Offshore Information for Area Contingency Planning

Los Angeles – Long Beach

Worst Case Discharge Scenario Modeling Overview

and

WCD Scenario Appendix (2A)

Technical Document #2

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1 Introduction

1.1 Purpose

In 2019, the Bureau of Safety and Environmental Enforcement (BSEE) sponsored a project in cooperation with the United States Coast Guard (USCG) to improve the content of the coastal zone area contingency plans (ACPs) with respect to the information necessary to effectively plan for and respond to large oil spills from offshore oil and gas facilities. This collaboration between BSEE, USCG Sector Los Angeles-Long Beach (LA-LB), resource trustees, state agencies, oil spill response organizations (OSROs), and Area Committees resulted in a series of technical documents that provide offshore information for southern California on:

- Offshore Oil and Gas Infrastructure (Pacific Technical Document #1)
- **Offshore Worst-Case Discharge Scenarios (Pacific Technical Document #2 and Appendix 2A)**
- Offshore Response Concept of Operations (Pacific Technical Document #3)
- Offshore Response Strategies and Best Management Practices (Pacific Technical Document #4)
- Sensitive Species Profiles and Best Management Practices (Pacific Technical Document #5).
- Offshore Environmental Sensitivity Indices (ESI) Atlas (Pacific Technical Document #6)

These documents were developed specifically for incorporation by reference into the coastal zone ACPs and are hosted on the BSEE Oil Spill Preparedness Division's (OSPD) website. In addition to the above technical documents, an inventory of offshore spill response equipment and a set of Offshore ESI maps were created and embedded in NOAA's Environmental Response Management Application (ERMA). Collectively, these materials provide a foundation of risk assessment, resources at risk, and conceptual response information to inform coastal zone ACP planning and responses to a significant offshore facility oil spill incident.

The WCD scenario information in this technical document is organized into three main components: Section contains a description of key modeling concepts and reference scales that are useful for understanding the oil spill trajectory data and figures that have been developed for each of the WCD scenarios. Section 3 contains a series of tables that collate and summarize key information regarding all of the WCD scenarios that were developed for the Los Angeles-Long Beach Area Contingency Plan. Appendix 2A contains specific, more detailed WCD scenario modeling data and trajectory figures (see hyperlinks below).

- Appendix 2A – Los Angeles-Long Beach WCD Scenarios

1.2 Project History and Participating Organizations

The Offshore ACP Project Team, consisting of personnel from the BSEE Oil Spill Preparedness Division (OSPD), the USCG Sector Los Angeles-Long Beach, the Bureau of Ocean Energy Management (BOEM), California Department of Fish and Wildlife, Office of Spill Prevention and Response (CDFW-OSPR), and RPS Group, conducted a comprehensive review of the current offshore oil and gas activities located within the area off of southern California. The activities within the data set includes current and planned exploratory drilling activities, pipelines, and platforms with associated production wells and pipelines. The goal of the review was to identify the most significant WCDs located within the Los Angeles-Long Beach ACP Planning Area and select a subset of scenarios for the initial modeling. Five scenarios were chosen for this analysis.

RPS Group conducted an oil spill fate and trajectory analysis for each scenario to estimate the projected level of oiling for the water surface, water column, and affected shorelines if no response actions were taken. A single deterministic trajectory simulation was developed for each scenario, using metocean data for each location that in past analyses had yielded the highest levels of shoreline oiling. In January 2024, a virtual meeting was held with federal, state, and tribal stakeholders to determine which scenarios would be selected for inclusion in the ACP. Figure 1 shows the factors and scoring used by the Project Team and stakeholders to conduct a comparative analysis and select the scenarios for further development in the ACP. The WCD scenarios in this technical document are the three WCD scenarios that were chosen by the stakeholders at that meeting.

Rationale for Rating Scenario Parameters & Environmental Oiling				
Parameters	**Red (Most Significant)**	**Orange**	**Green (Least Significant)**	**Comments**
Discharge Volume	> 10,000 bbls. The largest discharge volume is red.	1,000-10,000 bbls	< 1000 bbls	Relative ratings by size. **The scenario with largest volume discharge in each zone is automatically scored red.**
Distance to Shore	< 2 miles from shore	2-6 miles from shore	> 6 miles from shore	Discharges less than 2 miles from shore are rated red due to rapid response times required.
Time to Shore	Discharges with shoreline impacts that occur in less than five days.	Shoreline impacts between 5 and 60 days.	Shoreline impacts after 60 days.	Spills with the shortest response times for shoreline impact received highest rating.
Oil Type/API Gravity (persistence)	Heavy Crudes < 20 API	Heavy Crudes > 20 API	N/A	The heavier the grade of crude oil, the more persistent it will be in the environment.
Surface Oiling	Greater than 5,000 square miles.	Greater than 1,000 square miles	Less than 1,000 square miles	Spills causing the greatest swept surface area of oiling were considered the most significant.
Shoreline Oiling	Greater than 500 miles.	Greater than 50 miles.	Less than 50 miles.	Spills causing the longest length of shoreline oiling were considered the most significant.
Water Column Oiling	Significant water column oiling, millions of cubic meters.	Significant water column oiling, hundreds of thousands of cubic meters	Minimal water column oiling, less than 15,000 cubic meters.	Spills causing the largest volume of water column oiling were considered the most significant.

Figure 1. Rationale for Rating Scenario Parameters & Environmental Oil Exposure.

2 Oil Spill Modeling Information

2.1 Models Used

2.1.1 OILMAPDeep

The OILMAPDeep Model is a tool to evaluate potential accidental discharges of oil and gas from a deep-water well blowout. The results provide a description of the behaviour of the blowout plume, its evolution within the water column and the expected initial dilution (concentration decrease) with distance from the wellhead (seafloor). It provides information about the termination ("trap") height of the plume and the oil droplet size distribution(s) associated with the discharge. These results are used as initial conditions for modeling the far-field fate and trajectory modeling of the resulting subsurface plume and surface oil slick.

2.1.2 Spill Impact Model Application Package (SIMAP)

RPS' oil spill modeling system, SIMAP, or Spill Impact Model Application Package, was used to evaluate transport and weathering of oil in the far-field. SIMAP uses site-specific wind data and current data, and state-of-the-art transport and oil weathering algorithms. SIMAP was used to quantify areas swept by floating surface oil of varying thicknesses, concentrations of subsurface oil components (dissolved and particulate) in space and over time, and areas of shoreline impacted to varying degrees.

Processes simulated in the SIMAP include oil spreading (gravitational and by shearing), evaporation, transport, vertical and horizontal dispersion, emulsification, entrainment (natural and facilitated by dispersant), dissolution, volatilization of dissolved hydrocarbons from the surface water, adherence of oil droplets to suspended sediments, adsorption of soluble and sparingly-soluble aromatics to suspended sediments, sedimentation, and degradation (Figure 2). SIMAP is unique in that it not only models particulate oil content at the surface and in the water column, but it also accounts for the dissolved component of oil. SIMAP calculates the dissolved in-water concentrations and tracks them over time.

The SIMAP model was run for 45 days for the instantaneous discharges modeled for this phase of the project. All of the scenarios selected for the Pacific were simulated as 1-day discharges because each of the platforms are assisted lift. Assisted lift refers to the application of pumps or gas injection to assist the lifting of the heavier reservoir liquids. Without these pumps, it would be impossible for a continuous discharge to occur. The response would simply involve securing this pump.

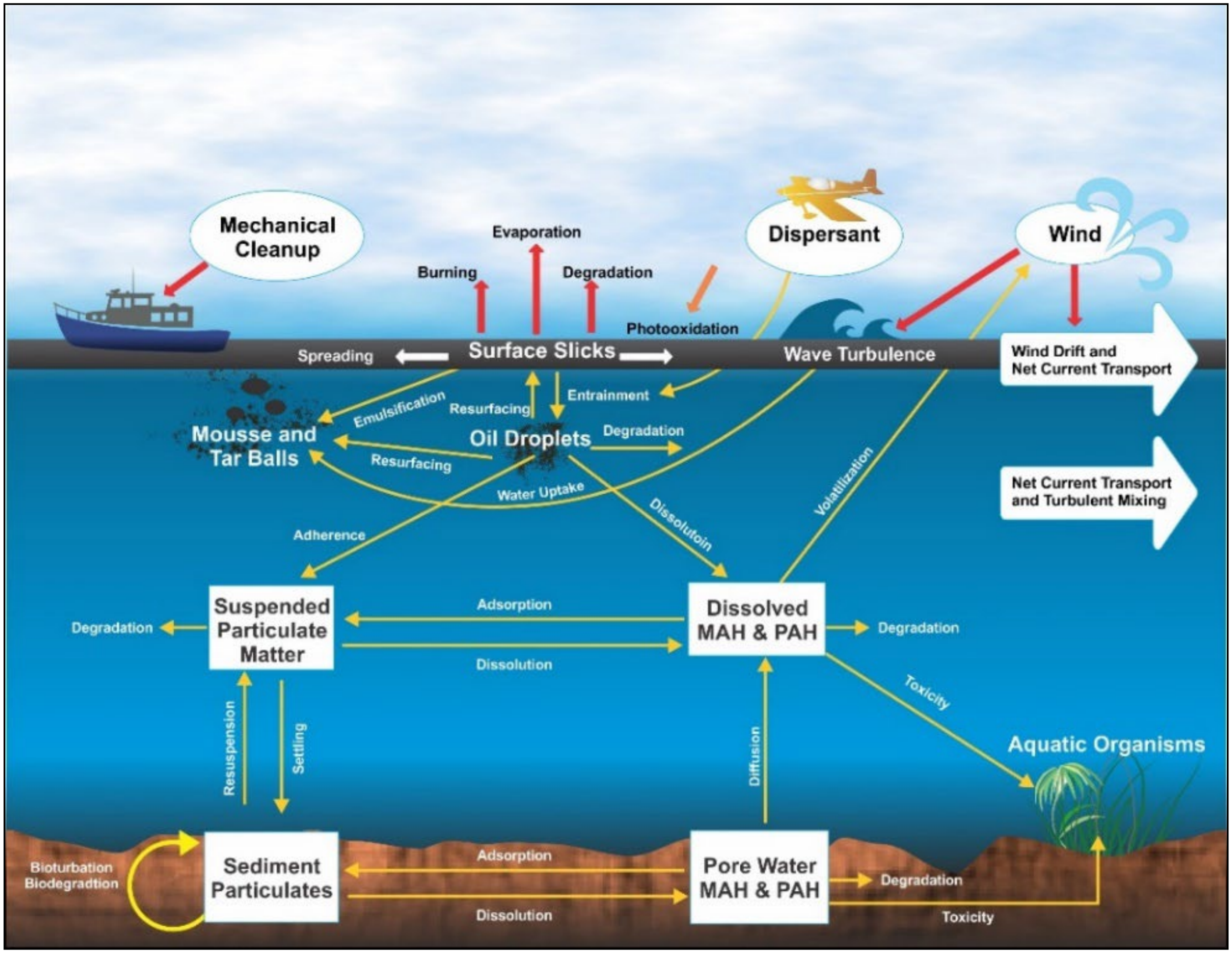

Figure 2. Open water oil fates and behavior processes simulated in the SIMAP modeling system.

2.2 Modeling Thresholds

The trajectory footprints for oiling and "minimum travel time" contours were calculated for specific thresholds where a minimum amount of oil thickness or waterborne concentrations were present (Table 1). Only those regions with oiling above the thresholds are shown in the figures.

Table 1. Thresholds used in the oil spill modeling.

Environmental Compartment	Surface Oiling	Surface Oiling	Surface Oiling	Shoreline Oiling	Water Column Oil Exposure
Threshold Amount	0.04 µm	10 µm	50 µm	10 µm	10 ppb Dissolved PAH*
Rationale For Threshold	A conservative threshold used to determine effects on socioeconomic resources (e.g., fishing may be prohibited when sheens are visible on the sea surface).	A conservative threshold for consideration of potential effects on birds, marine mammals, and sea turtles from floating oil	Industry-standard surface thickness for recoverable oil	A conservative screening threshold for potential ecological effects on shoreline fauna. Potential lethal effects threshold for birds on the shoreline.	Water column impacts (lethal) to plankton in the upper 20 m, and sublethal to lethal to other water column biota (adult, juvenile fish and invertebrates)
Visual Appearance	Fresh oil at this minimum thickness corresponds to a slick being barely visible as a colorless or silvery/grey sheen.	Fresh oil at this minimum thickness corresponds to a slick being barely visible or scattered sheen (colorless or silvery/grey), scattered tarballs, or widely scattered patches of thicker oil.	Heavy metallic sheen with patches of discontinuous brown oil	Transparent or Iridescent Films/Sheens	N/A

*10 ppb (µg/L) of whole oil Total hydrocarbon Concentration (THC) in the water column corresponds to ~0.1 ppb (µg/L) of dissolved Polycyclic Aromatic Hydrocarbons (PAHs) for fresh unweathered crude oil types (the soluble PAHs are approximately 1% of the total mass of fresh oil). This threshold can result in lethal water column impacts to fish larvae in deep waters (without UV exposure) and sublethal impacts to fish larvae in the upper 20 m.

2.3 Stochastic Modeling Outputs

Stochastic simulations provide insight into the probable behavior of an oil spill in response to temporally and spatially varying meteorological and oceanographic conditions. The stochastic model computes oil fate and transport for an ensemble of hundreds of individual simulations for each scenario, sampling the variability in regional and seasonal wind and current forces by starting each simulation on different dates within the chosen time. It then summates the results of all the simulations into a spatially-based probabilistic footprint for oiling at a specified threshold.

The stochastic analysis provides two main types of information: 1) footprints for the water's surface, water column, and shorelines, based on the associated probabilities that each area might be oiled, and 2) the shortest time required for oil to reach any point within the areas predicted to be oiled. It is important to note that any single simulation may encounter only a relatively small portion of this footprint.

2.3.1 Probability of surface oil exposure at the chosen threshold:

These maps define the area and probability in which the sea surface may be oiled at a particular concentration based on the summation of the resulting trajectories from the ensemble of simulations. The map does not imply that the entire contoured area would be covered with oil in the event of a spill. The map also does not provide any information on the quantity of oil in each area.

2.3.2 Minimum travel times:

The footprint on these maps corresponds to the probability map and illustrates the shortest time required for surface oil to reach any point within the footprint at a chosen threshold. These results are also based on the ensemble of all individual simulations. The stochastical data also provides estimates of the average time for oil to make landfall.

2.3.3 Probability of shoreline oil exposure at the chosen threshold:

The map defines the area in which shoreline oiling may be expected and the associated probability of oiling based on summation of the resulting trajectories from the ensemble of individual simulations run. The map does not imply that the entire contoured area would be covered with oil in the event of a spill. The map also does not provide any information on the quantity of oil in each area. The stochastical data also provides estimates for the percentage of simulations where oil makes landfall, and the maximum and average percentages of the oil discharge to make landfall.

2.3.4 Probability of water column oil exposure at the chosen threshold:

The map defines the area in which subsurface oiling may be expected and the associated probability of oiling based on the summation of the resulting trajectories from the ensemble of simulations.

2.4 Deterministic Modeling Outputs

For each spill scenario, one deterministic trajectory/fate simulation was run to investigate the specific "worst-case" simulation that could potentially occur using the metocean data from the corresponding stochastic simulations. The worst-case simulation was selected based on the start date and ensuing winds and currents that resulted in the largest amount of shoreline oiling. The "total length of shoreline oiled" was used as the indicator to compare and assess the degree of shoreline oiling.

2.4.1 Color Codes for Maximum Surface Oil Concentrations

Table 2 shows the figure colors, and corresponding oil appearance for the maximum *surface* oil concentrations that occurred, at any given location over the period of the simulation. The scale used in these deterministic figures for *water surface* oil concentrations is loosely based on the equivalent oil thicknesses described in the Bonn Agreement Oil Appearance Code (BAOAC) and are summarized as follows:

Table 2. Figure colors and corresponding oil appearance for the maximum surface oil concentrations.

Oil Concentrations on Water Surface (g/m^2)	Figure Color	Oil Appearance
1-5	Purple	Silver to Rainbow Sheen
5-25	Light Blue	Light Metallic Sheen
25-50	Light Brown	Heavy Metallic Sheen
50-100	Dark Brown	Discontinuous Dark Oil
100-200	Gray	Heavy Discontinuous Dark Oil
> 200	Black	Continuous Dark Oil

Note: Each g/m^2 of surface oil concentration is equal to 1 micrometer (µm) of surface oil thickness on average over the grid cell (i.e., 1 µm = 1 g/m^2).

This information is useful when viewing the nature/severity of the deterministic surface oil trajectories shown in each of the WCD scenarios. For example, the area in purple (1-5 g/m^2) would represent areas that experienced maximum concentrations mainly in the range of silver and rainbow sheens. This observation should be caveated, however, by the fact that the concentration shown is based on an average oil thickness/concentration for the area. Areas shown in purple may also contain patches of heavier and lighter oiling, as slicks are rarely uniform in their distribution. As such, where an area is depicted in purple for silver/rainbow sheen, it may have also experienced some smaller, thicker patches of oil in the metallic or dark range surrounded by larger areas of silver sheen or no oil, etc.

2.4.2 Color Codes for Shoreline Oil Concentrations

Table 3 shows the figure colors and corresponding oil appearance for the maximum shoreline concentrations of oiling that occurred at any given location over the period of the simulation. This scale can be used as visual reference points for the deterministic figures regarding *shoreline* oil concentrations.

Table 3. Figure colors and corresponding oil appearance for the maximum shoreline oil concentrations.

Oiling on Shorelines (g/m^2)	Figure Colors	Oil Appearance
Less than 100	Dark Green	Transparent or Iridescent Films/Sheens
100	Light Green	Visible oil stains that are too thin to scrape off
100-1,000	Light Green – Yellow Green	Stains to oil coatings that can be scraped off
1,000-10,000	Yellow – Dark Orange	Increasingly Thick Oil Cover
> 10,000	Red	Areas of Pooled Oil

2.4.3 Maximum Oil Concentration Maps

These figures show the maximum surface and shoreline concentrations that occur at any time and place over the entire period of the simulation. It is important to note that the deterministic trajectories of the spills for any single timestep will usually be much smaller in size, and in many areas less concentrated, than what is shown in the compilation maps. To illustrate this point, Figure 3 shows different timesteps of a slick trajectory from Day 2, Day 5, Day 10, Day 30, and Day 45. At the bottom right of the figure is the compilation map that shows the single highest oil concentrations that were recorded for any given time during the full 45 days of the simulation across the entire impacted area.

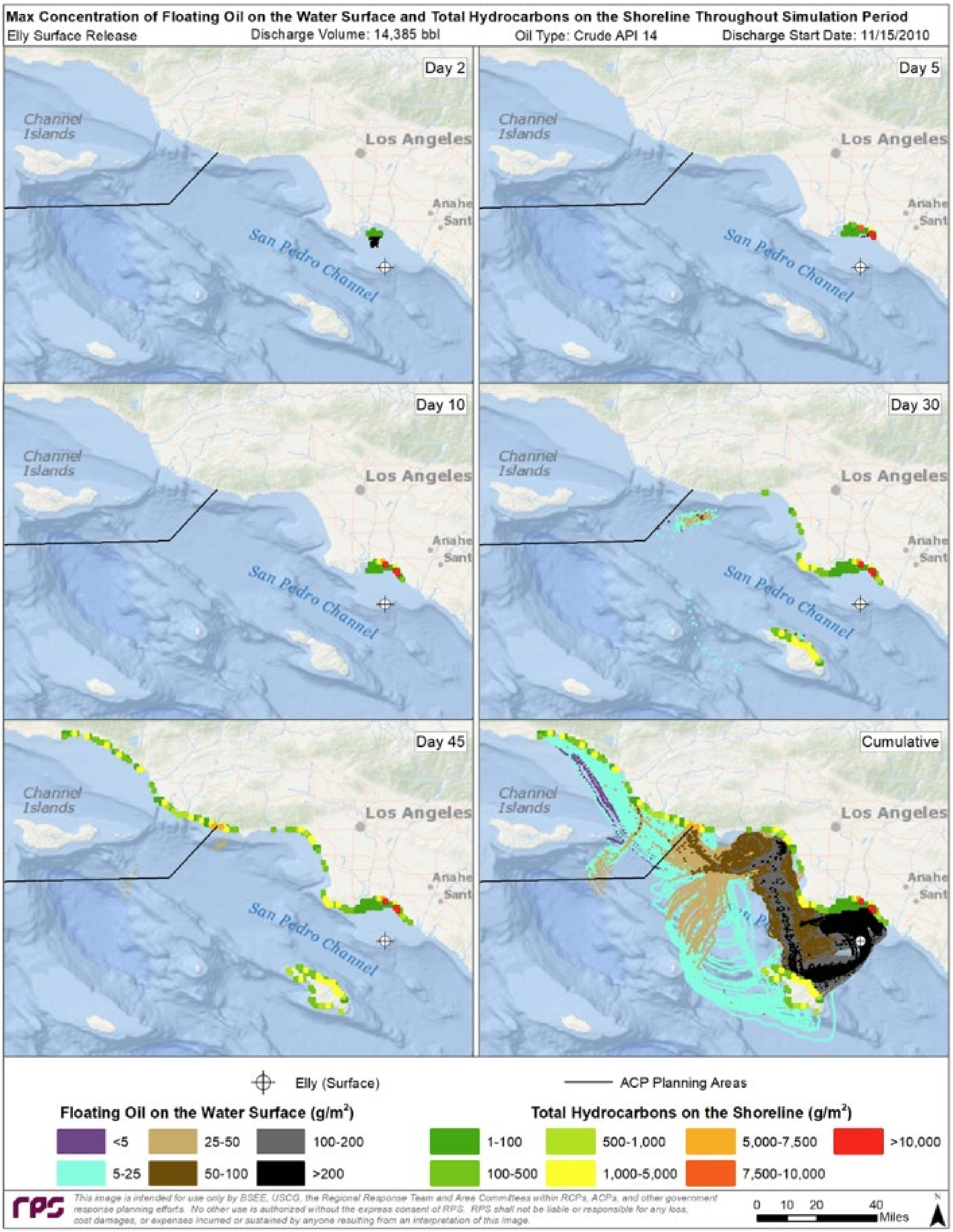

Figure 3. Deterministic modeling trajectory for maximum concentration of floating oil on the surface and total hydrocarbons on the shoreline at different points of the simulation period.

2.4.4 Maximum Water Column Oil Concentration:

The well blow out scenarios include figures showing a compilation of the single highest water column concentrations of dissolved Polycyclic Aromatic Hydrocarbons (PAHs) that were observed at any given location over the entire period of the simulation.

2.4.5 Total Oil Exposure and Mass Balance Information:

Information is provided on the total area oiled on the surface, subsurface, and shoreline at the specified ecological thresholds, and the mass balance information on the fate of the oil in various environmental compartments throughout the simulation. Note that surface area exposure provided here is the cumulative sum of areas swept by floating oil (spillets), which may include multiple exposures over the same area.

2.4.6 Minimum Surface Oil Viscosity Information*:*

As an oil spill is discharged into the environment and is exposed to wind, sunlight, and mixing energy from waves, it undergoes a weathering process. This weathering involves several processes, but for response purposes, two of the most important are the evaporation of the lighter components, and the formation of water in oil emulsions. Both processes effectively increase the viscosity of the oil. While the viscosity of spilled oil will generally increase over time, it can also be extremely sensitive to metocean changes, such as periods of increased wind and wave energy or significant temperature changes. As a result, the viscosity of an oil slick can be a very dynamic situation over time.

The oil viscosity figures in the WCD Scenario Appendix 2A show the minimum surface oil viscosity that occurred at any given location over the entire period of the simulation. It is important to note that the viscosities shown for the different areas of the oil slick for any single timestep may be very different than what is shown in the compilation maps. To illustrate this point, Figure 4 shows different timesteps of a slick's surface viscosity from Day 2, Day 5, Day 10, Day 30, and Day 45. At the bottom right of the figure is the compilation map that shows the minimum surface viscosity recorded for any given time during the full 45 days of the simulation across the entire impacted area.

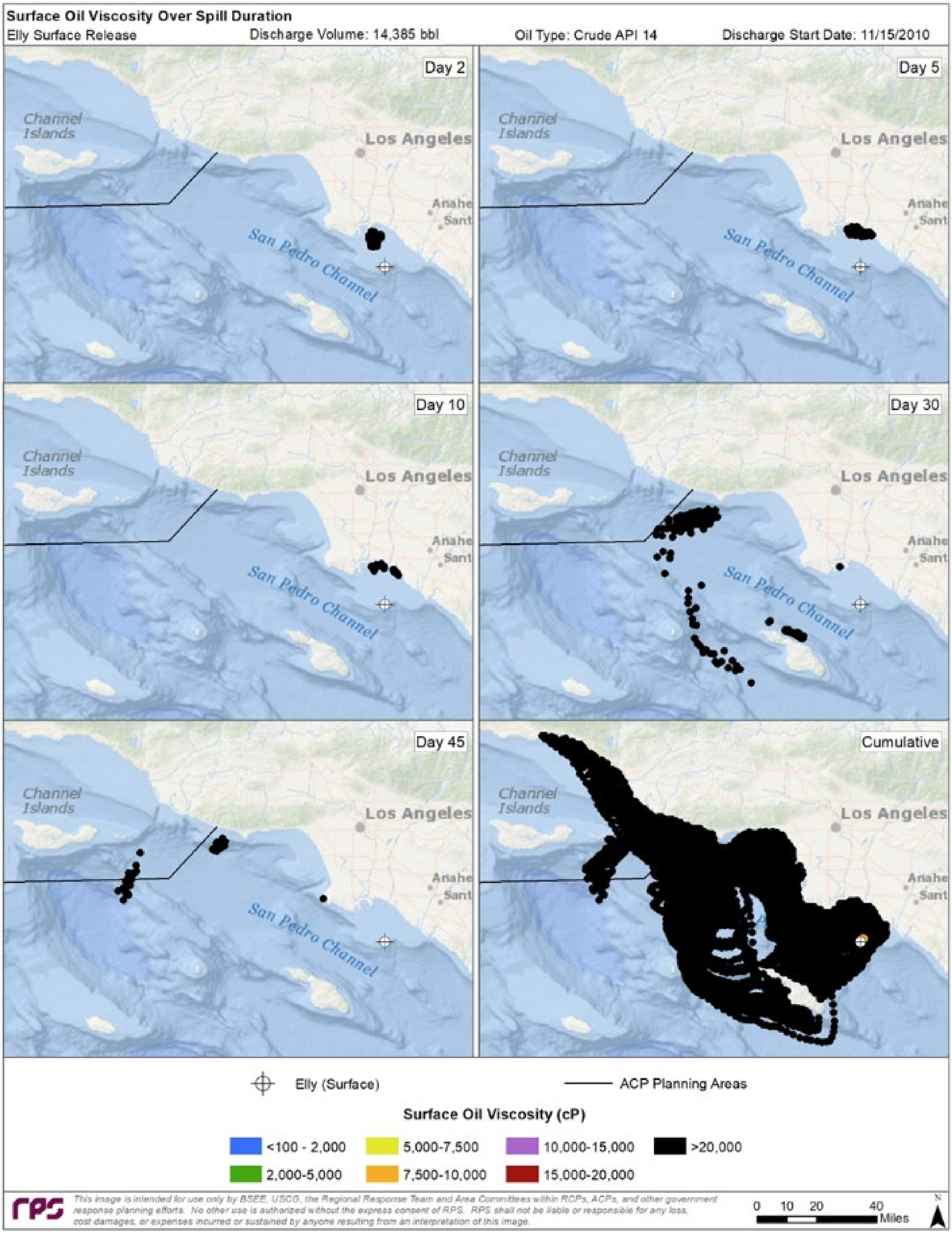

Figure 4. Deterministic modeling trajectory for minimum surface oil viscosity at different points of the simulation period.

Surface oil viscosity is an important factor for responders to consider when evaluating and selecting spill countermeasures and equipment types during an oil spill. A general rule of thumb is that the lower the oil viscosity is, the more countermeasures that may be applied. Alternatively, the higher the viscosity of the oil, the more difficult it will become for certain response equipment types or alternative technologies, such as in-situ burning or dispersants, to effectively remove the oil. For example, a fresh light or medium crude with a low viscosity may be a good candidate for mechanical recovery, dispersants, or in-situ burning. As oil weathers and emulsifies, its viscosity will increase, and the spill countermeasures that can be effectively applied may become more limited. Oil viscosity is particularly important with respect to how dispersible the oil will be. There is usually an upper viscosity limit, above which oil cannot be dispersed. Although this dispersibility limit is dependent upon the oil's specific chemical and physical properties, generally, dispersibility decreases with increasing viscosity. One general rule of thumb is that dispersants are optimally effective when viscosity is less than 2,000 cP and become increasingly ineffective when viscosity becomes greater than 10,000 cP. Table 4 provides a list of viscosities of common substances for reference.

Table 4. Viscosities of common substances for reference.

Product	Viscosity (cP)
Water at 70°F	1
Corn Oil	65
Maple Syrup	250-200
Honey	2,000-3,000
Chocolate Syrup	10,000-25,000
Ketchup or Mustard	50,000-70,000
Peanut Butter	150,000-250,000
Vegetable Shortening	1,000,000-2,000,000

Viscosity of an oil also impacts the effectiveness of mechanical recovery to remove the oil. Viscosity increases significantly in oils with a tendency to form water-in-oil emulsions where the material becomes much more viscous, and the volume of oil spilled can increase by three to four times. Different skimmer types should be used to maximize their effectiveness depending on the viscosity of the oil at different temporal points along its trajectory during the response. Weir, vortex, oleophilic rope, and disc skimmers are best used with oils at lower viscosities. For oil with higher viscosities, up to 100,000 cP, skimmer designs that can physically grab and move the oil into the skimmer's recovery sump are more effective.

3 WCD Scenarios

3.1 WCD Scenario Locations

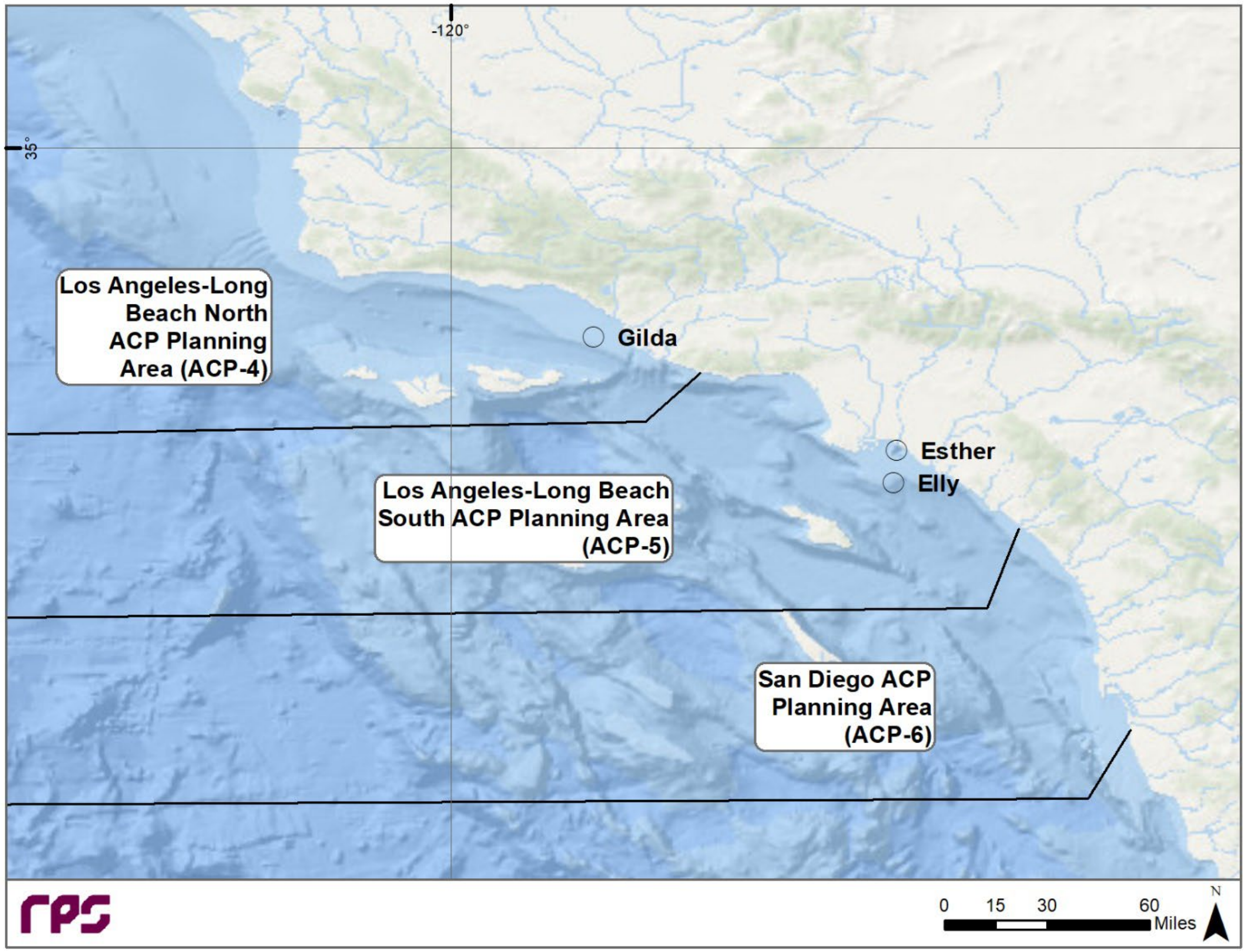

Figure 5. WCD Scenario Locations in the Los Angeles-Long Beach ACP Planning Area.

3.2 WCD Scenario Particulars

Table 5. WCD Scenario Particulars.

Scenario Number	ACP Planning Area	Area	Block	Operator	OSRP	WCD Scenario Name	Lease Status	Latitude	Longitude	Miles from Shore	Spill Type	Blow Out (bopd)	Tank (bbls)	Pipe (bbls)	1 Day Discharge Volume (bbls)	Actual API	Discharge Duration	Simulation Duration	Water Depth of Discharge (ft)	Pipe Opening (in)
1	ACP-4	LA	6862	DCOR	1007	Gilda	Production	34.198535	-119.395317	8.8	Batch	60	855	586	1,501	14.5	1 day	45 days	Surface	12"
2	ACP-5	LB	3095	DCOR (State)	1007	Esther	Production	33.719167	-118.114167	1.4	Batch	0	831	101	932	25.5	1 day	45 days	Surface	4"
3	ACP-5	LB	6438	Beta Operating Company	1019	Elly	Production	33.583403	-118.127089	8.6	Batch	1,215	9,563	3607.6	14,385	14	1 day	45 days	Surface	16"

Note: While most of the scenario parameters in this table have been collated from source documents submitted by the owners or operators of offshore facilities to the US Government, RPS Group performed the WCD oil spill modeling trajectory analyses conducted for this document under a contract sponsored by the BSEE. The modeling products in each of the ACP-specific WCD Scenario Appendix 2A will be different from the trajectory analyses conducted by owners and operators in their source documents, as it is expected that different trajectory models, metocean data, and modeling thresholds were used.

3.3 WCD Scenario Summary Results for Oil Exposure

Table 6. Environmental Oil Exposure Summary Results.

Oil Spill Scenario Parameters								Environmental Oiling at Designated Thresholds				
ID	Region	Scenario Name	Total Volume Discharged (bbl)	Discharge Duration (days)	Discharge Depth (m)	Approximate Distance to Shore (mi)	Oil Type + (API Gravity)	Swept Surface Area ($mi.^2$) Exceeding 0.04 µm	Swept Surface Area ($mi.^2$) Exceeding 10 µm	Shore Length (mi.) Exceeding 10 µm	Water Column Volume ($m.^3$) Exceeding 10 ppb Dissolved PAH	Time to Shore (hours)
1	ACP-4	Gilda	1,501	1	Surface	8.8	Heavy Crude (14.5)	895	895	134	24,018	73.0
2	ACP-5	Esther	932	1	Surface	1.4	Heavy Crude (25.5)	4,881	4,881	50	496,317	6.5
3A		Elly	14,385	1	Surface	8.6	Heavy Crude (14)	2,059	2,059	148	513,153	41
3B		Elly	14,385	1	Surface	8.6	Heavy Crude (14)	746	746	29	157,329	95.5

* Two deterministic modeling simulations are presented for Scenario 3, Elly. The actual WCD scenario as defined by the longest length of shoreline oiled was Scenario 3A. However, Scenario 3B is also included in Technical Document #2 and Appendix 2A to show a southerly trajectory which, from historical incidents in the region, is more likely to occur.

Table 7. Mass Balance Information for Worst Case Shoreline Oiling Simulation for each Scenario.

Summary of Mass Balance (%) at the End of Simulation									
ID	**Region**	**Scenario Name**	**Total Volume Discharged (bbl)**	**Surface (%)**	**Atmosphere (%)**	**Water Column (%)**	**Sediment (%)**	**Ashore (%)**	**Degradation (%)**
1	ACP-4	Gilda	1,501	0.2	27.9	0.0	0.0	68.6	3.3
2	ACP-5	Esther	932	0.0	24.3	0.0	<0.1	72.1	3.6
3A		Elly	14,385	3.1	25.7	0.0	0.0	67.8	3.4
3B		Elly	14,385	0.0	25.6	0.0	0.0	71.0	3.4

Table 8. Stochastic Information Regarding Shoreline Oiling for each Scenario.

Summary of Stochastic Results								
ID	Region	Scenario Name	Total Volume Discharged (bbl)	Percent of Simulation Reaching Shore (%)	Percent Volume of Released Oil Reaching Shore (%)		Time to Reach Shore (hours)	
					Maximum	Average	Minimum	Average
1	ACP-4	Gilda	1,501	100	73.4	65.0	14.0	63.3
2	ACP-5	Esther	932	100	70.9	64.9	2.0	12.6
3		Elly	14,385	100	71.2	65.1	22.0	75.9

* There is only one stochastic simulation for Scenario 3. The deterministic WCD simulations are pulled from the one stochastic modeling simulation.