Consuming less of an energy service is positive from an environmental perspective. Substituting energy-saving technology would tend to result in positive net gains to the environment. The amount of gain would depend on the extent of negative impacts from capital equipment fabrication.

Additional Domestic Production: Onshore oil and gas production has notable negative impacts on surface water, groundwater, and wildlife. It can also cause negative impacts on soils, air pollution, vegetation, noise, and odor. Offshore oil and gas production imposes the risk of oil spills affecting water quality, localized degradation of air quality, potential impacts on coastal wetlands dependent wildlife, and shoreline erosion from additional supply boat traffic. Offshore activities may also have negative impacts on social, cultural, and economic measures such as recreation.

Fuel Switching: The most likely substitutes for natural gas are oil, which would further increase imports, and coal for use in electricity generation. Coal mining causes severe damage to land and wildlife habitat. It also is a major contributor to water quality deterioration through acid drainage and siltation. Alternative transportation fuels may constitute part of the oil substitution mix. The mix depends on future technical and economic advances. No single alternative fuel appears to have an advantage at this time. Every fuel alternative imposes its own negative environmental effects.

Other Substitutes

Government could also impose other substitutes for natural gas and oil. The most likely sectors to target would be transportation, electricity generation, or various chemical processes. *Energy Alternatives and the Environment* discusses many of the alternatives at a level of detail impossible here.

Summary and Conclusion

Canceling a lease sale would eliminate the effects described for Alternative A (**Chapter 4.2.1.**). Other sources of energy would substitute for the lost production. Principal substitutes would be additional imports, conservation, additional domestic production, and switching to other fuels. These alternatives, except conservation, have significant negative environmental impacts of their own.

4.3. IMPACT-PRODUCING FACTORS AND SCENARIO – ACCIDENTAL EVENTS

The NEPA requires Federal agencies to consider potential environmental impacts (direct, indirect, and cumulative) of proposed actions as part of agency planning and decisionmaking. The NEPA analyses address many issues relating to potential impacts, including issues that may have a very low probability of occurrence, but which the public considers important or for which the environmental consequences could be significant.

The past several decades of data show that accidental spills ≥1,000 bbl associated with oil and gas exploration and development are low probability events in Federal OCS waters of the GOM.

This section describes accidental events associated with a proposed action, the Gulfwide OCS Program, and non-OCS activities that could potentially affect the biological, physical, and socioeconomic resources of the GOM. These include oil spills, blowouts, vessel collisions, and spills of chemicals or drilling fluids.

4.3.1. Oil Spills

4.3.1.1. Background

This section provides information and data for the following: (1) spills that have occurred from OCS operations and non-OCS operations; (2) estimated rates of oil spill occurrences, based on analysis of past spills; (3) projections of oil spills from OCS future operations and from other potential sources in the GOM area; (4) known OCS oil characteristics; (5) MMS spill prevention and spill preparedness and response plan requirements; and (6) industry capabilities to respond to spill incidents.

OCS spills are spills to U.S. waters from operations occurring due to oil and gas extraction activities that are a result of an OCS lease sale. They include spills that occur at offshore oil or gas development sites; spills that occur along routes used to transport oil and gas, services, and products back and forth from coastal support bases to offshore development sites; and spills that occur at onshore or coastal locations from support operations for the OCS oil and gas industry. The U.S. waters included are all marine waters, coastal waters, and inland waters of the coastal zone.

Non-OCS spills are all other spills that occur in U.S. waters.

4.3.1.1.1. Past Spill Incidents

4.3.1.1.1.1. Past Record of OCS Offshore Spills

The MMS maintains public records of OCS spills from activities that MMS regulates. The OCS offshore oil spills are spills that occur in Federal waters from OCS facilities and pipeline operations. The OCS facilities include drilling rigs, drillships, and storage, processing, or production structures that are used during OCS drilling, development, and production operations. The OCS offshore spills from pipeline operations are those that occur on the OCS and are directly attributable to the transportation of OCS oil.

Table 4-26 summarizes records on OCS offshore oil spills for seven different spill-size groupings for the period 1985-1999. Spill records for the period 1985-1999 are displayed because this time period is used in the EIS to project future spill risk. The period 1985-1999 is the most recent period for which spill statistics are available and best reflects current spill prevention and occurrence conditions. For the period 1985-1999, data are provided on the total number of spills, number of spills by operation, total volume of oil spilled, and the spill rate calculated from data on historical spills and production. The average spill size and median spill size during this period are given for each spill-size category.

Tables 4-27 and 4-28 provide information on OCS offshore oil spills ≥1,000 bbl that have occurred for the entire period that records are available (1964-2000), rather than just the 15-year time period discussed above in order to give the reader the entire history of spills ≥1,000 bbl. The data show that there were eight pipeline spills ≥1,000 bbl during the period 1985-1999. These occurred as the result of damage caused by anchors, fishing trawls, and hurricanes. During this same time period (1985-1999), there were no OCS spills ≥1,000 bbl from offshore facility operations.

The data from 1985 to 1999 are divided into two groups based on whether the spill was caused by an accident on a drilling or production facility or if the spill was caused by an accident during pipeline transport. The record shows that pipeline spills have occurred less frequently compared to spills at drilling and production facilities, but they have resulted in spills with the most volume, with the rate of spills ≥1,000 bbl continuing to increase over time. In contrast, since 1985, accidents during drilling and production have not resulted in any offshore spills ≥1,000 bbl, even though they make up about 75 percent of all OCS spills <50 bbl.

The data show that about 97 percent of OCS offshore oil spills have been ≤1 bbl (**Figure 4-6**). Although spills of ≤1bbl account for most OCS-related spill occurrences, spills of this size have contributed little (3%) to the total volume of OCS oil spilled. Most of the total volume of OCS oil spilled (90%) has been from spills ≥5 bbl.

Between 1985 and 1999, OCS operators produced about 5.81 BBO, and the amount of OCS oil spilled offshore totaled about 46,000 bbl. This amount is 8 x 10^{-6} percent of the amount produced, or 1 bbl spilled for about every 125,000 bbl of oil produced.

4.3.1.1.1.2. Past Record of OCS Coastal Spills

The OCS spills have occurred in coastal waters at shoreline storage, processing, or transport facilities supporting the OCS oil and gas industry and in State offshore waters and in navigation channels, rivers, and bays from barges and pipelines carrying OCS-produced oil. Only the USCG (USDOT, CG, 2001a) maintains records of spills in coastal waters and State offshore waters, but the database does not identify if the cause or source of the spill is related to OCS versus non-OCS activities. A pipeline carrying oil from a shore base to a refinery may be carrying oil stored from both State and OCS production; imported oil might also be commingled in the pipeline. Therefore, there are no past records available that contain only spills that have occurred in State offshore or coastal waters directly as a result of OCS oil and gas development. A portion of all coastal spill data is used in the analysis of spills presented in this document. A discussion of the numbers, volumes, and causes, for all coastal spills that have occurred in the GOM area is found below.

4.3.1.1.1.3. Past Record of All (OCS and non-OCS) Spills

Besides spills occurring from OCS oil and gas operations, oil spills have occurred from a large number of other sources, particularly from the extensive maritime industry that uses vessels to transport crude oil and petroleum products within the GOM and from other countries and states to GOM refineries and ports. Other sources include State oil and gas development operations and infrastructure, trucks, railcars, and mystery sources. The record for all spills that have occurred from 1973 to 2000 into U.S. navigable waters (including OCS and non-OCS spills) can be found at http://www.uscg.mil/hq/g-m/nmc/response/stats/Summary.htm (USDOT, CG, 2001a). Information on the number and size of tanker and barge spills ≥1,000 bbl that have occurred in U.S. waters and worldwide can be found in a recently published report by MMS (Anderson and LaBelle, 2000).

The following is a summary of what is known about trends in U.S. spill risk and is derived from analysis of 1973-2000 USGS data (USDOT, CG, 2001a) and Rainey (1992). This time period was used for this analysis rather than the 15-year time period used in the analysis of OCS spill data because the trend analysis completed by the USCG shows a steady trend spread over the entire time period rather than a distinct change relative to particular years.

Volumes Spilled

The total volume spilled from all spill incidents per year and the volume spilled per spill incident in U.S. waters has been on a steady downward trend since 1973. There have been no oil spills over 23,800 bbl (1 million gallons (gal)) since 1991. The majority of spills since 1973 involved discharges between 0.02 and 2.4 bbl (1 and 100 gal). The decline in oil-spill volume, particularly in the face of growing domestic demand for imported oil, represents the combined effects of an increasingly effective campaign of positive prevention and preparedness initiatives to protect U.S. coastal waters from oil pollution (USDOT, CG, 2001a). The total volume of oil spilled per year is declining. The total volume spilled in 2000 is at the lowest amount in over 25 years.

Number of Spills

A review of the USCG data shows that the total number of spill incidents occurring in U.S. waters has remained relatively constant from year to year. Since 1973, the number has varied between about 8,000 and 10,000 spills per year, with the exception of the mid 1980's when the numbers dipped below 4,000 spills. For GOM offshore waters, the number of incidents has slightly increased from pre-1990, peaking at about 2,400 spills in 1996.

Sources of Spills

Spills from tank vessels (ships and barges carrying oil) account for the majority of volume spilled. Thirty-two percent of the number of all spills from 1973 to 2000 occurred from non-tank vessels; 25.2 percent were “mystery” spills; 29.1 percent were from facilities and other non-vessels; 10.2 percent were from tank vessels; and 3.5 percent were from pipelines. From 1973 to 2000, 46.8 percent of the volume of oil spilled came from tank vessels; 22 percent from facilities and other non-vessels; 17.5 percent from pipelines; 7.7 percent from mystery spills; and 5.9 percent from non-tank vessels. The rates for oil spills ≥1,000 bbl from OCS platforms, tankers, and barges continues to decline, while the rate for OCS pipeline spills has increased. The majority of spills ≥1,000 bbl has occurred from vessels near terminals and are associated with coastal barging operations of petroleum products (Rainey, 1992).

Types of Oil Spilled

Crude oil and heavy oil accounted for the majority of the volume spilled (62%). Crude oil and heavy oil were the most frequent types of oil spilled (36% of the number of spills from 1973 to 2000 were the discharge of crude oil or heavy oil).

Location of Spills

About 75 percent of all spills and 83.8 percent of the volume of all spills occurred in waters 0 to 3 miles from shore. Overall, 63.7 percent of all spills from 1973 to 2000 occurred in the GOM area or within rivers draining into the GOM. For coastal spills sorted by type of waterbody: 47 percent have occurred in rivers and canals; 18 percent in bays and sounds; and 35 percent in harbors. For coastal spills sorted by coastal water designation: 32 percent of all coastal spills occur in State offshore waters 0-3 mi from shore; 4 percent occur in State offshore waters 3-12 mi from shore; and 64 percent occur in inland waters.

Louisiana has experienced the majority of large vessel spills. Rainey (1992) identified that, during 1974-1990 for oil spills ≥1,000 bbl, there have been 27 spills in Texas, 38 in Louisiana, 2 in Mississippi, 4 in Alabama, and 3 in Florida. The majority of these spills occurred on the Mississippi River, making the Mississippi River the most likely location of coastal spills.

The MMS also reviewed specific historical information on spill occurrence in the Mississippi/Alabama/Northwest Panhandle Florida, an area where little oil and gas support operations currently occur (USDOT, CG, 1995). There does not appear to be a difference between the causes of spills within the coastal waters of these States and what is expected for the entire GOM area. The USCG Contingency Plan for this area provides the following data. Between 1985 and 1989, the Mississippi/Alabama coastal area experienced 21 spills >12 bbl, 12 spills between 12 and 50 bbl, 7 spills between 50 and 1,000 bbl, and 2 spills ≥1,000 bbl. Of the 13 spills for which the source was identifiable, 6 spills were from vessel rupture/collisions, 4 were from tank overflows or breaks, 2 were from transfer hose ruptures, and 1 was from a pipeline. The two spills ≥1,000 bbl were caused by hull ruptures on vessels. Both large spills were a mixture of petroleum products. The USCG also estimated that the maximum probable spill risk would be at the Mobile/GIWW ship channel junction and would be a spill of 14,700 bbl. The records show that the primary source of spills in this area has been vessels bringing in petroleum products to meet these states' energy demands.

Between 1985 and 1989, the Florida northwestern coastal area experienced nine oil spills. All except one were small spills (between 12 and 50 bbl). One of these spills was from a fishing vessel. The one spill >50 bbl was a grounding of a vessel and hull rupture where 190 bbl of jet fuel were spilled. The USCG estimated that the average spill occurring within the Florida Panhandle area has been a petroleum product spill of diesel oil of about 70 bbl (**Chapter 4.3.1.1.2.**, Projections of Spill Incidents).

The MMS examined a number of variables that could serve as indicators of future spill occurrences and uses the volume of oil handled to approximate future risk of spill occurrence. Therefore, spill rates are calculated based on the assumption that spills occur in direct proportion to the volume of oil handled. The rate of spill occurrence is expressed as the number of spills per billion barrels of oil handled. A recently published paper by MMS provides more information on OCS spill-rate methodologies and trends (Anderson and LaBelle, 2000).

Spill records for the most recent period analyzed, 1985-1999, is used to project future spill risk from OCS operations for this EIS because data for this period reflect recent spill prevention and occurrence conditions. The 15-year record reflects how the spill rates have changed while still maintaining a significant portion of the record.

The spill rates for various spill-size categories and both OCS and non-OCS sources used to develop the estimated number of spills in this EIS are provided in **Table 4-29**. This table provides a comparison of estimated spill rates for OCS spills versus spill rates for other kinds of operations in the GOM.

4.3.1.1.2. Projections of Spill Incidents

Detailed projections on spills that could happen from a proposed action are provided in **Chapter 4.3.1.2.**, Risk Charaterization for Proposed Action Spills. Impacts associated with oil spills as a result of a proposed action are analyzed in **Chapter 4.4.** This section provides projections of future spill incidents associated with the OCS Program and other activities and puts into perspective spill risk associated with a proposed action. Impacts associated with the oil spills for all sources are analyzed in the cumulative analyses (**Chapter 4.5.**).

Table 4-15 provides the assumed number of spill events that could occur within coastal and offshore waters of the GOM area for a representative future year (2015). A total volume and number of spills over the 40-year analysis period could be calculated by multiplying the annual numbers shown in **Table 4-15**

times 40. However, MMS recognizes that there is a great deal of uncertainty in the estimates of the number and volumes of spills from sources other than OCS production because these sources are not regulated by MMS. **Table 4-30** shows an estimate of spills as a result of the OCS Program over the 40-year analysis period.

Table 4-15 provides the assumed number of spill events that could occur within coastal and offshore waters of the GOM area for a representative future year (chosen to be 10 years after a proposed lease sale). No annual average over the 40-year analysis period for all spills is appropriate because the timeframes and peak years vary for the different types of activities that could spill oil. For example, State oil production in the U.S. is expected to decline over the next 15 years or so. Because the energy needs of this Nation are projected to continue to increase, any decline in domestic oil production must be replaced by imports of both crude oil and petroleum products from outside this country or replaced by alternative energy sources.

The projections of future spill occurrences shown in **Table 4-15** were formulated using the following sources: a USCG database on spill incidents in all navigable waters (USDOT, CG, 2001a); an MMS spill database; an analysis of spills ≥1,000 bbl from OCS operations (Anderson and LaBelle, 2000); an analysis of spills from tanker and barge operations (Anderson and LaBelle, 2000); and a 1992 analysis of tanker and barge spills as a function of volumes of oil moved in GOM waters by various transport modes (Rainey, 1992). **Table 4-29** provides the spill occurrence rates used by MMS to make these projections. Database information was supplemented by personal communications with a number of individuals dealing with vessel transport and oil-spill incidents in the GOM area.

Summarized data on spill incidents of any size and source that occurred in the GOM was not available at the time of writing this document. As almost 38 percent of all U.S. spills have occurred within GOM waters and Gulf Coast States, the trends for all U.S. spills is assumed to be representative of trends in spills that have occurred in the GOM. Therefore data containing the past record for all U.S. spills was used to develop information on spill risk in GOM waters, whenever data specific to GOM occurrences are lacking.

4.3.1.1.2.1. Projections of Offshore Spills from OCS Program Operations

In order to understand the incremental contribution of a proposed action to the risk of spills for all OCS operations, MMS estimates the number of spills and the probability of one or more spills occurring as a result of the OCS Program—all future OCS oil exploration, development, and production (during the proposed action analysis period). Discussion of the methodology used to develop the assumed number and the probabilities of occurrence for OCS spills is presented in **Chapter 4.3.1.2.** as part of the analysis of a proposed action.

Probability of OCS Offshore Spills ≥1,000 bbl Occurring

The probabilities of one or more offshore spills ≥1,000 bbl occurring from future OCS operations are provided in **Table 4-30**. For the Gulfwide OCS Program, there is a greater than 99 percent chance that there would be an offshore spill ≥1,000 bbl occurring in the next 40 years. For the EPA OCS Program, there is a 19-43 percent chance that there would be an offshore spill ≥1,000 bbl in the next 40 years. For further information, see Ji et al. (2002).

Probability of OCS Offshore Spills ≥10,000 bbl Occurring

The probabilities of one or more offshore spills ≥10,000 bbl occurring from future OCS operations are provided in **Table 4-30**. This is a subset of projections for spills ≥1,000 bbl. For the Gulfwide OCS Program, there is greater than a 99 percent chance that one or more spills ≥10,000 bbl would occur in the next 40 years. For the EPA OCS Program, there is a 5-13 percent chance that there would be an offshore spill ≥10,000 bbl in the next 40 years.

Number of OCS Offshore Spills ≥1,000 bbl

Based on a statistical analysis of spill rates and assumed sources, and using the low and high resource estimates for the OCS Program (**Chapter 4.1.1.1.1.**, Proposed Action), MMS assumed the mean number of offshore oil-spill events estimated to occur as a result of future oil development operations. These mean numbers are published in Ji et al. (2002). **Table 4-30** provides the number of offshore spills ≥1,000 bbl and ≥10,000 bbl that MMS projects based on these estimated mean numbers (the assumed number is the rounded mean) by source and for each planning area, as well as the Gulfwide OCS Program. The assumed number of spills ≥1,000 bbl that could happen from future Gulfwide OCS Program operations during a period is estimated to be between 23 and 33 spills; the number of spills ≥10,000 bbl for the Gulfwide OCS Program is assumed to be between 6 and 9 spills. Based on these probabilities and the mean estimate, MMS assumes that between 0 and 1 spill ≥1,000 bbl is likely to occur in the EPA from all OCS operations in the next 40 years.

The number of possible spills ≥1,000 bbl that could occur shows a widespread frequency distribution. This is a Poisson distribution, which is commonly used for modeling systems in which the probability of an event occurring is very low and random. **Figures 4-7, 4-8, and 4-9** show that distribution, and the great deal of uncertainty as to the number of OCS spills assumed to occur. If the low resource estimate is realized, the number of possible spills ≥1,000 bbl that could occur Gulfwide ranges from 13 to 35, with a rounded mean number of 23 spills estimated. For the high resource estimate, the number ranges from 21 to 40, with the rounded mean number being 33.

OCS Program Offshore Spills <1,000 bbl

The number of spills that could occur was estimated by MMS for different size categories for the Gulfwide OCS Program, based on rounding the mean number of spills calculated. The following table provides MMS's estimate of the number of spills in each size group for different OCS oil development scenarios:

Size Category	OCS Program – Gulfwide
1 bbl	51,550-74,050
>1 and <50 bbl	1,150-1,650
≥50 and <1,000 bbl	250-350
≥1,000 bbl and <10,000 bbl	17-24
≥10,000 bbl	6-9

Table 4-15 provides these same numbers broken down into annual estimates.

Sources of OCS Offshore Spills

Table 4-30 also distinguishes spill occurrence risk by likely operation or source. Besides spills occurring from facilities and during pipeline transport, offshore spills could occur due to OCS future operations from shuttle tankers transporting OCS crude oil into ports. **Table 4-30** includes the likelihood of a spill from a shuttle tanker accident carrying OCS produced crude oil. The scenario with the highest risk of spill occurrence is the high-case resource estimate for the OCS Program in the CPA, which assumes some shuttle-tanker transport of OCS-produced oil. Under that scenario, there is a 49 percent chance that a spill ≥1,000 bbl and a 21 percent chance of a spill ≥10,000 bbl occurring from an OCS-related shuttle tanker during the analysis period.

Sizes of OCS Offshore Spills

Table 4-15 provides the assumed sizes for different size groups for future OCS spills. These spill sizes are based on average size spills that have occurred in each spill size group (**Table 4-26**). For spills ≥1,000 bbl, the median spill size (4,600 bbl) was used because it better represents a likely spill size rather than the average, which is skewed by a few very large events.

4.3.1.1.2.2. Projections of Coastal Spills from OCS Program Operations

Spills in coastal waters could occur at service bases supporting the OCS oil and gas industry, from the transportation of OCS-produced oil through State offshore waters, or from support vessel operations along navigation channels, rivers, and through coastal bays. The MMS projects that 94 to greater than 99 percent of oil produced as a result of OCS operations would be brought ashore via pipelines to oil pipeline shore bases and transferred via pipeline or barge to GOM coastal refineries. Because oil is commingled during storage at shore bases, this analysis of coastal spills focuses on spills that could occur prior to the oil leaving its initial shoreline facility.

Number of OCS Coastal Spills

The MMS calculates the number of coastal spills that could occur as a result of future OCS operations as a subset of all coastal spills. The MMS does not regulate the operations that could spill oil in the coastal zone and does not maintain a database on these spills. MMS relies on spill data obtained from the USCG Marine Safety Information System database and from State agencies. Since the available databases on coastal spills (USGS and States) do not differentiate between OCS and non-OCS sources, MMS proportions all spills occurring in the GOM coastal area by the volumes of oil handled by all oil-handling operations in the coastal area, including OCS support operations, State oil and gas production, intra-GOM transport, and coastal import/export oil activities (Rainey, 1992). For pipeline spills, a separate percentage is estimated to represent the proportion of the number of known pipeline spills by the two major sources of oil piped – State production and OCS production.

Using this approach, MMS estimates an annual number of probable spills that could occur in coastal waters due to Gulfwide OCS-related mishaps. These numbers are provided in **Table 4-15** for various size groups and for a representative future year. We estimate that about 1 spill ≥1,000 bbl and about 75-100 spills <1,000 bbl are likely to occur each year. The one spill ≥1,000 bbl is assumed to be from a pipeline accident.

Locations of OCS Coastal Spills

Oil and gas support operations are widespread from Texas to Alabama. The risk of spills occurring from these operations that support OCS activities would also be widely distributed in this coastal area, but primarily would be focused in the two areas receiving the largest volume of OCS-generated oil – the Houston/Galveston area of Texas and the deltaic area of Louisiana. Based on an in-house analysis of USCG data on all U.S. coastal spills between 1973 and 2000 (**Chapter 4.3.1.1.1.2**., Past Record of OCS Coastal Spills, and USDOT, CG, 2001a), MMS assumes 32 percent of OCS coastal spills occurring in State offshore waters 0-3 mi from shore, 4 percent in State offshore waters that are 3-12 mi from shore (Texas), and 64 percent in inland waters. Approximately 47 percent of inland spills are estimated to occur in coastal rivers and canals, 18 percent in bays and sounds, and 35 percent in harbors.

Sizes of OCS Coastal Spills

Coastal spill sizes specific to OCS operations are not known. For OCS coastal spills <1,000 bbl, a spill size of 6 bbl is assumed based on USCG data. For OCS coastal spills ≥1,000 bbl, a spill size of 4,200 bbl is assumed based on a composite of the median size of a pipeline spill and a barge spill (Anderson and LaBelle, 2000). These spills were identified as the two most likely sources of OCS-related spills that could occur in coastal waters and be ≥1,000 bbl.

4.3.1.1.2.3. Projections of Offshore Spills from Non-OCS Operations

Most non-OCS offshore spills occur from vessel and barge operations. Transit spills occur from navigation-related accidents such as collisions and groundings. Intrinsic spills are those occurring from accidents associated with the vessel itself, such as leaks from hull cracks, broken seals, and bilge upsets. Transfer spills occur during cargo transfer from accidents such as hose ruptures, overflows, and equipment failures.

Collisions and groundings have occurred very infrequently, less than one per 1,000 trips (USDOT, CG, 1993) and do not usually result in an oil spill. However, these accidents have resulted in the largest spills. The frequency of vessel collisions, and thus associated spills, increases as the proximity to shore increases because of the often-congested waterways in the GOM region.

Most small non-OCS offshore spills occur during the cargo transfer of fuel and crude oil. Lightering of oil (the transfer of crude oil from supertankers to smaller shuttle tankers) is a common occurrence in the GOM. There have been about 3-4 spills per 1,000 lightering transfers, with an average spill size of 3 bbl (USDOT, CG, 1993). Lightering of oil destined for the Pascagoula refinery occurs frequently in the OCS waters offshore Pascagoula, Mississippi, an area proximate to the proposed lease sale area. However, lightering is not restricted to this area for double-hulled vessels and could occur anywhere within the GOM.

Number of Non-OCS Offshore Spills

Table 4-15 provides MMS's projections of spills that could occur offshore from non-OCS sources for a typical future year. All offshore spills ≥1,000 bbl not related to OCS operations are assumed to occur from the extensive maritime barging and tankering operations that occur in offshore waters of the GOM. The analysis of spills from tankers and barges ≥1,000 bbl is based on an analysis of numbers of spills that occur annually from different modes of transportation of oil within the GOM region (Rainey, 1992). A total of 3-4 spills ≥1,000 bbl is assumed to occur for a typical future year from the extensive tanker and barge operations.

The estimate for spills <1,000 bbl that occur annually offshore and are not related to OCS operations was obtained from the Marine Safety Office, Pollution Response Department of the 8th USCG District (USDOT, CG, personal communication, 2001b). They estimated this number to be 200-250 spills <1,000 bbl occurring offshore annually from all non-OCS sources.

Sizes of Non-OCS Offshore Spills

Spill sizes for the spills assumed ≥1,000 bbl are derived from median spill sizes for each source, found in Anderson and LaBelle (2000). The average spill size of 6 bbl for spills <1,000 bbl was derived by an analysis of USCG data.

4.3.1.1.2.4. Projections of Coastal Spills from Non-OCS Operations

Coastal spills primarily occur from vessel accidents. Vessel accidents can spill oil from the tanks of import/export tankers while at ports or in bays and harbors; from the cargo tanks of barges and tank vessels that transport crude oil and petroleum products along channels, bayous, rivers, and especially while traversing the GIWW; and from fuel tanks of all other types of vessels, such as recreational boats or grain tankers. Other sources include spills during pipeline transport of petroleum products; crude oil; State oil and gas facilities; petrochemical refinery accidents; and from storage tanks at terminals.

Number of Non-OCS Coastal Spills

The same analytical approach used to estimate OCS coastal spills was used to estimate non-OCS coastal spills. These projections are included in **Table 4-15**. The USCG estimates that about 5-6 spills per 1,000 transfers of oil at ports and terminals (USDOT, CG, 1993).

Locations of Non-OCS Coastal Spills

Based on an MMS analysis of U.S. spill data maintained by the USCG (USDOT, CG, 2001a), the percentages of coastal spill occurrences in different waterbody types are expected to be as follows: 47 percent in rivers and canals; 18 percent in bays and sounds; and 35 percent in harbors. The probable locations can also be broken down by relative location to Federal waters: 32 percent of all coastal spills occur in State offshore waters 0-3 mi from shore; 4 percent occur in State offshore waters 3-12 mi from shore; and 64 percent occur in inland waters.

The majority of spills ≥1,000 bbl is expected to occur near terminals and in association with coastal barging operations of petroleum products (Rainey, 1992). For coastal spills <1,000 bbl, most are expected to occur most frequently during transfer operations.

Sizes of Non-OCS Coastal Spills

The MMS estimated the likely spill sizes for spills occurring in the coastal zone from all non-OCS sources. For spills ≥1,000 bbl, the median spill size for tankers in-port and the median spill size for barges carrying petroleum products was used, based on an MMS published analysis of spill data (Anderson and LaBelle, 2000). For spills <1,000 bbl estimated to occur, MMS analyzed the USCG data on all U.S. spills <50,000 gallons (1,190 bbl) and determined the average size spill for this category was 6 bbl. For spills during transfer operations at terminals, the average size is expected to be 18 bbl (USDOT, CG, 1993).

4.3.1.1.3. Characteristics of OCS Oil

The physical and chemical properties of oil greatly affect how it would behave on the water surface (surface spills) or in the water column (subsea spills), the persistence of the slick on the water, the type and speed of weathering process, the degree and mechanisms of toxicity, the effectiveness of containment and recovery equipment, and the ultimate fate of the spill residues. Crude oils are a mixture of hundreds of different compounds. Hydrocarbons account for up to 98 percent of the total composition. The chemical composition of crude oil can vary significantly from different producing areas; thus, the exact composition of oil being produced in OCS waters varies throughout the GOM. Information on what MMS believes is the likely characteristics of the crude oil that would be produced as a result of a lease sale in the EPA is found in **Chapter 4.3.1.2.1.9.**, Oil Types.

Data on the API gravities of existing reserves (Lore et al., 1999) were reviewed (Trudel et al., 2001). The API gravity is a measurement of the density of the oil. Weighting the gravities by the relative oil production, all of the oils displayed API gravities in the 32-36^{o} range, with an average of 33.9^{o}. This represents a fairly light crude oil. Sorting the data by water depth indicates that oils become slightly heavier as water depths increase.

Water Depth	API Gravity
0-60 m	35^{o}
61-200 m	34^{o}
201-900 m	32^{o}
>900 m	30^{o}

Besides crude oil that is produced on the OCS, accidents can occur which spill other types of petroleum hydrocarbons. Most of these spills have been small. Analysis of the 24 offshore oil spills >50 bbl and <1,000 bbl that occurred between 1985 and 1999 showed that 42 percent were diesel spills, 25 percent were condensate spills, and 21 percent were crude oil spills. The remaining spills were hydraulic fluids (2 spills) and diesel fuel or mineral oil-based drilling muds (2 spills). There has been one diesel spill ≥1,000 bbl (**Table 4-27**).

4.3.1.1.4. Spill Prevention Initiatives

The MMS has comprehensive pollution prevention requirements to guard against accidental spills. This regulatory framework is summarized in **Chapter 1.3.** Improvements in MMS operational requirements, ongoing efforts by the oil and gas industry to enhance safety and pollution prevention, and the evolution and improvement of offshore technology since 1980 have been successful in reducing the total volume of oil spilled from OCS operations. There has been an 89 percent decline in the volume of oil spilled per billion barrels produced from OCS operations from 1980 through the present (8,211 bbl/BBO from facilities and 1,493 bbl/BBO from pipelines) compared to the total volume spilled per billion barrels prior to 1980 (45,897 bbl/BBO from facilities and 44,779 bbl/BBO from pipelines).

Pollution prevention is addressed through proper design and requirements for safety devices to prevent continued flow from a well should a rupture in one of the pipelines or risers occur. Redundancy is provided for critical safety devices that would shut off flow from the well if, for example, a riser were to rupture. Wells, particularly subsea wells, include a number of sensors that help in detecting pressures and the potential for leaks in the production system. Safety devices are monitored and tested frequently to ensure their operation should an incident occur. Barriers are monitored to provide early warning of potential for loss containment. Contingency plans for dealing with a spill are addressed as part of the project-specific OCS development plan, which also requires MMS review and approval before development begins. Operators are required to install curbs, gutters, drip pans, and drains on platform and rig deck areas in a manner necessary to collect all contaminants and debris not authorized for discharge.

4.3.1.1.5. Spill-Response Capabilities

To ensure that industry maintains effective oil-spill response capabilities, MMS

- requires immediate notification to both the USCG and MMS for spills >1 bbl,
- conducts investigations to determine the cause of a spill,
- makes recommendations on how to prevent similar spills,
- assesses civil and criminal penalties if needed,
- oversees spill source control and abatement operations by industry,
- sets requirements and reviews and approves oil-spill response plans for offshore facilities,
- conducts unannounced drills to ensure compliance with oil-spill response plans,
- requires operators to train their staff in spill response,
- conducts inspections of oil-spill response equipment,
- requires industry to show financial responsibility to respond to possible spills, and
- manages oil-spill research on technology and related topics.

4.3.1.1.5.1. Oil-Spill Response Plans

The MMS regulations (30 CFR 254) require that all owners and operators of oil handling, storage, or transportation facilities located seaward of the coastline submit an OSRP for approval. The regulation at 30 CFR 254.2 requires that an OSRP must be submitted and approved before an operator can use a facility, or the operator must certify in writing to MMS that it is capable of responding to a "worst-case" spill or the substantial threat of such a spill. The facility must be operated in compliance with the approved OSRP or MMS-accepted "worst-case" spill certification. Owners or operators of offshore pipelines are required to submit an OSRP for any pipeline that carries oil, condensate, or gas with condensate; pipelines carrying essentially dry gas do not require an OSRP. The OSRP describes how an operator intends to respond to an oil spill. The OSRP may be site-specific or regional. The Emergency Response Action Plan within the OSRP outlines the availability of spill containment and cleanup equipment and trained personnel. It must ensure that full-response capability can be deployed during an oil-spill incident. The OSRP includes an inventory of appropriate equipment and materials, their availability, and the time needed for deployment. All MMS-approved OSRP's must be reviewed at least every two years and all resulting modifications must be submitted to MMS within 15 days whenever

(1) a change occurs that appreciably reduces an owner/operator's response capabilities;
(2) a substantial change occurs in the worst-case discharge scenario or in the type of oil being handled, stored, or transported at the facility;
(3) there is a change in the name(s) or capabilities of the oil-spill removal organizations cited in the OSRP; or
(4) there is a change in the applicable Area Contingency Plans.

4.3.1.1.5.2. Financial Responsibility

The responsible party for every covered offshore facility must demonstrate OSFR as required by OPA 90 (30 CFR 253). A covered offshore facility is any structure and all of its components, equipment, pipeline, or device (other than a vessel or other than a pipeline or deepwater port licensed under the

Deepwater Port Act of 1974) used for exploring, drilling, or producing oil, or for transporting oil from such facilities. The MMS ensures that each responsible party has sufficient funds for removal costs and damages resulting from the accidental release of liquid hydrocarbons into the environment for which the responsible party is liable.

4.3.1.1.5.3. Offshore Response and Cleanup Technology

A number of cleanup techniques are available for response to an oil spill. Open-water response options include mechanical recovery, chemical dispersion, in-situ burning, or natural dispersion. Although bioremediation was at one time considered for use in open water, studies have shown that this technique is not an effective spill-response option in open water because of the high degree of dilution of the product and the rapid movement of oil in open water. Effective use of bioremediation requires that the products remain in contact with the oil for extended periods of time.

Single or multiple spill-response cleanup techniques may be used in abating a spill. The cleanup technique chosen for a spill response would vary depending upon the unique aspects of each situation. The selected mix of countermeasures would depend upon the shoreline and natural resources that may be impacted; the size, location, and type of oil spilled; weather; and other variables. The overall objective of on-water recovery is to minimize the risk of impact by preventing the spread of free-floating oil. The physical and chemical properties of crude oil can greatly affect the effectiveness of containment and recovery equipment, dispersant application, and *in-situ* burning.

Mechanical Cleanup

Generally, mechanical containment and recovery is the primary oil-spill-response method used (33 CFR 153.305(a)). Mechanical recovery is the process of using booms and skimmers to pick up oil from the water surface. In a typical offshore oil-spill scenario, a boom is deployed in a V, J, or U configuration to gather and concentrate oil on the surface of the water. The oil is gathered in the wide end of the boom (front) and travels backward toward the narrow apex of the boom (back). The skimmer is positioned at the apex of the boom, where the oil is the thickest. The skimmer recovers the oil by sucking in the top layer via a weir skimmer, or the oil adheres to and is removed from a moving surface (i.e., an oleophylic skimmer). The oil is then pumped from the skimmer to temporary storage on an attendant vessel or barge, the latter of which serves as the skimming platform. When this on-board storage is full, the oil must be pumped into a larger storage vessel.

Mechanical oil-spill response equipment that is contractually available to the operators through Oil Spill Removal Organization (OSRO) membership or contracts would be called out to respond to an offshore spill in the proposed lease sale area. Each individual operator's response to a spill would differ according to the location of the spill, the volume and source of the spill, the OSRO under contract, etc. At this time, in the GOM, there are three major OSRO's that can respond to spills in the open ocean: (1) Clean Gulf Associates, (2) Marine Spill Response Corporation (MSRC), and (3) National Response Corporation. The equipment owned by these OSRO's is strategically located near the busier port areas throughout the GOM to service the oil and gas exploration and production operators and, in some cases, the marine transportation industry. Numerous smaller OSRO's that stockpile additional shoreline and nearshore response equipment are also located throughout the GOM coastal area.

In consideration of the present location of the major OSRO equipment stockpiles, it is expected that the oil-spill response equipment needed to respond to an offshore spill in the proposed lease sale area would first be called out of Fort Jackson, Louisiana; Venice, Louisiana; Pascagoula, Mississippi; or Mobile, Alabama. Additional equipment, if needed, can be called out from one or more of the following major oil-spill equipment base locations: Corpus Christi, Ingleside, Port Arthur, and Galveston, Texas; Lake Charles, New Iberia, Houma, Fourchon, Fort Jackson, and Venice, Louisiana; or Tampa, Florida. Response times for any of this equipment would vary, dependent on the location of the equipment, the staging area, and the spill site; and on the transport requirements for the type of equipment procured.

It is assumed that 10-30 percent of an oil spill in an offshore environment can be mechanically removed from the water prior to the spill making landfall (U.S. Congress, Office of Technology Assessment, 1990).

Should an oil spill occur during a storm, spill response from shore would occur following the storm. Spill response would not be possible while storm conditions continued, given the sea state limitations for skimming vessels and containment boom deployment. However, oil released onto the ocean surface during a storm event would be subject to accelerated rates of weathering and dissolution (i.e., oil and water would be agitated, forcing oil into smaller droplets and facilitating dissolution of the high end aromatic compounds present).

Dispersants

When dispersants are applied to spilled crude oil, the surface tension of the oil is reduced. This allows normal wind and wave action to break the oil into tiny droplets, which are dispersed into the upper portion of the water column. Natural processes then break down these droplets much quicker than they would if the oil were allowed to remain on the water surface.

Dispersants use must be in accordance with the Regional Response Teams' Preapproved Dispersant Use Manual. Consequently, dispersant use would be in accordance with the restrictions for specific water depths or distances from shore. For a deepwater (>1,000 ft water depth) spill ≥1,000 bbl, dispersant application may be a preferred response in the open-water environment to prevent oil from reaching a coastal area, in addition to mechanical response.

Based on the present location of dispersant stockpiles and dispersant application equipment in the GOM, it is expected that the dispersants and dispersant application aircraft initially called out for an oil-spill response to an offshore spill in the proposed lease sale area would come from Houma, Louisiana. Response times for this equipment would vary, depending on the spill site and on the transport time for additional supplies of dispersants to arrive at a staging location.

In-situ Burning

In-situ burning is an oil-spill cleanup technique that involves the controlled burning of the oil at or near a spill site. The use of this spill-response technique can provide the potential for the removal of large amounts of oil over an extensive area in less time than other techniques. *In-situ* burning involves the same oil collection process used in mechanical recovery, except instead of going into a skimmer, the oil is funneled into a fire-boom, a specialized boom that has been constructed to withstand the high temperatures from burning oil. Fire resistant booms are used to isolate the oil from the source of the slick. The oil in the fire-boom is then ignited and allowed to burn. While *in-situ* burning is another method for disposing of oil that has been collected in a boom, this method is typically more effective than skimmers when the oil is highly concentrated.

For oil to ignite on water, it must be at least 2-3 mm thick. Most oils must be contained with fireproof boom to maintain this thickness. Oils burn at a rate of 3-4 mm per minute. Most oils would burn, although emulsions may require treatment before they would burn. Water in the oil would affect the burn rate; however, recent research has indicated that this effect would be marginal. One approximately 200-m length of fire resistant boom can contain up to 11,000 gallons of oil, which takes about 45 minutes to burn. In total, it would take about three hours to collect this amount of oil, tow it away from a slick, and burn it (Fingas, 2001). Response times for bringing a fire-resistant boom onsite would vary, dependent on the location of the equipment, the staging area, and the spill site.

Natural Dispersion

In some instances, the best response to a spill may be to allow the natural dispersion of a slick to occur. Natural dispersion may be a preferred option for smaller spills of lighter nonpersistent oils and condensates that form slicks that are too thin to be removed by conventional methods and that are expected to dissipate rapidly, particularly if there are no identified potential impacts to offshore resources and a potential for shoreline impact is not indicated. In addition, natural dispersion may also be a preferred option in some nearshore environments when the potential damage caused by a cleanup effort could cause more damage than the spill itself.

4.3.1.1.5.4. Onshore Response and Cleanup Technology

Offshore response and cleanup is preferable to shoreline cleanup; however, if an oil slick reaches the coastline it is expected that the specific shoreline cleanup countermeasures identified and prioritized in the appropriate ACP's for various habitat types would be used. The sensitivity of the contaminated shoreline is the most important factor in the development of cleanup recommendations. Shorelines of low productivity and biomass can withstand more intrusive cleanup methods such as pressure washing. Shorelines of high productivity and biomass are very sensitive to intrusive cleanup methods, and in many cases, the cleanup is more damaging than allowing natural recovery.

Oil-spill response planning in the United States is accomplished through a mandated set of interrelated plans. The ACP represents the third tier of the National Response Planning System and was mandated by OPA 90. The ACP's cover subregional geographic areas. The ACP's are a focal point of response planning, providing detailed information on response procedures, priorities, and appropriate countermeasures. Seven ACP's cover the GOM coastal area. The ACP's are written and maintained by Area Committees assembled from Federal, State, and local governmental agencies that have pollution response authority; nongovernmental participants may attend meetings and provide input. The coastal Area Committees are chaired by respective Federal On-Scene Coordinators from the appropriate USCG Marine Safety Office and are comprised of members from local or area-specific jurisdictions. Response procedures identified within an ACP reflect the priorities and procedures agreed to by members of the Area Committees.

The single most frequently recommended spill-response strategy for the areas identified for protection in all of the applicable ACP's is the use of a shoreline boom to deflect oil away from coastal resources such as seagrass beds, marinas, resting areas for migratory birds, bird and turtle nesting areas, etc. If a shoreline is oiled, the selection of the type of shoreline remediation to be used would depend on the following: (1) the type and amount of oil on the shore; (2) the nature of the affected coastline; (3) the depth of oil penetration into the sediments; (4) the accessibility and the ability of vehicles to travel along the shoreline; (5) the possible ecological damage of the treatment to the shoreline environment; (6) weather conditions; (7) the current state of the oil; and (8) political considerations.

4.3.1.1.5.5. Shoreline Cleanup Countermeasures

The following assumptions regarding the cleanup of spills that contact coastal resources in the area of consideration were determined based upon the guidance ACP's for the coastal areas closest to the proposed lease sale area. Differences in the response priorities and procedures among the various ACP's applicable to the GOM reflect the differences in the identified resources needing spill protection in the area covered by each ACP.

Barrier Island/Fine Sand Beaches Cleanup

After the oiling of a barrier island/fine sand beach with a medium-weight oil, applicable cleanup options are manual removal, trenching (recovery wells), sediment removal, cold-water deluge flooding, shore removal/replacement, and warm-water washing. Other possible shoreline countermeasures include low-pressure cold-water washing, burning, and nutrient enhancement. Responders are requested to avoid the following countermeasures: no action; passive collection (sorbents); high-pressure, cold-water washing; hot-water washing; slurry sand blasting; vacuum; and vegetation cutting.

Fresh or Salt Marsh Cleanup

In all cases, cleanup options that avoid causing additional damage to the marshes would be selected. If a fresh or salt marsh becomes oiled with a medium-weight oil, the preferred cleanup option would be to take no action. Another applicable alternative would be trenching (recovery wells). Shore removal/replacement, vegetation cutting, or nutrient enhancement could be used. The option of using vegetation cutting as a shoreline countermeasure would depend upon the time of the year and would be considered generally only if re-oiling of birds is possible. Chemical treatment, burning, and bacterial addition are potential countermeasures under regulatory consideration. Responders are advised to avoid manual removal; passive collection; debris removal/heavy equipment; sediment removal; cold-water flooding; high- or low-pressure, cold-water washing; warm-water washing; hot-water washing; slurry sand blasting; and shore removal/replacement.

Coarse Sand/Gravel Beaches Cleanup

If a coarse sand/gravel beach becomes oiled with a medium-weight oil applicable cleanup options include manual removal, trenching (recovery wells), sediment removal, cold-water deluge flooding, and shore removal/replacement. Other possible shoreline countermeasures include low-pressure, cold-water washing; burning; warm-water washing; and nutrient enhancement. Responders are requested to avoid the following countermeasures: no action; passive collection (sorbents); high-pressure, cold-water washing; hot-water washing; slurry sand blasting; vacuum; and vegetation cutting.

Exposed or Sheltered Tidal Flats Cleanup

If exposed or sheltered tidal flat becomes oiled with a medium-weight oil, the preferred cleanup option is no action. Other applicable shoreline countermeasures for this resource include trenching (recovery wells) and cold-water deluge flooding. Other possible shoreline countermeasures include low-pressure, cold-water washing; vacuum; vegetation cutting; and nutrient enhancement. Responders are requested to avoid manual removal; passive collection; debris removal/heavy equipment; sediment removal; high-pressure, cold-water washing; warm-water washing; hot-water washing; slurry sand blasting; and shore removal replacement.

Seawall/Pier Cleanup

If a seawall or pier becomes oiled with a medium-weight oil, cleanup options include manual removal; cold-water flooding; low- and high-pressure, cold-water washing; warm-water washing; hot-water washing; slurry sand blasting; vacuum; and shore removal replacement. Other possible shoreline countermeasures include burning and nutrient enhancement. Responders are requested to avoid no action, passive collection (sorbents), trenching, sediment removal, and vegetation cutting.

4.3.1.2. Risk Characterization for Proposed Action Spills

Chapter 4.3.1.1. provided background information and statistics for past and future oil spills in the GOM. This section builds on that information and statistics and presents spill assumptions and scenarios for assessing risks associated with a proposed action.

Risk is defined as a probability of undesired effect, or the relationship between the magnitude of the effect and its probability of occurrence (Suter, 1993). For oil spills, the risk, or the probability of a spill resulting in harmful effects (Suter, 1993) is dependent upon the magnitude, frequency, routes of exposure, and duration of exposure to oil. The purpose of the following risk characterization is to provide a framework or set of assumptions on how much, how often, where, and when spilled oil can occur as a result of a proposed action. This framework or scenario can be used to infer or project (but not to predict or forecast) the most probable routes of exposure to oil and to determine what the chances are of harmful exposure to oil for a resource.

The MMS collects and evaluates data on past spills, along with using results from quantitative models, to characterize the risk from spill events that could occur from a proposed action. Estimates are made about the following that are pertinent to a proposed action: likely spill sources; likely spill sizes; the likelihood and frequency of occurrence for different size spills; timeframes for the persistence of spilled oil; volumes of oil lost from a floating slick due to weathering and cleanup; the likelihood of slick transport by wind and waves resulting in contact to specified environmental features; and the volume of oil dispersed into the atmosphere, water column, and sediments. These components provide the major framework for the exposure and effects assessment addressed in the analyses for the specific resources of concern (**Chapter 4.4.**, Environmental and Socioeconomic Impacts – Accidental Events).

4.3.1.2.1. Frequency, Magnitude, and Source of Spilled Oil from a Proposed Action

4.3.1.2.1.1. Mean Estimated Numbers of Offshore Spills from a Proposed Action

To estimate the mean number of spills that are likely to result from a proposed action, MMS multiplies spill rates based on past records (**Chapter 4.3.1.1.1.**, Past Spill Incidents) times the range of oil resources estimated to be developed as a result of a proposed action. A discussion of how the range of resource estimates was developed is provided in **Chapter 4.1.1.1.1.**, Proposed Action.

The statistical mean number of offshore spills calculated to occur, as a result of the production and transportation of oil during the analysis period associated with a proposed action are provided below:

Spill Size Group	Mean Number of Offshore Spills	
	Low	High
≤1 bbl	218.23	285.37
>1 and <10 bbl	48.56	63.50
≥10 and <50 bbl	1.05	1.38
≥50 and <500 bbl	0.41	0.54
≥500 and <1,000 bbl	0.03	0.04
≥1,000 bbl	0.10	0.13

The mean number of spills for all size categories reflects the fact that, as spill size increases, the occurrence rate decreases and the number of spills estimated to occur decreases. The mean number of spills ≥1,000 bbl estimated for a proposed action is 0.10 to 0.13.

4.3.1.2.1.2. Most Likely Number of Offshore Spill Events for a Proposed Action

Based on the mean number estimated, MMS makes assumptions about the most likely number of offshore spills occurring. The most probable number of offshore spills attributable to a proposed action is provided in **Table 4-31**. These projections are made by rounding the mean number, a statistical estimate, to a whole number. Since mean numbers can include a statistical likelihood of having a partial spill, MMS calculates the most likely number of spills and the statistical likelihood of one or more spills occurring. The MMS assumes that 220-290 spills ≤1 bbl; 50-60 spills >1 bbl and <10 bbl; 1 spill between 10 and 50 bbl, and 1 spill between 50 and 500 bbl are the likely numbers of spills occurring offshore over the 37 year life of a proposed action. For larger spills, even if the high case oil resources are developed, no spills are likely to occur as a result of a proposed action; i.e., the most likely number being zero (<0.5).

4.3.1.2.1.3. Most Likely Number of Coastal Spill Events for a Proposed Action

The MMS uses the USCG Marine Safety Information System database (USDOT, USCG, 2001a) to estimate the number of coastal oil spills attributable to a proposed action. Spills occurring in the GOM coastal area are proportioned by the volumes of oil handled for all oil-handling operations in the coastal area including OCS support operations, State oil and gas production, intra-GOM transport, and coastal import/export oil activities.

Table 4-32 provides the number of spills by size group estimated to occur in coastal waters (both offshore State waters and inland coastal waters) during the analysis period as a result of a proposed action. The MMS estimates that a total of 12-16 spills into GOM coastal waters are likely as a result of a proposed action. Of these spills, 10-12 are assumed to be ≤1 bbl and 3 >1 bbl and <50 bbl. No spills ≥50 bbl are assumed to occur in coastal waters as a result of support activities.

4.3.1.2.1.4. Probability of Spills Occurring as a Result of a Proposed Action

The probability of oil spills occurring assumes that spills occur independently of each other as a Poisson process. The Poisson process is a statistical distribution commonly used to model random events (Smith et al., 1982; Ji et al., 2002). The Poisson process can be used to calculate the likelihood of any number of spills. The results of these calculations are found in **Table 4-31**. For spills ≥l,000 bbl, the probability of one, two, three, four, or five spills occurring is provided in **Table 4-33**.

The MMS calculated the probability of “a” spill occurring (i.e., one or more spills) as a result of a proposed action sometime during its lifetime. There is a 99 percent chance of one or more spills >10 bbl occurring as a result of a proposed action, a 65-75 percent chance of a spill between 10 and 50 bbl, a 34-

42 percent chance a spill between 50 and 500 bbl, a 3-4 percent chance a spill between 500 and 1,000 bbl, and a 9-12 percent chance of a spill ≥1,000 bbl occurring sometime during the life of a proposed action.

The MMS also calculated the probability of the assumed number of spills occurring (the rounded mean). There is a 5-6 percent chance of 50-60 spills >1 bbl and <10 bbl occurring, a 35-37 percent chance of 1 spill between 10 and 50 bbl occurring, a 66 percent chance of zero spills between 50 and 500 bbl occurring, a 31 percent chance of 1 spill between 50 and 500 bbl occurring, a 96-97 percent chance of zero spills between 500 and 1,000 bbl occurring, and a 88-91 percent chance of zero spills ≥1,000 bbl occurring.

4.3.1.2.1.5. Most Likely Sizes of Spills from a Proposed Action

Table 4-31 provides the spill sizes that MMS estimates to be the most likely size that could occur offshore as a result of a proposed action. These spill sizes are based on the average size of past spills for each spill size group (**Table 4-26**).

For spills ≥1,000 bbl, the historic median spill size was used because it better represents a likely spill size rather than the average, which is skewed by a few events. The median size of spills ≥1,000 bbl that occurred during 1985-1999 is 4,551 bbl. Therefore, MMS assumes that the most likely size of a spill ≥1,000 bbl from a proposed action is 4,600 bbl.

Table 4-32 provides an assumed spill size, derived from the USCG statistics, for each of the size categories, for probable spills that could occur in coastal waters as a result of a proposed action. Ten to 12 spills are assumed to be 1 bbl and 3 spills are assumed to be 4 bbl. No larger spills are assumed.

4.3.1.2.1.6. Most Likely Source/Cause of Offshore Spills

An offshore spill from a proposed action could occur if there were an accident on the two projected production facilities or on the drillships while drilling the projected 30-40 wells, from a well blowout, or if there were a break or leak in associated pipelines.

Records show that about 72 percent of spills <1,000 bbl have occurred from mishaps during drilling and production. The kinds of accidents that could result in spills <1,000 bbl are expected to be similar to the causes of past accidents and include storage tank overfills, disconnected flow lines, processing equipment failures, etc. on facilities. The most frequently spilled oil has been diesel used to operate the facilities, not the crude oil being produced.

The MMS believes that the numbers of spills <1,000 bbl estimated (total about 270-350) are high for the level of activity projected (2 production facilities and 30-40 wells). The use of past records of spills on the shelf to predict a rate of spills per BBO produced or handled may lead to overestimates of spills when applied to deepwater operations. This number of spills has never occurred at an individual production site. The MMS continues to evaluate how it derives spill rates and possible differences between shelf and slope spill risks.

Blowouts that could occur from the drilling of wells (**Chapter 4.3.2.**) are often equated with catastrophic spills; however, in actuality very few blowout events have resulted in spilled oil, and the volumes spilled are often very small. Since 1998, four blowouts have resulted in oil spills with the amount of oil spilled ranging from <1 bbl to 200 bbl. **Table 4-27** shows that there have been no spills ≥1,000 bbl from blowouts in the last 30 years.

The probability of a spill ≥1,000 bbl occurring from a facility versus a pipeline accident is calculated by multiplying each source's spill rates by the volume of oil that would be produced or transported and applying the Poisson Process to this analysis. The results of these calculations for spills ≥1,000 bbl are shown in **Table 4-33**. **Table 4-33** indicates that the chance of a spill ≥1,000 bbl occurring on a facility (drillship or production facility) is very low to negligible (1% over the life of a proposed action). The analysis shows that the greatest risk of a spill ≥1,000 bbl occurring from a proposed action is from a pipeline break (9-11%). Causes of pipeline spills ≥1,000 bbl are assumed to be similar to those causes that resulted in past spills of this size since 1985 (shown on **Table 4-28**). Since 1985, all spills ≥1,000 bbl resulted from pipeline breaks caused by hurricanes or anchor and trawl damage. Better designs of offshore facilities have prevented accidents on platforms resulting from the same hurricanes that damaged the pipelines; prior to 1980, hurricane damage was the greatest cause of facility spills ≥1,000 bbl.

The risk of spills from support vessel operations while the vessel is docked at the offshore facility, such as a spill during transfer of diesel fuel, is accounted for in the facility spill estimates. The likelihood of a spill occurring from a service vessel accident offshore while enroute to or from an offshore facility is very low. A review of GOM vessel spills from 1960 to 1995 (size >238 bbl) (OSIR, 1997) was conducted and none of the vessels involved in spills were identified as supply vessels (Etkin, personal communication, 1998).

4.3.1.2.1.7. Most Likely Locations of Probable Offshore Spills

The MMS's reliance on historical records to project future spill occurrence limits our ability to project where a spill occurs, given that there has been no development in the proposed lease sale area. Understanding of the likely development patterns is used to estimate the most likely locations of a spill related to a proposed action.

The MMS knows from past experience that spills <1,000 bbl have primarily occurred at the development site. Therefore, MMS assumes most of the estimated smaller spills (<1,000 bbl) would occur in the proposed lease sale area at the two production sites or at the 30-40 well locations.

For larger spills, MMS uses likely source and the probability of occurrence to estimate the likely location of such a spill. There is a 1 percent chance of a facility spill ≥1,000 bbl occurring in the proposed lease sale area, which would be far from shore, given that the proposed lease sale area is about 70 mi from the Louisiana coast and 100 mi from the Florida coast.

There is a 9-11 percent chance of a spill ≥1,000 bbl occurring somewhere along the two pipeline corridors projected to be used to bring oil from the two offshore facilities to shore. The MMS assumes that, should a pipeline spill occur, it would occur along the portion of the pipeline corridors in the CPA, not in the EPA. This conclusion is based on two facts. First, the water depths in the proposed lease sale area are too deep for typical pipeline accidents to occur, and this makes the likelihood of occurrence much less. Almost all pipeline spills have been the result of an object breaking the line (14 of the 17 pipeline spills ≥1,000 bbl have occurred due to trawl or anchor damage. Second, all of the oil produced from a proposed action is expected to be piped to shorebases in Louisiana for processing (**Chapter 4.1.2.1.5.1.**, Pipeline Shore Facilities). **Figure 4-10** shows the expected pipeline corridors and shows that the portion of the pipeline length within the EPA is much smaller than the portion within the CPA. The MMS estimated the probability of a pipeline spill from a proposed action occurring in the CPA versus the EPA by approximating the distance along the pipeline corridors from the center points of each subarea in the proposed lease sale area to shore. The chance of a pipeline spill ≥1,000 bbl occurring along the portion of pipeline corridors in the EPA would be 25-35 percent (of the 9-11% chance of occurrence), and the chance that a pipeline spill would occur along the portion of the pipeline corridors in the CPA would be 66-75 percent. Multiplying the probability of the spill occurring within the EPA by the probability of it occurring results in a 2-4 percent chance of a pipeline spill ≥1,000 bbl occurring in the EPA.

4.3.1.2.1.8. Most Likely Locations of Probable Coastal Spills

Coastal spills are expected to occur near pipeline terminals or the major service bases. Pipeline terminals where oil produced from a proposed action would come ashore are those located in Louisiana, near Timbalier Bay, Grand Isle, or east of the Mississippi River. The primary service bases are located in Venice and Fourchon, Louisiana, and in Mobile, Alabama.

4.3.1.2.1.9. Oil Types

Crude oil is a complex mixture of thousands of chemical components. The relative concentrations of these components and the physical and chemical properties that result from these mixtures are very important. Information on the characteristics of the oil that could be produced is needed to determine how spilled oil would behave, how long it would persist in the environment, how well it would be able to be cleaned up, and its physical and toxicological effect on biota.

There have been very few samples of oil taken from the oil reservoirs in the proposed lease sale area. The summary of the area's geology (Appendix A.1) provides an overview of the play trends expected to be encountered should exploration and development occur. The MMS reviewed the few available API gravity measurements that were taken during a number of well tests from reservoirs located in CPA deepwater that are associated with plays in the EPA. The API gravities were all below 30°, indicating a fairly heavy crude oil type. It is not expected that this sampling is statistically representative. Two shallower water fields currently in production in the CPA are also considered representative of EPA oil—the Viosca Knoll Block 825 Field (Neptune) and the Viosca Knoll Block 956 Field (Ram-Powell). These oils have a high content of lighter molecular weight compounds.

Based on this information, MMS chose two oils as representative of future production in the proposed lease sale area. Whenever appropriate, this risk analysis makes calculations that incorporate the range of properties of these two oils. An oil from the Neptune Field (Viosca Knoll Block 825, referred to as Neptune Composite Oil) was selected to represent a "light" oil (31° API). A sample of this oil was sent to SINTEF laboratories in Norway under contract to MMS (Schrader and Moldestad, 2001). No GOM oil with comparable analytical data was available to represent a "heavy" oil (28° API). Another oil from the SINTEF database was selected to allow consideration of a heavier oil. This oil was identified as heavy Arabian crude; crude only found in the GOM area because a large volume of it is imported to GOM refineries. This crude oil is likely to contain significant asphaltenes and would therefore persist longer than lighter crudes. Also, it is likely to form a stable emulsion, and it would be more difficult to clean up or disperse. Thus, this oil likely provides an overestimate of oil resistance to weathering.

Within 60 days of commencing production, operators in the proposed lease sale area must provide chemical and physical characteristics of their liquid hydrocarbon production to MMS. This information is available for use in response in the event of a spill.

4.3.1.2.1.10. Estimated Total Volume of Oil from Assumed Spills

The MMS estimates the total volume of oil spilled from coastal spills by multiplying the assumed number of spills by the smallest and largest spill size in each size group sizes. A total of 13 to 162 bbl of oil (rounded to 15 to 160 bbl) is estimated.

The MMS estimates the total volume of oil spilled from offshore spills by multiplying the assumed number of spills by the smallest and largest spill size in each size group. The volume spill rate is the total volume of oil spilled from 1985 to 1999 (46,420 bbl) divided by the total OCS oil production (5.8 BBO), resulting in 0.000008 bbl per bbl of oil produced. Multiplying this rate times the amount of oil production estimated for a proposed action results in an estimated total volume spilled of approximately 500-700 bbl.

Adding both coastal and offshore estimates together results in 515-760 bbl. This volume represents the total loading of oil into GOM waters from assumed, coastal and offshore spill events occurring as a result of a proposed action. The total volume would not be spilled at the same time, but from a number of incidents occurring over the 37-year time period. Experts believe that oil dispersed into the water column has a residence time in GOM waters from a few days up to 6 months (**Chapter 4.3.1.2.2.**, Fate of Spilled Oil).

4.3.1.2.2. Fate of Spilled Oil

Oil is a mixture of different hydrocarbon compounds that begin reacting with the environment immediately upon being spilled. Once spilled, oil begins to spread out on the water surface. A number of processes alter the chemical and physical characteristics of the original hydrocarbon mixture, which results in the original mass spilled being partitioned to the sea surface, the atmosphere, the water column, and the bottom sediments. Weathering, the type and amount of cleanup, and the existing meteorological and oceanographic conditions determine the length of time that the slick remains on the surface of the water, as well as the characteristics of the oil at the time of contact with a particular resource.

The most likely source of a spill ≥1,000 bbl that could occur as a result of a proposed action is a pipeline break. To completely evaluate the fate of such a spill, more information not yet available is needed on the subsurface transport of oil released at the seafloor and how the seafloor release would affect the characteristics of the surface slick. Based on scientific evidence gathered to date, MMS expects that a spill occurring at the seafloor would quickly rise to the surface near the release, initially forming a very thin slick that would cover a surface area larger than if the oil were released at the surface. For purposes of analysis, we assume that the slick would behave similar to modeled surface spills, although it is likely that, because the slick is thinner and spread out more, the slick would likely break up faster than if it were released at the surface.

Given the water depths in the proposed lease sale area and along most of the pipeline corridors, the pipeline spill could occur at the seafloor in deepwater. To learn more about spills released at great depths, MMS has been involved in the study of the fate and behavior of spills in deepwater. In 1998, MMS organized the Deep Spills Task Force, a cooperative research effort between industry and government (Lane and LaBelle, 2000). This task force has completed (1) laboratory experiments to characterize how oil released under pressure would behave, (2) the development of a model that forecast the behavior of oil from a seafloor release, and (3) an experimental release of oil and gas off the coast of Norway in June 2000.

All evidence to date indicates that oil spills that occur at the seafloor from either a blowout or a pipeline break would rise in the water column reaching the sea surface. All known reserves in the GOM OCS to date have specific gravities and chemical characteristics that would result in the oil rising rather than sinking. Data from real spill incidents have shown that the proximity of the surface signature of the spilled oil is dependent upon water column currents and spill characteristics. The *Ixtoc* oil spill in Mexican waters of the GOM had substantial amounts of oil being transported horizontally in the water column as far as 20-30 km from the wellhead (Payne, 1981). An experimental release in Norway showed that the oil released at a depth of 844 m began appearing on the surface about an hour after release within a few hundred meters (horizontally) of the release site (Johansen et al., 2001). Oil continued to surface for several hours after the spill. Evidence from direct observation and remote imagery from space indicates oil slicks originating from natural seeps in the GOM occur on the sea surface almost directly above the known seep locations. Shipboard observations of a natural seep site during submersible operations noted the surface expression of rising oil at a horizontal distance of 100 m from the origin of the seep on the bottom (MacDonald et al., 1995).

4.3.1.2.2.1. Persistence

The persistence of an offshore oil slick is strongly influenced by how rapidly it spreads and weathers and by the effectiveness of oil-spill response in removing the oil from the water surface. As part of the risk analysis of an offshore OCS spill ≥1,000 bbl that could occur from a proposed action, MMS estimated its persistence time; specifically, how long such a spill would last as a cohesive mass on the surface of the water, capable of being tracked and moved by winds and currents. **Figures 4-11 through 4-14** provide a mass balance as a function of time for four scenarios. These scenarios represent the range of environmental conditions, oil types, and release locations determined to be typical of spill events ≥1,000 bbl related to a proposed action. The MMS estimates that a slick formed by such a spill would persist on the water surface between 2 and 30 days, dependent upon the range of conditions. For more information, see the following discussion of the mass balance.

It is expected that slicks from spills <1,000 bbl would persist a few minutes (<1 bbl), a few hours (<10 bbl), or a few days (10-1,000 bbl) on the open ocean. Spilled oil would rapidly spread out, evaporate, and weather, quickly becoming dispersed into the water column. Based on past OCS spill records, most spills <1,000 bbl are expected to be diesel, which dissipates very rapidly. Diesel is a distillate of crude oil and does not contain the heavier components that contribute to crude oil's longer persistence in the environment.

4.3.1.2.2.2. Mass Balance of Spilled Oil

The MMS estimated the amount of oil lost from a surface slick as a function of time (a mass balance of spilled oil) for four spill scenarios determined to represent the range of conditions expected of an oil spill event that could occur as a result of a proposed action. **Figures 4-11 through 4-14** summarize the model's results for four scenarios representing two possible oil types, four likely locations, and different environmental conditions possible for a spill event that could occur from a proposed action. An analysis of 16 different scenarios representing every combination of conditions was completed in order to choose the 4 scenarios. These four scenarios represent the minimum and maximum time frames that the slick remained a cohesive mass on the water surface for the range of conditions chosen. Two of the scenarios represent the minimum and maximum volumes of oil remaining in the slick over time for a spill event occurring in the EPA (**Figures 4-11 and 4-12**). Two of the scenarios represent the minimum and maximum volumes of oil remaining in the slick as a function of time for a spill event occurring in the CPA (**Figures 4-13 and 4-14**). **Figure 4-10** shows the locations analyzed.

The results show that, for the four scenarios chosen, a floating slick would be formed from a spill that could occur from a proposed action. A slick formed would dissipate from the sea surface between 48 hours and 30 days; the large range in time reflecting the range of environmental conditions that affect a surface slick, the range of cleanup that could occur, and the range of oil characteristics that could be encountered. The 48-hour period reflects a spill with weathering characteristics of a fairly light oil that does not emulsify (Neptune), a cleanup potential of 50 percent, and constant winds of 7 m/sec (**Figure 4-13**). The 30-day window reflects a spill of a fairly heavy crude that quickly forms stable emulsions inhibiting further weathering, a cleanup potential of 38 percent, and winter conditions reflecting a front that passes early and then winds that die down; this could be considered a worst case (**Figure 4-12**). By 10 days, for the two scenarios where oil still remains on the water surface, approximately 33-37 percent of the slick would be gone from the water surface due to natural weathering and 38-63 percent is expected to have been lost due to man's intervention (mechanical removal and chemical dispersion). These processes are discussed individually below.

The following provides the scenario parameters used for the four scenarios:

- a 4,600-bbl spill of 31° API oil lost over 12 hours as result of a potential pipeline break during summer conditions (30°C) (at DeSoto Canyon Block 884, sustained winds of 5 m/sec (**Figure 4-11**);
- a 4,600-bbl spill of 28° API oil lost over 12 hours as result of a potential pipeline break during winter conditions (12.5°C) at DeSoto Canyon Block 225, wind speeds represent a typical winter storm passage (**Figure 4-12**);
- a 4,600-bbl spill of 31° API oil lost over 12 hours as result of a potential pipeline break during winter conditions (20°C) at mean winds of 7 m/sec (**Figure 4-13**); and
- a 4,600-bbl spill of 28° API oil lost over 12 hours as result of a potential pipeline break during summer conditions (29°C) at Mississippi Canyon Block 952, mean winds of 4 m/sec (**Figure 4-14**).

The SINTEF oil-weathering model was used to numerically model weathering processes. Information on the SINTEF model can be found in Dahling et al. (1997) and Reed et al. (2000). The amounts of oil likely to be mechanically cleaned up and chemically dispersed were also estimated as discussed under "Likely Response/Cleanup of Spill."

4.3.1.2.2.3. Short-Term Fate Processes

Spreading

The two oils chosen as representative of proposed action production would float. In fact, all GOM oils encountered to date float, except under turbulent mixing conditions such as during a large storm offshore. On the sea surface, the oil is expected to rapidly spread out, forming a slick that is initially a few mm in thickness in the center and much thinner around the edges. The rate of spreading depends upon the viscosity of the spilled oil, the oceanographic conditions (wind, wave, and current), whether or not the oil is released at the water surface or subsurface, and whether the spill is instantaneous or continuous.

Spilled oil is expected to continue to spread until its thickest surface layer is about 0.1 mm. Once it spreads thinner than 0.1 mm, the slick would begin to break up into small patches, forming a number of elongated slicks, referred to as windrows, which align in the wind direction. The oil is not spread in a homogeneous layer. The oil film thickness varies, often by a factor of several thousand (Reed et al., 2000). If emulsification occurs (see below), a very small portion of the slick (less than 10% of the total area) would consist of patches of emulsion with a film thickness of 1-5 mm with an even thinner sheen trailing behind each patch of oil (<1 μm in thickness). **Figure 4-15** depicts a typical slick.

Weathering

Chemical, physical, and biological processes operate on spilled oil to change its volume and properties over time, reducing many of the components until the slick can no longer continue as a cohesive mass floating on the surface of the water. **Figure 4-16** illustrates the various weathering processes and **Figure 4-17** shows their relative importance with time. These natural processes are evaporation, water-in-oil emulsification, dissolution, oil-in-water dispersion, sedimentation, oxidation, and biodegradation. The degree that each of these processes affected spilled oil is dependent upon the chemical and physical properties of the oil, the weather conditions (wind, waves, temperature, and sunlight), and the properties of the seawater (salinity, temperature, bacteria, etc.) (Reed et al., 2000).

Evaporation

The evaporation of the light components of oil begins immediately, resulting in changes to the physical properties of the oil remaining on the sea surface. The rate of total mass loss by evaporation increases initially because of the increasing surface area, but decreases as the remaining amount of volatile hydrocarbons are lost. Evaporation is very important because the loss of the volatile hydrocarbons reduces the spilled oil's vapor pressure (a safety concern) and its acute toxicity, while increasing the oil's density and viscosity. The tarry fractions of the oil increase, which may result in tarball formation or stable emulsions (Fingas, 1997). For the four scenarios representative of the range of conditions that would affect a potential spill that could occur from a proposed action, about 30-45 percent of the Neptune Composite oil is likely to evaporate before the slick disperses in 2-3 days (**Figures 4-11 and 4-13**). Between 28 and 31 percent of the heavier crude is likely to evaporate before the slick disperses in 20-30 days (**Figures 4-12 and 4-14**).

Dissolution

Dissolution is not a major process affecting the persistence of a slick; dissolution of no more than a few percent is expected (NRC, 1985). The most soluble hydrocarbons are likely to be preferentially removed by evaporation, which is typically order of magnitude faster. Some components of oil are soluble in seawater; and this is an important route for biological uptake. Usually the more soluble an oil compound is, the more toxic it is. However, solution followed by rapid dilution throughout the water column tends to reduce adverse biological effects. No estimate of the loss of slick area due to this process is made. Omission of this process is not expected to significantly affect the estimate of the oil remaining on the water surface.

Water-in-Oil Emulsification

The formation of water-in-oil emulsions is the most important weathering process controlling the stability of surface slicks and the ability of man to remove oil from the sea surface. Emulsification is extremely dependent upon oil composition. Stable emulsions can last for years (Fingas and Fieldhouse, 1998). Many GOM oils do not form emulsions (Jokuty et al., 1996), which is useful to understand the rapid dispersion and extent of cleanup of surface slicks noted during past spill events (Rainey and Peuler, in preparation).

The oils chosen as representative of proposed action production were tested in the laboratory to determine if they formed emulsions (SINTEF, 2001). The Neptune Field Composite oil does not form stable water in oil emulsions on the sea surface. The heavy Arabian Crude, chosen to represent an upper end of heavy oils that might be developed, does.

4.3.1.2.2.4. Longer-Term Weathering Processes

Figures 4-11 through 4-14 show the estimated time a slick would remain on the surface, if a spill occurred at four locations (2 points along possible pipeline routes and 2 points within the proposed lease sale area). Given a number of conditions, a slick formed from a spill within the proposed lease sale area is estimated to remain floating on the water surface up to 30 days prior to dissipating (**Table 4-36**). A slick, formed from a spill along a possible pipeline route in the CPA, is estimated to remain floating on the water surface up to 20 days.

Most fate modeling tools developed by the scientific community have been designed to predict the fate of oil spills for only a few days in order to answer immediate response questions and because most spills, such as vessel grounding, would reach shore within this timeframe. Recently, MMS organized a workshop to improve the knowledge of long-term weathering processes (USDOC, NOAA and USDOI, MMS, 2002). The workshop was intended to initiate discussions among spill experts about what is known about the persistence and behavior of large open water oil slicks, to assess what is the state of knowledge of existing long-term weathering predictions for such spills, and to prioritize our information needs and research.

Oil-in-Water Dispersion/Mixing of Oil into the Water Column

Once spread out, oil slicks are subjected to the action of waves in the ocean. The waves break off oil globules that are pushed down into the water column. The size of the oil droplet determines the residence times of the oil-in-water dispersion. Large droplets tend to rise up and join with the surface slick again, whereas smaller droplets remain in suspension. Ocean turbulence acts to further disperse the oil-in-water droplets. The amount of the oil submerged in the water column increases with time. Droplet formation, breaking waves dynamics, and open ocean turbulence can be modeled to predict the amount of oil dispersed into the water column (Aravamudan et al., 1981; Reed et al., 2000). The concentration of oil in the water column under a slick varies but usually is less than 1 ppm. If one were to disperse a slick of 0.1-0.01 mm thickness into the water column, the maximum concentration would be 10 ppm if dispersed totally in the top 10 m. Audunson et al. (1984) reports oil concentrations on the order of tens of parts per billion under a experimental spill off Norway.

For the four scenarios representative of the range of conditions that would affect a potential spill that could occur from a proposed action, 8-21 percent of the Neptune Composite could disperse into the water column and 6-21 percent of the heavier crude could disperse into the water column (**Figures 4-11 through 4-14**).

Chemical and Photo-Oxidation

Oil compounds undergo chemical changes due to exposure to the sun. Oxidation can create products that are more toxic and more soluble than their parent compounds. Oxidation can also aid in slick breakup and are considered important in tarball formation.

At present, there are no models available that calculate the loss of slick volume due to this process (USDOC, NOAA and USDOI, MMS, 2002) although some scientists believe that it may play a significant role in changes to a slick after short-term processes diminish. Therefore, our estimate of the slick life for a spill may be an overestimation.

Biodegradation of Oil in the Water Column

The droplets of oil found in the water column as a result of a spill are distributed between soluble and oil droplet phases. The microorganisms in the seawater would rapidly start degrading the water-soluble oil compounds, removing them completely within a few days, generally resulting in reduced toxicity to marine organisms (USDOC, NOAA and USDOI, MMS, 2002). The degradation rates for the dispersed oil droplets are slower and range from 30 days to 6 months.

No estimate of the amount of oil removed from the surface slick area due to this process is made. Currently, there are no models available that calculate the loss of slick volume due to this process (USDOC, NOAA and USDOI, MMS, 2002) although some scientists believe that it may play a significant role in changes to a slick after short-term processes diminish. Therefore, our estimate of the slick life for a spill may be an overestimation.

Sedimentation

Sedimentation is the process where oil particles join particulate matter suspended in the water column, eventually sinking to the ocean bottom. This process was not modeled. It is thought that the long-term fate of spilled oil within the turbid waters of the offshore Mississippi River plume may be highly affected by this process.

Tarry Residues/Tarballs

Over time, if the slick is not completely dissipated, a tar-like residue may be left, and this floating residue breaks up into smaller tar lumps or tarballs. Not all oils form tarballs; many GOM oils do not (Jefferies, 1979). There is not scientific agreement over exactly what constitutes a tarball (USDOC, NOAA and USDOI, MMS, 2002). Most scientists agree that tarballs are floating residues primarily made up of the asphalt fraction of oil. Some believe they are oil that was once stranded on the shore, and some studies have found quantities of plant material, sand, and clay particles contained within tarballs (Payne, 1981). Tarballs range in size from a few mm to 30 cm. Some are quite soft in the middle and begin to flow on the beach due to atmospheric heating, while others are quite hard and brittle.

Most tarballs in the GOM have been identified chemically as being waxy residues from tanker cleaning discharges (Payne, 1981; Overton et al., 1983; USDOC, NOAA, 1979; Henry et al., 1993). Federal regulations now exist that prohibit the discharge of tanker washings.

Both of the oils chosen as representative of oils likely to be produced in the EPA are assumed to form some amount of tarry residues, if spilled. There are no models that estimate the percentage of the spilled oil that becomes tarballs.

4.3.1.2.2.5. Likely Response/Cleanup of Spill

Based on historic information, this EIS analysis assumes that dispersant application would be effective on 20-50 percent (S.L. Ross Environmental Research Ltd., 2000) of the treated oil. The assumptions used in calculating the amounts removed as a result of dispersant use and mechanical recovery efforts for the four 4,600-bbl spill scenarios are listed below:

- All of the spills occurred and were reported at 6 a.m.
- Spill-response efforts were conducted during daylight hours only. A 12-hour operational window was assumed for both the winter and summer season.
- Mechanical response equipment included fast-response units having a USCG de-rated skimming capacity of 3,400 bbl/day owned by the oil-spill-response cooperative, Clean Gulf Associates. This equipment was procured from Ft. Jackson, Louisiana, and Pascagoula, Mississippi, for response to DeSoto Canyon Blocks 884 and 225 and Viosca Knoll Block 948.
- Dispersant application aircraft was deployed from Houma, Louisiana. This location also served as the staging location for loading dispersants. Three aircraft, two DC3's and one DC4, were deployed for dispersant application.
- Sea-state conditions: during the summer—waves were 2 ft; during the winter—waves ranged from 1.3 to 8 ft.
- A dispersant effectiveness rate of 30 percent was assumed for the treated 31^o API oil. Based on the weathering of this oil, the initial dispersant effectiveness rate of 30 percent of the treated 28^o API oil dropped to 20 percent on day 2 in the DeSoto Canyon Block 225 scenario and on day 3 of the Mississippi Canyon Block 952 scenario (S.L. Ross Environmental Research Ltd., 2000).
- Approximately 10 percent of the 31^o API oil and 15 percent of the 28^o API oil was mechanically removed. This is based on information that 10-30 percent of a spill in an offshore environment can be mechanically removed from the water prior to the spill making landfall (U.S. Congress, Office of Technology Assessment, 1990) and on the chemical characteristics of the oils used for these scenarios.
- Because of the projected stable emulsion formation of the 28^o API, it was assumed that dispersant application would no longer be effective after 48-72 hours in the scenarios involving this oil.

Figures 4-11 through 4-14 provide the estimated amounts of oil that are expected to be removed by the application of dispersants or mechanically recovered for the four 4,600-bbl pipeline spill scenarios analyzed in this EIS. For the possible range of spill conditions estimated for a spill that could occur from a proposed action within the EPA, 23-39 percent of the slick could be chemically dispersed and 9-15 percent mechanically removed. For the possible range of spill conditions estimated for a spill that could occur from a proposed action within the CPA, 23-48 percent of the slick could be chemically dispersed and 15-27 percent can be mechanically removed.

4.3.1.2.3. Direct Exposure/Contact with Locations Where Sensitive Resources May Occur

4.3.1.2.3.1. Transport of Slicks by Winds and Currents

Spills ≥1,000 bbl

The MMS uses a numerical model to calculate the likely trajectory of a surface slick, should a spill occur. A description of the trajectory model, called the OSRA (oil spill risk analysis) model, can be found in a separate report (Ji et al., in preparation), and its results are summarized in this EIS and published in the same report.

The OSRA model simulates thousands of spills launched throughout the GOM OCS and calculates the probability of these spills being transported and contacting specified environmental resources. The probability of a spill being transported and contacting specified resources is then multiplied by the estimated mean number of spills that could be transported (**Chapter 4.3.1.2.1.1.**, Mean Estimated Numbers of Offshore Spills from a Proposed Action). The results are used to estimate the risk of future spills occurring and contacting environmental features. The OSRA results in a numerical expression of risk based on spill rates, projected oil production, and trajectory modeling.

The OSRA model simulates the trajectory of a point launched from locations mapped onto a gridded area. The gridded area represents an area of the GOM and the point's trajectory simulates a spill's movement on the surface of water using modeled ocean current and wind fields. The model uses temporally and spatially varying, numerically computed ocean currents and winds.

The OSRA model can simulate a large number of hypothetical trajectories from each launch point. Spill trajectories are launched once per day from each origin point and are time stepped every hour until a statistically valid number of simulations have been run to characterize the risk of contact. The simulated oil spills for this EIS were "launched" from approximately 4,000 points uniformly distributed 6-7 mi apart within the GOM OCS. This spacing between launch points is sufficient to provide a resolution that creates a statistically valid characterization of the entire area (Price et al., 2001).

The model tabulates the number of times that each trajectory moves across or touches a location (contact) occupied by polygons mapped on the gridded area. These polygons represent locations of various environmental features. The OSRA model compiles the number of contacts to each environmental feature that result from the modeled trajectory simulations from all of the launch points for a specific area. Contact occurs for offshore features if the trajectory simulation passes through the polygon. Contact occurs for land-based features if the trajectory simulation touches the border of the feature. The simulation stops when the trajectory contacts the lines representing the land/water boundary or the borders of the domain. The probability of contact to an environmental feature is calculated by dividing the number of contacts by the number of trajectories started at various launch locations in the gridded area.

The output from this component of the OSRA model provides information on the likely trajectory of a spill by wind and current transport, should one occur and persist for the time modeled in the simulations; the calculations for this EIS were modeled for 30 days.

The analysis of the fate of a possible OCS spill (**Chapter 4.3.1.2.2.**) shows that the slicks likely to be formed would persist on the water surface, capable of being transported by winds and currents, for 2-30 days before dispersing, dependent upon the location, season, and type of oil spilled. Given this range, the OSRA model results used in this risk analysis include two time periods for analysis: (1) the likelihood of contact that could occur within 10 days after a spill occurs and (2) the likelihood of contact that could occur up to 30 days. There are very little records that support that a spill would last for up to 30 days.

Spills <1,000 bbl

As discussed above, to be transported by winds and currents, an oil slick must remain a floating cohesive mass. Based on fate model calculations and what is known about past spills, MMS assumes that spills ≤50 bbl would not persist long enough to be transported a significant distance away from their origin point; however, spills ≥50 bbl and <1,000 bbl would remain a cohesive mass long enough to be transported some distance. The MMS therefore assumes that a slick formed from a spill in this size range could float away from the spill location for up to 3 days by winds and currents prior to dissipating.

4.3.1.2.3.2. Offshore Surface Area Covered by Spilled Oil/Surface Layer Thickness

The surface area covered by a slick as a function of time is dependent upon many complex factors that include the degree of drifting and spreading that the spilled oil has undergone on the water surface, meteorological and oceanographic conditions, and the amount cleaned up and weathered. Soon after a spill occurs, the surface water area reaches a maximum, as the oil rapidly spreads out until the slick becomes spread into a thin rainbow sheen that begins breaking up.

The MMS estimates the thickness and water surface covered by an oil slick formed from a range of conditions for different times after a spill event (≥1,000 bbl). **Tables 4-35 to 4-38** summarize MMS's calculations for four scenarios representing two possible oil types, four likely locations, and different environmental conditions possible for a spill event that could occur from a proposed action. These four scenarios represent the minimum and maximum time frames that the slick remained a cohesive mass on the water surface for the range of conditions chosen. The surface area is estimated using the calculation of the volume of oil remaining in a slick over time (**Figures 4-11 through 4-14**) and the NOAA correlation tables that predict slick area versus volume (http://response.restoration.noaa.gov/oilaids/spiltool/). If an offshore spill ≥1,000 bbl of oil were to occur as a result of a proposed action and typical offshore response was to take place, and dependent on the range of oil characteristics and environmental conditions, the maximum water surface area covered by such a slick would be between 0.20 and 1 mi^{2}.

4.3.1.2.3.3. Likelihood of an Offshore Spill Occurring and Contacting Modeled Locations of Environmental Resources

Spills ≥1,000 bbl

A more complete measure of spill risk was calculated by multiplying the probability of contact generated by the OSRA model by the probability of occurrence of one or more spills ≥1,000 bbl as a result of a proposed action. This provides a risk factor that represents the probability of a spill occurring as a result of a proposed action and contacting the resource of concern. These numbers are often referred to as "combined probabilities" because they combine the risk of occurrence of a spill from OCS sources and the risk of such a spill contacting sensitive environmental resources.

The OSRA results show that there is a risk of <0.5 percent of resources being exposed to a spill resulting from a proposed action. The likelihood of a spill ≥1,000 bbl occurring, transported on the water surface by winds and currents, and reach locations of identified resource habitats, offshore features, or counties and parishes ranges from less than 0.5-5 percent for the resources analyzed. **Figures 4-18 through 4-36** show the locations of the resources analyzed and the range in the combined probabilities of occurrence and contact for two time periods (10 and 30 days) and for two different oil development scenarios (low and high). **Table 4-34** provides a listing of only those resources or parishes where OSRA model analysis resulted in probabilities >0.5 percent and provides the probabilities for these features.

Spills <1,000 bbl

Based on fate model calculations and what is known about past spills, MMS assumes that for a spill >50 bbl and <1,000 bbl would be transported by winds and currents for up to 3 days prior to the slick dissipating.

A review of the transport probabilities showed that, if a spill <1,000 bbl were to occur within the proposed lease sale area, it would not make landfall within 3 days.

Therefore, the only risk of contact from spills <1,000 bbl associated with a proposed action is assumed to be from spills occurring in the CPA along the proposed pipeline corridors, outside of the proposed lease sale area (**Chapter 4.1.1.8.1.**, Pipelines). A review of transport probabilities for these pipeline routes does show a small likelihood that contact could occur within 3 days. Given that there is a 9-11 percent chance of a pipeline spill of a few bbl occurring from a proposed action, the chance of it occurring at a location where landfall would occur would be much less.

4.3.1.2.3.4. Length of Shoreline That Could be Exposed to Stranded Oil if an Offshore Spill Occurring as a Result of a Proposed Action were to Contact Land

An estimate of the maximum shoreline length that would be exposed to spilled oil, should a spill come ashore, is a simple arithmetic calculation based on the estimated surface water area covered (**Chapter 4.3.1.2.3.2.**). The calculation assumes that the slick would be carried 30 m inshore of the shoreline, either onto the beachfront up from the water's edge or into the bays and estuaries, and would be spread out at a uniform thickness of 1 mm; this assumes that no oil-spill boom is used.

For ≥1,000 bbl spills originating within the proposed lease sale area, the OSRA model transport probabilities of contact (an intermediate product in the OSRA model calculations) shows that no oil would make it to shore from the proposed lease sale area prior to 3 days. Therefore, the maximum length of shoreline that would be contacted by a spill occurring within the proposed lease sale area is estimated from the maximum water surface area that was calculated after 3 days. **Tables 4-35 and 4-36** summarize the calculations for the two scenarios representing two possible oil types, two locations within the EPA, and different environmental conditions possible for a spill event that could occur from a proposed action within the EPA. Between 3 and 80 km of shoreline could be exposed to stranded oil, dependent upon the season, wind and wave conditions, and type of oil. There is a 1 percent chance of a platform spill occurring within the EPA, and a 2-4 percent chance of a pipeline spill ≥1,000 bbl occurring in the EPA, calculated by multiplying the risk of occurrence times the risk of location. The risk of these spills occurring and reaching shoreline would be much less. Only spills occurring near Louisiana State waters along the pipeline systems bringing a proposed action oil to Louisiana terminals have a chance of reaching shore prior to 3 days. The maximum length of shoreline contacted by a spill ≥1,000 bbl occurring proximate to the Louisiana shoreline, for the conditions analyzed, is estimated to be 20-70 km of shoreline, assuming a slick were to reach land by 24 hours.

Tables 4-37 and 4-38 summarize MMS's calculations for two scenarios representing two possible oil types, two locations within the CPA, and different environmental conditions possible for a spill event ≥1,000 bbl that could occur from a proposed action anywhere along the pipeline corridors within the CPA. After 3 days, the maximum length of shoreline that could be exposed to stranded oil is estimated to be 10 km, dependent upon the season, wind and wave conditions, and type of oil.

Once oil is beached, some redistribution of the oil due to longshore currents and further smearing of the slick from its original landfall could also occur. It should be noted that these are likely overestimates of shoreline contact that do not include adjustment for the use of diversion booming and other shoreline protection measures.

4.3.2. Blowouts

Improperly balanced well pressures that result in sudden, uncontrolled releases of fluids from a wellbore or wellhead are called blowouts. Blowouts can happen during exploratory drilling, development drilling, production, well completions, or workover operations. One-third of blowouts were associated with shallow gas flows. Most blowouts last for a short duration, with half lasting less than a day.

From 1992 to 2001, a total of 43 blowouts have occurred in the OCS with an average of 4 blowouts per 1,000 well starts. From 1995 to 2001, the blowout rate rose from 1 per 1,000 well starts to 6 per 1,000 well starts. The rate is the same for wells drilled in shallow and deep water. During the last three years there were slightly more blowouts associated with development (6 per 1,000 well starts) than exploration (5 per 1,000 well starts). For this EIS, blowout rates of 7 per 1,000 well starts and 2 per 1,000 existing wells were used.

Blowouts may result in the release of synthetic drilling fluid or loss of oil. From 1992 to 2001, less than 10 percent of the blowouts have resulted in spilled oil. Of the 43 blowouts that have occurred during this period, four resulted in oil release ranging from 0.5 to 200 bbl.

In 1997, an MMS-funded study on the fate and behavior of oil well blowouts (S.L. Ross Environmental Research Ltd., 1997). Oil well blowouts generally involve two fluids—crude oil (or condensate) and natural gas. A highly turbulent zone occurs within a few meters of the discharge point, then rapidly loses momentum with distance. In deepwater (>300 m) with lower temperatures and higher pressures, gas may form hydrates and the volume of gas may be depleted through dissolution into the water. Larger droplets would reach the surface faster and closer to the source, while smaller droplets would be carried farther by the currents before reaching the surface.

Severe subsurface blowouts could resuspend and disperse abundant sediments within a 300-m radius from the blowout site. The fine sediment fraction could be resuspended for more than 30 days. The coarse sediment fraction (sands) would settle at a rapid rate within 400 m from the blowout site, particularly in a 30-m water depth and a 35-cm/sec blowout scenario.

The MMS requires the use of (BOP's and that BOP systems are tested at specific times: (1) when installed, (2) before 14 days have elapsed since the last BOP pressure test, and (3) before "drilling out" each string of casing or a liner (30 CFR 250.407). A 1996 MMS-funded study looked at the reliability of BOP's (Tetrahedron, Inc., 1996). This study found that subsea BOP's had a lower failure rate (28%) than surface BOP's (44%). A test was considered to have failed if any piece of equipment had to be physically repaired or sent for repairs after the test.

An estimated 0-1 blowouts could occur from activities resulting from a proposed action in the CPA. For OCS Program activities in the GOM for the years 2003-2042, the estimated total number of blowouts is 215-259.

4.3.3. Vessel Collisions

The MMS data show that, from 1995 to 2001, there were 56 OCS-related collisions. Most collision mishaps are the result of service vessels colliding with platforms or vessel collisions with pipeline risers. Approximately 10 percent of vessel collisions with platforms in the OCS caused diesel spills. To date, the largest diesel spill associated with a collision occurred in 1979 when an anchor-handling boat collided with a drilling platform in the Main Pass Area, spilling 1,500 bbl.

Safety fairways, traffic separation schemes, and anchorages are the most effective means of preventing vessel collisions with OCS structures. In general, fixed structures such as platforms and drilling rigs are prohibited in fairways. Temporary underwater obstacles, such as anchors and attendant cables or chains attached to floating or semisubmersible drilling rigs, may be placed in a fairway under certain conditions. A limited number of fixed structures may be placed at designated anchorages. The USCG's requirements for indicating the location of fixed structures on nautical charts and for lights, sound-producing devices, and radar reflectors to mark fixed structures and moored objects also help minimize the risk of collisions. In addition, the USCG 8th District's Local Notice to Mariners (monthly editions and weekly supplements) informs GOM users about the addition or removal of drilling rigs and platforms, locations of aids to navigation, and defense operations involving temporary moorings. Marked platforms often become aids to navigation for vessels (particularly fishing boats and vessels supporting offshore oil and gas operations) that operate in areas with high densities of fixed structures.

The National Offshore Safety Advisory Committee (NOSAC) examined collision avoidance measures between a generic deepwater structure and marine vessels in the GOM (NOSAC, 1999). The NOSAC offered three sets of recommendations: (1) voluntary initiatives for offshore operators; (2) joint government/industry cooperation or study; and (3) new or continued USCG action. The NOSAC (1999) proposes that oil and gas facilities be used as aids-to-navigation because of their proximity to fairways, fixed nature, well-lighted decks, and inclusion on navigational charts. Mariners intentionally set and maintain course toward these facilities, essentially maintaining a collision course. Unfortunately, most deepwater facilities do not install collision avoidance radar systems to alert offshore facility personnel of a potentially dangerous situation. The NOSAC estimates that 7,300 large vessels (tankships, freight ships, passenger ships, and military vessels) pass within 35 mi of a typical deepwater facility each year. This estimate resulted in approximately 20 transits per day for the 13 deepwater production structures existing in 1999. The NOSAC found the total collision frequency to be approximately one collision per 250 facility-years (3.6×10^{-3} per year). The NOSAC estimated that if the number of deepwater facilities increases to 25, the estimated total collision frequency would increase to one collision in 10 years. A cost-benefit analysis within the report did not support the use of a dedicated standby vessel for the generic facility; however, the analysis did support the use of a radar system on deepwater facilities if the annual costs of the system were less than or equal to $124,500.

The OCS-related vessels could collide with marine mammals, turtles, and other marine animals during transit. To limit or prevent such collisions, NOAA Fisheries provides all boat operators with "Whalewatching Guidelines," which is derived from the Marine Mammal Protection Act. These guidelines suggest safe navigational practices based on speed and distance limitations when encountering marine mammals. The frequency of vessel collisions with marine mammals, turtles, or other marine animals probably varies as a function of spatial and temporal distribution patterns of the living resources, the pathways of maritime traffic (coastal traffic is more predictable than offshore traffic), and as a function of vessel speed, the number of vessel trips, and the navigational visibility.

4.3.4. Chemical and Drilling Fluid Spills

Various chemicals are applied to the well or to the production process. Some of the chemicals used exhibit hazardous characteristics, such as corrosivity or toxicity to aquatic organisms. The manufacture, storage, transport, handling, and disposal of these chemicals are regulated by several agencies including USEPA, OSHA, and USCG. Discharges from offshore facilities are limited by the USEPA NPDES permit limits. Other releases of these chemicals are not allowed; however, an accidental spill could occur during offshore transport or storage. A recent study of chemical spills examined the types and volumes of chemicals used in OCS activities. The study determined that only two chemicals could potentially impact the marine environment—zinc bromide and ammonium chloride (Boehm et al., 2001). Both of these chemicals are used for well treatment or completion and therefore are not in continuous use; thus, the risk of a spill for these chemicals is very small. Most other chemicals are either nontoxic or used in small quantities.

Zinc bromide is of particular concern because of the toxic nature of zinc. The study modeled a spill of 45,000 gallons of a 54-percent aqueous solution, which would result in an increase in zinc concentrations to potentially toxic levels. Direct information on the toxicity of zinc to marine organisms is not available; however, the toxicity of zinc to a freshwater crustacean (*Ceriodaphnia dubia*) indicated that exposure to 500 ppb of zinc results in measurable effects. One factor not considered in the model is the rapid precipitation of zinc in marine waters, which would minimize the potential for impact.

Ammonium chloride was modeled using potassium chloride as a surrogate. The model looked at a spill of 4,717 kg of potassium chloride powder. The distribution of potassium would overestimate the distribution of ammonia released during a spill. The model indicated that close to the release point, ammonia concentrations could exceed toxic levels for time scales of hours to days. Additional information on the degradation of ammonia in seawater would be needed for a more complete evaluation.

Accidental riser disconnects could result in the release of large quantities of drilling fluids and are of particular concern when SBF are in use. The use of SBF occurs primarily in deepwater where large volumes can be released. Three recent (2000-2001) riser disconnects occurred in the GOM OCS. Each release occurred as a result of unplanned riser disconnect near the seafloor. The contents of the riser was discharged within an hour of the disconnect. In all cases, approximately 600-800 bbl of SBF were discharged at the seafloor. The fate and effects of such a large release of SBF have never been studied. Localized anoxic conditions at the seafloor would be expected as the SBF is biologically degraded.

4.4. ENVIRONMENTAL AND SOCIOECONOMIC IMPACTS – ACCIDENTAL EVENTS

4.4.1. Impacts on Air Quality

Accidents related to a proposed action, such as oil spills and blowouts, can release hydrocarbons or chemicals, which would cause the emission of air pollutants. Some of these pollutants are precursors to ozone. Typical emissions from OCS accidents consist of hydrocarbons; only fires produce a broad array of pollutants, including all NAAQS-regulated primary pollutants. The criteria pollutants considered here are NO_2, CO, SO_x, VOC's, and PM_{10}.

Once pollutants are released into the atmosphere, atmospheric transport and dispersion processes begin circulating the emissions. Transport processes are carried out by the prevailing net wind circulation. Dispersion depends on emission height, atmospheric stability, mixing height, exhaust gas temperature and velocity, and wind speed. For emissions inside the atmospheric boundary layer, the