Offshore Oil Spill Model Summary

Project Background

To inform assessment of the risks that potential oil spills pose to Delaware, the Delaware Department of Natural Resources and Environmental Control (DNREC) commissioned a study examining the trajectory and fate of released oils for a suite of hypothetical spills along the Mid-Atlantic. Hypothetical hydrocarbon release scenarios were simulated using the SIMAP oil spill modeling system in its two different modes, in order to first evaluate the probable effects associated with varying environmental conditions (i.e., stochastic mode) and then to evaluate the details of each spill type under a set of conditions representative of a worst-case situation (i.e., deterministic mode). Twelve hypothetical stochastic release scenarios were modelled off the continental shelf of Delaware, New Jersey, and Virginia (see spill locations in Exhibit 1). Oil spills into offshore waters can result in trajectories that move in various directions, depending upon the winds and currents prevailing at the time. Thus, the impacts of oil spills are subject to the time sequence of environmental conditions at the time of and following a spill. To reproduce the natural variability of environmental conditions, historical wind and current data, which vary both spatially (multiple points) and temporally (changing with time), were used in the stochastic mode of this study. Representative (i.e., deterministic) worst-case spill events were then identified from the suite of individual trajectories simulated in the stochastic analyses and were selected based on the greatest length of shoreline oiled above a conservative threshold of concern (1.0 g/m^2)[1]. These spills were used to characterize a probable event trajectory and oil mass balance. Furthermore, response modeling (i.e., surface dispersant, mechanical removal, and in-situ burning [ISB]) was conducted on selected representative spill events.

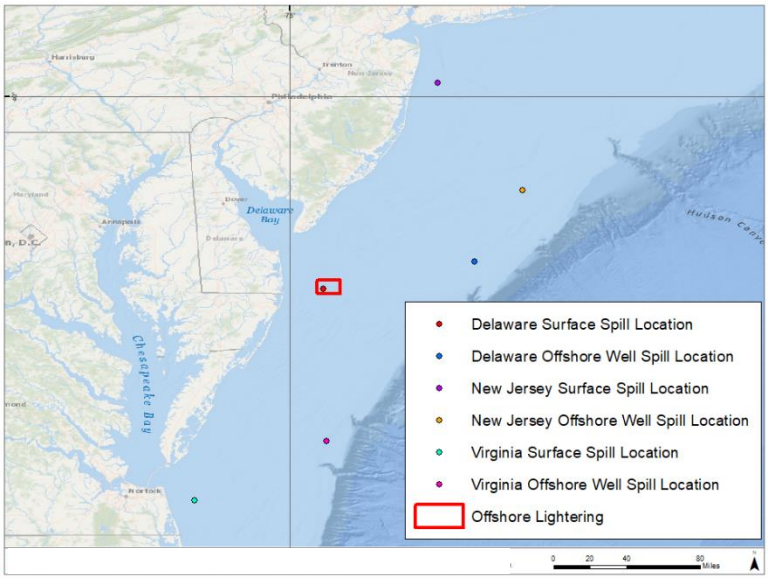

Exhibit 1. Locations of hypothetical surface and subsurface oil releases off Delaware, New Jersey and Virginia. Location of the hypothetical surface spill site off the coast of Delaware is highlighted by the red box.

This summary document focuses on five representative surface cases off the coast of Delaware. Detailed results for all scenarios are included in the full technical report.[2]

[1] The threshold of 1 g/m^2 (~1 µm thick on average over the grid cell) represents an oil amount that would appear as a dull brown color. This is the threshold above which effects on socioeconomic resources may occur (e.g., need for shoreline cleanup).

[2] RPS. 2021. Delaware Department of Natural Resources and Environmental Control (DNREC) Oil Spill Modeling and Impacts Assessment Final Report, prepared for Industrial Economics and DNREC.

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Modeled Scenarios

The spill location for the modelled Delaware surface releases is located <20 miles (<32 km) off the coast of Delaware (Exhibits 1 and 2). The volumes modelled were those of representative vessel spills of 126 barrels (bbl), 2,240 bbl, and 200,000 bbl of light crude oil with an API of 37. This oil type was chosen because the primary oil type that is imported into the region is light sweet (low sulfur) crude oil. Early oil exploration in the Mid-Atlantic by BOEM identified a potential for light crudes and condensates to be present. Four of the five spill scenarios represent spills occurring in the summer, and one is for a spill occurring during the winter.

Exhibit 2. Selected Modeled Oil Spill Deterministic Scenarios for Offshore Delaware.

Scenario ID	Spill Region	Spill Event	Oil Type	Spill Volume	Season	Discharge Duration	Model Duration	Location
1	Offshore Delaware	Surface Release	Crude Oil	High Volume (200,000 bbl) Unmitigated	Summer	1 hr	30 Days	Offshore lightering track offshore Delaware Bay at 38.4875°N, 74.7334°W
2				High Volume (200,000 bbl) Mitigated	Summer			
3				Low Volume (126 bbl)	Summer			
4				High Volume (200,000 bbl) Unmitigated	Winter			
5				Medium Volume (2,240 bbl)	Summer			

Model Results

For each modelled deterministic scenario, a mass balance plot along with maps of cumulative surface, shoreline, and water column oil exposure were produced. These cumulative maps show the maximum oil exposure on surface waters, shorelines, or in the water column at any point during the simulation (note that these maps do not depict the extent of oil contamination at any instant in time). The mass balance plots show the amount of oil in each environmental compartment (i.e., on the surface, in the atmosphere, in the water column, on the shoreline, etc.) over time. Examples of the cumulative surface oil exposure and mass balance plot for the unmitigated and response-mitigated high-volume (200,000 bbl) scenarios are provided in Exhibit 3.

Exhibit 4 summarizes the final mass balance of the spilled oil at the end of the 30-day simulations for the five selected Delaware location modelling scenarios. The overall trends in the mass balance did not differ greatly between scenarios due to the fact that the same oil type was modelled across scenarios. In most cases, almost half of the released oil evaporated within the first five days of the release. Less than 1% of the released oil was predicted to remain at the end of most of the simulations. The degraded portion of the mass balance is from biodegradation, which occurs when the oil enters into the water column and becomes available to microbes. Oil residuals on shore that did not evaporate would either be cleaned up or remain on shore until it degrades.

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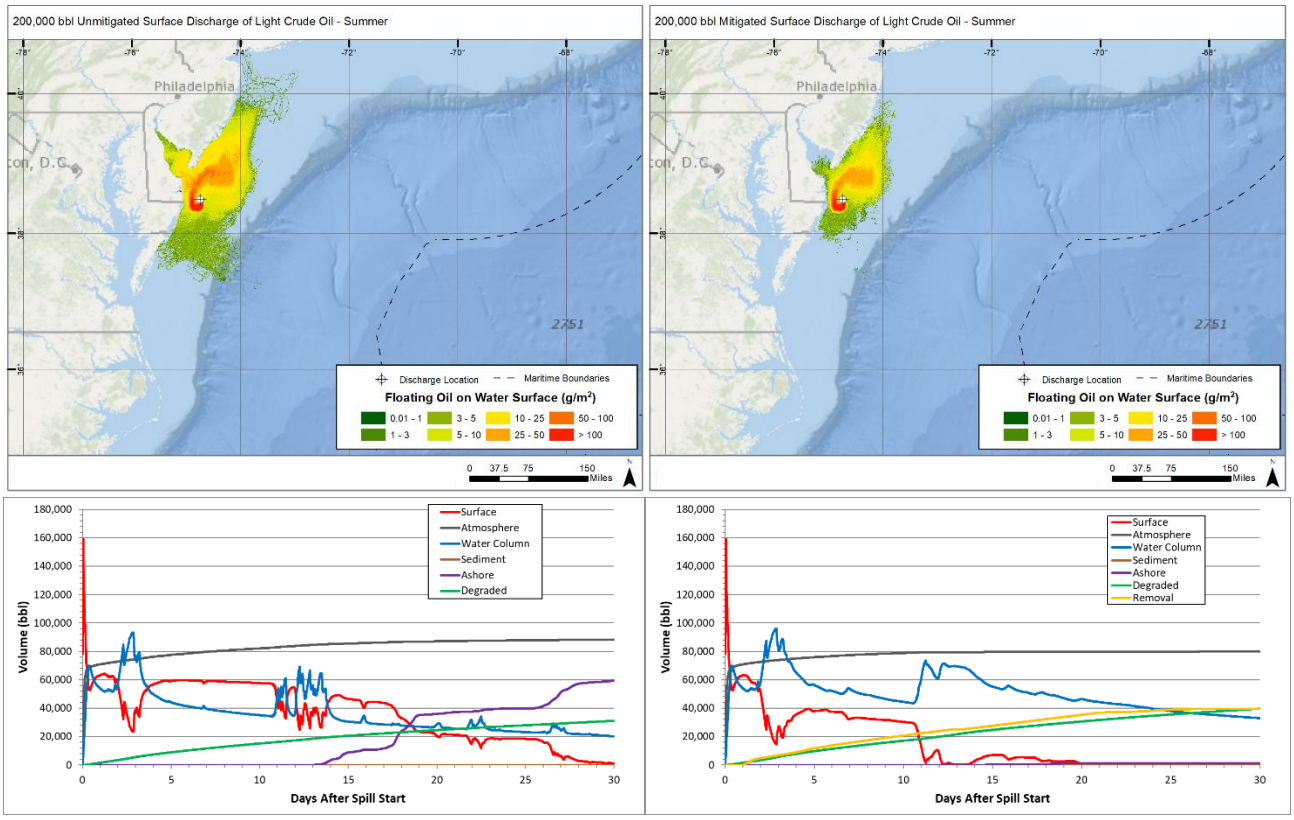

Exhibit 3. Examples of the maximum water surface oil exposure at any point in time throughout both the unmitigated (top left) and response-mitigated (top right) 30-day simulation high-volume simulations in the summer season, offshore of Delaware. The corresponding mass balance (i.e., oil volume by environmental compartment over time) plots are provided on the bottom.

Shoreline oiling was consistently at a maximum for the unmitigated cases that began in the summer, with the length of shoreline oiled proportionally related to the volume of oil released (see Exhibit 5). Response deployment reduced the amount of shoreline oiling in a high-volume release from 354 mi (569 km) to 76 mi (123 km) (Exhibit 5).

Potential oil exposures to organisms (i.e., fish eggs, larvae, and other plankton) within the water column are summarized in Exhibit 6. The concentrations of oil to which these organisms are exposed were primarily composed of polycyclic aromatic hydrocarbons (PAHs), which vary in space and time. The durations of exposure are provided to give a sense of the short periods of time that these fish and invertebrates would be exposed at the threshold of concern. Exposure to PAHs in the water column and maximum exposure time increase with spill volume in the unmitigated cases, with exposures at the most conservative threshold dissipating within 4 hours during the low volume release and 46 hours during the medium volume release. The degree of exposure to PAHs within the water column is higher in the mitigated high-volume case as response methods, specifically dispersant, break oil into smaller droplets, allowing for increased entrainment within the water column.

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Exhibit 4. Mass balance at the end of the simulation for the worst-case run for shoreline oiling for each of the five scenarios at the Delaware release location.

Spill Scenario	Season	Percent of Oil by End of Simulation				
		Surface	Atmos-phere	Shore-line	Water	Degraded
High Volume (Unmitigated)	Summer	<1	44	29	10	16
High Volume (Mitigated)[a]	Summer	0	40	<1	16	20
Low Volume	Summer	<1	52	29	7	11
High Volume (Unmitigated)	Winter	11	47	23	7	12
Medium Volume	Summer	<1	49	31	8	12

[a]23% of released oil removed via response methods.

Exhibit 5. Shoreline lengths oiled by >1 g/m^2 (1µm on average) for the run with maximum shoreline length oiled for each of the five scenarios at the Delaware release location.

Spill Scenario	Season	Length Oiled (mi)			Length Oiled (km)		
		>1g/m^2	>10g/m^2	>100g/m^2	>1g/m^2	>10g/m^2	>100g/m^2
High Volume (Unmitigated)	Summer	354	340	263	569	564	424
High Volume (Mitigated)	Summer	76	76	48	123	122	77
Low Volume	Summer	141	44	0	227	71	0
High Volume (Unmitigated)	Winter	274	272	222	441	438	357
Medium Volume	Summer	234	177	49	376	285	79

Exhibit 6. Modelled dissolved PAH exposure volumes (i.e., exposed at any instant in time) and overall duration of exposure (in any location) in surface waters for the five scenarios at the Delaware release location. (One km^3 is equivalent to 1 billion m3 and 1.3 billion cubic yards.)

Spill Scenario	Season	Volume Contaminated		Max Exposure Time	
		>1 ppb (km^3)*	>10 ppb(km^3)*	>1 ppb (hours)**	>10 ppb (hours)**
High Volume (Unmitigated)	Summer	10	2	537	182
High Volume (Mitigated)	Summer	11	3	507	274
Low Volume	Summer	0.003	0	4	0
High Volume (Unmitigated)	Winter	9	2	720	172
Medium Volume	Summer	0.2	0.008	46	6

* Volume of water which exceeded 1 ppb and 10 ppb at any given time
** Maximum number of hours with exposure concentrations >1 or 10 ppb

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Key Conclusions

Key conclusions of this study include the following:

- With one representative oil type (light crude) used throughout the study, the model results are primarily controlled by the release volume and the use of response measures.
- The light crude oil used in this study has a relatively low viscosity when fresh. The nature of the oil generally leads to more evaporation and less surface/shoreline oiling at the end of the simulation, as compared to a heavier crude or fuel oil.
- The low and medium volume surface releases resulted in surface oil footprints that remained in nearshore waters off the coast of Delaware.
- For each of the modelled scenarios, the maximum surface oil exposure concentration was >100 g/m^2 (which would appear as the dark true color of the oil or as the color of emulsions) within the immediate vicinity of the release location.
- The length of shoreline oiled increased with the spill volume for each scenario.
- When comparing the mitigated and unmitigated high-volume spill scenarios, the trajectories of the highest concentrations of floating oil followed similar paths but differences can be noted in the overall size of the surface and shoreline footprints. When response options were used, the length of shoreline oiled dropped considerably when compared to the unmitigated scenarios. The unmitigated high-volume surface releases resulted in larger footprints and higher concentrations of surface oil (>100 g/m^2) and shoreline oiling (>7,500 g/m^2) than those including mitigating response activities.

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