Offshore Information for Area Contingency Planning

Offshore Worst-Case Discharge Scenarios and Modeling

Los Angeles-Long Beach

Technical Document #2
Appendix 2A

May 2024

Record of Changes

Change Number	Change Description	Section Number	Change Date	Name
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1. Introduction

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 Technical Document #2 is organized into three main components: Section 2 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 Pacific. Appendix 2A contains specific, more detailed WCD scenario modeling data and trajectory figures for the Los Angeles-Long Beach ACP. For each WCD scenario, stochastic modeling figures are included for the surface, shoreline, and water column exceeding the ecological threshold of 10 µm for the surface and shoreline and 10 ppb (µg/L) of dissolved Polycyclic Aromatic Hydrocarbons (PAH) for the water column. For the surface, a minimum time to impact figure is also included. The worst-case deterministic modeling results are then presented showing the mass balance of the oil throughout the simulation and the cumulative oil in the water column. Response Planning information is presented, including the surface stochastic modeling probability footprint and minimum time for a threshold of 50 µm, the Cumulative Maximum Concentration of Floating Oil on the Water Surface and Total Hydrocarbons on the Shoreline at any time during the simulation, and the cumulative footprint of minimum surface viscosity through the simulation. If any of these figures are not included for a given scenario, the modeling results for that scenario did not exceed the indicated threshold.

2. Environmental Conditions and Data Analysis

To understand the behavior of marine spills, it is necessary to analyze and evaluate the predominant environmental conditions in the area of interest. Winds and currents are the key forcing agents that control the transport and weathering of an oil spill. To reproduce the natural variability of the environment, the oil spill model requires wind and current datasets that vary both spatially and temporally. The following sections describe the key environmental conditions that dominate in the region of interest and more specifically in the model domain.

2.1 Wind Dataset – NOGAPS

For the modeling domain, wind data were obtained from the Navy Operational Global Atmospheric Prediction System (NOGAPS) forecast product.

NOGAPS was developed by the Naval Research Laboratory (NRL) to support a wide range of Navy oceanographic and atmospheric requirements (Hogan and Rosmond, 1991; Rosmond, T.E., 1992). The forecast model assimilates both in-situ data (from ships and moored and drifting buoys) and satellite observations, such as wind speed over the ocean, from the Special Sensor Microwave/Imager instrument aboard the Defense Meteorological Satellite Program polar orbiting satellites. This data assimilation is implemented by using the multi-variate optimum interpolation approach (Goerss and Phoebus, 1992).

Table 1. Specifics of the wind dataset used for the modeling.

Name of Dataset	NOGAPS
Coverage	-135°E to -111°E 15°N to 37°N
Owner/Provider	NRL
Horizontal Grid Size	0.5° x0.5°
Hindcast Period	2009
Time Step	3 hourly

2.1.1 Wind Analysis – NOGAPS

Because the wind conditions at Elly show strong resemblance to Esther due to their proximity, wind roses for only Gilda and Esther are presented here (Figure 1). At Gilda, wind direction is relatively variable but predominately coming from the northwest quadrant with relatively low speed. At Esther, the wind is predominantly coming from the west-southwest, and the wind speed is lowest among the sites.

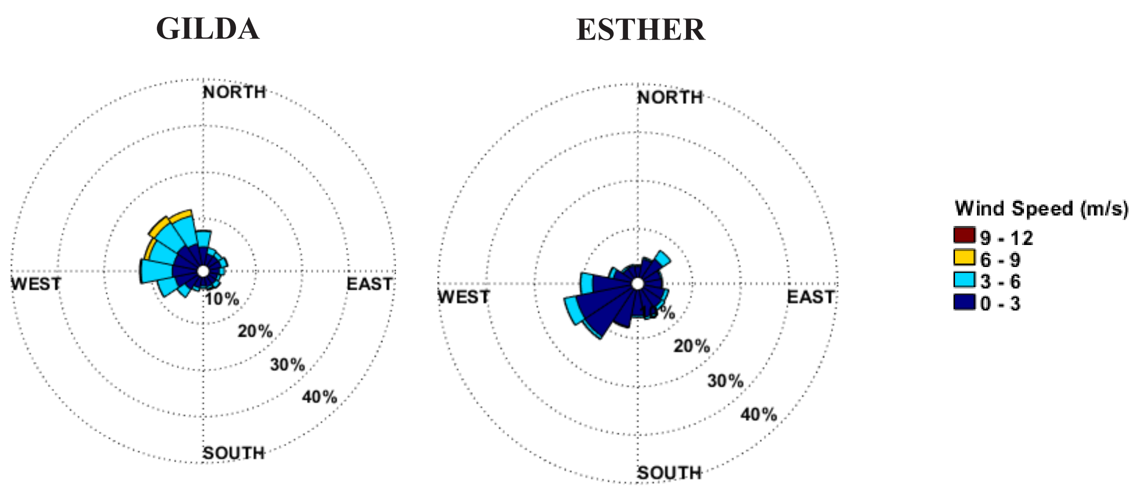

Figure 1. Annual NOGAPS wind roses for 2009 in the modeling domain. Wind speeds are in m/s, using meteorological convention (i.e., direction wind is coming from).

2.2 Global Current Dataset – HYCOM

Current data was obtained from the HYCOM (HYbrid Coordinate Ocean Model), a 1/12-degree global simulation assimilated with NCODA (Navy Coupled Ocean Data Assimilation) from the US Naval Research Laboratory (Halliwell, 2004). This dataset captures the oceanic large-scale circulation in the area of interest. NCODA uses the model forecast as a first guess in a three-dimensional (3D) variational scheme and assimilates available satellite altimeter observations from the Naval Oceanographic Office (NAVOCEANO) Altimeter Data Fusion Center, in-situ Sea Surface Temperature (SST), and available in-situ vertical temperature and salinity profiles from XBTs (Expendable Bathythermographs), Argo floats, and moored buoys. Details of the data assimilation procedure are described in Cummings and Smedstad (2013) and Cummings (2005). Fox et al. (2002) described the technique for projecting surface information (collected for assimilation) downward.

Table 2. The specifics of the current datasets used for the modeling.

Name of Dataset	HYCOM
Coverage	-135°E to -111°E 15°N to 37°N
Owner/Provider	NRL
Horizontal Grid Size	1/12°
Output Frequency	Daily

2.2.1 Current Analysis – HYCOM

Similar to the winds, current conditions at Elly show strong resemblance to Esther due to their proximity. Therefore, current roses for Gilda and Esther are presented here (Figure 2). At Gilda, current is predominantly flowing towards the southeast while at Esther, the current direction remains in the southeast quadrant most of the time with the highest speed.

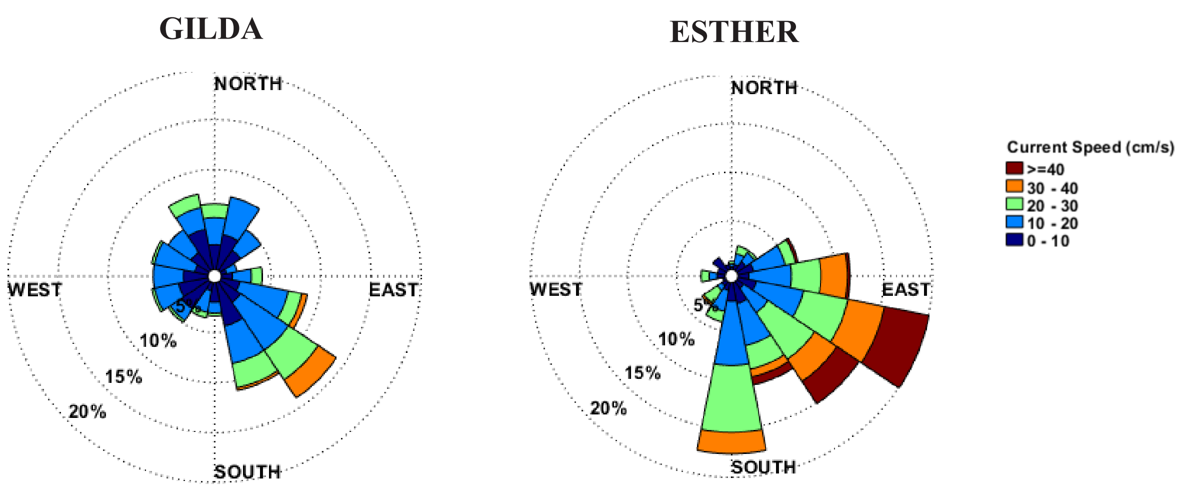

Figure 2. Annual HYCOM current roses for 2009 in the modelling domain. current speeds are in cm/s, using oceanographic convention (i.e., direction current is going towards).

The current intensity and direction map for offshore Southern California show the equatorward flowing slow current along the coast (Figure 3).

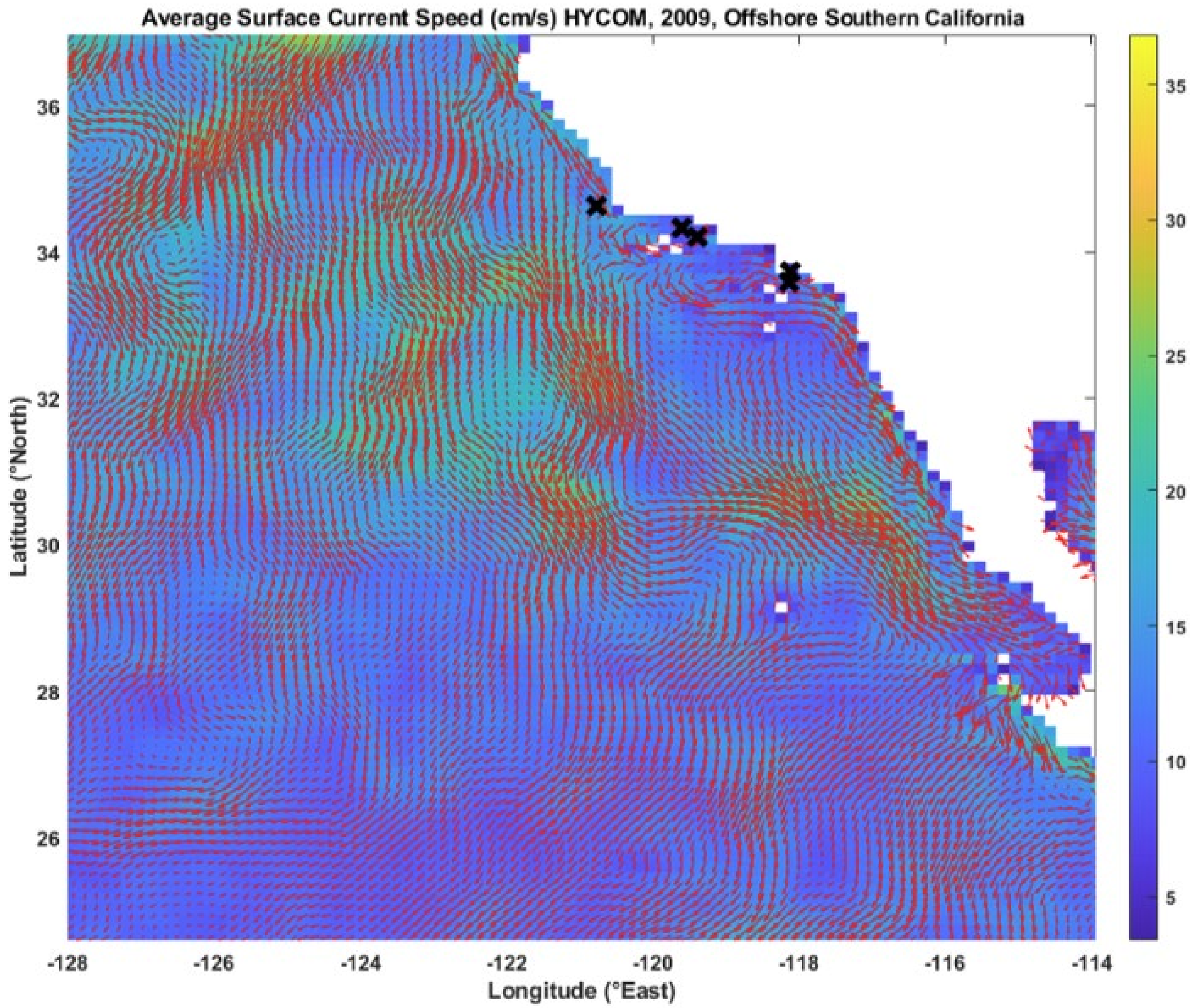

Figure 3. Spatial distribution of averaged HYCOM surface current directions and speeds for offshore Southern California. The black crosses show the location of the spill sites.

3. Gilda Surface Well Blowout

3.1 Scenario Description

The Gilda WCD Scenario is a surface well blowout with the following key parameters.

Table 3. Scenario Key Parameters.

Discharge Depth (m)	Distance from Shore (mi)	Oil Type	Spill Type	Discharge Duration (days)	Discharge Flowrate (bbl/day)	Total Oil Discharged (bbl)
Surface	8.8	Heavy Crude API = 14.5	Surface Well Blowout	1	1,501	1,501

3.2 Potential Oil Contact with the Environment and Resources at Risk

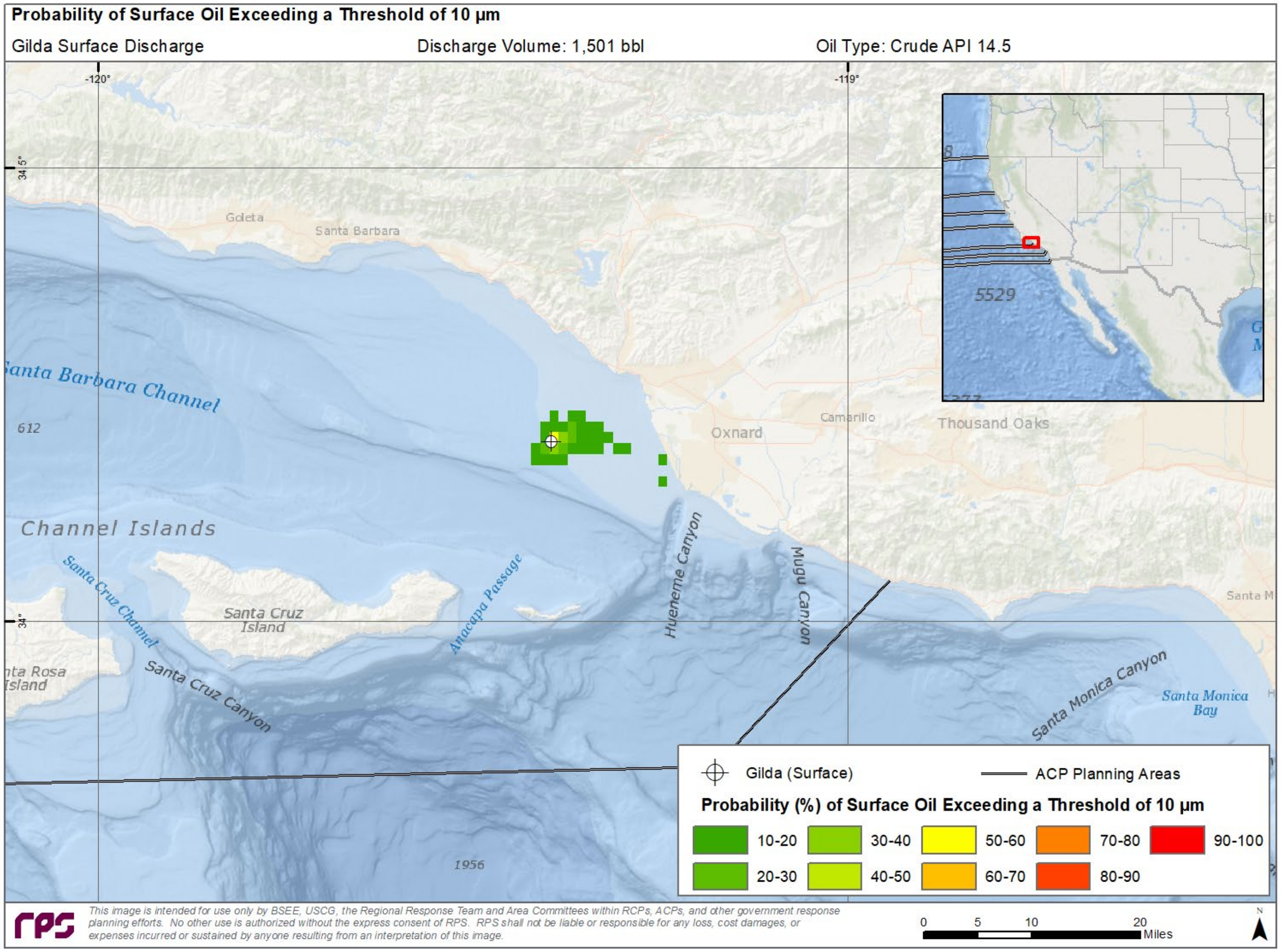

Figure 4. Probability Footprint for Oil on the Water Surface with Average Thickness greater than the Ecological Threshold of 10 µm.

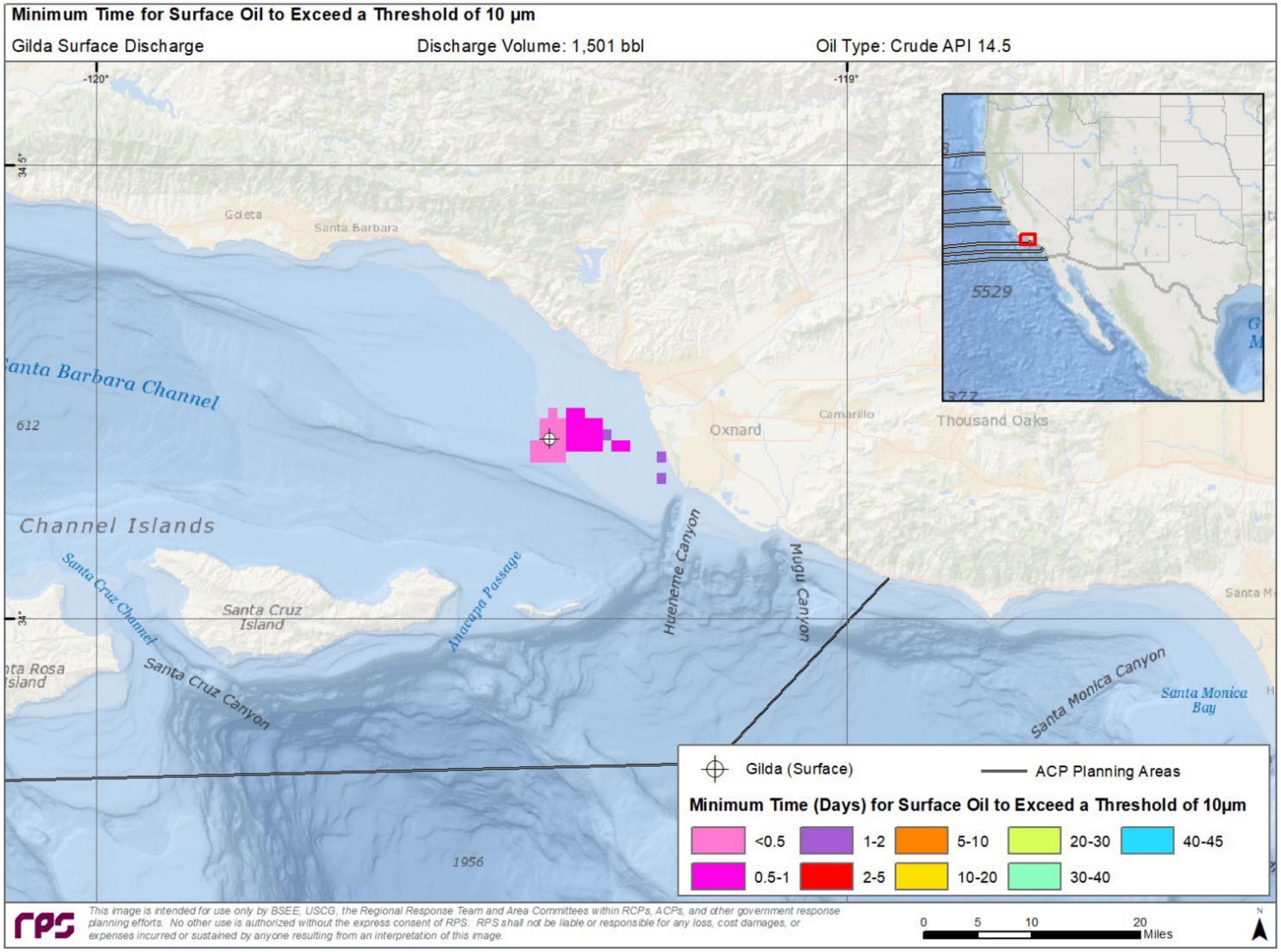

Figure 5. Minimum Time for Oil on the Water Surface with Average Thickness greater than the Ecological Threshold of 10 µm.

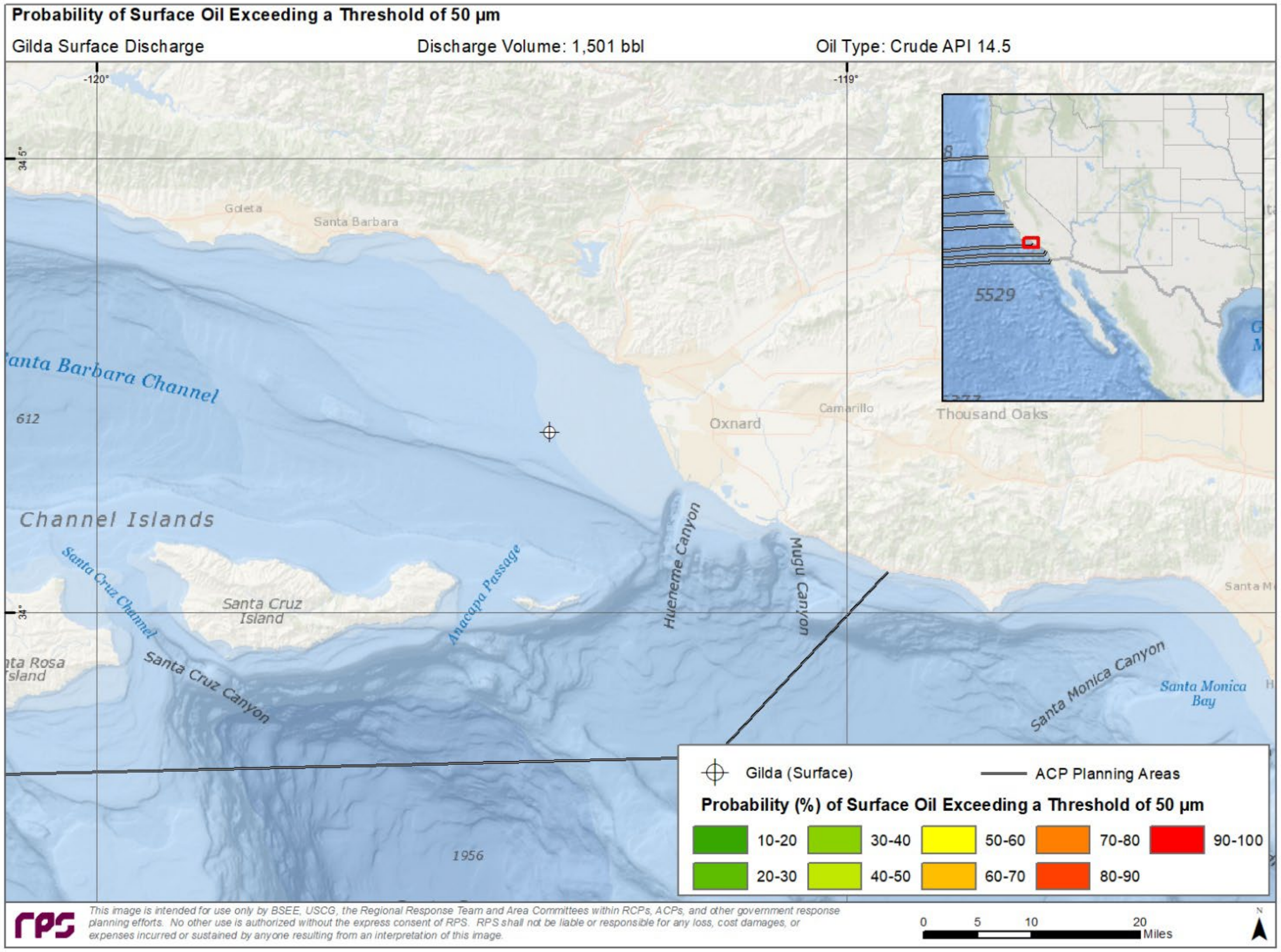

Figure 6. Probability Footprint for Surface Oil exposure greater than 50 µm. In this thickness range, oil will appear as a continuous to discontinuous patches of dark oil in quantities where high volume on-water mechanical recovery operations will be the most productive.

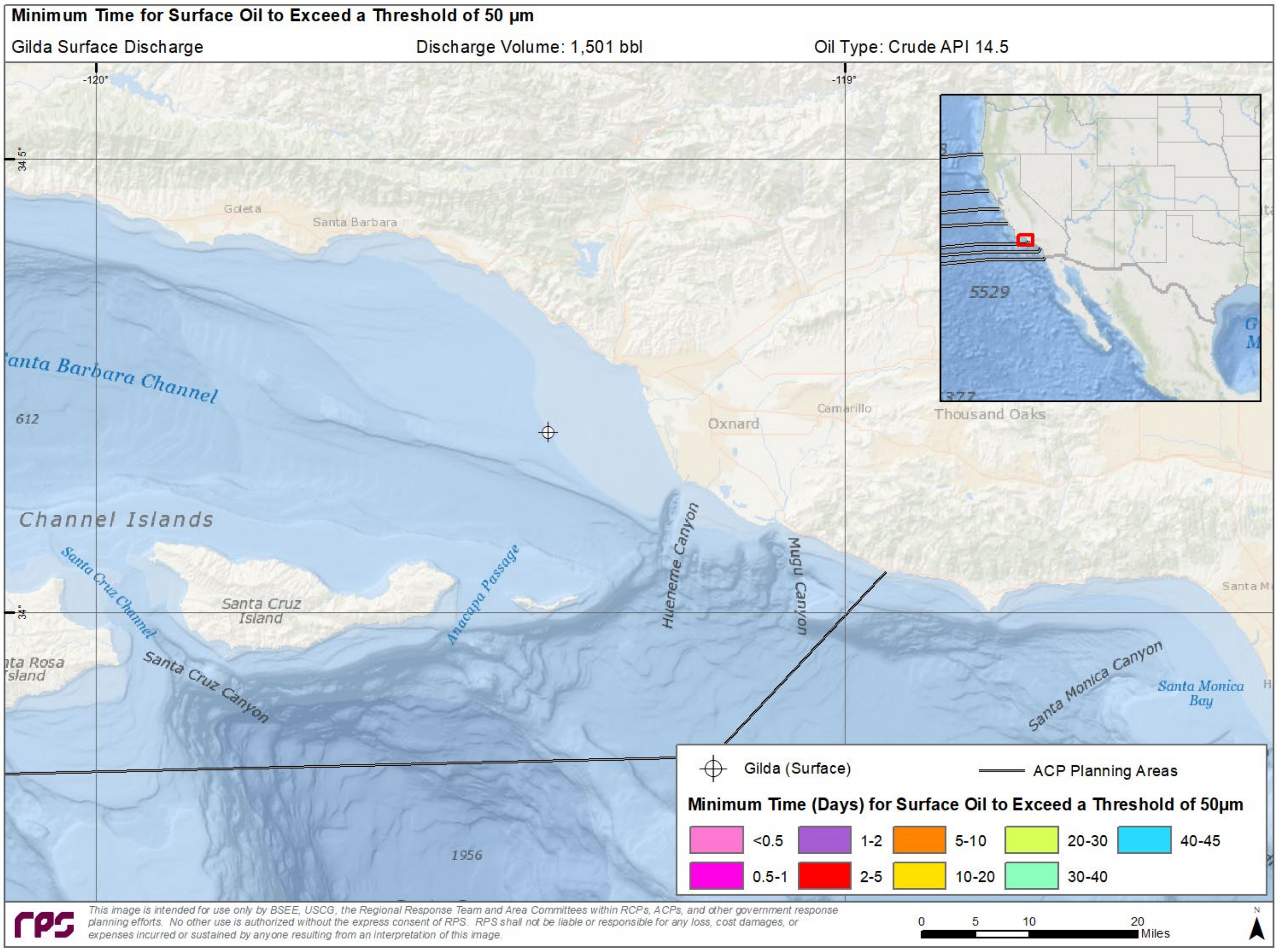

Figure 7. Minimum Travel Time for Surface Oil exposure greater than 50 µm.

Table 4. Oil Spill Stochastic Results – Predicted Shoreline Impacts.

Percentage of Simulations Reaching shore (%)	Percent volume of discharged oil reaching shore (%)		Time to Reach Shore (hours)	
	Maximum	Average	Minimum	Average
100	73.4	65.0	14.0	63.3

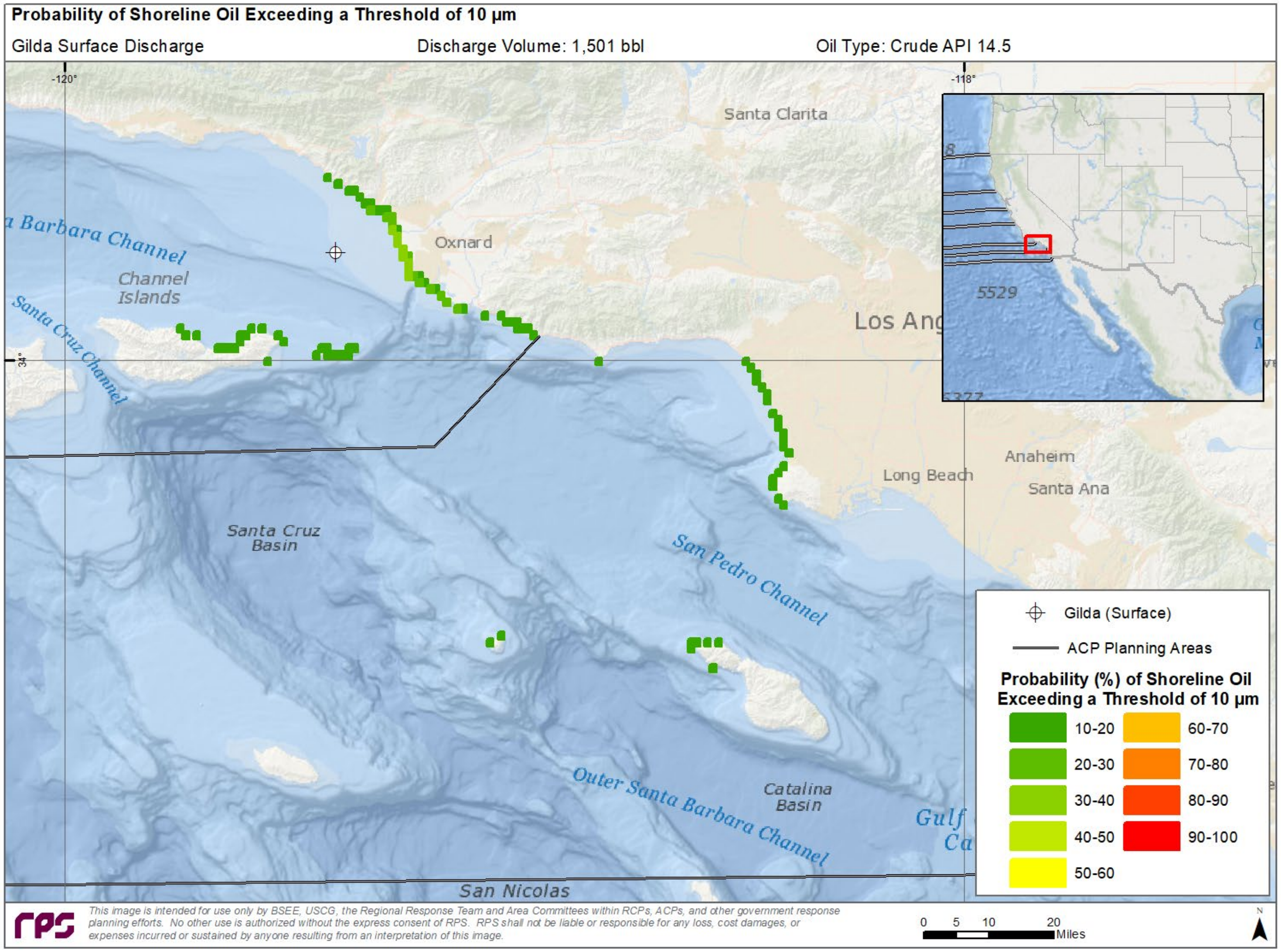

Figure 8. Probability Footprint for Oil on the Shoreline with Average Thickness greater than the Ecological Threshold of 10 µm. This thickness of oil may appear on the shore as dark stain or film. 10 µm is a conservative ecological screening threshold for potential sublethal effects on fauna and birds on the shoreline.

The “worst case” deterministic simulation is a single oil trajectory run using the time period and ambient conditions that resulted in the greatest area of shoreline oiling. The simulation resulted in oiling in the following cumulative amounts:

- Swept Oiled Surface Area Exceeding 0.04 µm (Socioeconomic Impact) = 895 mi^2
- Swept Oiled Surface Area Exceeding 10 µm (Ecological Impact) = 895 mi^2
- Oiled Shoreline Exceeding 10 µm (Ecological Impact) = 134 mi
- Water Column Oil Exposure Exceeding 10 ppb Dissolved PAH (Ecological Impact) = 24,018 m^3
- Time to Shore = 73 hrs

These impact values are calculated considering no response measures are taken to secure the source of the spill or to contain, remove, or disperse oil at the scene.

Table 5. Mass balance at the end of the worst case deterministic simulation (% of the total volume of oil discharged*).

Total Oil Discharged	Surface	Evaporated	Water Column	Sediment	Ashore	Degraded
1,501 bbl	0.2%	27.9%	0.0%	0.0%	68.6%	3.3%

*Important to note these values are not indicative of the maximum amount of oil in each compartment, but instead show the final amount of oil in each compartment.

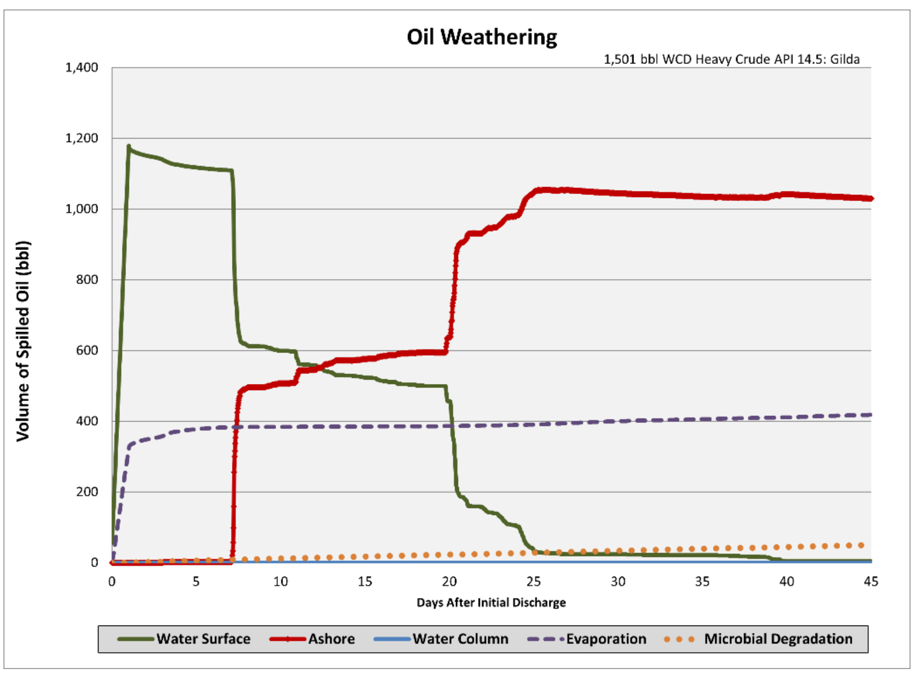

Figure 9. Mass balance over time for worst-case deterministic simulation.

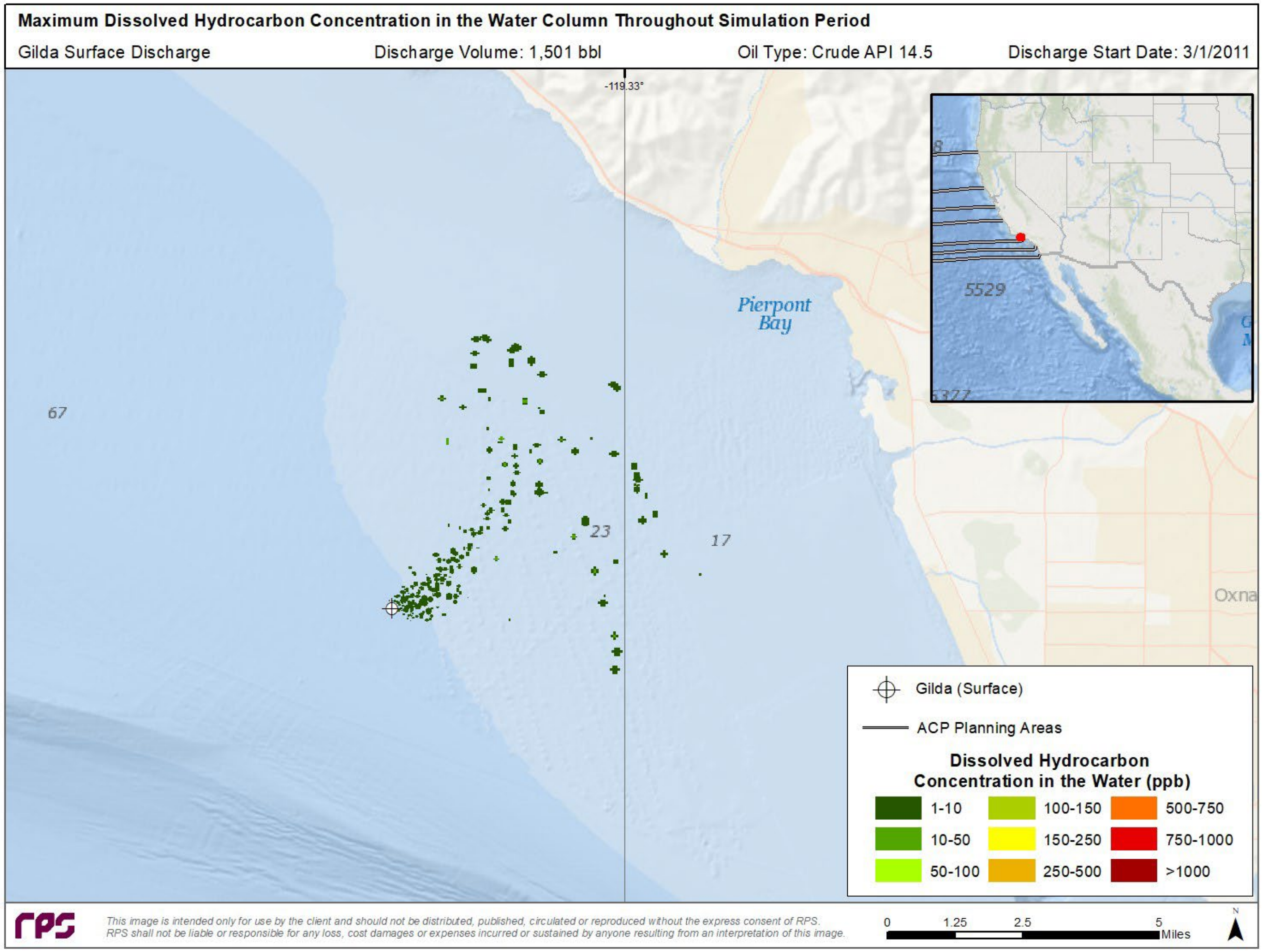

Figure 10. Cumulative Maximum Concentration of Dissolved Polycyclic Aromatic Hydrocarbons (PAH) within the water column at any time during the worst-case deterministic simulation period. Dissolved PAH concentrations greater than ~10 µg/L (~10 ppb) could affect plankton in the upper ~20 m and impart sublethal to lethal effects on other water column biota (adult, juvenile fish, and invertebrates).

3.3 Response Planning Information

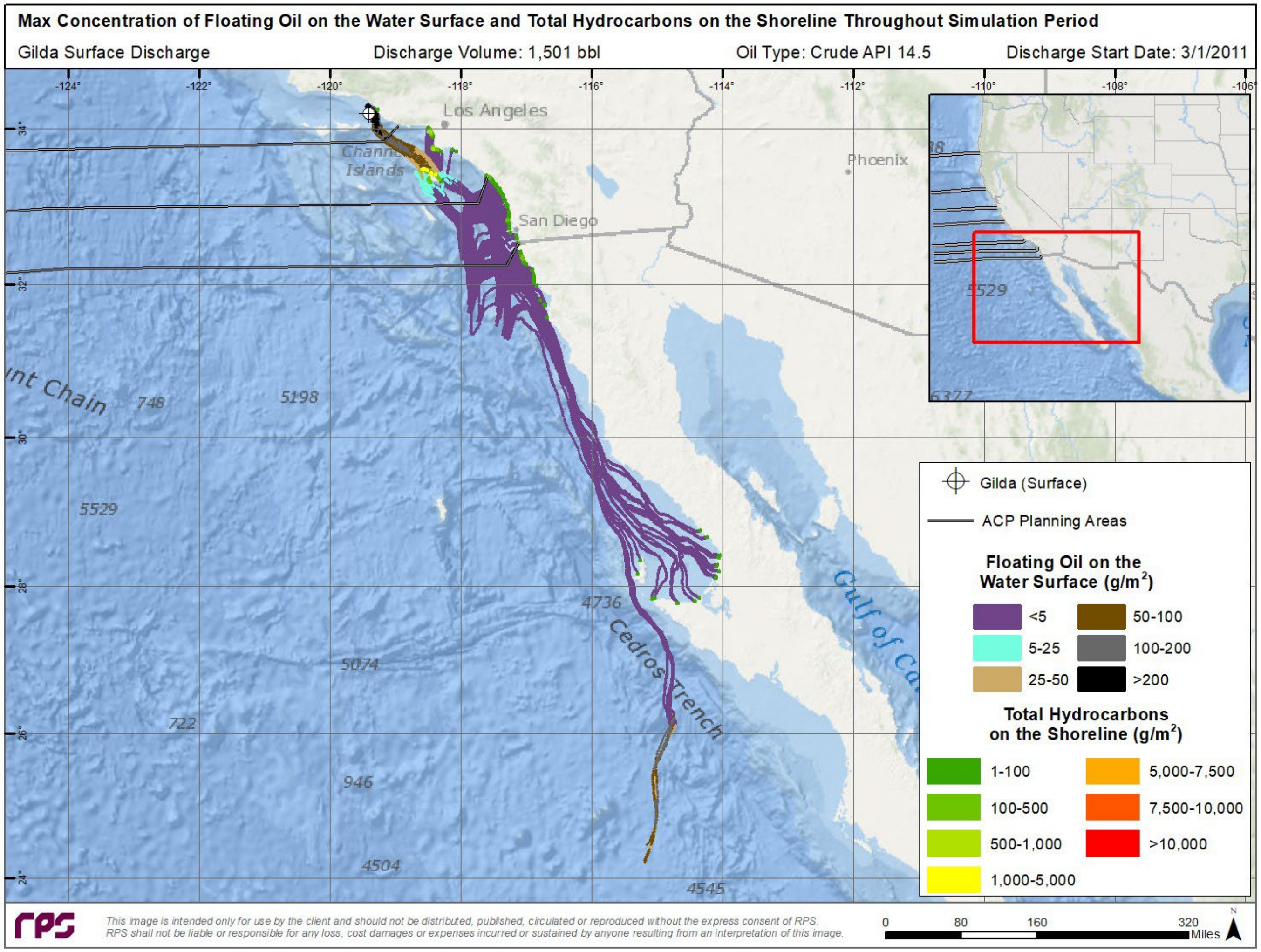

Figure 11. Cumulative Maximum Concentration of Floating Oil on the Water Surface and Total Hydrocarbons on the Shoreline at any time during the worst-case deterministic simulation.

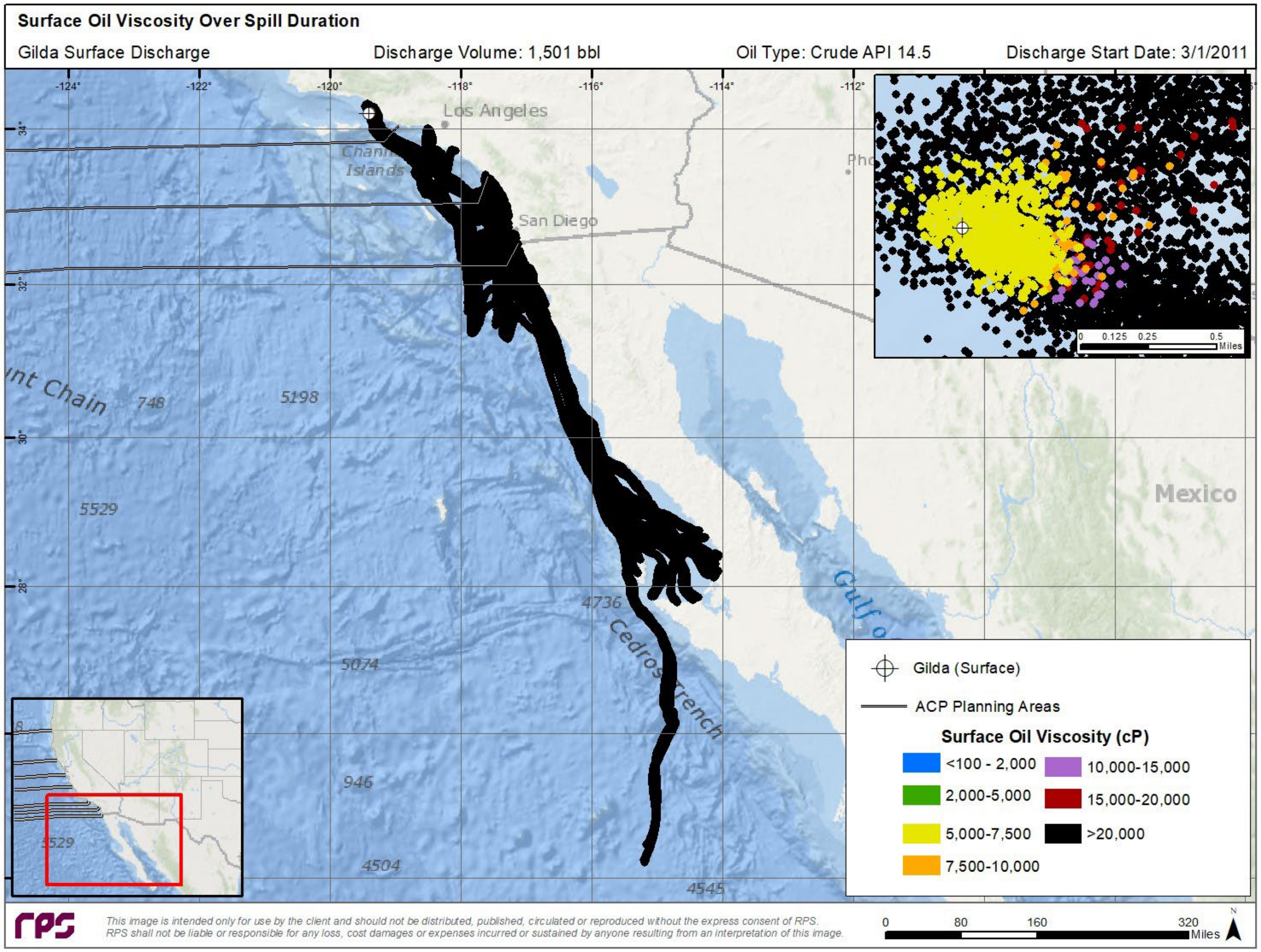

Figure 12. Cumulative footprint of exposure to surface floating oil greater than the minimum oil viscosity over a 45-day period for the worst-case deterministic simulation. Viscosities greater than those mapped may be present at any location at any specific time in the simulation. This graphic provides a perspective of how oil viscosity may change as oil is transported away from the discharge site over time, and what areas may be amenable to dispersant operations where enough quantities of oil are present.

4. Esther Surface Well Blowout

4.1 Scenario Description

The Esther WCD Scenario is a surface well blowout with the following key parameters.

Table 6. Scenario Key Parameters.

Discharge Depth (m)	Distance from Shore (mi)	Oil Type	Spill Type	Discharge Duration (days)	Discharge Flowrate (bbl/day)	Total Oil Discharged (bbl)
Surface	1.4	Heavy Crude API = 25.5	Surface Well Blowout	1	932	932

4.2 Potential Oil Contact with the Environment and Resources at Risk

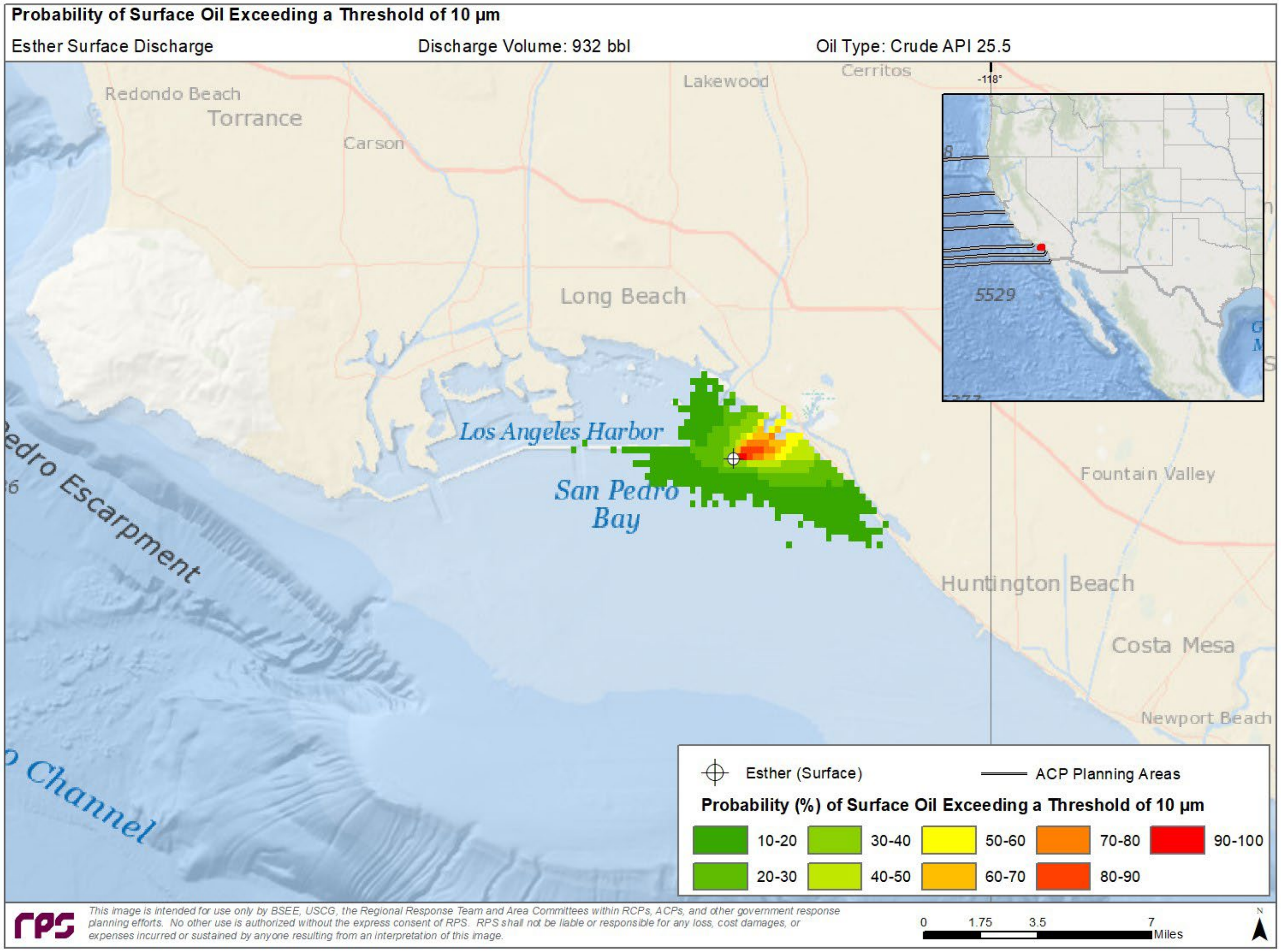

Figure 13. Probability Footprint for Oil on the Water Surface with Average Thickness greater than the Ecological Threshold of 10 µm

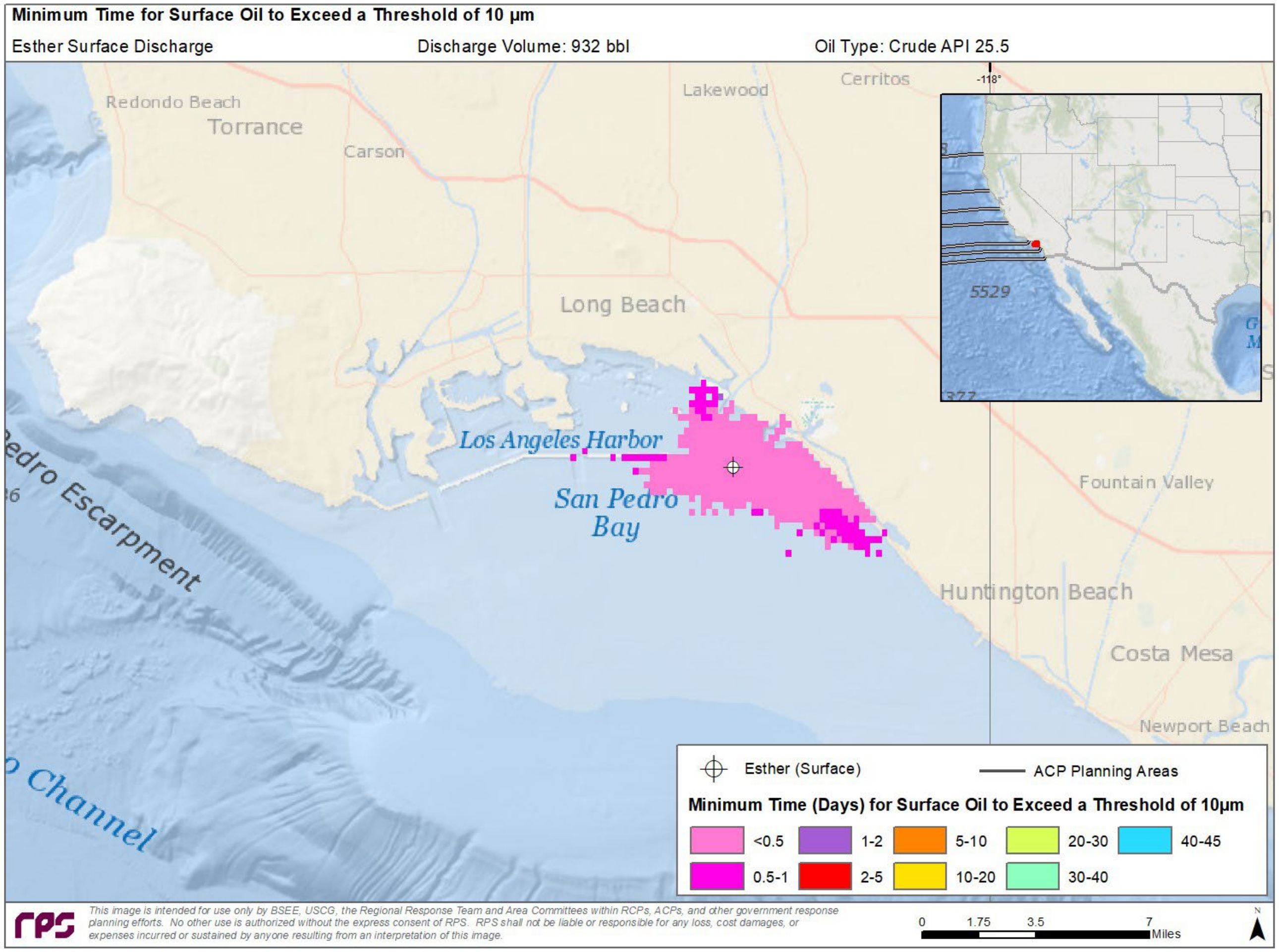

Figure 14. Minimum Time for Oil on the Water Surface with Average Thickness greater than the Ecological Threshold of 10 µm.

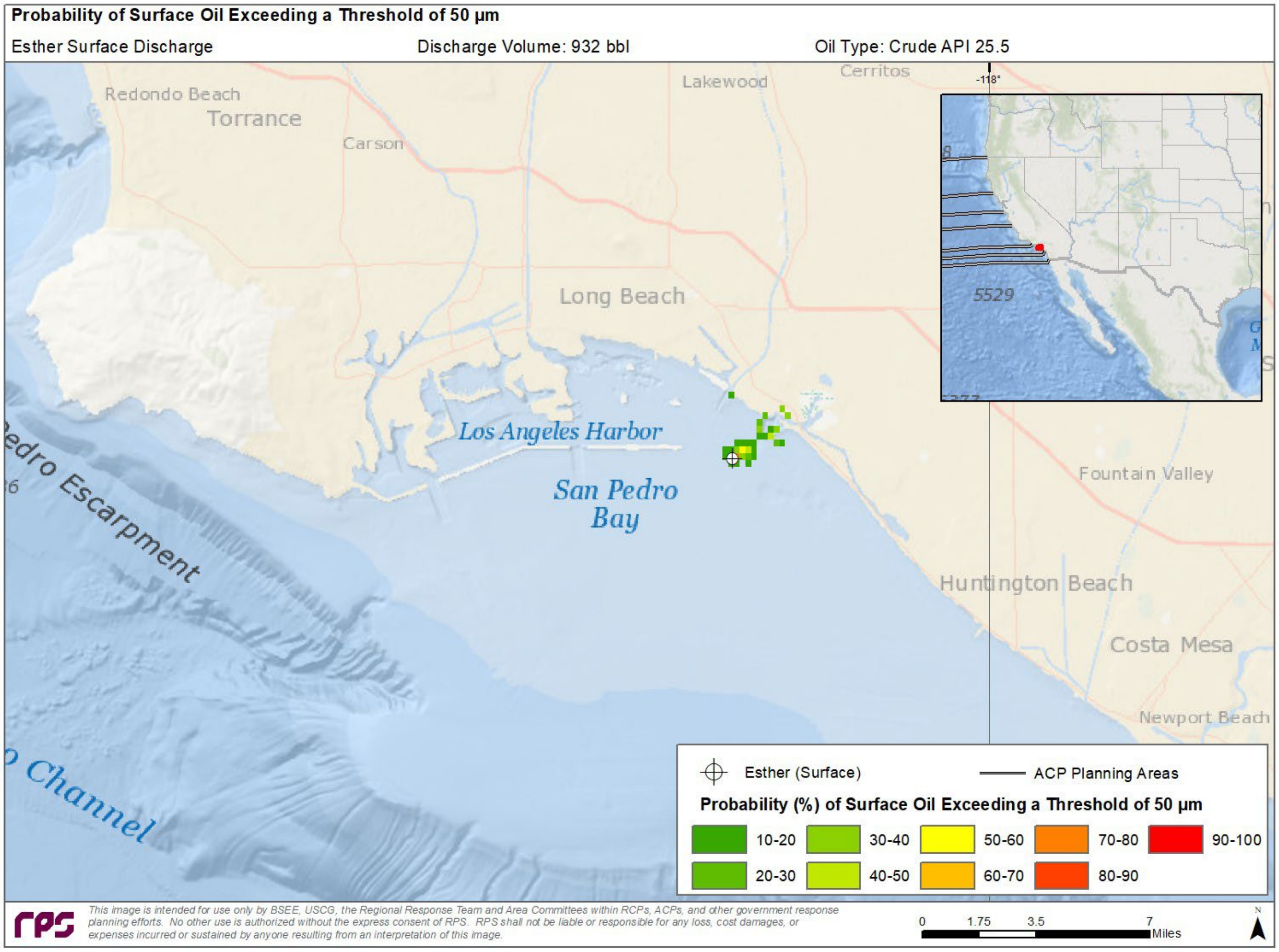

Figure 15. Probability Footprint for Surface Oil exposure greater than 50 µm. In this thickness range, oil will appear as a continuous to discontinuous patches of dark oil in quantities where high volume on-water mechanical recovery operations will be the most productive.

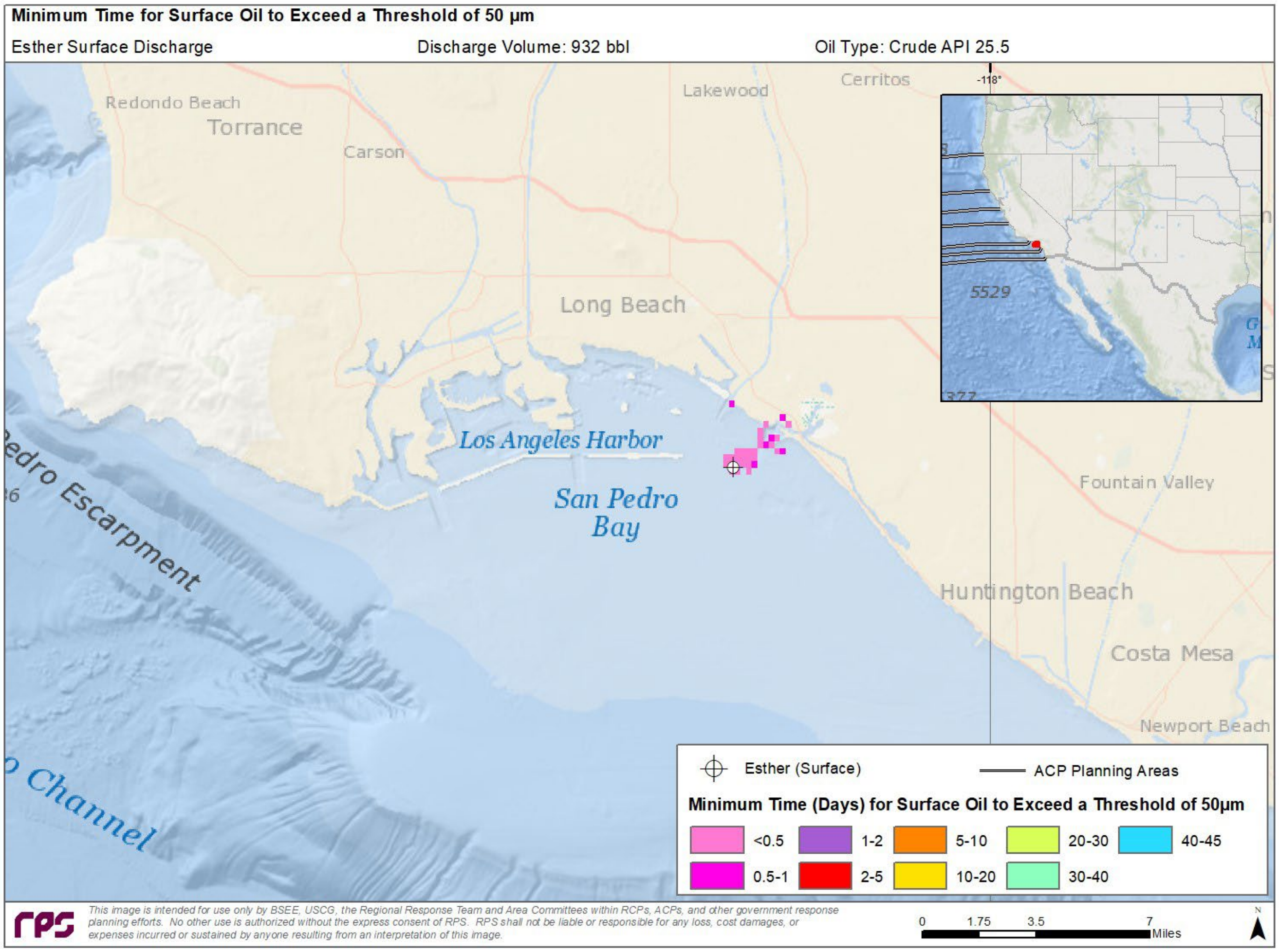

Figure 16. Minimum Travel Time for Surface Oil exposure greater than 50 µm.

Table 7. Oil Spill Stochastic Results – Predicted Shoreline Impacts.

Percentage of Simulations Reaching shore (%)	Percent volume of discharged oil reaching shore (%)		Time to Reach Shore (hours)	
	Maximum	Average	Minimum	Average
100	70.9	64.9	2.0	12.6

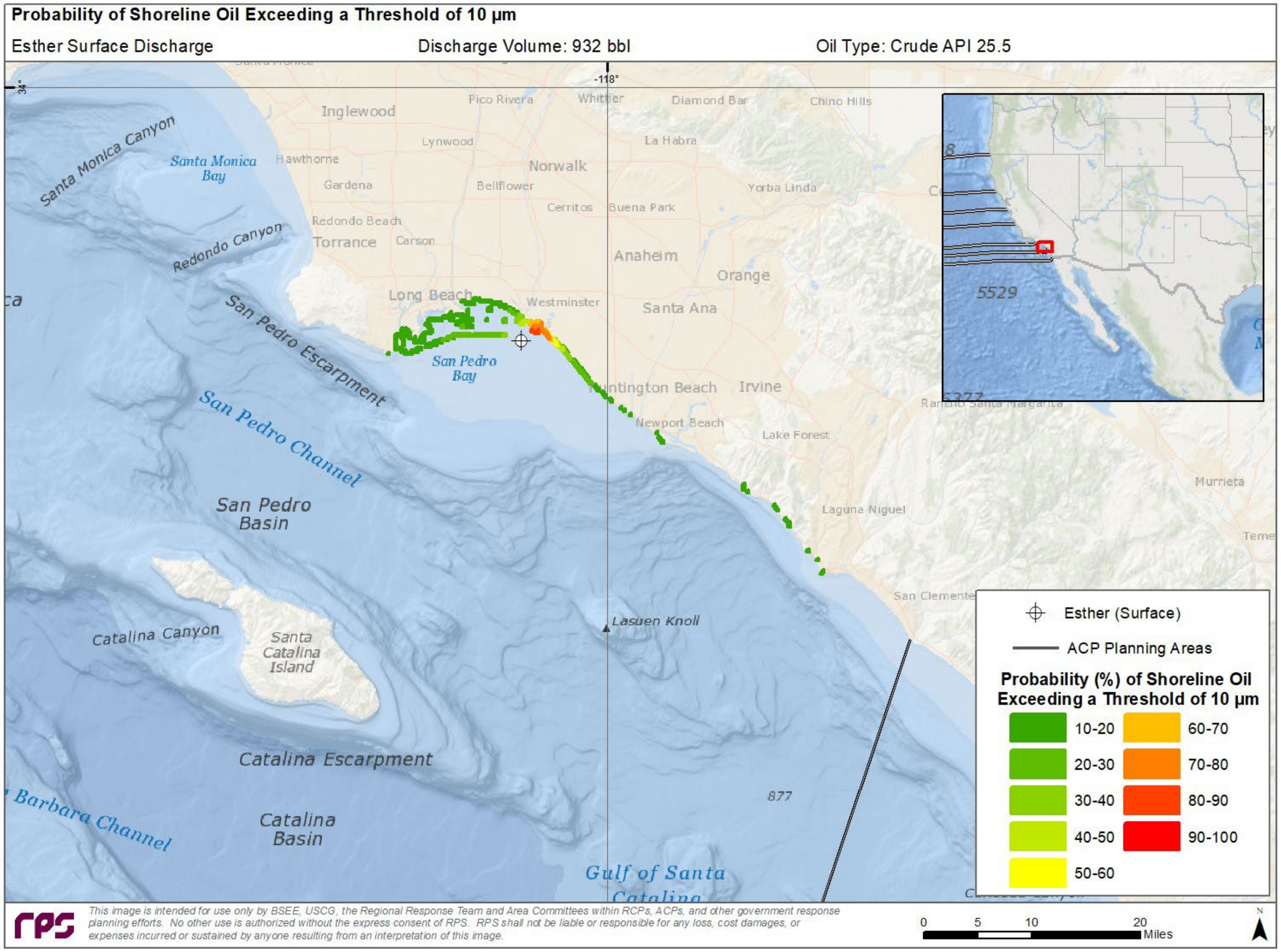

Figure 17. Probability Footprint for Oil on the Shoreline with Average Thickness greater than the Ecological Threshold of 10 µm. This thickness of oil may appear on the shore as dark stain or film. 10 µm is a conservative ecological screening threshold for potential sublethal effects on fauna and birds on the shoreline.

The "worst case" deterministic simulation is a single oil trajectory run using the time period and ambient conditions that resulted in the greatest area of shoreline oiling. The simulation resulted in oiling in the following cumulative amounts:

- Swept Oiled Surface Area Exceeding 0.04 µm (Socioeconomic Impact) = 4,881 mi^2
- Swept Oiled Surface Area Exceeding 10 µm (Ecological Impact) = 4,881 mi^2
- Oiled Shoreline Exceeding 10 µm (Ecological Impact) = 50 mi
- Water Column Oil Exposure Exceeding 10 ppb Dissolved PAH (Ecological Impact) = 496,317 m^3
- Time to Shore = 6.5 hours

These impact values are calculated considering no response measures are taken to secure the source of the spill or to contain, remove, or disperse oil at the scene.

Table 8. Mass balance at the end of the worst-case deterministic simulation (% of the total volume of oil discharged*).

Total Oil Discharged	Surface	Evaporated	Water Column	Sediment	Ashore	Degraded
932 bbl	0.0%	24.3 %	0.0%	<0.1%	72.1%	3.6%

*Important to note these values are not indicative of the maximum amount of oil in each compartment, but instead show the final amount of oil in each compartment.

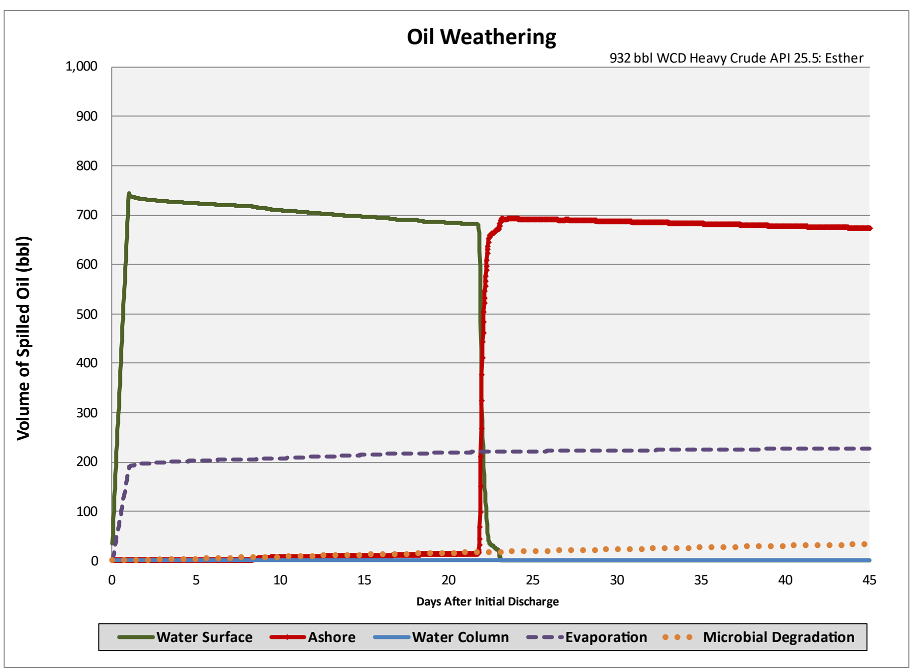

Figure 18. Mass balance over time for worst-case deterministic simulation.

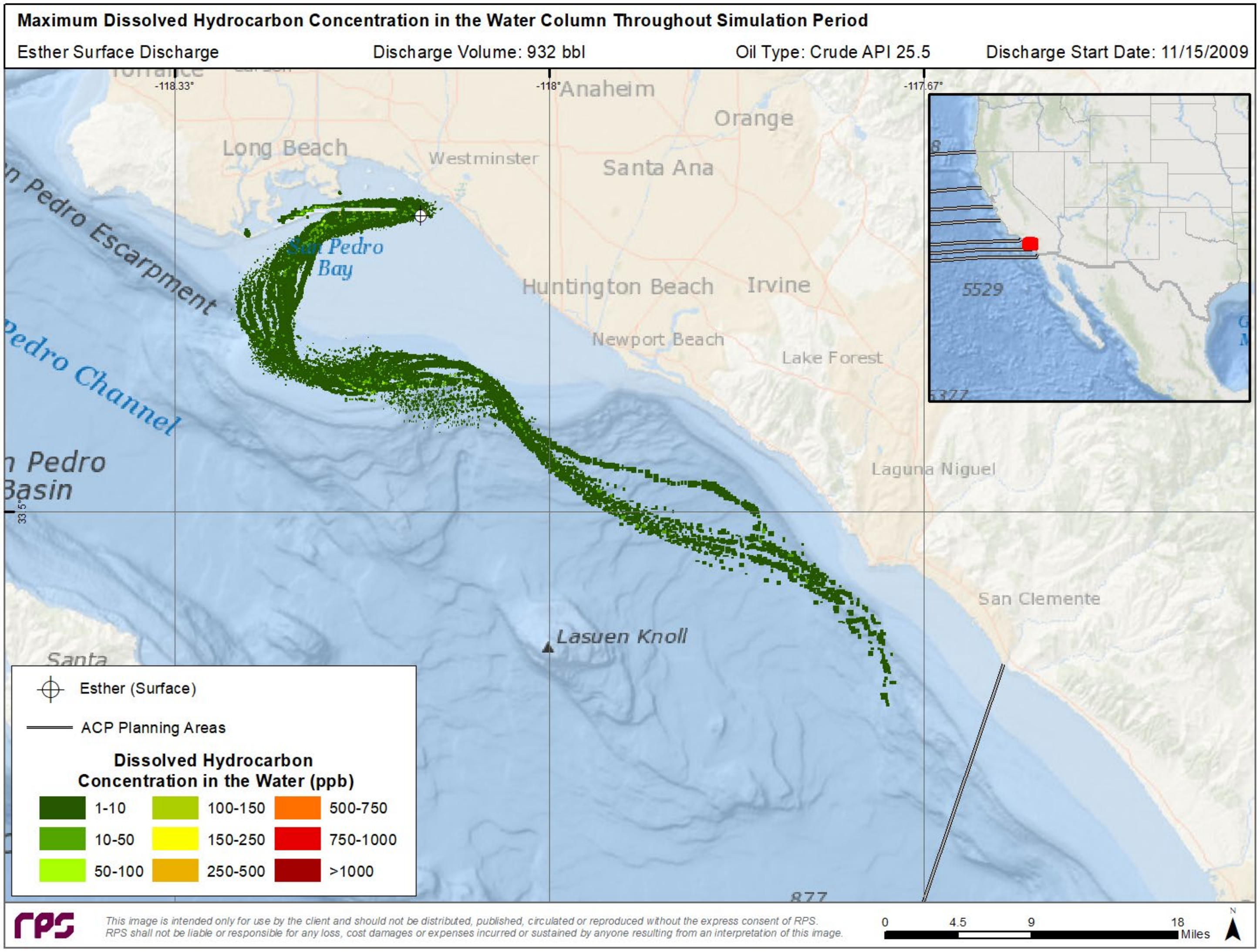

Figure 19. Cumulative Maximum Concentration of Dissolved Polycyclic Aromatic Hydrocarbons (PAH) within the water column at any time during the worst-case deterministic simulation period. Dissolved PAH concentrations greater than ~10 µg/L (~10 ppb) could affect plankton in the upper ~20 m and impart sublethal to lethal effects on other water column biota (adult, juvenile fish, and invertebrates).

4.3 Response Planning Information

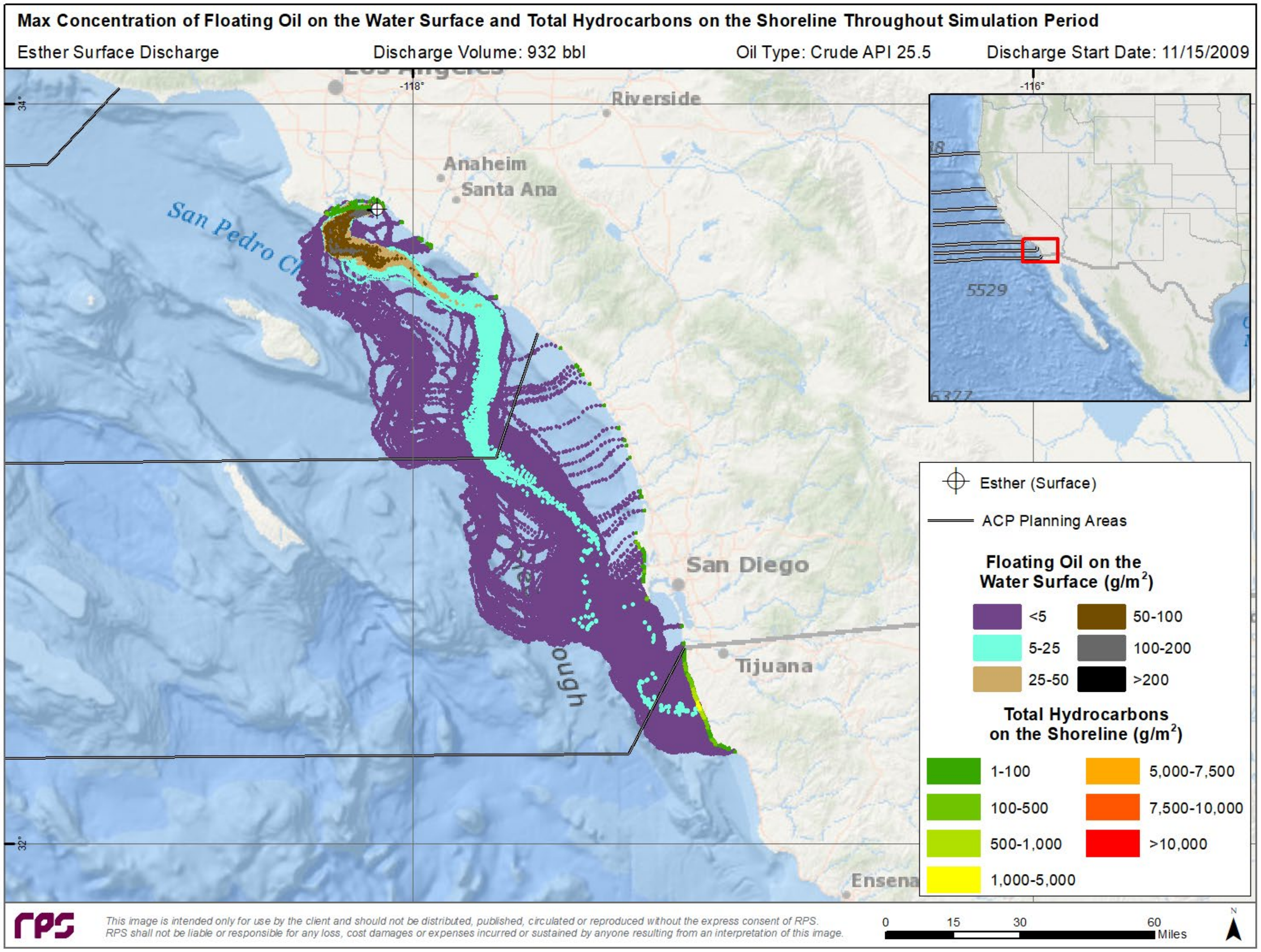

Figure 20. Cumulative Maximum Concentration of Floating Oil on the Water Surface and Total Hydrocarbons on the Shoreline at any time during the worst-case deterministic simulation.

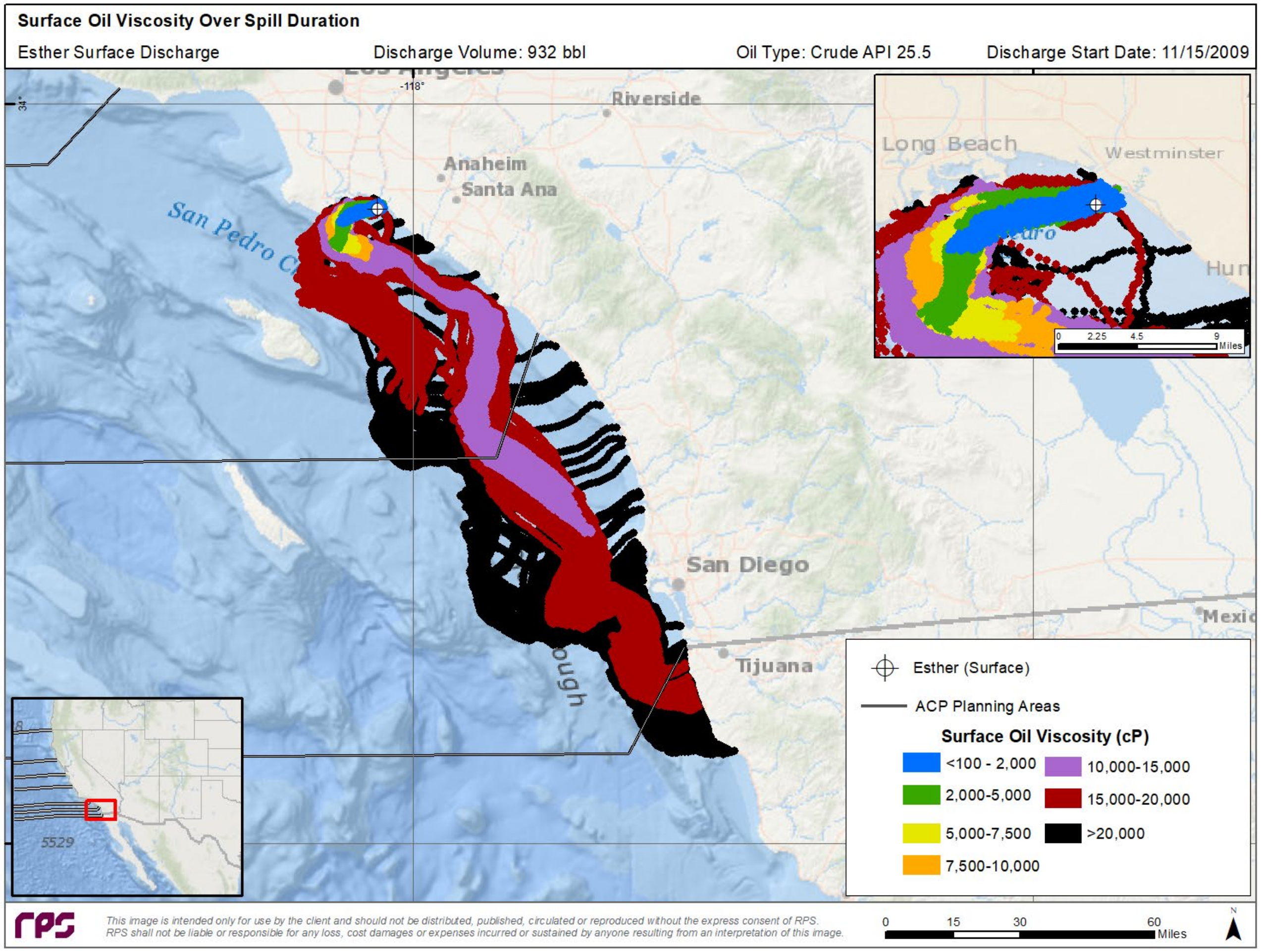

Figure 21. Cumulative footprint of exposure to surface floating oil greater than the minimum oil viscosity over a 45-day period for the worst-case deterministic simulation. Viscosities greater than those mapped may be present at any location at any specific time in the simulation. This graphic provides a perspective of how oil viscosity may change as oil is transported away from the discharge site over time, and what areas may be amenable to dispersant operations where enough quantities of oil are present.

5. Elly Surface Well Blowout

5.1 Scenario Description

The Elly WCD Scenario is a surface well blowout with the following key parameters.

Table 9. Scenario Key Parameters.

Discharge Depth (m)	Distance from Shore (mi)	Oil Type	Spill Type	Discharge Duration (days)	Discharge Flowrate (bbl/day)	Total Oil Discharged (bbl)
Surface	8.6	Heavy Crude API = 14	Surface Well Blowout	1	14,385	14,385

5.2 Potential Oil Contact with the Environment and Resources at Risk

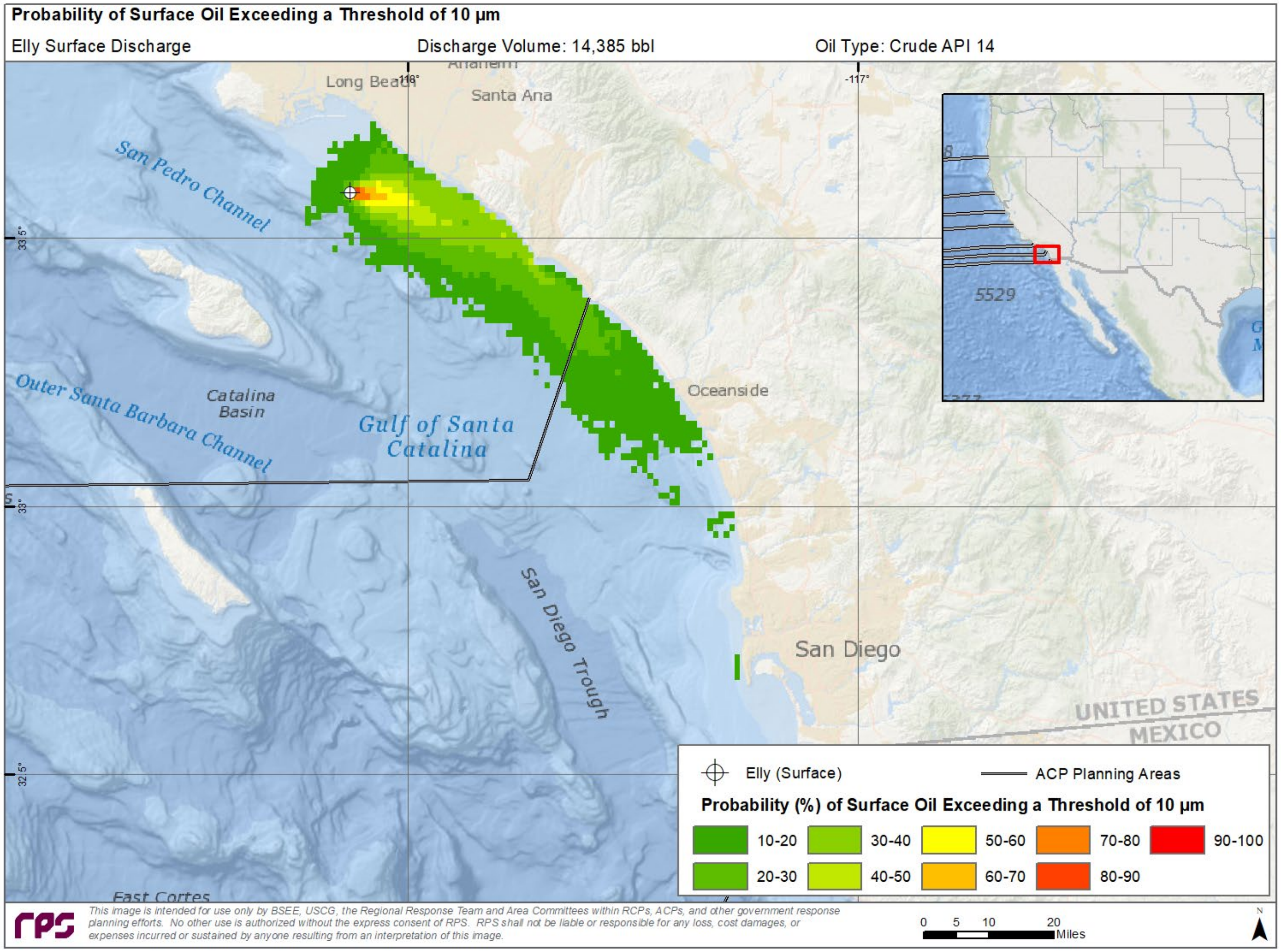

Figure 22. Probability Footprint for Oil on the Water Surface with Average Thickness greater than the Ecological Threshold of 10 µm.

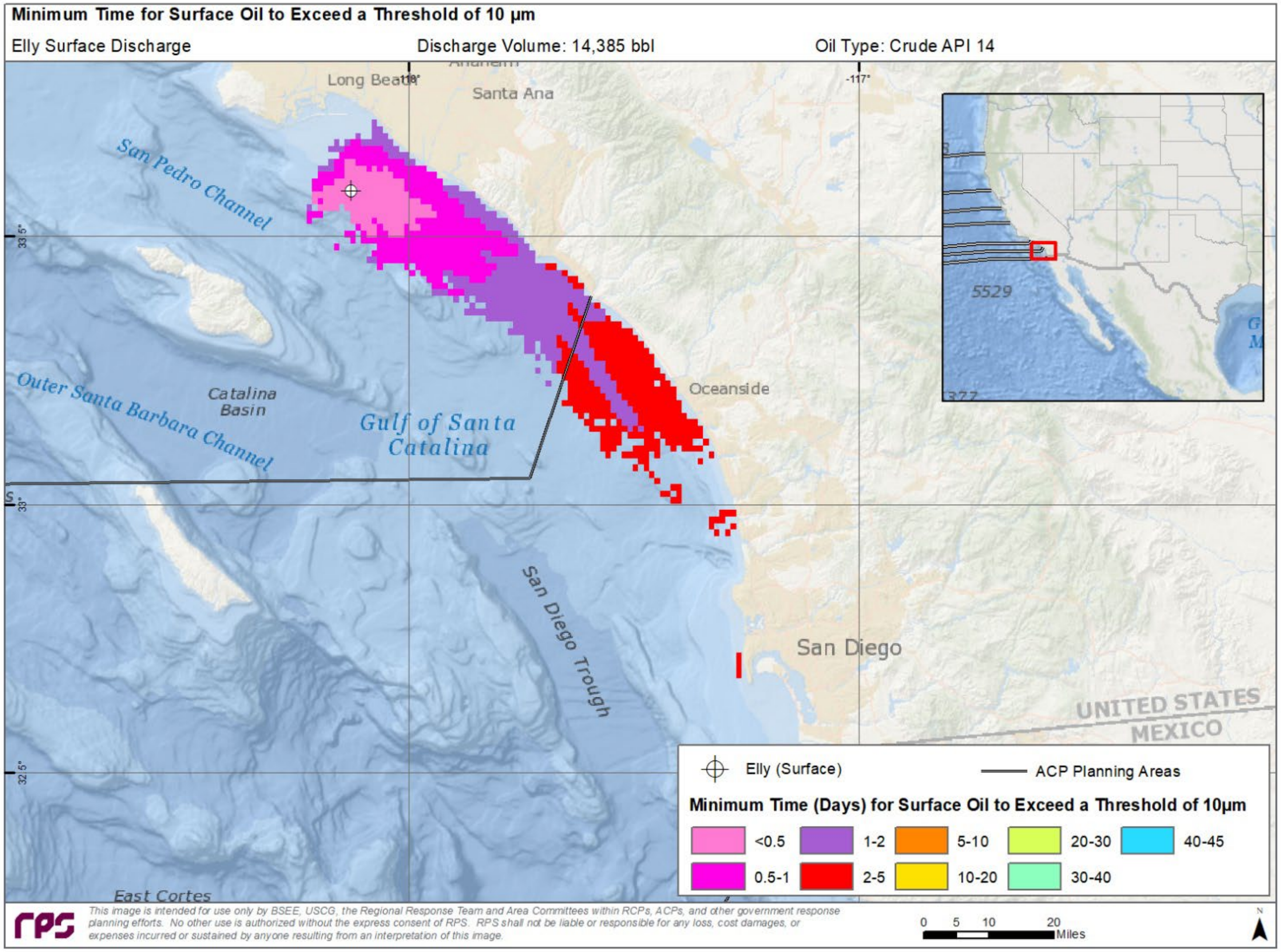

Figure 23. Minimum Time for Oil on the Water Surface with Average Thickness greater than the Ecological Threshold of 10 µm.

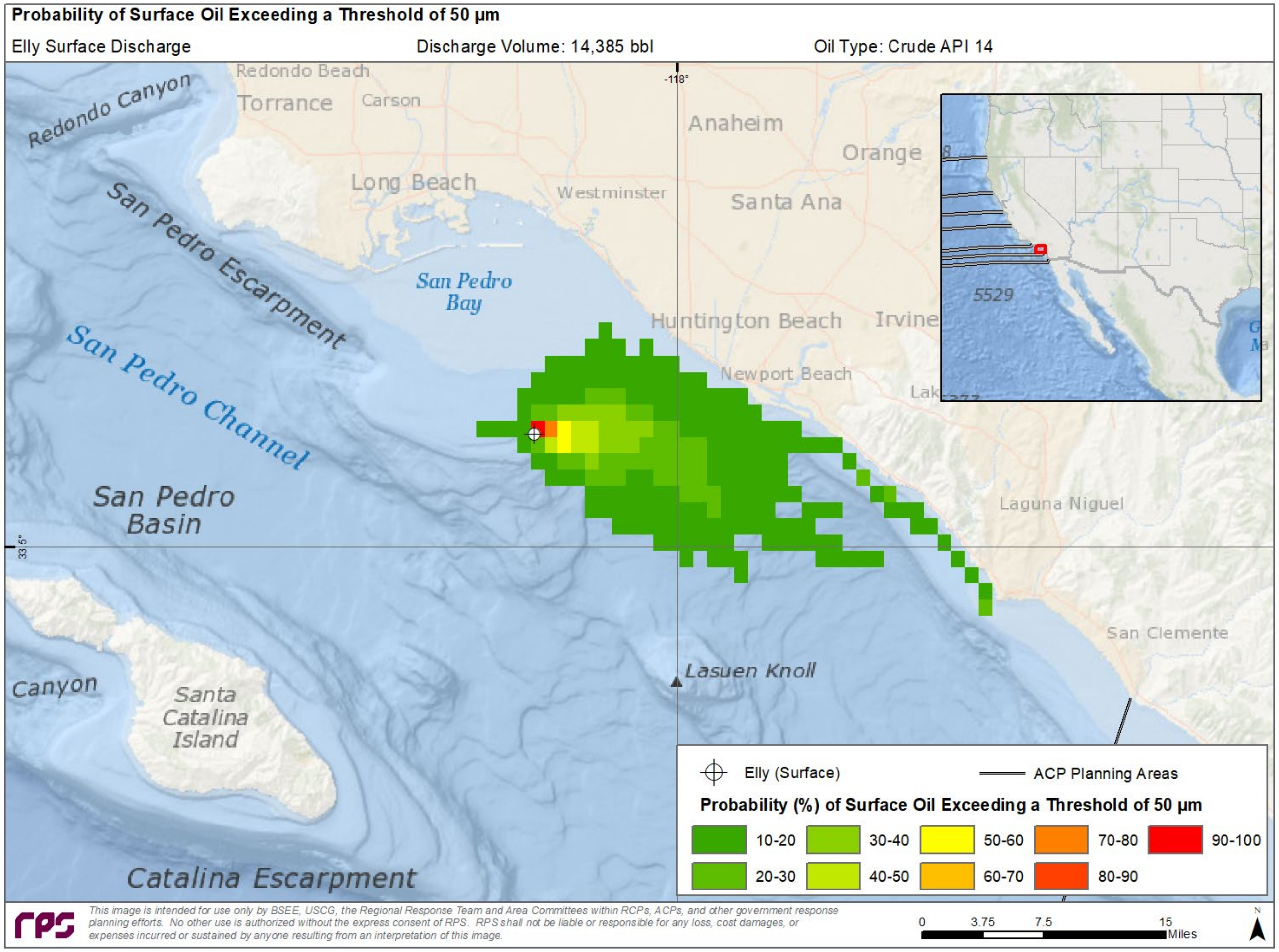

Figure 24. Probability Footprint for Surface Oil exposure greater than 50 µm. In this thickness range, oil will appear as a continuous to discontinuous patches of dark oil in quantities where high volume on-water mechanical recovery operations will be the most productive.

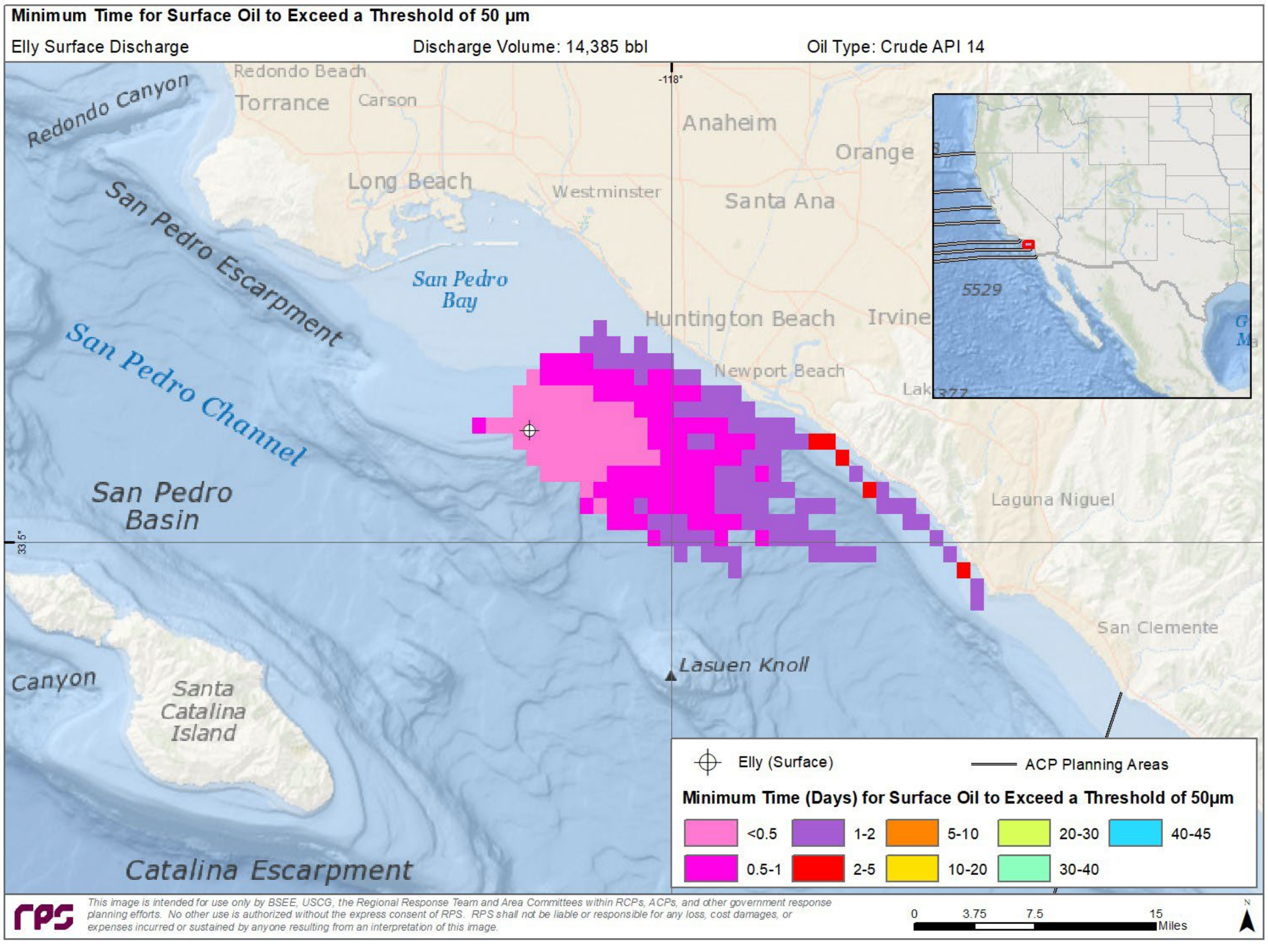

Figure 25. Minimum Travel Time for Surface Oil exposure greater than 50 µm.

Table 10. Oil Spill Stochastic Results – Predicted Shoreline Impacts.

Percentage of Simulations Reaching shore (%)	Percent volume of discharged oil reaching shore (%)		Time to Reach Shore (hours)	
	Maximum	Average	Minimum	Average
100	71.2	65.1	22.0	75.9

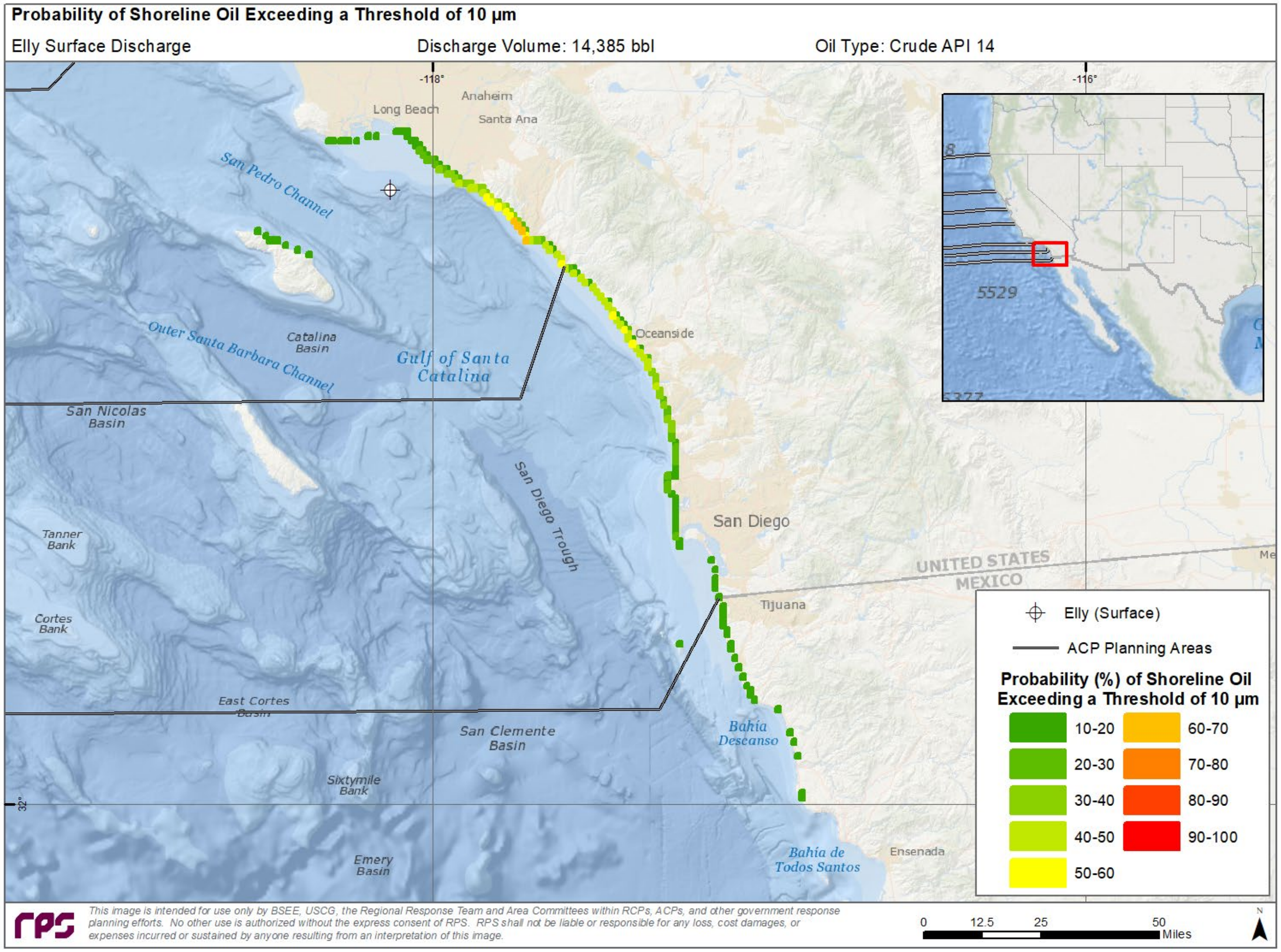

Figure 26. Probability Footprint for Oil on the Shoreline with Average Thickness greater than the Ecological Threshold of 10 µm. This thickness of oil may appear on the shore as dark stain or film. 10 µm is a conservative ecological screening threshold for potential sublethal effects on fauna and birds on the shoreline.

5.3 WCD Scenarios

The "worst case" deterministic simulation is a single oil trajectory run using the time period and ambient conditions that resulted in the greatest length of shoreline oiling. In this scenario for Elly, two worst-case discharge scenarios were selected. WCD Scenario A was the actual worst-case scenario based on length of shoreline oiled. However, in working with the local stakeholders, it was determined that, from experience, a southern trajectory would be a much more likely result. Therefore, both deterministic simulations are shown here to illustrate two possibilities of impacts from a spill from the Elly platform. The stochastic simulations shown in the previous section show the likelihood of oiling in different locations, as a reference.

For both WCD Scenario A and WCD Scenario B, the impact values were calculated considering no response measures were taken to secure the source of the spill or to contain, remove, or disperse oil at the scene in order to truly show a worst-case situation.

5.3.1 WCD Scenario A

WCD Scenario A resulted in oiling in the following cumulative amounts:

- Swept Oiled Surface Area Exceeding 0.04 µm (Socioeconomic Impact) = 2,059 mi^2
- Swept Oiled Surface Area Exceeding 10 µm (Ecological Impact) = 2,059 mi^2
- Oiled Shoreline Exceeding 10 µm (Ecological Impact) = 148 mi
- Water Column Oil Exposure Exceeding 10 ppb Dissolved PAH (Ecological Impact) = 513,153 m^3
- Time to Shore = 41 hrs

Table 11. Mass balance at the end of the worst case deterministic simulation (% of the total volume of oil discharged*).

Total Oil Discharged	Surface	Evaporated	Water Column	Sediment	Ashore	Degraded
14,385 bbl	3.1%	25.7%	0.0%	0.0%	67.8%	3.4%

*Important to note these values are not indicative of the maximum amount of oil in each compartment, but instead show the final amount of oil in each compartment.

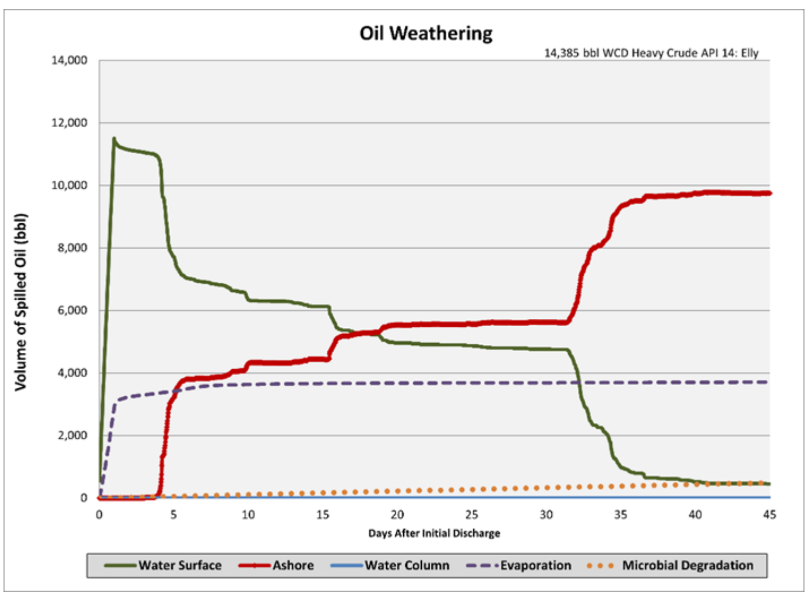

Figure 27. Mass balance over time for worst case deterministic simulation.

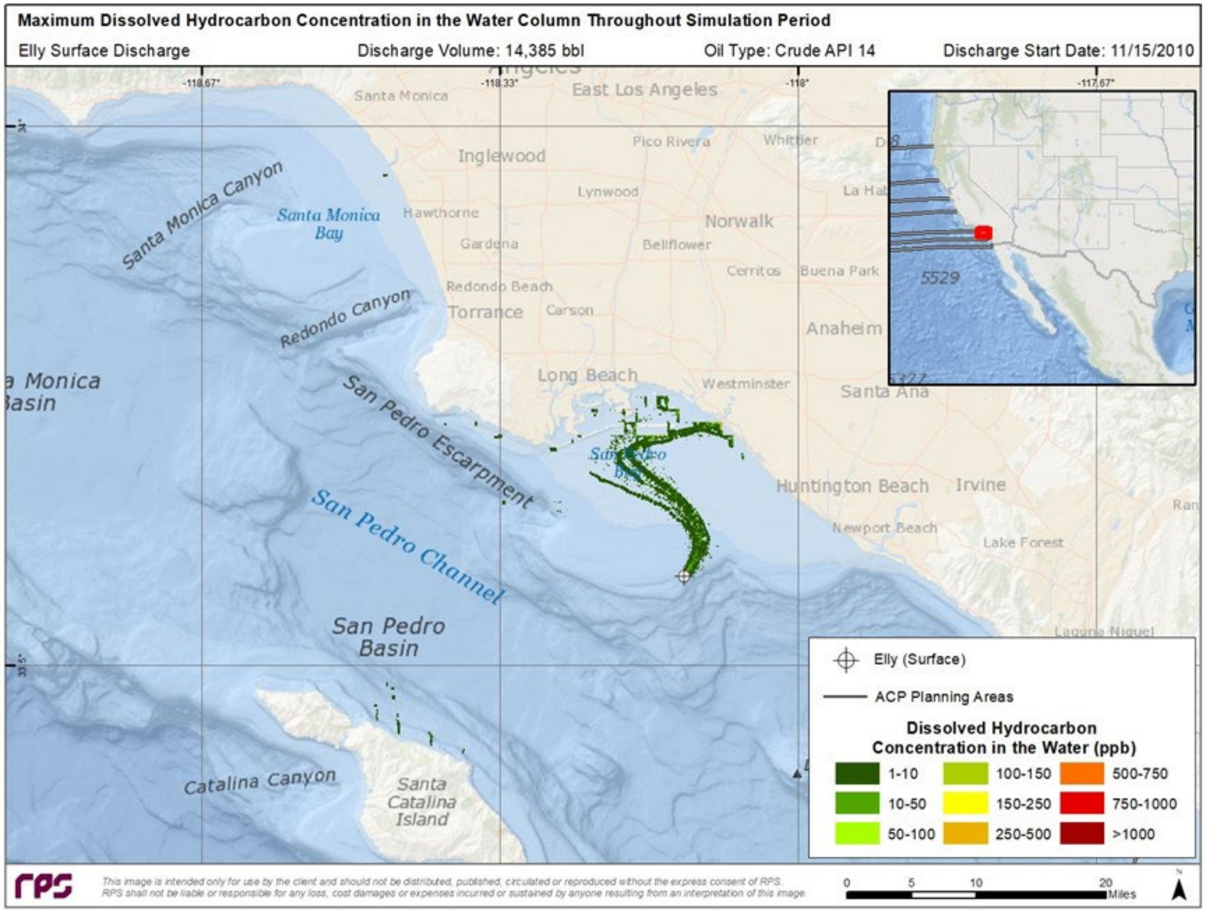

Figure 28. Cumulative Maximum Concentration of Dissolved Polycyclic Aromatic Hydrocarbons (PAH) within the water column at any time during the worst-case deterministic simulation period. Dissolved PAH concentrations greater than ~10 µg/L (~10 ppb) could affect plankton in the upper ~20 m and impart sublethal to lethal effects on other water column biota (adult, juvenile fish, and invertebrates).

5.3.1.1 Response Planning Information – WCD Scenario A

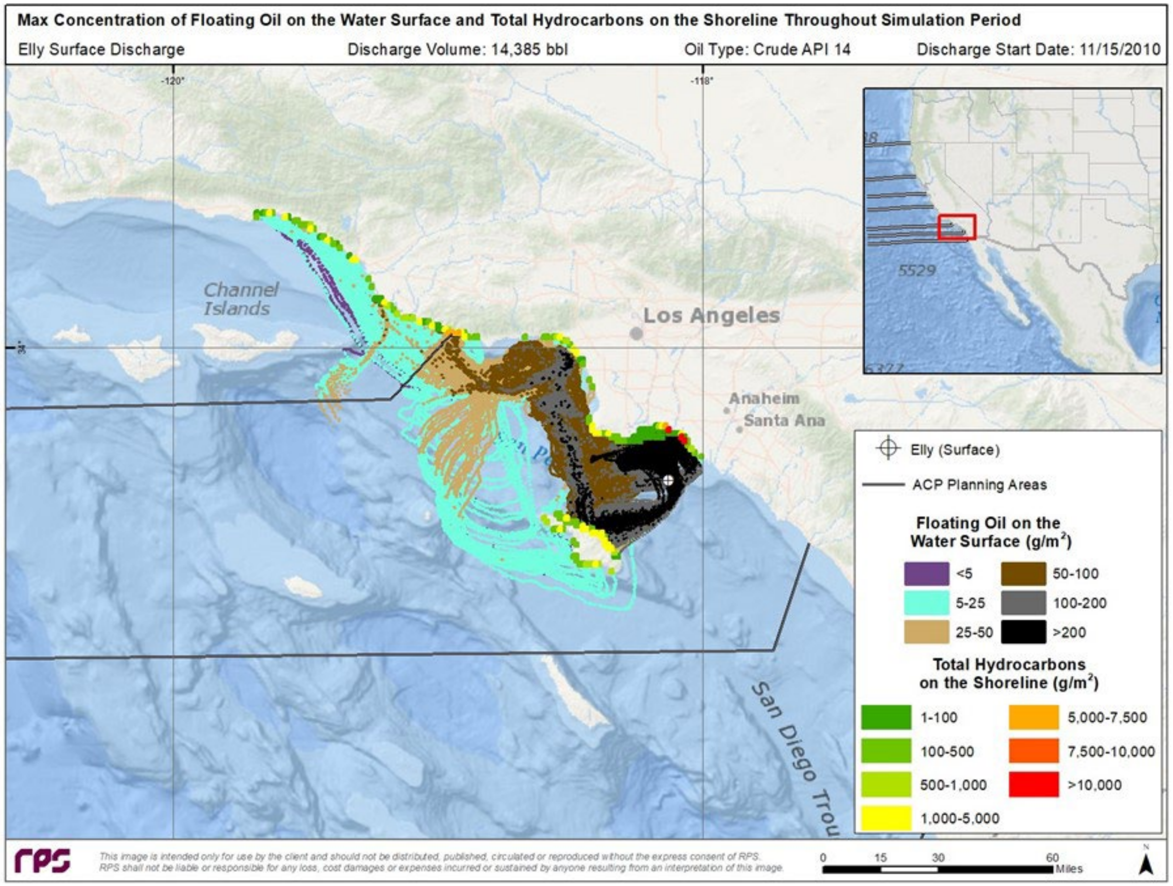

Figure 29. Cumulative Maximum Concentration of Floating Oil on the Water Surface and Total Hydrocarbons on the Shoreline at any time during the worst-case deterministic simulation.

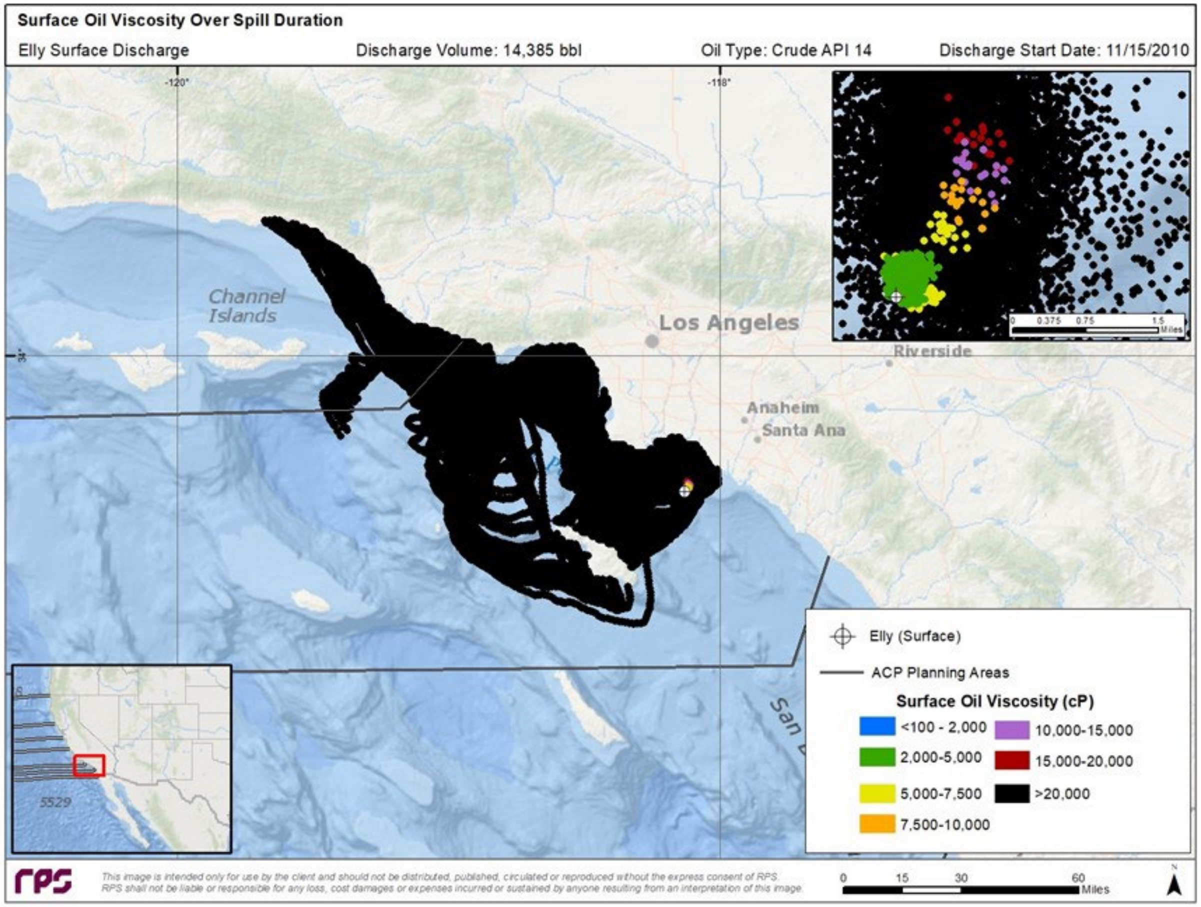

Figure 30. Cumulative footprint of exposure to surface floating oil greater than the minimum oil viscosity over a 45-day period for the worst-case deterministic simulation. Viscosities greater than those mapped may be present at any location at any specific time in the simulation. This graphic provides a perspective of how oil viscosity may change as oil is transported away from the discharge site over time, and what areas may be amenable to dispersant operations where enough quantities of oil are present.

5.3.2 WCD Scenario B

WCD Scenario B resulted in oiling in the following cumulative amounts:

- Swept Oiled Surface Area Exceeding 0.04 µm (Socioeconomic Impact) = 746 mi^2
- Swept Oiled Surface Area Exceeding 10 µm (Ecological Impact) = 746 mi^2
- Oiled Shoreline Exceeding 10 µm (Ecological Impact) = 29 mi
- Water Column Oil Exposure Exceeding 10 ppb Dissolved PAH (Ecological Impact) = 157,329 m^3
- Time to Shore = 95.5 hrs

Table 12. Mass balance at the end of the worst-case deterministic simulation (% of the total volume of oil discharged*).

Total Oil Discharged	Surface	Evaporated	Water Column	Sediment	Ashore	Degraded
14,385 bbl	0.0%	25.6%	0.0%	0.0%	71.0%	3.4%

*Important to note these values are not indicative of the maximum amount of oil in each compartment, but instead show the final amount of oil in each compartment.

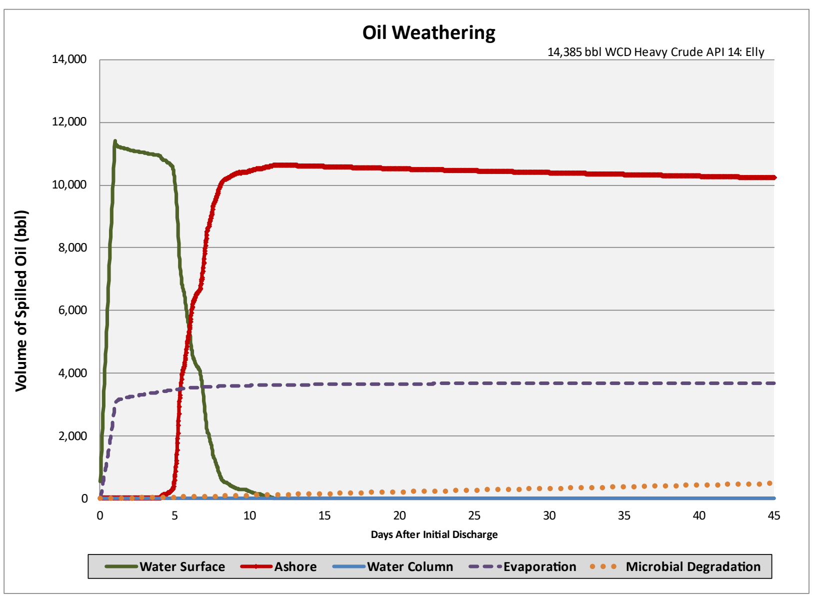

Figure 31. Mass balance over time for worst case deterministic simulation.

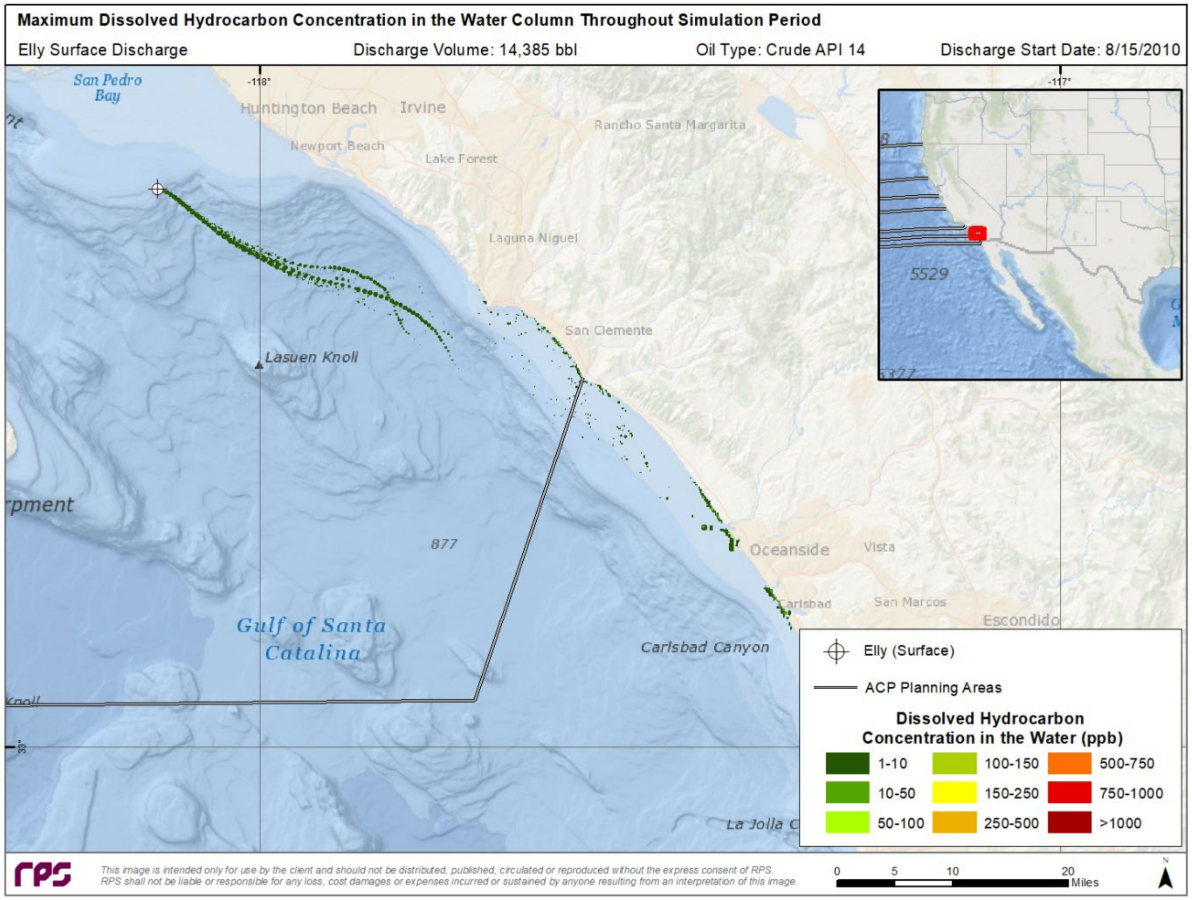

Figure 32. Cumulative Maximum Concentration of Dissolved Polycyclic Aromatic Hydrocarbons (PAH) within the water column at any time during the worst case deterministic simulation period. Dissolved PAH concentrations greater than ~10 µg/L (~10 ppb) could affect plankton in the upper ~20 m and impart sublethal to lethal effects on other water column biota (adult, juvenile fish, and invertebrates).

5.3.2.1 Response Planning Information – WCD Scenario B

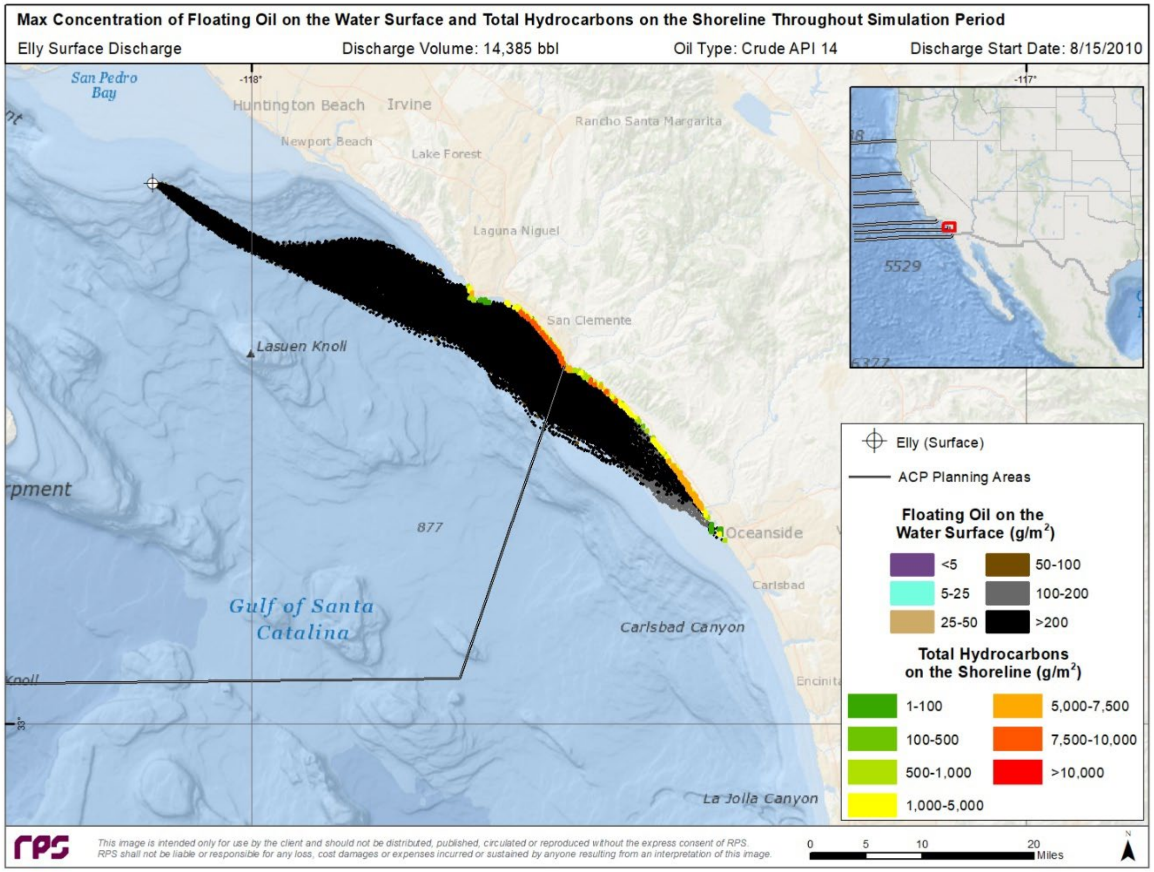

Figure 33. Cumulative Maximum Concentration of Floating Oil on the Water Surface and Total Hydrocarbons on the Shoreline at any time during the worst-case deterministic simulation.

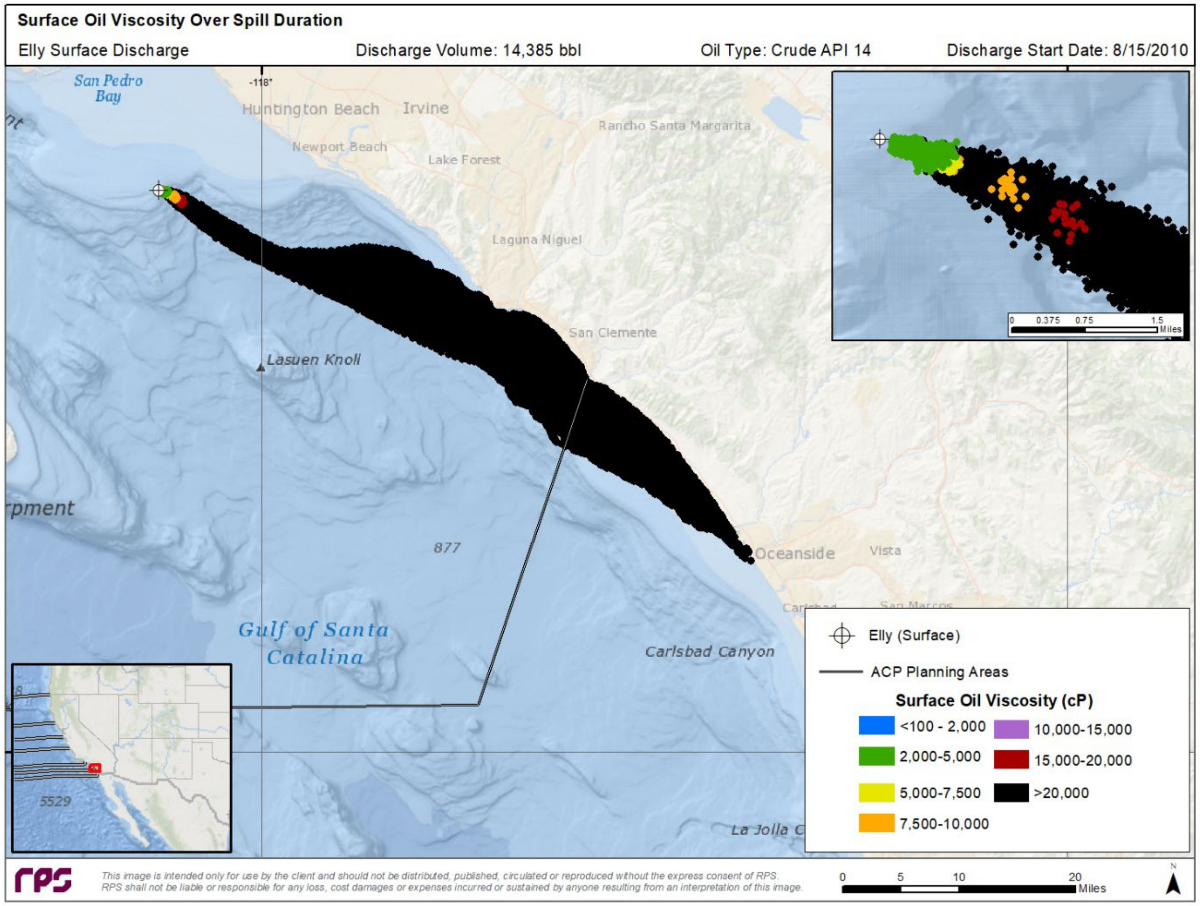

Figure 34. Cumulative footprint of exposure to surface floating oil greater than the minimum oil viscosity over a 45-day period for the worst-case deterministic simulation. Viscosities greater than those mapped may be present at any location at any specific time in the simulation. This graphic provides a perspective of how oil viscosity may change as oil is transported away from the discharge site over time, and what areas may be amenable to dispersant operations where enough quantities of oil are present.

6. References

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