessment; Restoration Planning; and Restoration Implementation.

1.4.1 Preassessment Phase

The purpose of the Preassessment Phase is to determine if trustees have the jurisdiction to pursue restoration under OPA, and, if so, whether it is appropriate to do so. This preliminary phase begins when the trustees are notified of the incident by response agencies or other persons.

Once notified of an incident, trustees must first determine the threshold criteria that provide their authority to initiate the NRDA process, such as applicability of OPA and potential for injury to natural resources under their trusteeship. Based on early available information, trustees make a preliminary determination whether natural resources or services have been injured. Through coordination with response agencies, trustees next determine whether response actions will eliminate the threat of ongoing injury. If injuries are expected to continue, and feasible restoration alternatives exist to address such injuries, trustees may proceed with the NRDA process.

1.4.2 Restoration Planning Phase

The purpose of the Restoration Planning Phase is to evaluate potential injuries to natural resources and services and use that information to determine the need for and scale of restoration actions. The Restoration Planning Phase provides the link between injury and restoration. The Restoration Planning Phase has two basic components: injury assessment and restoration selection.

NATURAL RESOURCE DAMAGE ASSESSMENT
Oil Pollution Act of 1990
Overview of Process

PREASSESSMENT PHASE

- Determine Jurisdiction
- Determine Need to Conduct Restoration Planning

RESTORATION PLANNING PHASE

- Injury Assessment
  - Determine Injury
  - Quantify Injury
- Restoration Selection
  - Develop Reasonable Range of Restoration Alternatives
  - Scale Restoration Alternatives
  - Select Preferred Restoration Alternative(s)
  - Develop Restoration Plan

RESTORATION IMPLEMENTATION PHASE

- Fund/Implement Restoration Plan

Exhibit 1.1 NRDA process under the OPA regulations.

1.4.2.1 Injury Assessment

The goal of injury assessment is to determine the nature, degree, and extent of any injuries to natural resources and services. This information is necessary to provide a technical basis for evaluating the need for, type of, and scale of restoration actions. Under the OPA regulations, injury is defined as an observable or measurable adverse change in a natural resource or impairment of a natural resource service. Trustees determine whether there is:

- Exposure, a pathway, and an adverse change to a natural resource or service as a result of an actual discharge; or

- An injury to a natural resource or impairment of a natural resource service as a result of response actions or a substantial threat of a discharge.

To proceed with restoration planning, trustees also quantify the degree, and spatial and temporal extent of injuries. Injuries are quantified by comparing the condition of the injured natural resources or services to baseline, as necessary.

1.4.2.2 Restoration Selection

(a) Developing Restoration Alternatives

Once injury assessment is complete or nearly complete, trustees develop a plan for restoring the injured natural resources and services. Under the OPA regulations, trustees must identify a reasonable range of restoration alternatives, evaluate and select the preferred alternative(s), and develop a Draft and Final Restoration Plan. Acceptable restoration actions include any of the actions authorized under OPA (restoration, rehabilitation, replacement, or acquisition of the equivalent) or some combination of those actions

Restoration actions under the OPA regulations are either primary or compensatory. Primary restoration is action taken to return injured natural resources and services to baseline, including natural recovery. Compensatory restoration is action taken to compensate for the interim losses of natural resources and/or services pending recovery. Each restoration alternative considered will contain primary and/or compensatory restoration actions that address one or more specific injuries associated with the incident. The type and scale of compensatory restoration may depend on the nature of the primary restoration action, and the level and rate of recovery of the injured natural resources and/or services given the primary restoration action.

When identifying the compensatory restoration components of the restoration alternatives, trustees must first consider compensatory restoration actions that provide services of the same type and quality, and of comparable value as those lost. If compensatory actions of the same type and quality and comparable value cannot provide a reasonable range of alternatives, trustees then consider other compensatory restoration actions that will provide services of at least comparable type and quality as those lost.

(b) Scaling Restoration Actions

To ensure that a restoration action appropriately addresses the injuries resulting from an incident, trustees must determine what scale of restoration is required to return injured natural resources to baseline levels and compensate for interim losses. The approaches that may be used to determine the appropriate scale of a restoration action are the resource-to-resource (or service-to-service approach) and the valuation approach. Under the resource-to-resource or service-to-service approach to scaling, trustees determine the appropriate quantity of replacement natural resources and/or services to compensate for the amount of injured natural resources or services.

Where trustees must consider actions that provide natural resources and/or services that are of a different type, quality, or value than the injured natural resources and/or services, or where resource-to-resource (or service-to-service) scaling is inappropriate, trustees may use the valuation approach to scaling, in which the value of services to be returned is compared to the value of services lost. Responsible parties (RPs) are liable for the cost of implementing the restoration action that would generate the equivalent value, not for the calculated interim loss in value. An exception to this principle occurs when valuation of the lost services is practicable, but valuation of the replacement natural resources and/or services cannot be performed within a reasonable time frame or at a reasonable cost. In this case, trustees may estimate the dollar value of the lost services and select the scale of the restoration action that has the cost equivalent to the lost value.

(c) Selecting a Preferred Restoration Alternative

The identified restoration alternatives are evaluated based on a number of factors that include:

- Cost to carry out the alternative;

- Extent to which each alternative is expected to meet the trustees' goals and objectives in returning the injured natural resources and services to baseline and/or compensating for interim losses;

- Likelihood of success of each alternative;

- Extent to which each alternative will prevent future injury as a result of the incident, and avoid collateral injury as a result of implementing the alternative;

- Extent to which each alternative benefits more than one natural resource and/or service; and

- Effect of each alternative on public health and safety.

Trustees must select the most cost-effective of two or more equally preferable alternatives.

(d) Developing a Restoration Plan

A Draft Restoration Plan will be made available for review and comment by the public, including, where possible, appropriate members of the scientific community. The Draft Restoration Plan will describe the trustees' preassessment activities, as well as injury assessment activities and results, evaluate restoration alternatives, and identify the preferred restoration alternative(s). After reviewing public comments on the Draft Restoration Plan, trustees develop a Final Restoration Plan. The Final Restoration Plan will become the basis of a claim for damages.

1.4.3 Restoration Implementation Phase

The Final Restoration Plan is presented to the RPs to implement or fund the trustees' costs of implementing the Plan, therefore providing the opportunity for settlement of the damage claim without litigation. Should the RPs decide to decline to settle the claim, OPA authorizes trustees to bring a civil action for damages in federal court or to seek an appropriation from the Oil Spill Liability Trust Fund (FUND) for such damages.

1.5 Basic Terms and Definitions

Legal and regulatory language often differ from conventional usage. This section defines and describes a number of important terms used in this document and in the OPA regulations. Trustees should also refer to the OPA regulatory language of Appendix A (at § 990.30), and Appendix C for additional, related definitions.

1.5.1 Baseline

> "*Baseline* means the condition of the natural resources and services that would have existed had the incident not occurred. Baseline data may be estimated using historical data, reference data, control data, or data on incremental changes (e.g., number of dead animals), alone or in combination, as appropriate." (OPA regulations at § 990.30)

Baseline refers to the condition of natural resources and services that would have existed had the incident not occurred. Although injury quantification requires comparison to a baseline condition, site-specific baseline information that accounts for natural variability and confounding factors prior to the incident may not be required. In many cases, injuries can be quantified in terms of incremental changes resulting from the incident, rather than in terms of absolute changes relative to a known baseline. In this context, site-specific baseline information is not necessary to quantify injury. For example, counts of oiled bird carcasses can be used as a basis for quantifying incremental bird mortality resulting from an incident, thereby providing the basis for planning restoration.

The OPA regulations do not distinguish between baseline, historical, reference, or control data in terms of value and utility in determining the degree and spatial and temporal extent of injuries. These forms of data may serve as a basis of a determination of the conditions of the natural resources and services in the absence of the incident.

Types of information that may be useful in evaluating baseline include:

- Information collected on a regular basis and for a period of time from and prior to the incident;
- Information identifying historical patterns or trends on the area of the incident and injured natural resources and services;
- Information from areas unaffected by the incident, that are judged sufficiently similar to the area of the incident with respect to the parameter being measured; or
- Information from the area of the incident after particular natural resources or services have been judged to have recovered.

1.5.2 Exposure

> "*Exposure* means direct or indirect contact with the discharged oil." (OPA regulations at § 990.30)

Exposure is broadly defined to include not only direct physical exposure to oil, but also indirect exposure (e.g., injury to an organism as a result of disruption of its food web). However, documenting exposure is a prerequisite to determining injury only in the event of an actual discharge of oil. The term *exposure* does not apply to response-related injuries and injuries resulting from a substantial threat of a discharge of oil.

1.5.3 Incident

> "*Incident* means any occurrence or series of occurrences having the same origin, involving one or more vessels, facilities, or any combination thereof, resulting in the discharge or substantial threat of discharge of oil into or upon navigable waters or adjoining shorelines or the Exclusive Economic Zone, as defined in section 1001(14) of OPA (33 U.S.C. 2701(14))." (OPA regulations at § 990.30)

When a discharge of oil occurs, natural resources and/or services may be injured by the actual discharge of oil, or response activities related to the discharge. When there is a substantial threat of a discharge of oil, natural resources and/or services may also be injured by the threat or response actions related to the threat.

1.5.4 Injury

> "*Injury* means an observable or measurable adverse change in a natural resource or impairment of a natural resource service. Injury may occur directly or indirectly to a natural resource and/or service. Injury incorporates the terms 'destruction,' 'loss,' and 'loss of use' as provided in OPA." (OPA regulations at § 990.30)

Section 1002(b)(2)(A) of OPA authorizes natural resource trustees to assess damages for "injury to, destruction of, loss of, or loss of use of" natural resources. The definition of *injury* incorporates these terms. The definition also includes the injuries resulting from the actual discharge of oil, a substantial threat of a discharge of oil, and/or related response actions.

Injury can include adverse changes in the chemical or physical quality, or viability of a natural resource (i.e., direct, indirect, delayed, or sublethal effects). Potential categories of injuries include adverse changes in:

- Survival, growth, and reproduction;
- Health, physiology and biological condition;
- Behavior;
- Community composition;
- Ecological processes and functions;
- Physical and chemical habitat quality or structure; and
- Services to the public.

Although injury is often thought of in terms of adverse changes in biota, the definition of injury under the OPA regulations is broader. Injuries to non-living natural resources (e.g., oiled sand on a recreational beach), as well as injuries to natural resource services (e.g., lost use associated with a fisheries closure to prevent harvest of tainted fish, even though the fish themselves may not be injured) may be considered.

1.5.5 Natural Resources and Services

> "*Natural resources* means land, fish, wildlife, biota, air, water, ground water, drinking water supplies, and other such resources belonging to, managed by, held in trust by, appertaining to, or otherwise controlled by the United States (including the resources of the Exclusive Economic Zone), any State or local government or Indian tribe, or any foreign government, as defined in section 1001(20) of OPA (33 U.S.C. 2701(20))." (OPA regulations at § 990.30)

Natural resources provide various services to other natural resources and to humans, and loss of services is included in the definition of injury under the OPA regulations.

"*Services* (or *natural resource services*) means the functions performed by a natural resource for the benefit of another natural resource and/or the public." (OPA regulations § 990.30)

Natural resource services may be classified as follows:

- Ecological services - the physical, chemical, or biological functions that one natural resource provides for another. Examples include provision of food, protection from predation, and nesting habitat, among others; and

- Human services - the human uses of natural resources or functions of natural resources that provide value to the public. Examples include fishing, hunting, nature photography, and education, among others.

In considering both natural resources and services, trustees are addressing the physical and biological environment, and the relationship of people with that environment.

1.5.6 Oil

"*Oil* means oil of any kind or in any form, including, but not limited to, petroleum, fuel oil, sludge, oil refuse, and oil mixed with wastes other than dredged spoil. However, the term does not include petroleum, including crude oil or any fraction thereof, that is specifically listed or designated as a hazardous substance under 42 U.S.C. 9601(14)(A) through (F), as defined in section 1001(23) of OPA (33 U.S.C. 2701(23))." (OPA regulations at § 990.30)

Under the OPA regulations, the definition of *oil* includes petroleum, as well as non-petroleum oils (i.e., fats and oils from animal and vegetable sources). However, in assessing injury resulting from non-petroleum oils, trustees should consider the differences in the physical, chemical, biological, and other properties, and in the environmental effects of such oils on the natural resources of concern.

1.5.7 Pathway

"*Pathway* means any link that connects the incident to a natural resource and/or service, and is associated with an actual discharge of oil." (OPA regulations at § 990.30)

Pathway is the medium, mechanism, or route by which the incident has resulted in an injury. Pathways may include movement/exposure through the water surface, water column, sediments, soil, groundwater, air, or biota.

Pathway determination may include, but is not limited to, an evaluation of the sequence of events by which the discharged oil was transported from the incident and either:

- Came into direct physical contact with the exposed natural resource (e.g., oil transported from an incident by ocean currents, wind, and wave action directly to shellfish); or

- Caused an indirect injury to a natural resource and/or service (e.g., oil transported from an incident by ocean currents, wind, and wave action cause reduced populations of bait fish, which in turn results in starvation of a fish-eating bird; or, oil transported from an incident by currents, wind, and wave action causes the closure of a fishery to prevent potentially tainted fish from being marketed).

Pathway determination does not require that injured natural resources and/or services be directly exposed to oil. In the example provided above, fish-eating birds are injured as a result of decreases in food availability. However, if an injury is caused by direct exposure to oil, the pathway linking the incident to the injury should be determined.

As with exposure, establishing a pathway is a prerequisite to determining injury, except for response-related injuries and injuries resulting from a substantial threat of a discharge of oil.

In order to generate data used to derive the compensation formula, the NRDAM/CME was run at a series of latitude-longitude grids where each grid cell has associated environmental characteristics such as depth, habitat type, temperature, currents, etc. The environmental data were similar to "reality," but simplified and modified to describe generic environmental conditions for spills. Each of the habitat types contains specific biological data. The biological database (Volume IV of the NRDAM/CME, Version 2.4, documentation) contains wildlife, fishery species, and fishery young-of-the-year abundances per unit area. Fishery and young-of-the-year abundances differ for open water versus structured (Exhibit 2.1), and for estuarine versus marine habitats. Wildlife abundances are assumed only in habitats where those species exist. The database also contains lower trophic level production rates by trophic habitat type (Exhibit 2.1). All abundances and rates vary seasonally.

The types of habitats differentiated for the estuarine and marine compensation formula are a simplification of that in the NRDAM/CME, which is based on Cowardin et al. (1979). Zones and trophic habitats are clearly defined in the NRDAM/CME documentation (Volume I, Section 6). The following is further clarification.

"Estuarine environment" means deepwater tidal habitats that are usually semi-enclosed by land but have an open, partially obstructed, or sporadic access to the open ocean and in which ocean water is at least occasionally diluted by freshwater runoff from the land. The estuarine environment extends upstream and landward to where ocean-driven salts measure less than 0.5 parts per thousand during the period of average annual low flow; and (1) seaward to an imaginary straight line closing the mouth of a river, bay, or sound; or (2) to the seaward limit of wetland emergents, shrubs, or trees where not included in (1) of this definition. The estuarine environment also includes offshore areas of continuous upwellings of freshwater containing typical estuarine plants and animals.

"Marine environment" means the greater of the open ocean extending landward from the seaward limit of the fishery conservation zone established by the Magnuson Fishery Conservation and Management Act of 1976 or the Exclusive Economic Zone established by Presidential Proclamation 5030 (48 FR 10605, March 10, 1983) to one of the following: (1) the landward limit of the intertidal (see below); or (2) the seaward limit of the estuarine environment. The marine environment does not include offshore areas of continuous upwellings of freshwater containing typical estuarine plants and animals.

"Intertidal" means an estuarine or marine environment with hard shore or sand beach in which the substrate is exposed and flooded by tides. It incorporates: (1) the splash area, which lies above the extreme high water level of spring tide; (2) the upper shore, which lies between the average high tide level and the extreme high water level of spring tides; (3) the midshore, which lies between the average low tide level and the average high tide level; and (4) the lower shore, which lies between the extreme low water level of spring tides to the average spring tide level.

"Subtidal" means an estuarine or marine environment in which the substrate is continuously submerged. All subtidal applications used to generate the compensation formula are included in the estuarine and marine environment scenarios.

The biological data also vary by region for the coastal United States, termed (biological) provinces. A listing of the provinces and their boundaries are in Exhibit 2.1, which is identical to Exhibit 6.1 of the NRDAM/CME, Version 2.4, documentation.

Representative habitat-province combinations were used in model runs to develop the compensation formula. These habitat-province combinations are referred to herein as "cases." A total of 55 cases were used in the model runs, as listed in Exhibits 2.2 to 2.4 and summarized in Exhibit A.1 of Appendix A. Case IDs beginning with the letter "M" refer to scenarios occurring in marine environments; those beginning with "E" refer to estuarine scenarios; and those beginning with "I" refer to intertidal scenarios. In Exhibits 2.2 to 2.4, the "Province # Run" heading lists the province code number, from the list in Exhibit 2.1, in which the model was run for the noted cases. The numbers in parentheses show other provinces from Exhibit 2.1 that are sufficiently similar in characteristics to be adequately represented by the "Province # Run."

For each of the 55 cases, 100 runs of the model were made: 4 seasons x 5 oil types x 5 volumes spilled. Seasonal variation in biological abundances and temperature are important influences on resulting damages. Thus, the compensation formula damages vary by season of the spill. The seasons are defined as follows:

Winter	January 1 - March 31
Spring	April 1 - June 30
Summer	July 1 - September 30
Fall	October 1 - December 31

Spill dates used in model runs were set at the beginning of each season so that resulting damages would reflect the season of the spill (i.e., January 5, April 5, July 5, and October 5), and would be unlikely to extend into a different season. The season is meant to be representative of the time period where most of the injury is expected to have occurred. This is most often that season containing the date of the spill. However, if a spill occurs at a change in seasons, the following season may be more representative.

Due to the simplified nature of the compensation formula, it would be impossible to have every specific type of oil represented. Therefore, it was necessary to select representative oil types of the many crude and petroleum products that might be discharged.

The types of oils and total volumes spilled into U.S. waters from 1973-1990, as available in the U.S. Coast Guard Pollution Reporting System (PIRS) database, are in Appendix C, Exhibit C.1. Most spills are of crude oil, followed by gasolines, fuel oils, and diesel. Collectively, miscellaneous oils amount to a considerable number and volume of spills.

In addition, the recently published Port Needs Study, Maio et al. (1991), provide estimates of cargo tons transported into or out of 23 U.S. ports (Appendix C, Exhibits C.2 and C.3). The major commodities are crude oil, gasoline, distillate fuels, and residual fuels. The percentage of cargo (Exhibit C.3) by oil type varies considerably by port. However, there is no clear pattern by region of the country. Therefore, the same oil types were used for model spill runs in all regions of the U.S.

Five oil types were selected to be representative of the many oils that might be spilled (and for which the formula may be used):

Heavy crude
Light crude
No. 2 Fuel oil
Diesel
Gasoline

When the compensation formula is used for an actual spill case, an oil in the above table must be selected which most closely represents the spilled oil. Exhibit A.6 (Appendix A) gives suggested choices for the types of oils contained in the U.S. Coast Guard oil spill data set (CHRIS). The most similar oil was based on the viscosity and percentage components of the oil. The properties of the oil types are given in Volume III of the NRDAM/CME documentation.

Timothy Goodspeed (NOAA, Strategic Environmental Assessment Division, pers. comm., Nov. 1991) has analyzed the numbers and volumes of spills of oil of all types into U.S. waters using data obtained from the U.S. Coast Guard PIRS database. (Appendix C, Exhibit C.4) His analysis shows that 99.8% of spills are less than 50,000 gallons and 99% of spills are less than 10,000 gallons. Thus, for model runs used to develop the compensation formula, the spill volumes used were:

100 gal
1,000 gal
5,000 gal
10,000 gal
50,000 gal

The spills are all assumed to be instantaneous and spilled on the water surface.

Exhibit 2.1 Provinces and their boundaries (National Estuarine Atlas, NOAA, 1985).

Prov. Code	Province	Water Bodies and Boundaries
1	Northern Maine Coast	Passamaquoddy Bay (Maine-Canadian border) to line from Port Clyde to Monhegan Is., ME; incl. northern Gulf of Maine (<200m depth)
2	So. Maine and New Hampshire Coast	Port Clyde to NH-Mass. border; incl. NW Gulf of Maine (<200m) (southwest of line from Port Clyde to Monhegan Is. and north of 42° 52'N at NH-Mass border)
3	Gulf of Maine	central Gulf of Maine (>200m depth, east of Cape Cod at 69° 50'W, north of 42° 20'N)
4	Mass. Bay	Mass and Cape Cod Bays (NH border to Provincetown: west of 69° 50'W, outside Boston Harbor, south of 42° 52'N)
5	Boston Harbor	Boston Harbor (inside line from Hull to Nahant = Boston Bay of National Estuarine Atlas)
6	Georges Bank	Georges Bank (ICNAF 5Ze) (40° N - 42° 20'N, 65° 30'W - 69° 50'W)
7	Offshore Mid-Atlantic	South of Georges Bank, Atlantic Mid-Atlantic offshore (35° N - 40° N, >200m, plus >200m depth north of 40° N and west of 69° 50'W)
8	So. New England Shelf	So. New England Shelf (ICNAF 5Zw, west of 69° 50'W, east of Montauk Pt. at 71° 52'W, <200m, not incl. Buzzards and Narragansett Bays)
9	Buzzards Bay	Buzzards Bay (inside line from Cuttyhunk Is. to Gooseberry Neck)
10	Narragansett Bay	Narragansett Bay (north of line from Sakonnet Pt. to Narragansett Pier - as in National Estuarine Atlas)
11	Long Island Sound	Long Island Sound (west of Montauk Pt. at 71° 52'W = LIS and Gardiners Bay in National Estuarine Atlas)
12	New York Harbor	Hudson R. and NY harbor (inside line from Rockaway Pt. to Sandy Hook -- Hudson River/Raritan Bay in National Estuarine Atlas)
13	NY-NJ Shelf	NY-NJ Shelf (ICNAF 6A) (west of 71° 52'W, north of Cape May at 39° N, <200m)

Exhibit 2.1 (continued)

14	Delaware Bay	Delaware River and Delaware Bay (inside line from Cape May to Cape Henlopen)
15	Delmarva Shelf	Delmarva Shelf (ICNAF 6B) (Cape Henlopen to Cape Henry, 37° N - 39° N, <200m)
16	Upper Chesapeake	Upper Chesapeake Bay (north of 38° 30'N)
17	Lower Chesapeake	Lower Chesapeake Bay (south of 38° 30'N and inside (north of) line from Cape Charles to Cape Henry)
18	James River	James River and Hampton Roads (inside Hampton Roads Bridge-Tunnel)
19	Pamlico Sound	Pamlico Sound, Albemarle Sound complex (inside barrier islands running from Virginia Beach to Cape Lookout)
20	Hatteras Shelf	Virginia and North Carolina Shelf (ICNAF 6C) (35° N - 37° N, <200m, Cape Henry to Cape Lookout)
21	Carolina Shelf	No. and So. Carolina coast and shelf (Cape Lookout to So. Carolina-Georgia border at Hilton Head and Calibogue Sound, 32° 05'N - 35° N, <200m)
22	Georgia Bight	Georgia coast, Georgia Bight and Northern Florida coast (Savannah, Ga. to Cape Canaveral = Cape Kennedy, 28° 30'N - 32° 05'N, <200m)
23	Offshore Carolinian	Carolinian offshore (>200m, Cape Hatteras to Cape Canaveral, 28° 30'N - 35° N)
24	SE Florida Shelf	Southeast Florida coast and shelf (Cape Canaveral to Key Largo, 25° 10'N - 28° 30'N, <200m, not incl. Biscayne Bay)
25	Biscayne Bay	Biscayne Bay (inside line from Cape Florida to Ragged Keys)
26	Straits of Florida	Straits of Florida (Cape Canaveral to Key West, 23° 30'N - 28° 30'N, east of 82° W, >200m)
27	Caribbean Is.	Puerto Rico, U.S. Virgin Islands; Caribbean Sea islands
28	Florida Bay	Florida Bay and Everglades (east of line from Cape Romano to Key West, incl. shelf of Fla. Keys <200m)
29	SW Florida Shelf	Southwest Florida coast and shelf (Key West to Cedar Key, <200m, not incl. Fla. Bay, 24° 20'N - 29° 07'N)
30	Tampa Bay	Tampa Bay (inside line from Anna Maria I. to Egmont Key to Mullet Key)

Exhibit 2.1 (continued)

31	Offshore Gulf of Mexico	Gulf of Mexico >200m deep (west of 82° W)
32	South Texas Shelf	So. Texas coast and shelf (Port Aransas, TX to Mexican border, <200m, 26° N - 27° 50'N)
33	Florida-Miss. Shelf	Fla. panhandle, Ala., Miss. coast and shelf: (Cedar Key, Florida to Mississippi R. Delta, <200m)
34	Mobile Bay	Mobile Bay
35	Mississippi Sound	Miss. Sound, Lake Borgne Sound inside barrier islands (seaward); Lake Pontchartrain, Lake Maurepas (landward)
36	Mississippi River	Miss. River and Delta
37	Louisiana-No. Texas Shelf	La.-No. Texas coast and shelf (Miss. R. Delta to Port Aransas, TX)
38	Port Arthur	Sabine Lake, Port Arthur
39	Galveston Bay	Galveston Bay, Houston
40	So. Calif. Coast	So. Calif. coast and shelf incl. San Diego Bay (Mexican border to Huntington Beach, 32° 35'N - 33° 40'N, <200m)
41	Los Angeles Coast	Los Angeles coastal region (Huntington Beach to Point Dume, 33° 40'N - 34° N, <200m)
42	So. California Offshore	Offshore southern California (Mexican border to San Miguel Island, 32° 35'N - 34° N, >200m)
43	Santa Barbara Channel	Santa Barbara Channel (north of 34° N running along line from Pt. Dume to Anacapa Is. and through Channel Islands, east of line from Richardson Rock to Pt. Conception)
44	Central Calif. Coast	Central Calif. coast and shelf (Point Conception to Cape Mendocino, 34° 27'N - 40° 30'N, <200m)
45	Central Calif. Offshore	Offshore central California (San Miguel Is. to Cape Mendicino, 34° N - 40° 30'N, >200m)
46	San Francisco Bay	Sacramento River Delta to San Francisco Bay (inside Golden Gate Bridge)
47	No. Calif-Oregon Coast	No. Calif. and Oregon coast and shelf (Cape Mendocino to OR-Wash. border, 40° 30'N - 46° 15'N, <200m)
48	Columbia River	Columbia River

Exhibit 2.1 (continued)

49	Washington Outer Coast	Washington outer coast and shelf (Or-Wash. border to Cape Flattery, 46° 15'N - 48° 30'N, <200m)
50	Oregon-Wash. Offshore	No. Calif., Oregon, Wash. offshore (Cape Mendocino to Cape Flattery, >200m, 40° 30'N - 48° 30'N)
51	Puget Sound	Puget Sound (landward); Strait of Juan De Fuca, Strait of Georgia (seaward)
52	SE Alaska	SE Alaska coast and shelf (Dixon Entrance to Cape Spencer, <200m)
53	Yakutat	Coast of Alaska, Cape Spencer to Cape Suckling, <200m)
54	Copper River Shelf	Copper River Delta and shelf offshore of Prince William Sound (Cape Suckling to Cape Puget, <200m)
55	Prince Wm. Sound	Prince William Sound
56	Kenai Shelf	Kenai shelf (Cape Puget to Cape Elizabeth, <200m)
57	Upper Cook Inlet	Upper Cook Inlet (north of Anchor Point)
58	Lower Cook Inlet	Lower Cook Inlet (south of Anchor Point and line from Cape Douglas to Shuyak Is. to Cape Elizabeth, incl. Barren Is. area)
59	Shelikof Strait	Shelikof Strait (Cape Douglas to Kilokak Rocks)
60	Kodiak Shelf	Kodiak shelf - seaward side of Kodiak Island complex (Shuyak Is. to Trinity Is., <200m)
61	Chignik Shelf	south side of Alaska Peninsula (Kilokak Rocks to Kupreanof Pt., <200m)
62	So. AK Peninsula	south side of Alaska Peninsula (Kupreanof Pt. to Unimak Pass, <200m)
63	Aleutian	Aleutian Islands west of Unimak Pass (shelf north and south of islands, <200m)
64	Gulf of Alaska	Gulf of Alaska and North Pacific (>200m deep)
65	So. Bering Sea Shelf	Southern Bering Sea shelf (east of Unimak Pass and shelf break, to south of 60° N, north of Alaska Peninsula, <200m)
66	Bristol Bay	Bristol Bay (inside line from Cape Menshikof to Cape Newenham)
67	Kuskokwin Bay	Kuskokwim Bay (inside line from Cape Newenham to Cape Mendenhall on Nunivak Is.; south of 60° N latitude in Etolin Strait)

Exhibit 2.1 (continued)

68	No. Bering Sea	Northern Bering Sea Shelf (north of 60° N, south of line from East Cape = Mys Dezhneva to Cape Prince of Whales in Bering Strait, <200m)
69	Yukon Delta	Yukon Delta and River
70	Bering Sea Offshore	Offshore Bering Sea (>200m)
71	Norton Sound	Norton Sound (east of line from Point Romanof to Cape Nome)
72	Kotzebue Sound	Kotzebue Sound (inside line from Cape Espenberg to Cape Krusenstern)
73	Chukchi Sea	Chukchi Sea (north of Bering Strait to Point Barrow)
74	Beaufort Sea	Beaufort Sea (east of Point Barrow to Canadian border)
75	Hawaii	Hawaiian Islands (<200m)
76	Polynesia	Guam, other Pacific islands (<200m)
77	Central Pacific	Central Pacific (>200m)

Exhibit 2.2 Marine subtidal (rock, cobble, sand, mud) cases.

Case ID	Province # Run (Represent)	Province Name	Region Represented
M01	6 (3,6)	Georges Bank	Gulf of Maine - Georges Bank
M02	13 (7-8, 13, 15, 20)	NY-NJ Shelf	Mid-Atlantic Offshore
M03	21 (21-23)	Carolina Shelf	Carolinas to No. Fla. Shelf-Offshore
M04	29 (24, 26, 27, 29, 31-32)	SW Florida Shelf	So. Fla., So. Texas, Caribbean Shelf-Offshore
M05	37 (33, 35, 37)	La.-No. Texas Shelf	No. Gulf of Mexico Shelf
M06	43 (40-43)	Santa Barbara Channel	So. California Shelf-Offshore
M07	44 (44-45)	Central Calif. Coast (Gulf of Farallones)	Central Calif. Shelf-Offshore
M08	47 (47, 49-50)	Oregon Coast	Oregon-Wash. Shelf-Offshore
M09	56 (52-54, 56, 58-64)	Kenai Shelf	Gulf of Alaska
M10	65 (65-67, 70)	So. Bering Sea Shelf	So. Bering Sea
M11	71 (68, 71-73)	Norton Sound	No. Bering Sea to Chukchi Sea
M12	74 (74)	Beaufort Sea	Beaufort Sea
M13	75 (75-77)	Hawaii	Pacific Islands Shelf-Offshore

Exhibit 2.3 Estuarine and nearshore subtidal and intertidal cases. See Exhibit 2.6 for regions represented by each case.

Case ID	Province # Run (Represent)	Province Name	Location	Habitat Type (Exhibit 2.1)
E01	2 (1,2,4)	So. Maine and N.H. Coast	Casco Bay at Portland, ME	Rock-mud, open water
E02	4 (1-15)	Mass. Bay	Just north of Cape Ann	Saltmarsh, mud flats
E03	5 (5)	Boston Harbor	Boston Harbor entrance	Rock-mud, open water
E04	9 (8-9)	Buzzards Bay	In channel, near entrance	Rock-mud, open water
E05	10 (10)	Narragansett Bay	Near Newport in East Passage	Rock-mud, open water
E06	11 (11)	Long Island Sound	Western LIS	Rock-mud, open water
E07	12 (12)	NY Harbor	Arthur Kill	Rock-mud, open water
E08	14 (13-15)	Delaware Bay	Near mouth	Rock-mud, open water
E09	16 (16)	Upper Chesapeake	Baltimore (or Annapolis)	Rock-mud, open water
E10	17 (17-22)	Lower Chesapeake	Just inside Ches. Bay Bridge Tunnel	Rock-mud, open water
E11	19 (1-23)	Pamlico Sound	SW nearshore area	Seagrass beds (eelgrass)
E12	21 (16-24)	Carolina Shelf	Savannah River	Saltmarshes and flats
E13	25 (24-28)	Biscayne Bay	Miami	Rock-mud, open water
E14	26 (25-29)	Straits of Florida	Coral reefs along Florida Keys	Coral reef
E15	28 (24-32, 75-77)	Florida Bay	Near Key West	Seagrass beds

Exhibit 2.3 (continued)

E16	28 (24-32, 75-77)	Florida Bay	Everglades near mangroves	Mangrove swamp, mud flats
E17	30 (29-30, 32)	Tampa Bay	Near entrance	Rock-mud, open water
E18	34 (33-37)	Mobile Bay	Near entrance	Rock-mud, open water
E19	37 (33-39)	La.-No. Texas Shelf	Near wetlands in Barataria Bay	Saltmarsh, mud flat, seagrass beds
E20	39 (38, 39)	Galveston Bay	Near entrance	Rock-mud, open water
E21	40 (40-43)	So. California Coast	San Diego Bay area, Tijuana Estuary	Mud open water, saltmarsh
E22	44 (40-51)	Central California Coast	Monterey Bay near kelp beds	Kelp beds
E23	46 (44,46)	San Francisco Bay	San Francisco Bay just inside Golden Gate	Rock-mud, open water
E24	46 (44,46)	San Francisco Bay	At Sacramento R. Delta	Saltmarshes, mudflats
E25	48 (48)	Columbia River	Columbia River	Rock-mud, open water
E26	49 (47-50)	Washington Outer Coast	Grays Harbor open bay	Rock-mud, open water
E27	49 (47-51)	Washington Outer Coast	Grays Harbor near marshes	Saltmarsh, mudflats
E28	51 (51)	Puget Sound	Strait of Juan de Fuca near seaward entrance	Rock-mud, open water
E29	51 (51)	Puget Sound	Near Seattle	Rock-mud, open water
E30	55 (52-74)	Prince William Sound	PWS near entrance to Valdez arm	Rock-mud, open water, gravel shores, fjords
E31	57 (52-74)	Upper Cook Inlet	Near Anchorage	Mud flats
E32	65 (52-74)	So. Bering Sea Shelf	Port Moller near eelgrass	Seagrass beds
E33	75 (75-77)	Hawaii	Kaneohe Bay	Sand, open water
E34	75 (75-77)	Polynesia	Coral reef or atoll	Coral reef

Exhibit 2.4 Intertidal cases for beach damages.

CASE ID	**Province # Run (Represent)**	**Province Name**	**Intertidal Habitat**	**Region Represented**
I01	2 (1-39)	So. Marine and N.H. Coastal	Hard shore	East and Gulf of Mexico Coasts
I02	47 (40-51)	No. Calif-Oregon Coast	Hard shore	West Coast
I03	56 (52-74)	Kenai Shelf	Hard shore	Alaska
I04	75 (75-77)	Hawaii	Hard shore	Pacific Island
I05	20 (1-26)	Hatteras Shelf	Sand beach	East Coast
I06	37 (27-39)	La.-No. Texas Shelf	Sand beach	Gulf of Mexico
I07	44 (40-74)	Central California Coast	Sand beach	West Coast and Alaska
I08	75 (75-77)	Hawaii	Sand beach	Pacific Islands

For each case, the spill site and wind direction were chosen so that the spilled oil remained in the habitat-province designated for that case as much as possible. In this way the resulting damages are for the volume of oil spilled in that type of habitat and province. Spill locations (latitude and longitude) and wind directions used are in Exhibit A-3 (Appendix A). In some cases, the grid in the area of the spill was set up as a hypothetical location, with the desired habitat type assigned to all grid cells in the path of the spill. These cases are noted in Exhibit A-3 with an asterisk. Exhibit A-4 describes modifications needed to edit existing (default) habitat grids in Version 2.4 of the NRDAM/CME. These modifications can be made to the NRDAM/CME, Version 2.4, using the habitat editing tool (see Volume II of the documentation for Version 2.4). Various environmental inputs, discussed below, are specified by the user when a case is run.

International Station Meteorological Climate Summary (ISMCS) data set, available from the National Climatic Data Center (NCDC), was used to characterize winds for cases E01-E34, which represent the estuarine and nearshore subtidal and intertidal environments. The ISMCS data set is contained on CD-ROM. Along with summaries of several other meteorological parameters for over 5500 locations worldwide, the ISMCS data set contains monthly and annual wind speed and direction probability distributions for all coastal observation sites in the vicinity of each province. For the purposes of the compensation formula, annual speed and direction wind statistics were used. A mean wind vector for each station was obtained by calculating probability-weighted vectors for each speed-direction bin in the matrix, summing the east and north vector components, then dividing by the number of bins to determine the mean wind vector. A summary of the reference station and characteristic mean wind for each estuarine and nearshore case is presented in Exhibit B-1 in Appendix B.

Statistical summaries of data obtained from offshore meteorological buoys (Gilhousen et al., 1990) were used to characterize the mean wind for the offshore provinces. At these locations, the characteristic wind was chosen by selecting the most probable direction bin and the most probable speed bin from the annual speed-direction summary for the buoy selected as being most representative of the area. The reference stations, their locations, and characteristic mean winds for each offshore subtidal province are presented in Exhibit B-2 of Appendix B.

In most locations where spills occur, background (non-tidal) currents are relatively low. Thus, zero background current was assumed in all model runs.

Tidal currents are most important nearshore. Thus, in some nearshore and intertidal cases typical (mean based on NOAA's published tide tables) tidal currents were assumed, with the direction of the flood assumed up-estuary, upriver or towards shore (Exhibit A-5, Appendix A). Tidal period was 24.8 hours (one per day) in the Gulf of Mexico and 12.4 hours (2 per day) elsewhere.

Tidal ranges used (Exhibit A-5) were taken from CERC (1984) except those for Alaska, which came from Gundlach et al. (1986). Each spill event is assumed to start at high tide.

Monthly mean air and surface water temperatures, and annual mean suspended sediment concentrations and settling velocities, were assumed in the model runs. These are provided as defaults in the NRDAM/CME, Version 2.4. Values used are in Volume III of the NRDAM/CME (Version 2.4) documentation. All of these environmental parameters are specific to biological province (Exhibit 2.2).

Ice data for the Bering Sea, Norton Sound, and the Beaufort Sea (cases M10, M11, M12) were compiled as mean percent ice coverage by month for each of the three provinces from the Alaska Marine Ice Atlas published by University of Alaska (LaBelle et al., 1983). Documentation for this is available in NRDAM/CME, Version 2.4. Default ice data from Version 2.4 should be used for these compensation formula runs.

SETTING UP CASE EXAMPLES OF RUNS USED TO DEVELOP THE COMPENSATION FORMULA — CHAPTER 4

The cases used to generate the compensation formula may be run using the NRDAM/CME, Version 2.4. This section outlines the steps needed to run the cases that are relevant to a specific spill scenario or set of scenarios (i.e., not all 5500 runs need to be made to examine the compensation formula for a specific scenario or region). Sections 5 and 6 discuss interpretation of the results and generation of a compensation formula based on model runs, respectively. This allows examination of the compensation formula that would be generated based on runs of Version 2.4 of the NRDAM/CME and the methodologies of the January 1994 proposed compensation formula.

Inputs to the NRDAM/CME for compensation formula runs are summarized in Exhibit 4.1. The user needs to create a wind file and a current file to use in these runs according to the specifications listed in Exhibit 4.1. Additionally, the habitat grid for the location of the spill needs to be edited to be of uniform habitat (i.e., a hypothetical environment) if the case is listed in Exhibit A.4. Otherwise, the default habitats of the NRDAM/CME Version 2.4 should be used.

The steps for performing a compensation formula run are as follows. The NRDAM/CME User's Manual (Volume II of the documentation) and the Tutorial for the NRDAM/CME (French and Rines, 1995) should be consulted for more specified details on running the software.

(1) Enter the NRDAM/CME Version 2.4 program and select the location for the case to be run. Exhibit A-1 lists the cases under the appropriate locations.

(2) Create a wind file using the wind data entry tool in the NRDAM/CME. The wind data needs to be specific to the case and season. The same file can be used for all oils and volumes spilled for that case. The wind should be constant starting on the spill date (according to season, Exhibit 4.1) and continuing for at least one month, at the speed and direction specified in Exhibit A.3.

(3) Create a current file if the case assumed non-zero tidal currents (Exhibit A.5). For all cases background currents are assumed zero. Tidal currents as per Exhibit A.5 should be entered with either one or two tides per day, as specified. A unique current file must be created for each case. This file may be used for all runs of varying season, oil, or volume spilled for a given case.

(4) To enter the currents, first create a grid surrounding the spill site and large enough to encompass any potentially affected areas for the scenarios. Next enter the tidal vector specified in Exhibit A.5 at the spill site. The current entry tool will spread the vector uniformly over the current grid to create unidirectional current field. The current tool also asks the user if one or two tides per day are desired (Exhibit A.5).

(5) If specified as necessary in Exhibit A.4, edit the habitat grid (using the habitat editor tool in NRDAM/CME Version 2.4) where the spill site occurs. Exhibit A.4 describes the habitat code changes needed. For cases in wetlands ("saltmarsh" or "wetland"), change subtidal open water habitats to extensive wetlands and intertidal habitats to fringing wetlands. For eelgrass and coral reef habitats, change all subtidal cells to these types. For rocky shore habitat, change all intertidal cells to this type. The cells to edit are those downwind of the spill site.

(6) Under the run model menu option, set up and run the scenario desired. Exhibit 4.1 outlines the sources of the needed data to be entered into the scenario form. Steps 2,3, and 4 above set up all needed files. All other inputs are made while setting up the scenario to run.

Exhibit 4.1 Summary of Model Inputs for compensation formula runs using the NRDAM/CME (Version 2.4).

User Input	Source of Information/Entry
Spill site: latitude longitude	[from Exhibit A-3, based on selection of case from Exhibit A-1 and A-2]
Habitat and editing	[use default habitats at spill site, unless specified otherwise in Exhibit A-4]
Spill date: year month day hour	 1991 Jan, Apr., July, or Oct. for winter, spring, summer, or fall 5 0
Spill amount (gal.): Stage 1 Stage 2	 100, 1000, 5000, 10000, or 50000 0
Spill duration (hrs): Stage 1 Stage 2	 0 0
Chemical (oil)	Heavy (Prudhoe) crude, Light crude, No. 2 Fuel, Lt. Diesel, or Gasoline [use Exhibit A-6 to select an appropriate proxy to the oil spilled]
Wind file	[Create wind file of constant wind starting at the spill date according to Exhibit A-3]
Current file	[If no currents; no file used] [If tidal currents: create current grid surrounding study site with no (0) background current and uniform diurnal or semi-diurnal flood tidal currents at speed and direction given in Exhibit A-5]
Cleanup file	None
Ice file	For cases other than M10, M11, and M12: none Case M10: Ice Grid 5 Case M11: Ice Grid 4 Case M12: Ice Grid 1
Time of high tide	0 hours

Exhibit 4.1 (continued)

Tide range (m)	[from Exhibit A-5]
Air temperature	Default for location*
Water temperature	Default for location*
Suspended sediment; concentration settling velocity	 Default for location* Default for location*
Price Index	117.2
Closures	None
* These defaults are supplied by the user interface as part of the prompt when a case is run. They are documented in Volume III of the documentation for the NRDAM/CME, Version 2.4.	

The compensation formula in the January 1994 proposed rule was based on an interpolation of 5,500 model runs. All results were calculated in mid-1991 U.S. dollars.

In general with increasing volume spilled, damages ($) increase while damages ($) per gallon spilled decrease. The damages are also very sensitive to oil type spilled. Heavier crudes and fuels remain as slicks for longer periods and, therefore, oil more wildlife than light distillates. However, the light distillates contain more toxic aromatic components that can injure more fish, shellfish, and their young-of-the-year, especially when wind entrains the oil in the water column and at higher temperatures.

The highest damages result in locations (cases) and seasons where biological abundances are highest, e.g., seagrass beds, mangrove swamps, and wetlands on the Pacific coast where birds concentrate (due to the scarcity of suitable habitat). West coast and Alaska damages are generally dominated by wildlife losses because of high relative abundances of these animals and low temperatures. California wildlife losses are relatively high both because of higher wildlife abundances and larger non-consumptive use values due to a larger population of people over which the values are aggregated.

It should be noted that the use of artificially large uniform habitats (such as wetlands) in running cases for the compensation formula may magnify the damages resulting from a spill at a given location over that which would be obtained from the NRDAM/CME, Version 2.4, run with default (mixed) habitats. The purpose of the compensation formula is to estimate damages if the entire volume spilled were retained in the selected habitat. Thus, the volume spilled in a given habitat should match as closely as possible that which occurred in reality. NOAA's January 1994 proposed OPA NRDA regulations allow damages for two sublots of the spill into two habitats to be used in calculating damages using the compensation formula.

The relationship between damages and volume spilled is a complex non-linear function which varies by case and conditions. This is because of the many non-linear algorithms in the model and the complexity of the environment for the model run (gridded habitat types, depths, etc.) Thus, the proposed compensation formula was derived by a linear interpolation of the model run results for a given case, season, and oil type.

GENERATION OF THE COMPENSATION FORMULA AND RESULTING DAMAGES CHAPTER 6

The compensation formula calculates damages for each of 5 ranges of volume spilled, from 0 gallons to 50,000 gallons. The five volumes defining ranges are 100, 1000, 5000, 10000, and 50000 gallons. The volumes included in the range are greater than or equal to the minimum and less than the maximum, with the exception of 50,000 gallons, which is included in the largest volume category. 1991 $ damages for the interval of spill size is a linear function of spill volume:

$$1991\$ = m(VOL) + b$$

where m is the slope, VOL is the volume spilled in gallons, and b is the intercept.

The values of m and b are calculated from damages obtained at the two volumes defining the interval, $VOL_1 < VOL_2$, just below and above the spill volume of interest:

$$m_{1,2} = \frac{(1991\$_2 - 1991\$_1)}{(VOL_2 - VOL_1)}$$

$$b_{1,2} = 1991\$_2 - m(VOL_2)$$

where $m_{1,2}$ and $b_{1,2}$ are specific to the volume range, case, oil and season. Note that the proposed rule of January 1994 did not include spills of less than 10 gallons as applicable for the compensation formula. However, the range of 10 to 100 gallons is calculated using zero damages and gallons for 1991$ and VOL_1, respectively.

Thus, if one wishes to develop the formula and resulting damages for a selected spill scenario, one would proceed as follows. The volume spilled affected some area. The 1994 proposed rule allowed accounting for one or two habitat-province combinations affected. The volume affecting each of the possible habitat-province combinations of Exhibit A-1 and A-2 needs to be estimated. (Note that the 1994 proposed rule allowed cleanup volume over the first 24 hours after the spill to be subtracted.) The two most significant habitat-province combinations in terms of spill volume and effects should be selected as the cases to use.

Runs for the case(s) should be performed for the oil type, season, and the two volumes defining ranges just below and above the case's spill volume. The calculations above then provide slope and intercept for the range of volumes, case, oil, and season. The damages for the spill scenario are then calculated as:

$$\sum_i 1991\$_i = \Sigma\left(m_i (VOL_i) + b_i\right)$$

where the subscript i represents the case, oil, season and volume range combination. VOL_i is the actual volume assigned to case-oil-season-range i.

Damages calculated in 1991 U.S. dollars may be translated to U.S. dollars of another year using the gross national product price deflator price index. This may be obtained from the Economic Report of the President (e.g., 1990) or the Survey of Current Business for years not yet in the Economic Report.

In addition to the damages resulting from biological injuries that are specified by the above formula, damages due to lost recreational use of beaches may be claimed. These damages are calculated from closures of beaches for known lengths of shore and times. The data and procedures are described fully in the documentation to the proposed OPA rule, compensation formula, and in Version 2.4 of the NRDAM/CME (which uses the same data).

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DATA SPECIFICATIONS FOR COMPENSATION FORMULA MODEL RUNS — APPENDIX A

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Exhibit A.1 Location key for estuarine and marine compensation formula cases.

EAST AND GULF COASTS (Location = E_COAST):	
M01	Gulf of Maine - Georges Bank
M02	Mid-Atlantic shelf - offshore
M03	Carolinas to No. Fla. shelf - offshore
M04	So Fla., Caribbean, So. Texas, shelf-offshore
M05	No. Gulf of Mexico shelf
E01	Maine to Mass. Bay coast
E02	NE saltmarsh
E03	Boston Harbor
E04	Buzzards Bay and So. Mass. coast
E05	Narragansett Bay
E06	Long Island Sound
E07	NY Harbor
E08	NY-NJ - Delaware bays
E09	Upper Chesapeake Bay
E10	Lower Chesapeake Bay
E11	Atlantic eelgrass bed
E12	SE saltmarsh
E13	SE Fla. and Caribbean bays
E14	Atlantic and Caribbean coral reef
E15	Subtropical seagrass bed
E16	Mangrove swamp
E17	Tampa Bay and So. G. of Mexico bays
E18	Mobile Bay and No. G. of Mexico bays
E19	Gulf of Mexico wetlands
E20	Galveston Bay and No. Texas Bays
I01	East and Gulf of Mexico coast rocky shore
I05	East coast sand beach
I06	Gulf of Mexico coast sand beach
PACIFIC COAST (Location = W_COAST):	
M06	So. California shelf-offshore
M07	Central California shelf-offshore

Exhibit A.1 (continued)

M08	Oregon-Wash. shelf-offshore
E21	So. California saltmarsh
E22	California kelp bed
E23	San Francisco Bay
E24	Northern California wetland
E25	Columbia River
E26	Pacific NW coastal bay
E27	Pacific NW wetlands
E28	Strait of Juan de Fuca
E29	Puget Sound
I02	West coast rocky shore
I07	West and Alaska coast sand beach
ALASKA (Location = ALASKA):	
M09	Gulf of Alaska
M10	So. Bering Sea
M11	No. Bering Sea to Chuckchi Sea
M12	Beaufort Sea
E30	Gulf of Alaska bays, sounds
E31	Gulf of Alaska mud flats
E32	Alaska eelgrass bed
I03	Alaska rock-gravel shoreline
PACIFIC ISLANDS (Location = PACIF_IS):	
M13	Pacific islands shelf - offshore
E33	Pacific islands bays
E34	Pacific coral reef
I04	Pacific island rocky shore
I08	Pacific island sand beach

Exhibit A.2 Case IDs for each province and habitat combination.

Province # Name		Hard Shore	Sand Beach	Mud Flat	Salt-marsh	Man-grove Swamp	Kelp Bed	Sea-grass Bed	Coral Reef	Estuarine Subtidal open water	Marine Subtidal open water
1	Northern Maine Coast	I01	I05	E01	E02	-	-	E11	-	E01	E01
2	So. Maine and New Hampshire Coast	I01	I05	E01	E02	-	-	E11	-	E01	E01
3	Gulf of Maine	I01	I05	E01	E02	-	-	E11	-	E01	M01
4	Mass. Bay	I01	I05	E01	E02	-	-	E11	-	E01	E01
5	Boston Harbor	I01	I05	E03	E02	-	-	E11	-	E05	-
6	Georges Bank	-	-	-	-	-	-	-	-	-	M01
7	Offshore Mid-Atlantic	-	-	-	-	-	-	-	-	-	M02
8	So. New England Shelf	I01	I05	E04	E02	-	-	E11	-	E04	M02
9	Buzzards Bay	I01	I05	E04	E02	-	-	E11	-	E04	-
10	Narragansett Bay	I01	I05	E05	E02	-	-	E11	-	E05	-
11	Long Island Sound	I01	I05	E06	E02	-	-	E11	-	E06	-
12	New York Harbor	I01	I05	E07	E02	-	-	E11	-	E07	-
13	NY-NJ Shelf	I01	I05	E08	E02	-	-	E11	-	E08	M02
14	Delaware Bay	I01	I05	E08	E02	-	-	E11	-	E08	-
15	Delmarva Shelf	I01	I05	E08	E02	-	-	E11	-	E08	M02
16	Upper Chesapeake	I01	I05	E09	E12	-	-	E11	-	E09	-
17	Lower Chesapeake	I01	I05	E10	E12	-	-	E11	-	E10	-
18	James River	I01	I05	E10	E12	-	-	E11	-	E10	-
19	Pamlico Sound	I01	I05	E10	E12	-	-	E11	-	E10	-
20	Hatteras Shelf	I01	I05	E10	E12	-	-	E11	-	E10	M02
21	Carolina Shelf	I01	I05	E10	E12	-	-	E11	-	E10	M03
22	Georgia Bight	I01	I05	E10	E12	-	-	E11	-	E10	M03
23	Offshore Carolinian	-	-	-	-	-	-	-	-	-	M03
24	SE Florida Shelf	I01	I05	E13	E12	E16	-	E15	-	E13	M04

Exhibit A.2 (continued)

25	Biscayne Bay	I01	I05	E13	-	E16	-	E15	E14	E13	-
26	Straits of Florida	I01	I05	E13	-	E16	-	E15	E14	E13	M04
27	Caribbean Is.	I01	I06	E13	-	E16	-	E15	E14	E13	M04
28	Florida Bay	I01	I06	E13	-	E16	-	E15	E14	E13	-
29	SW Florida Shelf	I01	I06	E17	-	E16	-	E15	E14	E17	M04
30	Tampa Bay	I01	I06	E17	-	E16	-	E15	-	E17	-
31	Offshore Gulf of Mexico	-	-	-	-	-	-	-	E14	-	M04
32	South Texas Shelf	I01	I06	E17	E19	E16	-	E15	-	E17	M04
33	Florida-Miss. Shelf	I01	I06	E18	E19	-	-	E19	-	E18	M05
34	Mobile Bay	I01	I06	E18	E19	-	-	E19	-	E18	-
35	Mississippi Sound	I01	I06	E18	E19	-	-	E19	-	E18	M05
36	Mississippi River	I01	I06	E18	E19	-	-	E19	-	E18	-
37	Louisiana-No. Texas	I01	I06	E18	E19	-	-	E19	-	E18	M05
38	Port Arthur	I01	I06	E20	E19	-	-	E19	-	E20	-
39	Galveston Bay	I01	I06	E20	E19	-	-	E19	-	E20	-
40	So. Calif. Coast	I02	I07	E21	E21	-	E22	E21	-	E21	M06
41	Los Angeles Coast	I02	I07	E21	E21	-	E22	E21	-	E21	M06
42	So. California Offshore	I02	I07	E21	E21	-	E22	E21	-	E21	M06
43	Santa Barbara Channel	I02	I07	E21	E21	-	E22	E21	-	E21	M06
44	Central Calif. Coast	I02	I07	E24	E24	-	E22	E24	-	E23	M07
45	Central Calif. Offshore	-	-	-	-	-	-	-	-	-	M07
46	San Francisco Bay	I02	I07	E24	E24	-	E22	E24	-	E23	M07
47	No. Calif-Oregon Coast	I02	I07	E27	E27	-	E22	E27	-	E26	M08
48	Columbia River	I02	I07	E27	E27	-	E22	E27	-	E25	-
49	Washington Outer Coast	I02	I07	E27	E27	-	E22	E27	-	E26	M08
50	Oregon-Wash. Offshore	I02	I07	E27	E27	-	E22	E27	-	E26	M08
51	Puget Sound	I02	I07	E27	E27	-	E22	E27	-	E29	E28

Exhibit A.2 (continued)

52	SE Alaska	I03	I07	E31	E32	-	-	E32	-	E30	M09
53	Yakutat	I03	I07	E31	E32	-	-	E32	-	E30	M09
54	Copper River Shelf	I03	I07	E31	E32	-	-	E32	-	E30	M09
55	Prince Wm. Sound	I03	I07	E31	E32	-	-	E32	-	E30	E30
56	Kenai Shelf	I03	I07	E31	E32	-	-	E32	-	E30	M09
57	Upper Cook Inlet	I03	I07	E31	E32	-	-	E32	-	E30	M09
58	Lower Cook Inlet	I03	I07	E31	E32	-	-	E32	-	E30	M09
59	Shelikof Strait	I03	I07	E31	E32	-	-	E32	-	E30	M09
60	Kodiak Shelf	I03	I07	E31	E32	-	-	E32	-	E30	M09
61	Chignik Shelf	I03	I07	E31	E32	-	-	E32	-	E30	M09
62	So. AK Penisula	I03	I07	E31	E32	-	-	E32	-	E30	M09
63	Aleutian	I03	I07	E31	E32	-	-	E32	-	E30	M09
64	Gulf of Alaska	I03	I07	E31	E32	-	-	E32	-	E30	M09
65	So. Bering Sea Shelf	I03	I07	E31	E32	-	-	E32	-	E30	M10
66	Bristol Bay	I03	I07	E31	E32	-	-	E32	-	E30	M10
67	Kuskokwin Bay	I03	I07	E31	E32	-	-	E32	-	E30	M10
68	No. Bering Sea	I03	I07	E31	E32	-	-	E32	-	E30	M11
69	Yukon Delta	I03	I07	E31	E32	-	-	E32	-	E30	-
70	Bering Sea Offshore	I03	I07	E31	E32	-	-	E32	-	E30	M10
71	Norton Sound	I03	I07	E31	E32	-	-	E32	-	E30	M11
72	Kotzebue Sound	I03	I07	E31	E32	-	-	E32	-	E30	M11
73	Chukchi Sea	I03	I07	E31	E32	-	-	E32	-	E30	M11
74	Beaufort Sea	I03	I07	E31	E32	-	-	E32	-	E30	M12
75	Hawaii	I04	I08	E33	-	E16	-	E33	E34	E33	M13
76	Polynesia	I04	I08	E33	-	E16	-	E33	E34	E33	M13
77	Central Pacific	I04	I08	E33	-	E16	-	E33	E34	E33	M13

Exhibit A.3 Spill locations, wind direction (degrees, from), and wind speed (knots, m/sec) for each case used to derive the compensation formula (* = hypothetical scenario assuming the desired habitat is present and extensive at the spill location).

Case ID	Location Description	Latitude (N) (deg, min)	Longitude (W) (deg, min)	Wind Dir (deg) from	Wind Speed kts (m/sec)
E01	Casco Bay, Portland, ME	43 20.866	70 17.330	215	5 (2.5)
E02	Cape Ann, Mass. Bay, saltmarsh*	42 42.866	70 37.350	80	7 (3.6)
E03	Boston Harbor	42 23.800	70 55.583	0	7 (3.6)
E04	Buzzard's Bay Channel	41 30.000	70 54.000	220	6 (2.8)
E05	Narragansett Bay	41 28.233	71 24.860	180	6 (2.8)
E06	Long Island Sound	40 53.0	73 44.0	250	6 (3.2)
E07	New York Harbor	40 41.650	74 2.500	85	4 (2.0)
E08	Delaware Bay	38 52.000	75 3.000	155	5 (2.6)
E09	Upper Chesapeake Bay	38 27.166	76 23.580	180	5 (2.6)
E10	Lower Chesapeake Bay	36 57.0	76 8.900	180	6 (3.1)
E11	Pamlico Sound, eelgrass bed *	35 41.716	75 33.000	45	6 (2.8)
E12	Savannah River	32 2.0	80 50.800	190	4 (2.3)
E13	Biscayne Bay, FL	25 21.333	80 18.130	190	6 (3.0)
E14	Florida Keys - coral reef *	24 36.150	81 9.600	242	8 (3.8)
E15	Florida Bay - seagrass bed	24 53.450	80 42.730	180	8 (3.8)
E16	Florida Everglades, mangroves	25 8.0	80 42.0	110	5 (2.5)
E17	Tampa Bay	27 37.783	82 39.850	220	5 (2.3)
E18	Mobile Bay	30 15.3	88 0.0	180	5 (2.7)

Exhibit A.3 (continued)

E19	Louisiana coastal wetlands	29 16.3	90 2.3	135	6 (3.0)
E20	Galveston Bay	29 23.183	94 48.710	160	5 (2.7)
E21	So. Calif. wetland *	32 43.200	117 12.300	350	6 (2.8)
E22	Monterey Bay kelp bed	36 55.716	121 54.910	350	6 (2.8)
E23	San Francisco Bay	37 47.400	122 19.680	330	8 (4.0)
E24	Sacramento R. Delta	38 3.000	121 55.130	270	8 (4.0)
E25	Columbia River	46 14.616	123 55.610	270	5 (2.6)
E26	Grays Harbor, Wash., open water	46 56.1	124 7.0	260	4 (2.2)
E27	Willapa Bay, Wash., wetlands *	46 42.0	124 2.0	270	4 (2.2)
E28	Strait of Juan de Fuca	48 27.0	124 37.0	295	6 (2.9)
E29	Puget Sound	47 41.233	122 27.910	340	4 (2.2)
E30	Prince William Sound, AK	60 41.64	146 55.0	30	7 (3.3)
E31	Upper Cook Inlet, mudflats	60 59.1	149 43.0	295	7 (3.3)
E32	Port Moller, eelgrass beds *	55 57.550	160 47.510	295	7 (3.3)
E33	Kaneohe Bay, Hawaii	21 32.133	157 49.460	345	8 (4.2)
E34	Pacific coral reef, Hawaii *	21 43.266	158 1.100	45	8 (4.2)
M01	Georges Bank	41 35.0	69 37.0	270	14 (6.9)
M02	New York - NJ Shelf	39 4.000	74 20.0	210	14 (6.9)
M03	Carolinas Shelf	33 12.0	78 30.0	240	14 (6.9)
M04	Florida Shelf	25 30.0	82 0.0	90	14 (6.9)
M05	La. - N. Texas Shelf	28 35.000	93 6.950	150	14 (6.9)

Exhibit A.3 (continued**)**

M06	Santa Barbara Channel	34 20.516	120 19.750	290	14 (6.9)
M07	Central Calif. Shelf	38 26.283	123 22.860	335	14 (6.9)
M08	Oregon Coast	46 0.0	124 24.300	0	5 (2.6)
M09	Kenai Shelf	58 40.0	151 22.0	225	7 (3.3)
M10	South Bering Sea	58 31.166	166 57.310	0	10 (5.1)
M11	Norton Sound	64 28.0	161 42.0	50	14 (6.9)
M12	Beaufort Sea	70 28.233	148 31.350	270	8 (3.8)
M13	Hawaii, offshore, <200 m	20 58.5	157 16.0	270	8 (4.2)
I01	Maine, rocky shore	43 42.316	70 12.950	200	5 (2.5)
I02	Oregon, rocky shore*	45 9.0	124 0.0	0	5 (2.6)
I03	Kenai Peninsula, gravel shore	59 16.0	150 50.0	225	7 (3.3)
I04	Hawaiian rocky shore	21 43.0	158 0.0	40	8 (4.2)
I05	Cape Hatteras, sand beach	35 25.700	75 26.880	165	6 (3.1)
I06	Texas Coast, sand beach	29 40.000	94 3.0	70	5 (2.7)
I07	California, sand beach	36 1.000	121 31.230	320	8 (4.0)
I08	Hawaiian sand beach	21 37.083	157 53.0	330	8 (4.2)

Exhibit A.4 Habitat editing for creation of hypothetical scenarios in uniform habitats. The default habitat types in the grid(s) noted should be changed to the desired habitat type using the NRDAM/CME (Version 2.4) habitat editor.

Case ID	**Uniform Habitat Assumed**	**Version 2.4 Grid(s) to Edit**	**Version 2.4 Default Habitat**	**Edited Habitat Type**
E2	Saltmarsh	0402	Sand Beach	Fringing wetland
			Fringing mudflat	Fringing wetland
			Subtidal silt-mud	Extensive wetland
E11	Eelgrass bed	1902, 1901	Subtidal silt-mud	Seagrass bed (subtidal)
E14	Coral reef	2803	Subtidal silt-mud	Subtidal coral reef
E21	Wetland	4001	Sand beach	Fringing wetland
			Subtidal silt-mud	Extensive wetland
E27	Wetland	4901	Sand Beach	Fringing wetland
			Subtidal silt-mud	Extensive wetland
			Seagrass bed (subtidal)	Extensive wetland
E32	Eelgrass bed	6502	Subtidal silt-mud	Seagrass bed (subtidal)
E34	Coral Reef	7504	Subtidal silt-mud	Subtidal coral reef
I02	Rocky shore	4704	Sand Beach	Rocky shore
			Seagrass bed (subtidal)	Subtidal silt-mud
			Fringing wetland	Rocky Shore

Exhibit A.5 Tidal currents used for model runs for those cases where tidal currents were assumed on-zero. (The direction is that of the major axis and the flood tide.)

Case ID	Flood Direction (degrees toward)	Speed kts (m/sec)	# of Tides per day	Tide Range (m)
E02	270	0.5 (.25)	2	4.0
E12	10	0.5 (.25)	2	1.5
E16	0	0.25 (.13)	1	0.8
E19	0	0.1 (.05)	1	0.3
E21	135	0.5 (.25)	2	1.2
E24	90	0.5 (.25)	2	1.2
E27	90	0.5 (.25)	2	2.1
E31	140	1.0 (.50)	2	5.0
I01	315	0.1 (.05)	2	4.0
I02	90	0.1 (.05)	2	2.1
I03	315	0.1 (.05)	2	3.0
I04	135	0.1 (.05)	2	0.1
I05	270	0.1 (.05)	2	1.5
I06	315	0.1 (.05)	1	0.3
I07	90	0.1 (.05)	2	1.2
I08	225	0.1 (.05)	2	0.1

Exhibit A.6 Closest oil type in compensation formula to various oils that may be spilled.

CHRIS CODE	**SPILLED OIL TYPE**	**CLOSEST OIL**
CHx	CRUDE HYDROCARBON FEEDSTOCK	Light crude
DFF	DISTILLATES - FLASH FEEDSTOCK	Gasoline
Gxx	GASOLINES	Gasoline
JPx	JET FUELS	Diesel
KRS	KEROSENE	Diesel
MNS	MINERAL SPIRITS	Gasoline
Nxx	NAPHTHAS	Gasoline
OCF	OIL, CLARIFIED	Light crude
ODS	DIESEL	Diesel
OFR	NO. 4 FUEL OIL	No. 2 fuel oil
OFV	NO. 5 FUEL OIL	No. 2 fuel oil
OIL	CRUDE OIL	Heavy or light crude
OLB	LUBRICATING OIL	Heavy crude
OMx	MINERAL/MOTOR OIL	Heavy crude
OOx	NO. 1 FUEL OIL	Diesel
OPT	PENETRATING OIL	No. 2 fuel oil
ORD	ROAD OIL	Heavy crude
ORG	RANGE OIL	No. 2 fuel oil
OSD	SPINDLE OIL	No. 2 fuel oil
OSX	NO. 6 FUEL OIL	Heavy crude
OSY	SPRAY OIL	No. 2 fuel oil
OTB	TURBINE OIL	Light crude
OTD	NO.2-D FUEL OIL	No. 2 fuel oil
OTW	NO.2 FUEL OIL	No. 2 fuel oil
PTN	PETROLEUM NAPHTHA	Gasoline
WTO	WASTE OILS	Heavy crude

SOURCES OF ENVIRONMENTAL DATA FOR COMPENSATION FORMULA CASES — APPENDIX B

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Exhibit B-1 Mean wind speed assumed for each case, based on reference station summaries from International Station Meteorological Climate Summary (ISMCS) data. The mean wind direction is for the same data, but was not necessarily used in the simulations (see text for explanation).

Estuarine/ Nearshore Case(s)	Reference Wind Station Name	Reference Station WMO#	Mean wind speed		Mean Wind Direction (deg)
			(m/sec)	(knots)	
E1	Portland, ME	726060	2.5	4.9	279
E2, E3	Boston, MA	725090	3.6	6.9	287
E4, E5	Providence, RI	725070	2.8	5.4	280
E6, E7	NY Kennedy, NY	744860	3.2	6.2	282
E8	Wilmington, DE	724089	2.6	5.1	286
E9	Baltimore, MD	724060	2.6	5.0	288
E10	Norfolk, VA	723080	3.1	6.0	256
E11	Cape Hatteras, NC	723040	2.8	5.4	255
E12	Jacksonville, FL	722060	2.3	4.5	262
E13	Miami, FL	722020	3.0	5.8	245
E14, E15	Key West, FL	722010	3.8	7.5	232
E16	Fort Myers, FL	722106	2.5	4.9	242
E17	Tampa, FL	722110	2.3	4.4	253
E18	Mobile, AL	722230	2.7	5.3	253
E19	Port Arthur, TX	722410	3.0	5.9	248
E20	Houston, TX	722430	2.7	5.3	249
E21	San Diego, CA	722900	2.6	5.1	302
E22, E23, E24	San Francisco, CA	724940	4.0	7.8	309
E25	Portland, OR	726900	2.6	5.1	275
E26, E27	Quillayute, WA	727970	2.2	4.3	269
E28	Whidbey Island, WA	727975	2.9	5.7	273
E29	Seattle-Tacoma, WA	727930	2.8	5.4	259
E30	Kodiak, AK	703500	3.3	6.4	277
E31	Anchorage, AK	702730	2.1	4.0	252
E32	Adak, AK	704543	4.2	8.2	275
E33	Kaneohe Bay, HI	911760	4.2	8.2	220
E34	Pago Pago, PI	917650	4.2	8.2	238

Exhibit B.2 Mean wind speed for each case, based on NOAA data buoy and ISMCS summaries. The mean wind direction is for the same data, but was not necessarily used in the simulations (see text for explanation).

Offshore Case	Buoy # Station Name	Buoy Latitude (deg N)	Buoy Longitude (deg W)	Mean Wind Speed (m/s)	(knots)	Mean Wind Direction (deg)
M1	44003	40.8	68.5	6.9	13.5	270
M2	44001	38.7	73.6	6.9	13.5	210
M3	41005	31.7	79.7	6.9	13.5	240
M4	42003	26.0	85.9	6.9	13.5	090
M5	42011	29.6	93.5	6.9	13.5	150
M6	46023	34.3	120.7	6.9	13.5	330
M7	46013	38.2	123.3	6.9	13.5	330
M8	46027	41.8	124.4	2.6	5.0	000
M9	46001	56.3	148.3	6.9	13.5	240
M10	46017	60.3	172.3	6.9	13.5	030
M11	46016	63.3	170.3	6.9	13.5	060
M12	Barrow	71.3	156.8	3.8	7.3	240
M13	51003	19.2	160.8	6.9	13.5	060

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Exhibit C.1 Oil Types and Volumes (Gallons) spilled into U.S. Waters (1973-90) from the U.S. Coast Guard Coastal Oil Spill Data Set.

CHRIS CODE	OIL TYPE	NUMBER OF SPILLS	LARGEST SPILL	TOTAL VOLUME
Axx	ASPHALTS	495	111510	782833
CCx	CREOSOTE	254	10000	14813
CHx	CRUDE HYDROCARBON FEEDSTOCK	6	966000	985859
DFF	DISTILLATES FLASH FEEDSTOCK	175	120000	193093
Gxx	GASOLINES	7155	1345683	10753454
JPx	JET FUELS	816	840000	3828917
KRS	KEROSENE	391	442000	1734667
LNG	LIQUIDFIED NAT. GAS	76	2352	12851
LPG	LIQUIFIED PETRO. GAS	80	126000	273481
MNS	MINERAL SPIRITS	77	8000	19387
Nxx	NAPTHAS	183	109200	160398
OCF	OIL, CLARIFIED	2468	252000	5956817
ODS	DIESEL	6428	237343	1776014
OFR	NO. 4 FUEL OIL	1380	1000000	2333450
OFV	NO. 5 FUEL OIL	192	339360	457740
OIL	CRUDE OIL	41531	10500000	59072725
OLB	LUBRICATING OIL	2866	32000	185190
OMX	MINERAL/MOTOR OIL	3876	1050000	1929301
OOx	NO. 1 FUEL OIL	8414	6000020	11908571
OPT	PENETRATING OIL	445	9999	61283
ORD	ROAD OIL	160	200000	285743
ORG	RANGE OIL	459	1260000	2388506
OSD	SPINDLE OIL	675	4100	36698
OSX	NO. 6 FUEL OIL	7824	7500000	29351645
OSY	SPRAY OIL	963	300000	458327
OTB	TURBINE OIL	686	4400	44550
OTD	NO.2-D FUEL OIL	3725	2041662	4024831
OTW	NO.2 FUEL OIL	8991	1260000	6170111
PTN	PETROLEUM NAPHTHA	43	84000	217449
WCA,WPF	WAXES	71	12000	52758
WTO	WASTE OILS	3538	28000	183245

Exhibit C.2 1987 cargo tons by port, from port needs study (Maio, et al., 1991).

PORT	CRUDE OIL	GASOLINE	JET FUEL	KEROSENE	DISTIL. FUEL	RESID. FUEL	LUBRIC. OIL	LIQUID PETROL.	TOTAL
PORTLAND, ME	3,509,529	1,806,678	36,068	77,409	1,401,896	872,129	1,045,044		8,748,753
PORTSMOUTH, NH		204,422	101,1165	76,975	975,523	678,943		276,235	2,313,263
MASS BAY (BOSTON)	69,329	5,555,568	1,072,776	160,762	6,245,174	4,610,408	107,505	1,190	17,822,712
PROVIDENCE, RI		4,113,118	91,032	70,606	2,813,174	1,079,368	23,323	137,570	8,328,191
LONG ISLAND SOUND		6,858,246	340,852	142,081	6,387,891	3,734,934	35		17,464,039
NY HARBOR, NY	21,026,134	69,534,220	4,379,760	1,690,811	40,089,710	66,855,793	1,845,914	194,520	205,616,862
DELAWARE BAY	19,566,687	4,095,034	259,758	151,378	3,174,576	9,498,950	181,784	165,845	37,094,012
CHES. SOUTH	4,082,102	3,793,159	1,939,939	181,721	4,092,513	13,215,390	153,159	122,267	27,580,250
CHES. NORTH	12,770	2,251,247	673,880	153,169	2,109,124	4,558,946	87,768	1,085	9,847,989
WILMINGTON, NC		721,598	265,641	66,103	463,970	1,640,897	1,131	33,763	3,193,103
JACKSONVILLE, FL	57,864	2,527,855	198,014	11,081	1,160,897	2,331,553	25,732	368	6,313,364
TAMPA, FL	59,356	6,433,835	836,517	16,685	1,828,477	2,397,246	2,723	184,712	11,759,551
MOBILE, AL	50,083,688	15,081,242	4,081,571	84,132	7,863,673	3,954,439	178,042	1,208,241	82,535,028
NEW ORLEANS, LA	41,161,693	7,770,950	1,133,791	548,502	5,567,757	13,499,880	1,201,450	1,785,827	72,669,850
PORT ARTHUR, TX	56,166,351	7,644,221	895,801	354,611	5,032,171	7,334,836	3,088,813	237,952	80,754,756
HOUSTON/GALVESTON, TX	56,205,563	17,415,739	2,134,244	640,545	10,420,739	27,186,804	4,014,688	2,312,732	120,331,054
CORPUS CHRISTI, TX	21,620,987	8,523,719	463,073	181,465	4,839,946	6,398,233	18,938	172,940	42,219,301
LOS ANGELES, CA	24,778,907	2,710,933	887,654	25	2,933,927	16,139,137	778,544	78,546	48,307,673
SANTA BARBARA, CA	23,622,119	1,592,526	523,820	19	1,700,504	3,348,222	498,104	46,087	31,331,401
SAN FRANCISCO, CA	51,575,876	10,246,361	1,692,704	44	5,121,013	22,264,977	1,696,273	918	92,598,166
PORTLAND, OR	771,266	1,342,643	128,307		1,165,202	1,168,754	184,400	84	4,760,656
PUGET SOUND, WA	11,040,962	1,906,218	440,263	3,426	1,294,845	3,808,260	54,438	20,791	18,569,203
ANCHORAGE, AK	133,751	63,577	189,769		59,800	66,792	9,009	32,753	555,451

Exhibit C.3 Percent of 1987 cargo tons by port, from port needs study (Maio, et al., 1991).

PORT	CRUDE OIL	GASOLINE	JET FUEL	KEROSENE	DISTIL. FUEL	RESID. FUEL	LUBRIC. OIL	LIQUID PETROL.
PORTLAND, ME	40.11%	20.65%	0.41%	0.88%	16.02%	9.97%	11.95%	0.00%
PORTSMOUTH, NH	0.00%	8.84%	4.37%	3.33%	42.17%	29.35%	0.00%	11.94%
MASS BAY (BOSTON)	0.39%	31.17%	6.02%	0.90%	35.04%	25.87%	0.60%	0.01%
PROVIDENCE, RI	0.00%	49.39%	1.09%	0.85%	33.78%	12.96%	0.28%	1.65%
LONG ISLAND SOUND	0.00%	39.27%	1.95%	0.81%	36.58%	21.39%	0.00%	0.00%
NY HARBOR, NY	10.23%	33.82%	2.13%	0.82%	19.50%	32.51%	0.90%	0.09%
DELAWARE BAY	52.75%	11.04%	0.70%	0.41%	8.56%	25.61%	0.49%	0.45%
CHES. SOUTH	14.80%	13.75%	7.03%	0.66%	14.84%	47.92%	0.56%	0.44%
CHES. NORTH	0.13%	22.86%	6.84%	1.56%	21.42%	46.29%	0.89%	0.01%
WILMINGTON, NC	0.00%	22.60%	8.32%	2.07%	14.53%	51.39%	0.04%	1.06%
JACKSONVILLE, FL	0.92%	40.04%	3.14%	0.18%	18.39%	36.93%	0.41%	0.01%
TAMPA, FL	0.50%	54.71%	7.11%	0.14%	15.55%	20.39%	0.02%	1.57%
MOBILE, AL	60.68%	18.27%	4.95%	0.10%	9.53%	4.79%	0.22%	1.46%
NEW ORLEANS, LA	56.64%	10.69%	1.56%	0.75%	7.66%	18.58%	1.65%	2.46%
PORT ARTHUR, TX	69.55%	9.47%	1.11%	0.44%	6.23%	9.08%	3.82%	0.29%
HOUSTON/GALVESTON, TX	46.71%	14.47%	1.77%	0.53%	8.66%	22.59%	3.34%	1.92%
CORPUS CHRISTI, TX	51.21%	20.19%	1.10%	0.43%	11.46%	15.15%	0.04%	0.41%
LOS ANGELES, CA	51.29%	5.61%	1.84%	0.00%	6.07%	33.41%	1.61%	0.16%
SANTA BARBARA, CA	75.39%	5.08%	1.67%	0.00%	5.43%	10.69%	1.59%	0.15%
SAN FRANCISCO, CA	55.70%	11.07%	1.83%	0.00%	5.53%	24.04%	1.83%	0.00%
PORTLAND, OR	16.20%	28.20%	2.70%	0.00%	24.48%	24.55%	3.87%	0.00%
PUGET SOUND, WA	59.46%	10.27%	2.37%	0.02%	6.97%	20.51%	0.29%	0.11%
ANCHORAGE, AK	24.08%	11.45%	34.16%	0.00%	10.77%	12.02%	1.62%	5.90%

Exhibit C.4 Oil Spills in U.S. Coastal Waters (Timothy Goodspeed, NOAA Strategic Environm. Assess. Div., pers. comm., Nov. 1991).

	# of Incidents		Vol. of Incidents	
Spill Volume (gallons)	**mean**	**%**	**mean**	**%**
Sheen	491	5.13%		
Unknown	1,589	16.58%		
0-49	5,100	53.21%	52,516	0.36%
50-99	619	6.45%	39,627	0.27%
100-499	1,006	10.49%	207,956	1.44%
500-999	235	2.45%	153,339	1.06%
1,000-2,499	242	2.52%	363,437	2.51%
2,500-4,999	115	1.20%	400,757	2.77%
5,000-9,999	87	0.91%	593,934	4.10%
10,000-49,999	72	0.75%	1,476,983	10.21%
50,000-99,000	13	0.13%	891,519	6.16%
100,000-999,999	15	0.15%	3,766,625	26.03%
Greater than 1 Million	2	0.02%	6,524,235	45.09%
Totals	9,586	100.00%	14,470,127	100.00%