Offshore Information for Area Contingency Planning

Offshore Worst Case Discharge Scenarios and Modeling

Arctic and Western Alaska ACP
Chukchi Sea

Technical Document #2
Appendix 2B

May 2023

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, the Bureau of Ocean Energy Management (BOEM), USCG Sector Anchorage, Alaska Department of Environmental Conservation (ADEC), resource trustees, state agencies, oil spill removal organizations (OSROs), and the Arctic and Western Alaska Area Committee resulted in a series of technical documents that provide offshore information on:

- Oil and Gas Infrastructure (Arctic and Western Alaska Technical Document #1)
- Worst Case Discharge Scenarios (Arctic and Western Alaska Technical Document #2 and Appendices 2A-C)
- Response Concept of Operations (Arctic and Western Alaska Technical Document #3)
- Response Strategies and BMPs (Arctic and Western Alaska Technical Document #4)
- Sensitive Species Profiles (Arctic and Western Alaska Technical Document #5).

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.

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 Alaska. Appendices 2A – 2C contain specific, more detailed WCD scenario modeling data and trajectory figures for each of the regions in the Arctic and Western Alaska ACP Planning Area. Appendix 2A contains the modeling information for the one offshore WCD Scenario in the Chukchi Sea.

2 Meteorological and Oceanographic Conditions in Chukchi Sea

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. Optimally, the minimum window of time for stochastic simulations is 5 to 10 years; therefore, long-term records of wind and current data were obtained from the outputs of global numerical atmospheric and ocean circulation models for this modeling.

2.1 Wind Dataset – NCEP CFSR

For the Chukchi Sea, wind data were obtained from the European Centre for Medium-Range Weather Forecasts (ECMWF) Reanalysis Product for an 8-year period (2008 to 2015), as described in Table 1. The ECMWF provides the ERA-Interim reanalysis product that includes wind hindcast data on a global scale. ERA-Interim covers the period of January 1st, 1979 to August 31st, 2019. Gridded data products include a large variety of three-hourly surface parameters, describing atmospheric as well as ocean-wave and land-surface conditions.

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

Name of Dataset	ERA-Interim
Coverage	140.3 °W – 134.3°E 59.3 °N – 84 °N
Owner/Provider	ECMWF
Horizontal Grid Size	0.75°x0.75°
Hindcast Period	2008 - 2015
Time Step	3 hourly

Figure 1 describes the variability of wind speed and direction near Burger J based on the ERA-Interim dataset. The annual ERA-Interim wind rose near Burger J shows the wind direction ranges from northeast, east-northeast, to east. Wind speeds are presented in m/s, using meteorological convention (i.e., direction wind is coming from).

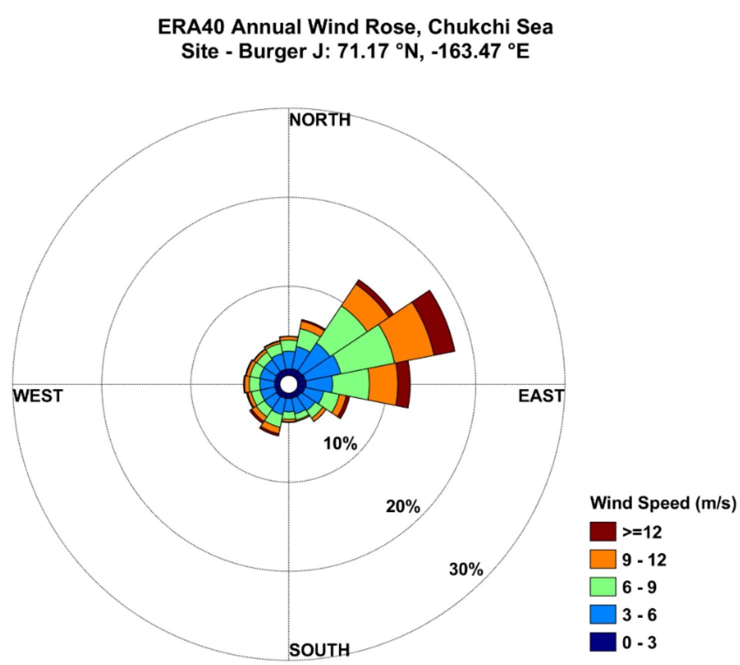

Figure 1. Annual ERA-Interim wind rose near Burger J, within the Chukchi Sea. Wind speeds are in m/s, using meteorological convention (i.e., direction wind is coming from).

2.2 Global Current Dataset – TOPAZ4

Current data for the Beaufort and Chukchi Seas were obtained from the coupled ice-ocean model, TOPAZ4 (Towards an Operational Prediction system for the North Atlantic European coastal Zones) (Sakov *et al*., 2012). TOPAZ4 is a coupled ocean-sea ice data assimilation system for the North Atlantic and the Arctic, developed by the Nansen Environmental and Remote Sensing Center (NERSC) and publicly available through the Norwegian Meteorological Institute. Daily mean 3-dimensional current speed and direction were acquired for the time period May 1, 2008 – January 31, 2015 (Table 2).

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

Name of Dataset	TOPAZ4
Coverage	131 °W – 136.2 °E 54.4 °N – 64.5 °N
Owner/Provider	E.U. Copernicus Marine Service Information
Bathymetry	GEBCO
Wind Forcing	ERA-Interim
Tides	-
Horizontal Grid Size	12.5 km
Hindcast Period	5/1/2008 – 11/2010 11/2011-1/31/2015
Output Frequency	Daily

Figure 2 describes the variability of current speed and direction near Burger J based on the TOPAZ4 dataset. The annual TOPAZ4 current rose near Burger J shows the current predominately flows towards the northwest. Current speeds are displayed in cm/s, using oceanographic convention (i.e., direction current is going to).

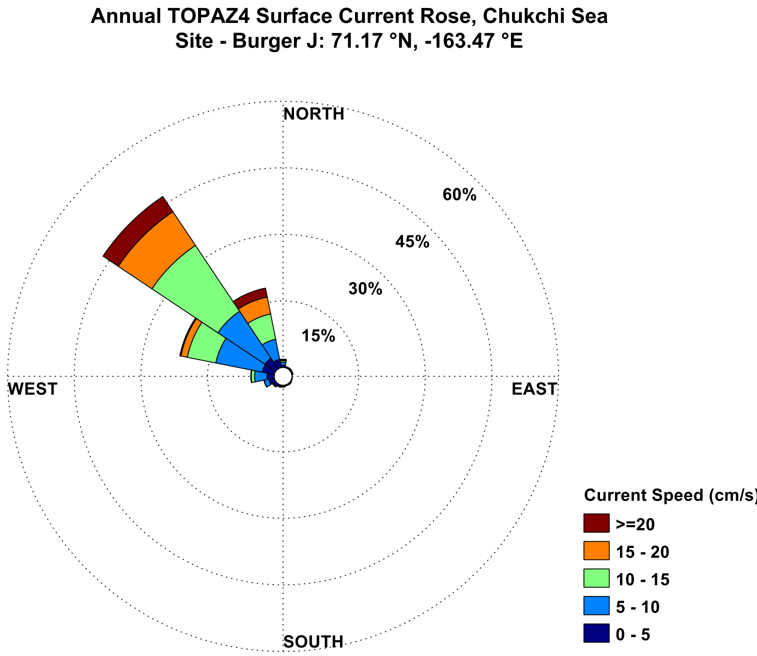

Figure 2. Annual TOPAZ4 rose near Burger J, within the Chukchi Sea. Current speeds in cm/s, using oceanographic convention (i.e., direction current is going to).

3 Burger J Surface Well Blowout

3.1 Scenario Description

The Burger J WCD Scenario is a surface well blowout with the following key parameters

Table 3. Scenario Key Parameters.

Discharge Depth (m)	Distance from Shore (NM)	Oil Type	Spill Type	Ice Coverage	Discharge Duration (days)	Discharge Flowrate (bbl/day)	Total Oil Discharged (bbl)
-42	66.68	Heavy Crude API = 27	Surface Well Blowout	Open Water	30	25,000	750,000

3.2 Potential Oil Contact with the Environment and Resources at Risk

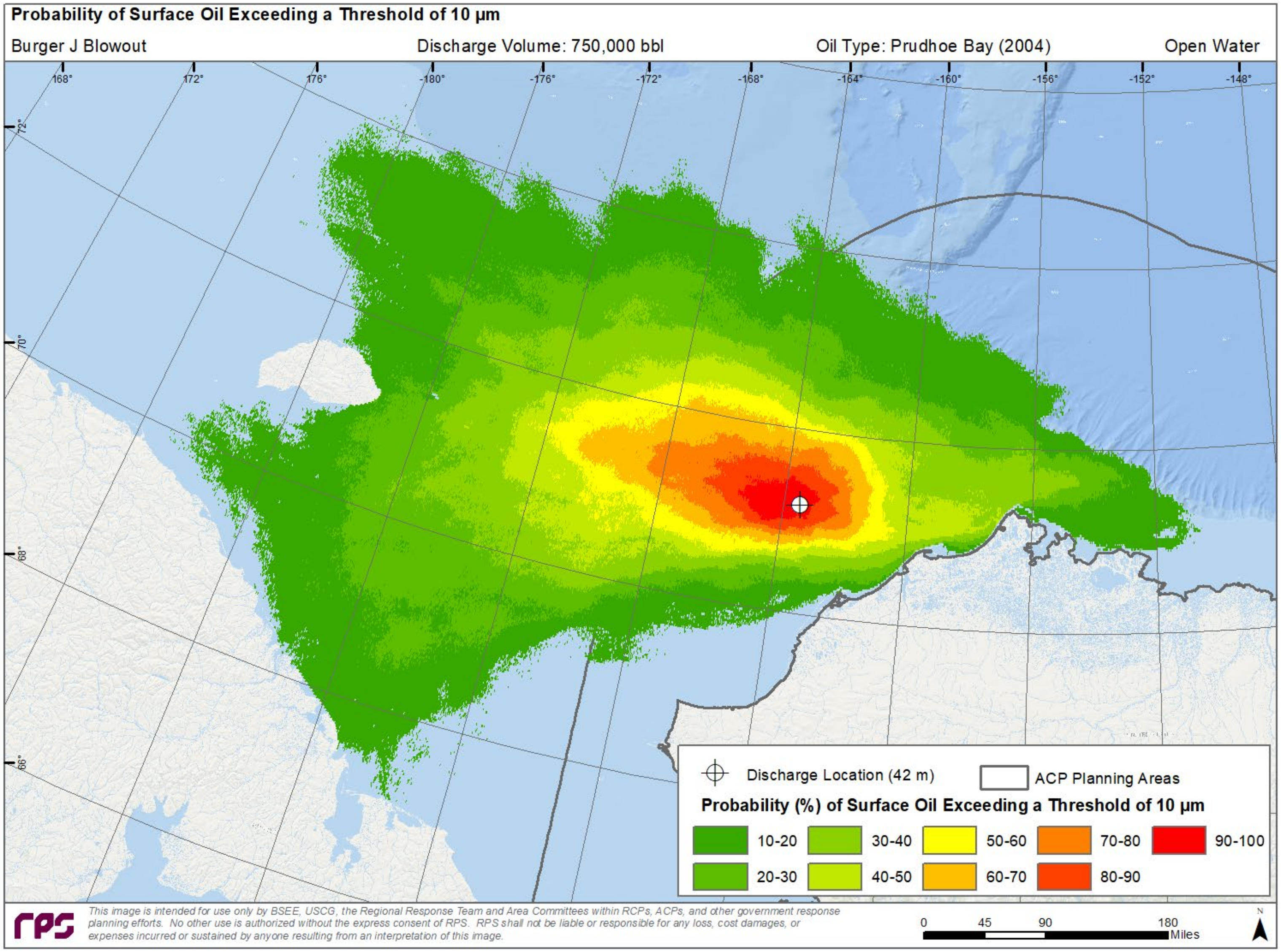

Figure 3. Probability Footprint for Oil on the Water Surface with Average Thickness greater than the Ecological Threshold of 10 µm.

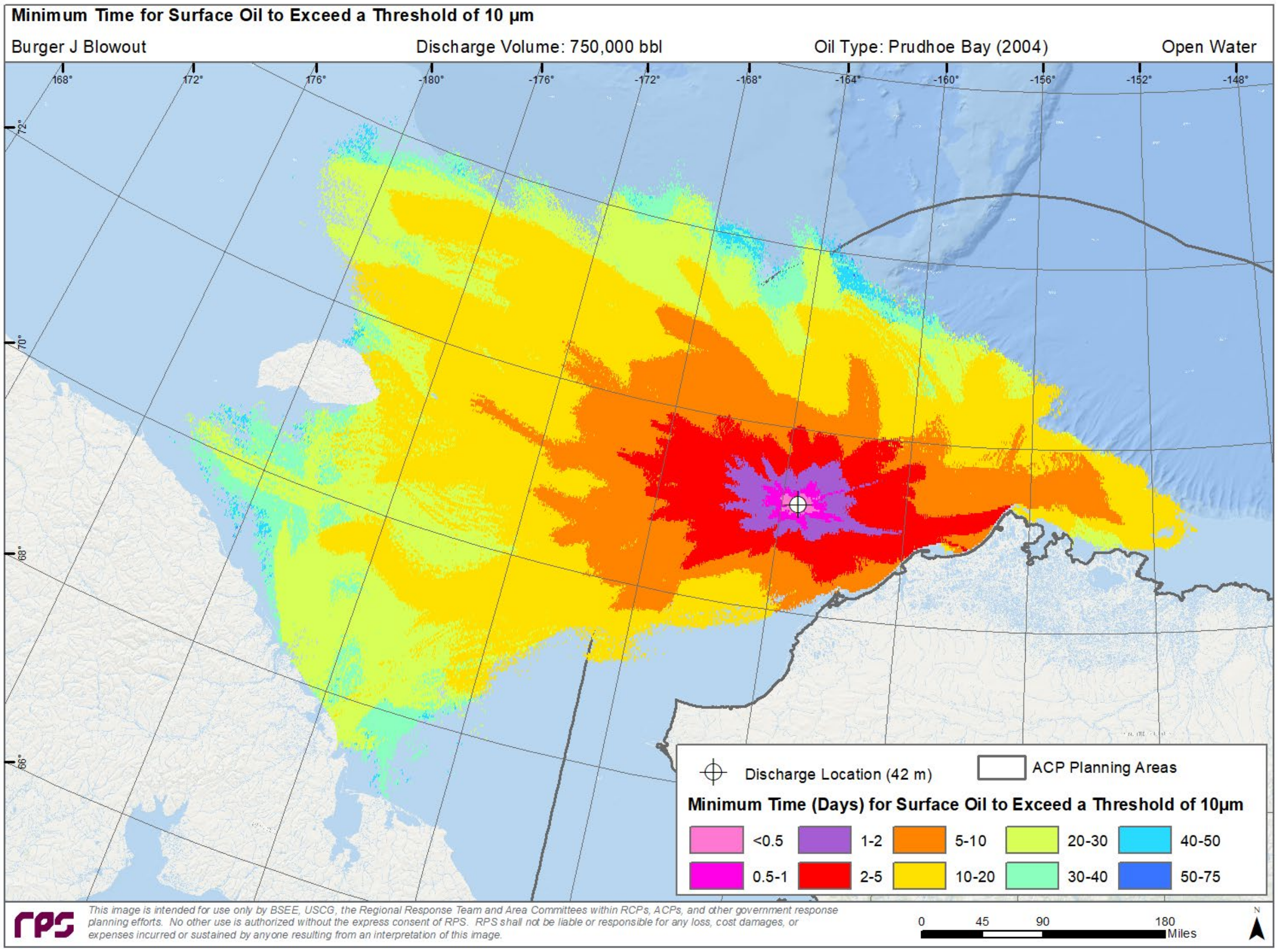

Figure 4. Minimum Time for Oil on the Water Surface with Average Thickness greater than the Ecological Threshold of 10 μm.

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**
84	36	9	69.4	700.6

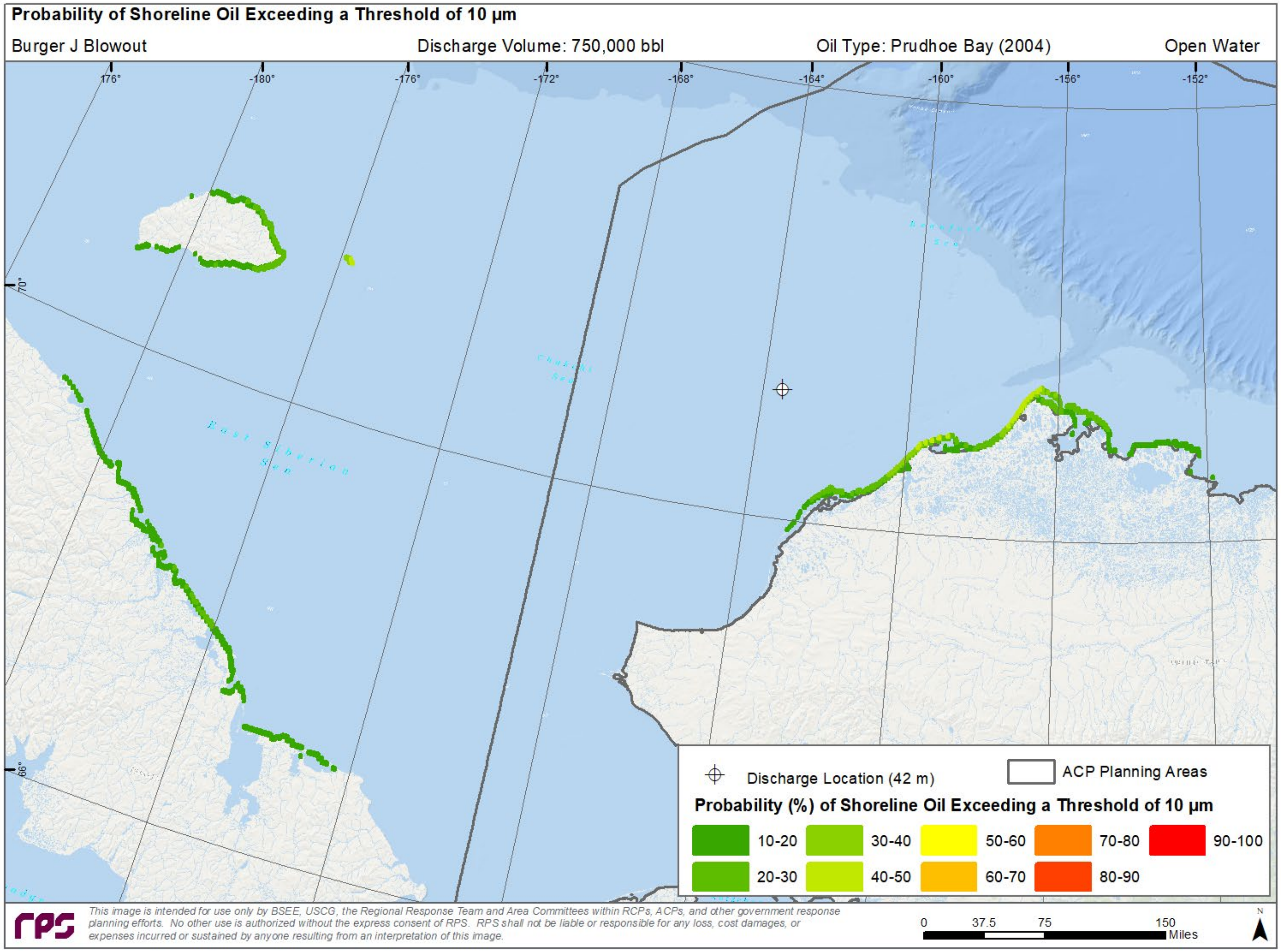

Figure 5. Probability Footprint for Oil on the Shoreline with Average Thickness greater than the Ecological Threshold of 10 µm. This thickness of oil may appear on the shore as dark stain or film. 10 µm is a conservative ecological screening threshold for potential sublethal effects on fauna and birds on the shoreline.

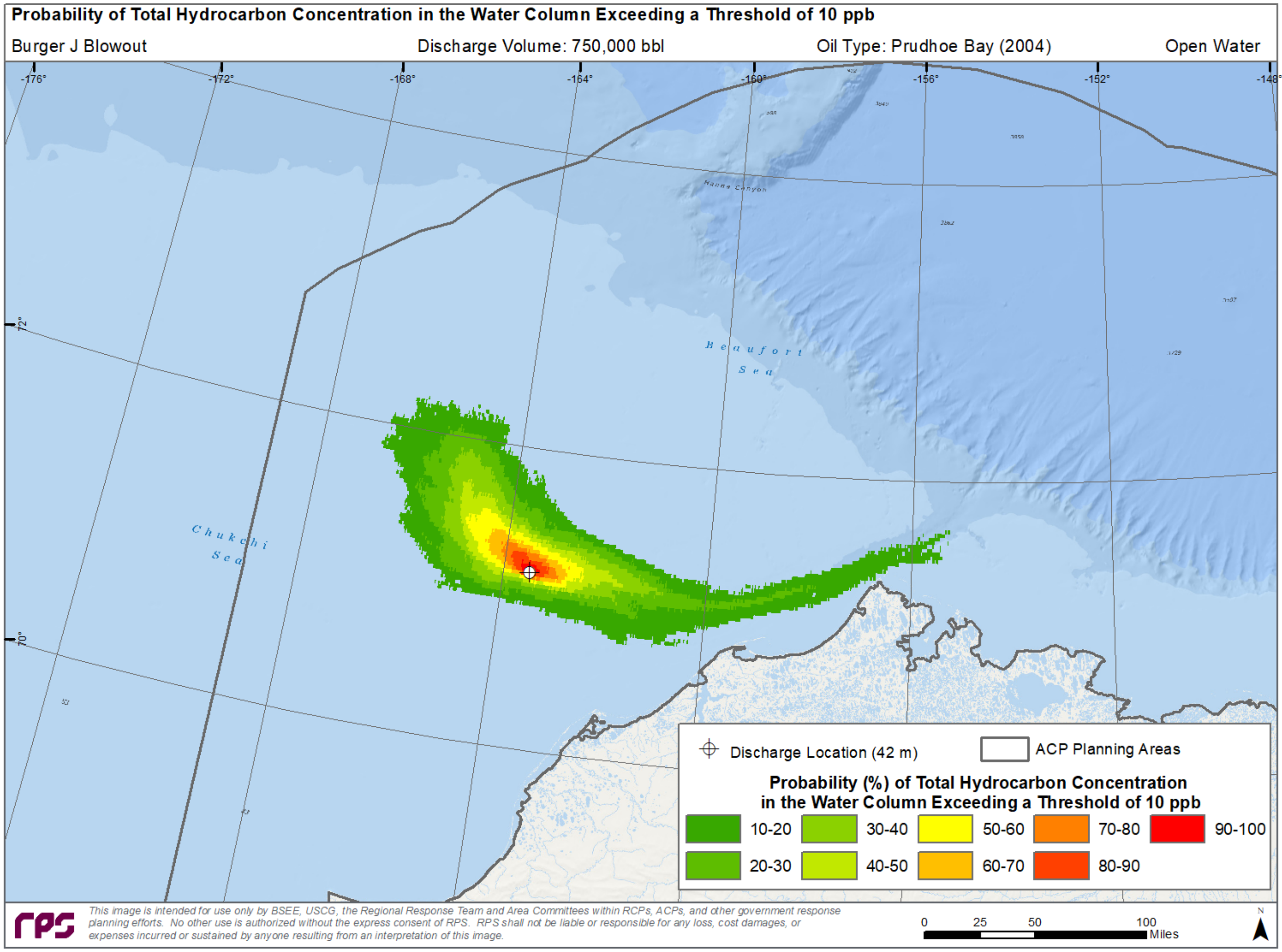

Figure 6. Probability Footprint for Total Hydrocarbon Concentration (THC) concentrations in the Water Column greater than the Ecological Threshold of 10 µg/L (~10 ppb). 10 ppb (µg/L) of whole oil (THC) corresponds to ~0.1 µg/L (~1 ppb) of dissolved Polycyclic Aromatic Hydrocarbons (PAHs) for fresh crude oils. This threshold can result in sublethal impacts to early life stages of fish and invertebrates in the upper ~20 meters of the water column if exposed to UV light.

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) = 321,418 mi^2
- Swept Oiled Surface Area Exceeding 10 µm (Ecological Impact) = 322,326 mi^2
- Oiled Shoreline Exceeding 10 µm (Ecological Impact) = 817 mi
- Water Column Oil Exposure Exceeding 10 ppb Dissolved PAH (Ecological Impact) = 38,828 million m3
- Time to Shore = 15.3 days

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
750,000bbl	29.9%	19.7%	2.6%	<0.1%	25.5%	22.2%

*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.

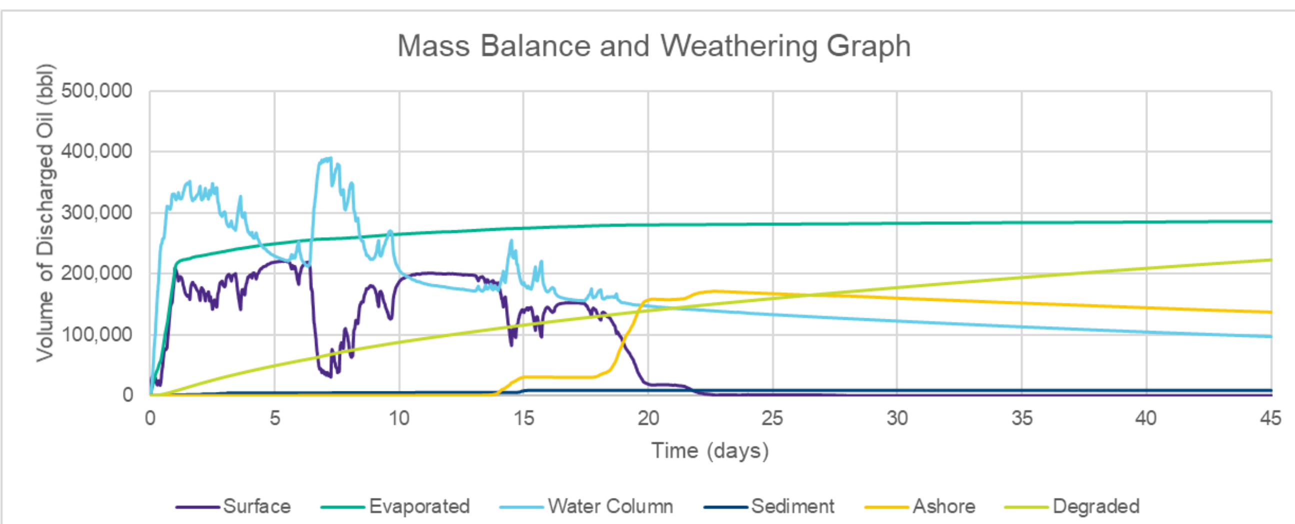

Figure 7. Mass Balance over Time for worst case deterministic simulation.

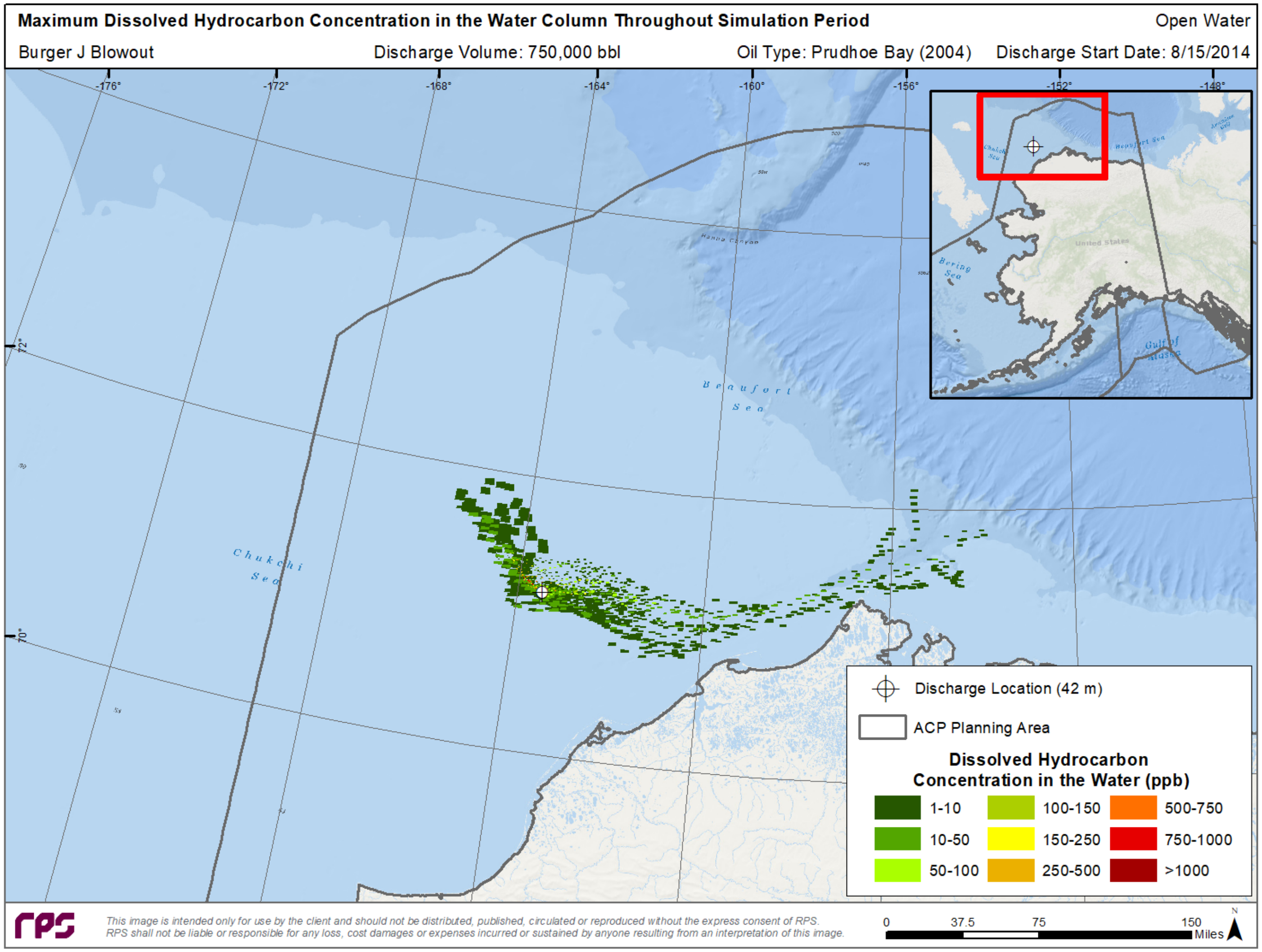

Figure 8. Cumulative Maximum Concentration of Dissolved Polycyclic Aromatic Hydrocarbons (PAH) within the water column at any time during the worst case deterministic simulation period. Dissolved PAH concentrations greater than ~10 µg/L (~10 ppb) could affect plankton in the upper ~20 m and impart sublethal to lethal effects on other water column biota (adult, juvenile fish, and invertebrates).

3.3 Response Planning Information

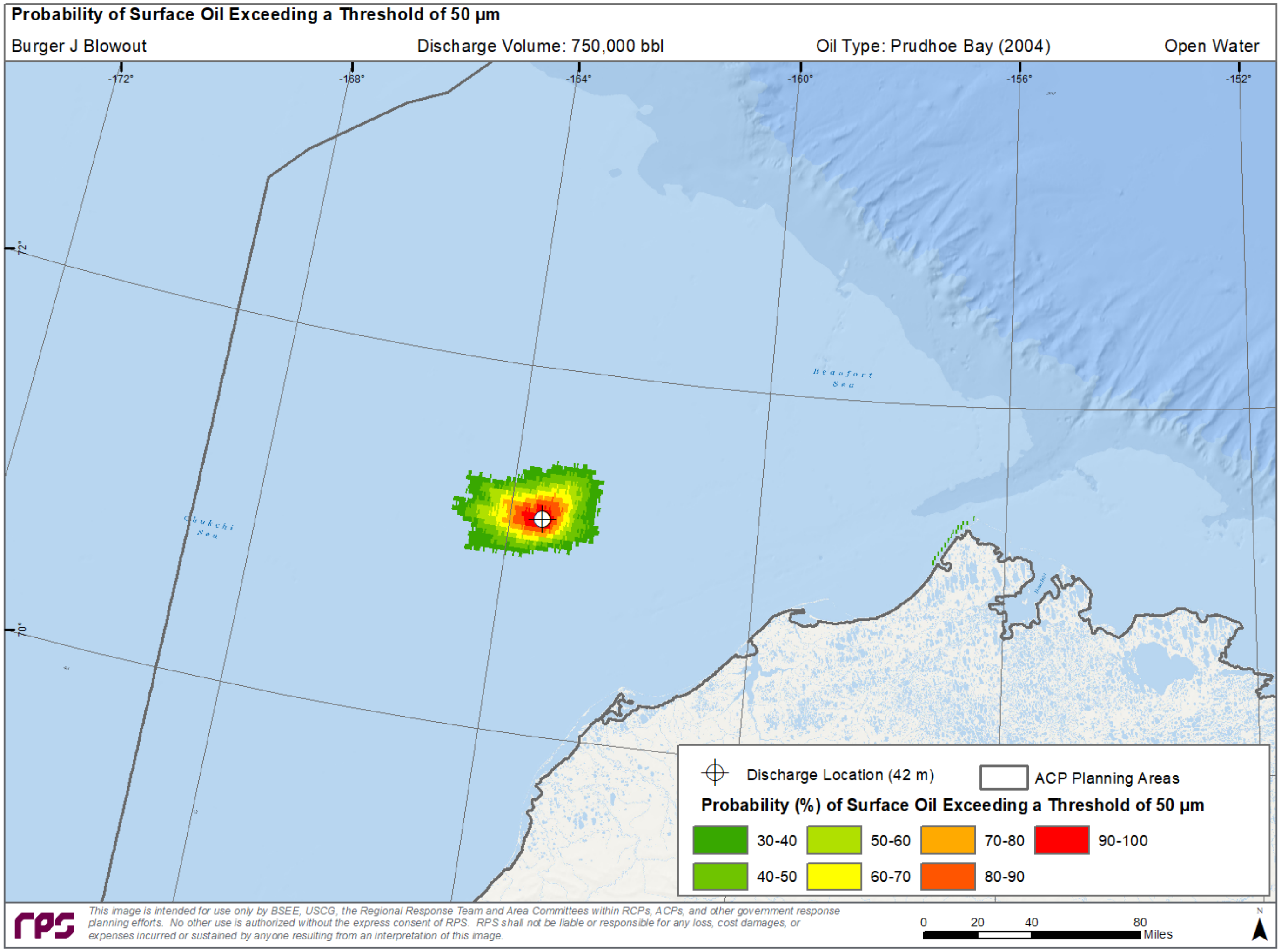

Figure 9. Probability Footprint for Surface Oil exposure greater than 50 µm. In this thickness range, oil will appear as a continuous to discontinuous patches of dark oil in quantities where high volume on-water mechanical recovery operations will be the most productive.

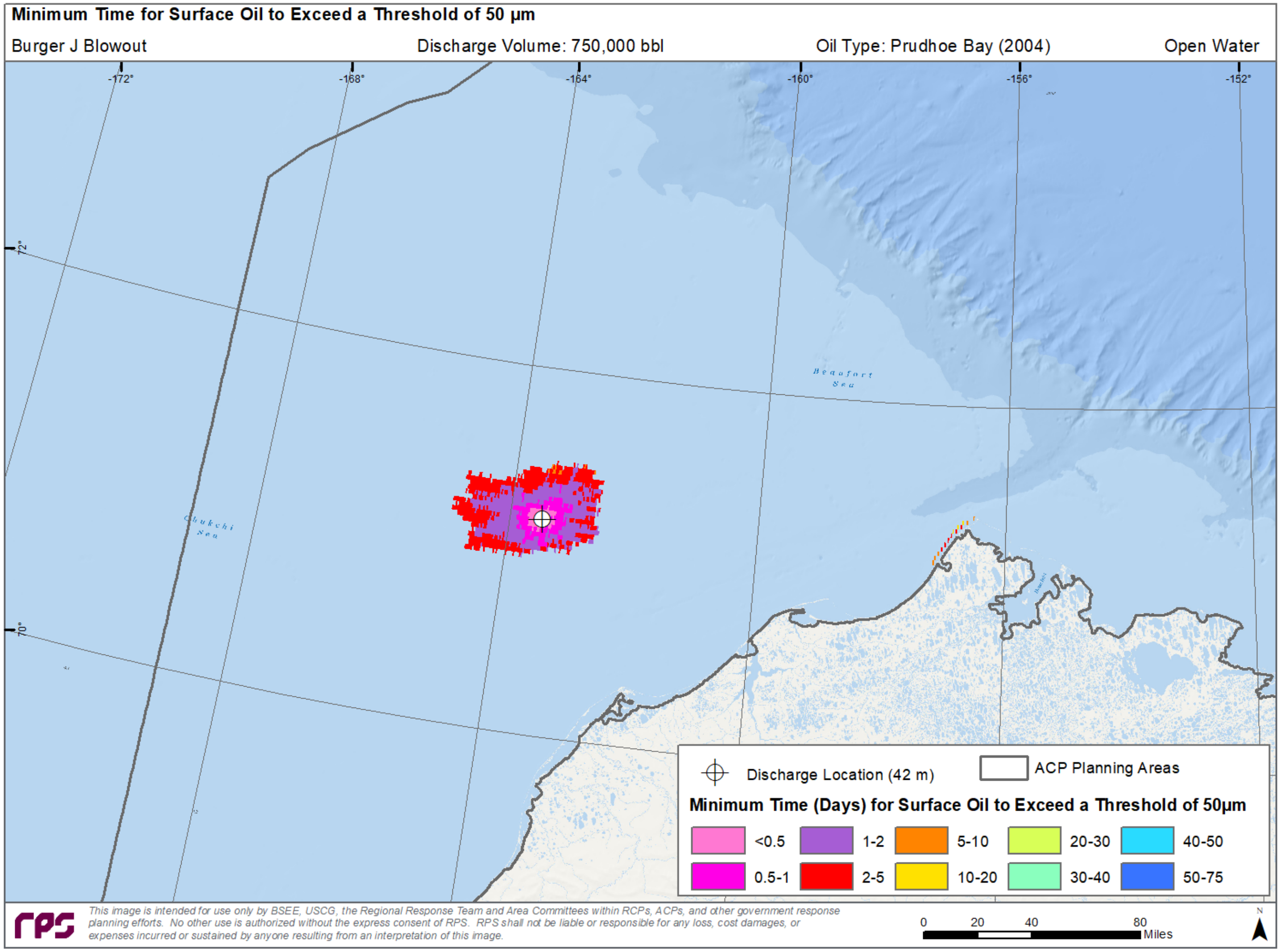

Figure 10. Minimum Travel Time for Surface Oil exposure greater than 50 µm.

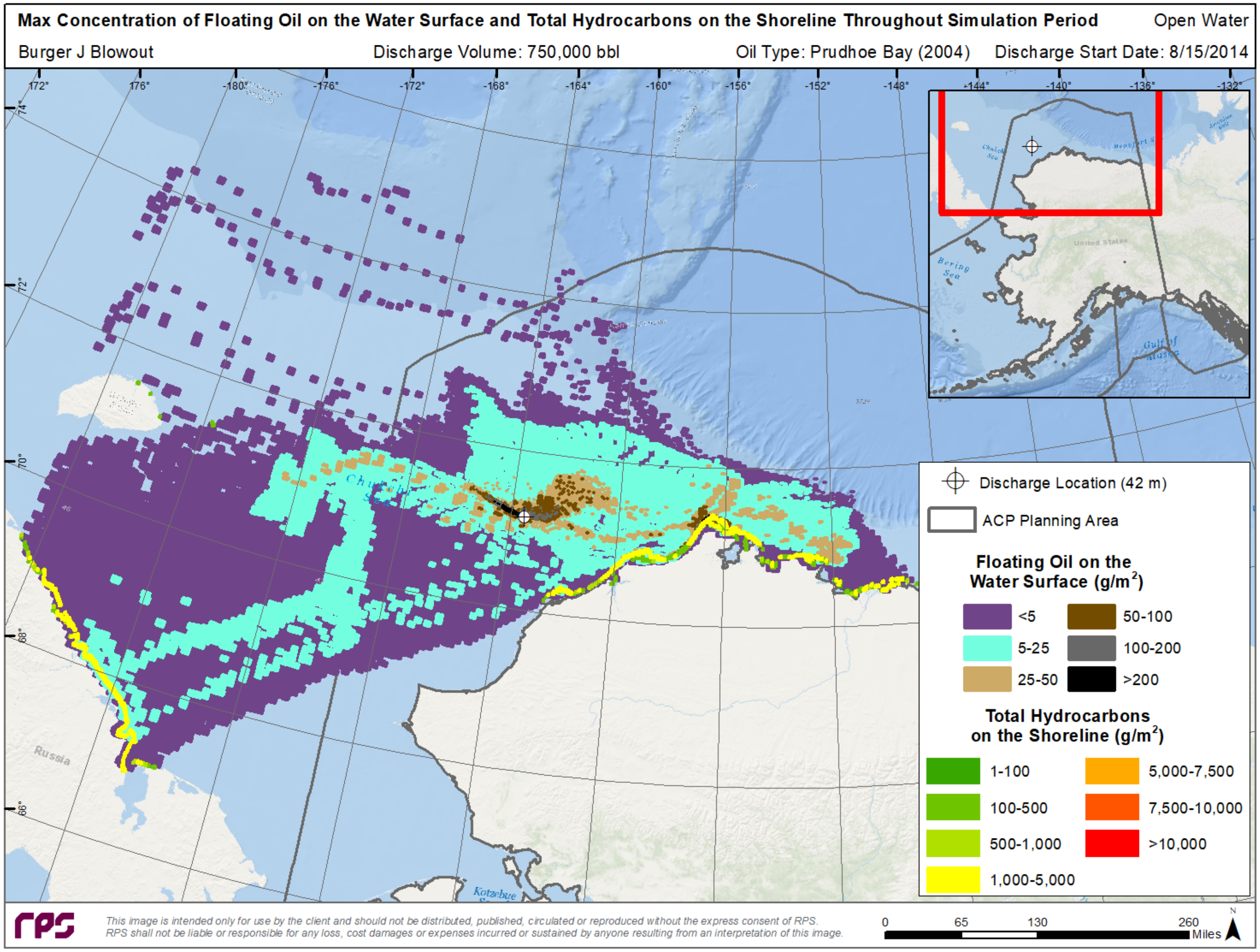

Figure 11. Cumulative Maximum Concentration of Floating Oil on the Water Surface and Total Hydrocarbons on the Shoreline at any time during the worst case deterministic simulation.

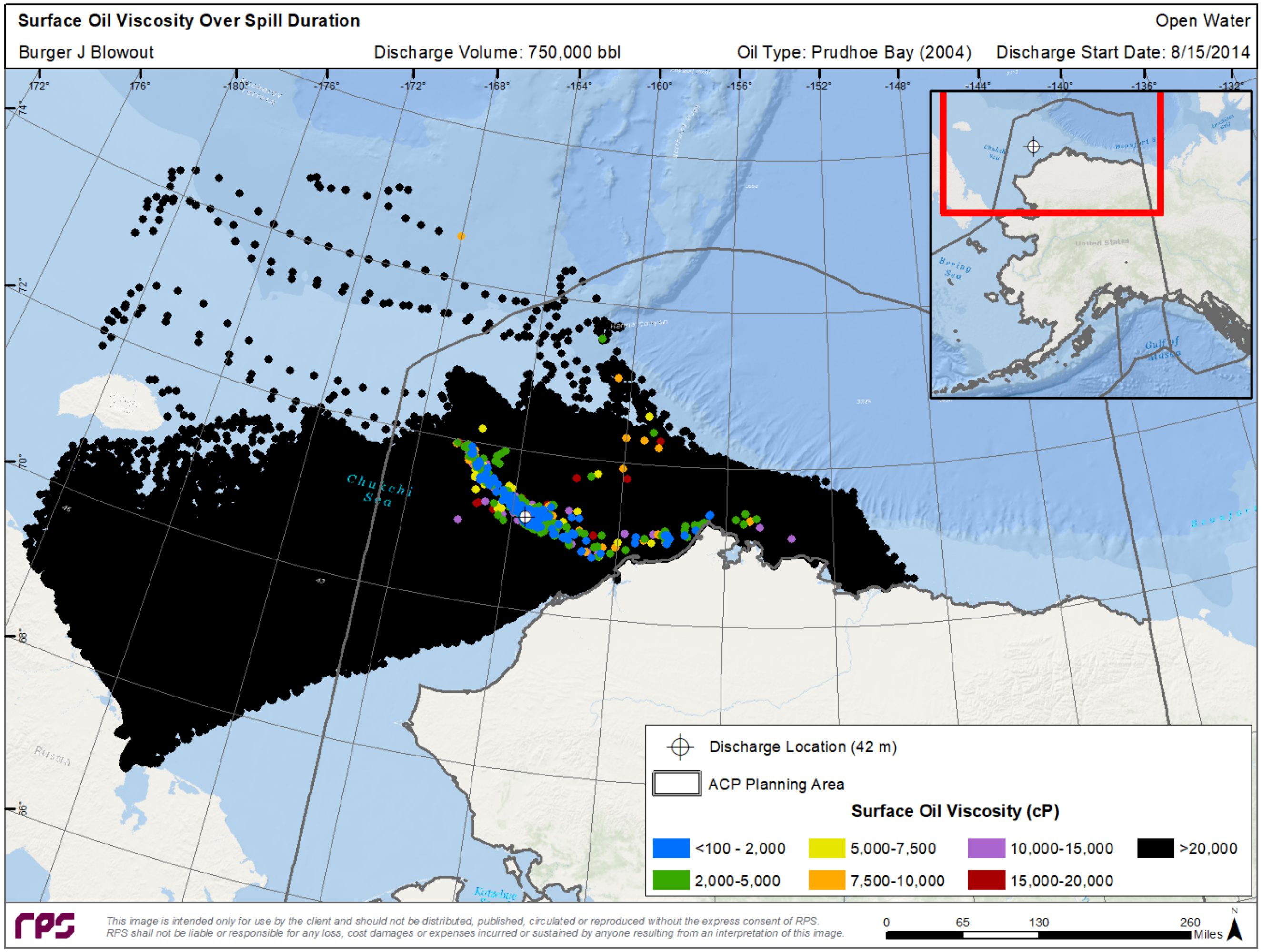

Figure 12. Cumulative footprint of exposure to surface floating oil greater than the minimum oil viscosity over a 75-day period for the worst case deterministic simulation. Viscosities greater than those mapped may be present at any location at any specific time in the simulation. This graphic provides 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.