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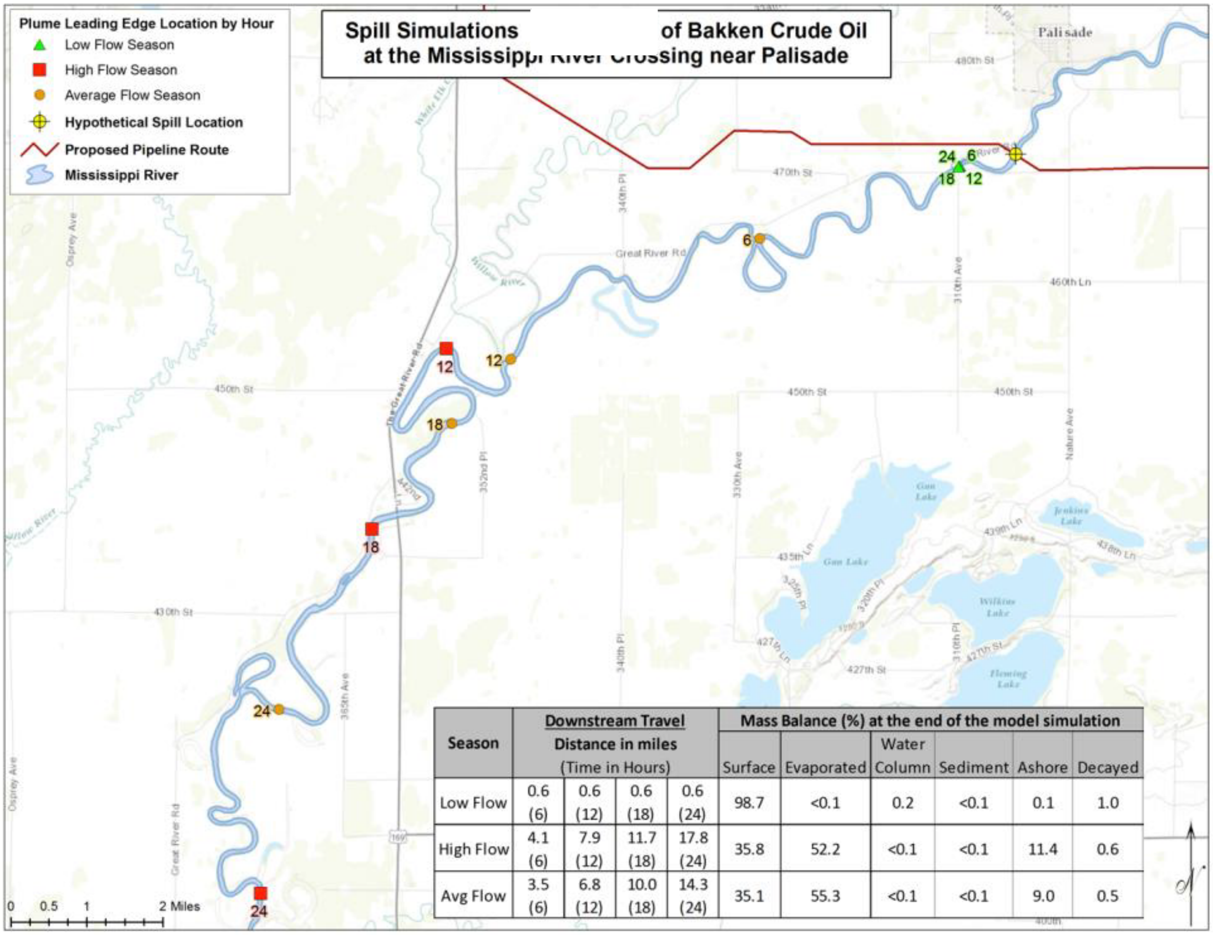

Season	Downstream Travel Distance in miles (Time in Hours)				Mass Balance (%) at the end of the model simulation					
					Surface	Evaporated	Water Column	Sediment	Ashore	Decayed
Low Flow	0.6 (6)	0.6 (12)	0.6 (18)	0.6 (24)	98.7	<0.1	0.2	<0.1	0.1	1.0
High Flow	4.1 (6)	7.9 (12)	11.7 (18)	17.8 (24)	35.8	52.2	<0.1	<0.1	11.4	0.6
Avg Flow	3.5 (6)	6.8 (12)	10.0 (18)	14.3 (24)	35.1	55.3	<0.1	<0.1	9.0	0.5

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Figure 6-35 Predicted Downstream Transport of Bakken Crude oil at the Mississippi River at Palisade Release Location

During high and average river flow conditions, the relatively calm waters (i.e., not a lot of surface breaking disturbances) of the Mississippi River near Palisade did not entrain oil into the water column. Rather, these releases were typified by large amounts of floating oil, which formed thick surface oil slicks over much of the river (Figure 6-40 and Figure 6-47). At the end of the 24-hour simulation, floating oil thicknesses greater than 1 mm (heavy black oil) remained on the water surface. There was no floating surface oil less than 0.01 mm thick (dark brown sheen).

Extensive shoreline oiling and limited sediment oiling was observed for approximately 17.5 miles (28.2 km) of the river below the release location under high river flow conditions (Figure 6-42) and 19.2 miles (30.9 km) under average river flow conditions (Figure 6-49).

Surface oil evaporated rapidly over the 24-hour simulation (Figure 6-36, Figure 6-43, and Table 6-3). As Bakken is a much lighter crude oil with a higher volatile content than CLB, greater than 50% is predicted to evaporate over 24 hours (Table 6-3), nearly 2.5 times that of the CLB (Table 6-2). There was a low potential for Bakken entrainment into the water column due to the low winds, which did not cause surface breaking waves, and the lack of rapids, riffles, and waterfalls in this area of the Mississippi. Because of this, total hydrocarbon concentrations (i.e. whole oil in the water column) were extremely low due to the oil remaining on the surface of the water and not entrained within the water column.

The maximum concentration of dissolved aromatics was greater than 5,000 ppb in small regions within the spill extent; however, most of the dissolved aromatic concentrations were between 10 and 50 ppb (Figure 6-41 and Figure 6-48). Concentrations were higher for Bakken scenarios, when compared to the CLB scenarios, due to the higher aromatic content of the lighter Bakken oil. Of the oil that made its way into the water column, a portion did interact with SPM. Total hydrocarbon concentrations on the sediment were generally less than 0.01 g/m^2, with small segments as high as 0.5 g/m^2 (Figure 6-42 and Figure 6-49). Concentrations on the shore were generally between 100-500 g/m^2, which was lower than the CLB scenario. This is due to the lower viscosity of the Bakken, which results in thinner oiling of shorelines. Additionally, less oil would be expected to reach sediments in the Bakken releases, when compared to the CLB. The highest sediment concentrations were predicted for the high river flow scenario due to the higher concentration of TSS in the water column.

For the low river flow scenario, the hydrocarbon trajectory at the end of the 24-hour simulation extended 0.5 miles (0.8 km) from the spill location (Figure 6-53). This distance was only approximately one-third that of the CLB and was the result of the difference in oil density. Bakken is a much less dense oil and would rise through the water column more rapidly than the CLB. Because the oil spends less time in the water column, before it rises to the surface and sticks to the underside of the ice, it is transported less distance downstream. Under low river flow conditions the 100% surface coverage of ice kept the entrained oil in the water column at the ice/water interface (98.7%) (Figure 6-50 and Figure 6-54). Patchy oiling along river banks was observed, however the majority of the oil remained trapped under the ice (Table 6-2). Slightly lower amounts of oil were predicted along shorelines for Bakken, compared to CLB. Concentrations on the shore were primarily greater than 500 g/m^2 within the vicinity of the release location, with some segments downstream with concentrations less than 1 g/m^2 (Figure 6-56). A larger portion of the soluble portion of the Bakken dissolved into the water column and was transported downstream, resulting in elevated dissolved aromatic concentrations within the water column (Figure 6-55). Dissolved aromatic components traveled downstream from the initial spill location with maximum concentrations greater than 5,000 ppb in regions within the spill extent (Figure 6-55). Much larger portions of the river are predicted to experience dissolved aromatic concentrations in excess of 5,000 ppb, when compared to average or low flow scenarios. At the end of the 24-hour simulation, floating oil greater than 1 mm thick (heavy black oil) remained under the ice (Figure 6-54). There was no floating surface oil less than 0.1 mm thick (black oil). Small amounts of sediment oiling did extended down to approximately 1.2 miles (1.9

km) (Figure 6-56), although the total hydrocarbon concentrations on the sediment were generally less than 0.01 g/m². There was very little decay from any of the three hypothetical releases within the timeframe modeled.

6.2.1.2.1 Trajectory and Fate Results for High Flow (Spring)

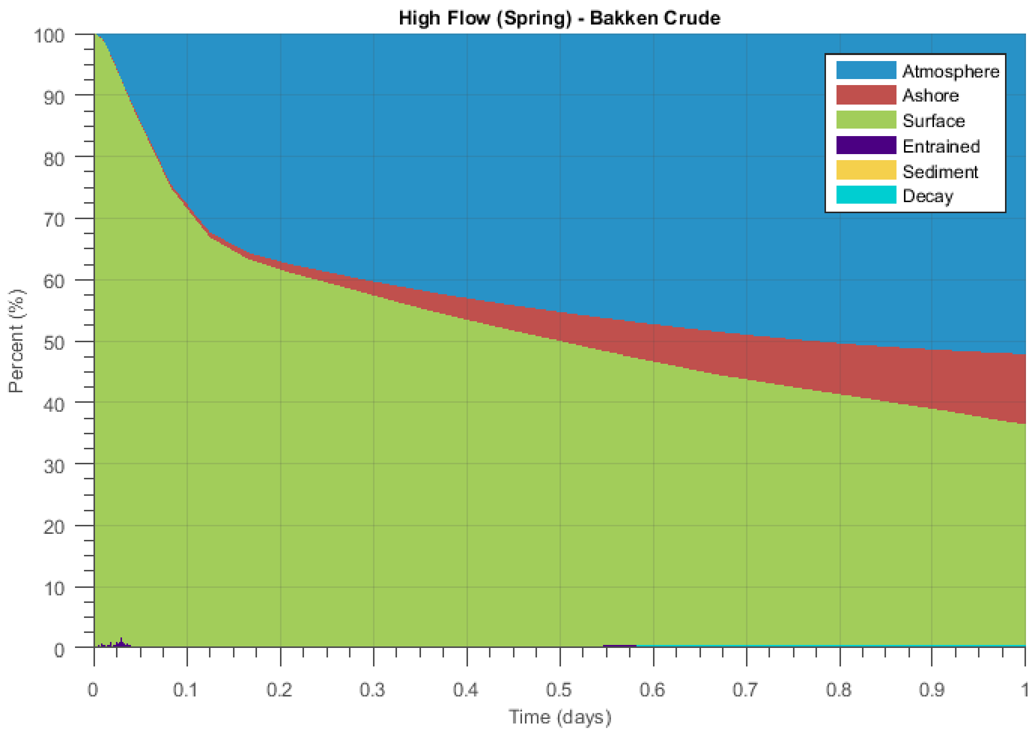

Figure 6-36 Oil Mass Balance Graph for the Release of Bakken Crude at the Mississippi River at Palisade Release Location During the High Flow (Spring) Season

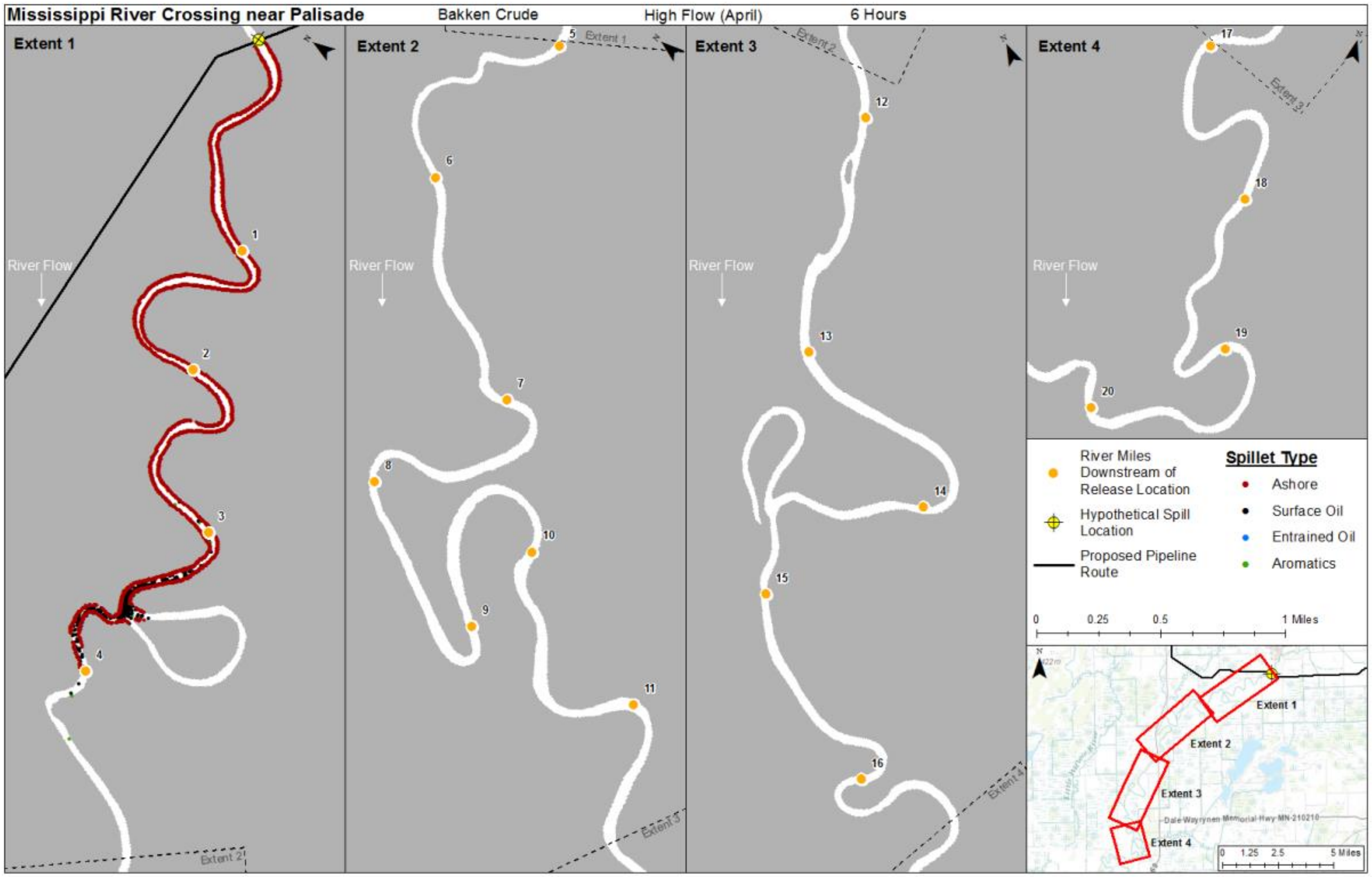

Figure 6-37 Oil Trajectory at 6 Hours for the Release of Bakken Crude at the Mississippi River at Palisade Release Location During the High Flow (Spring) Season

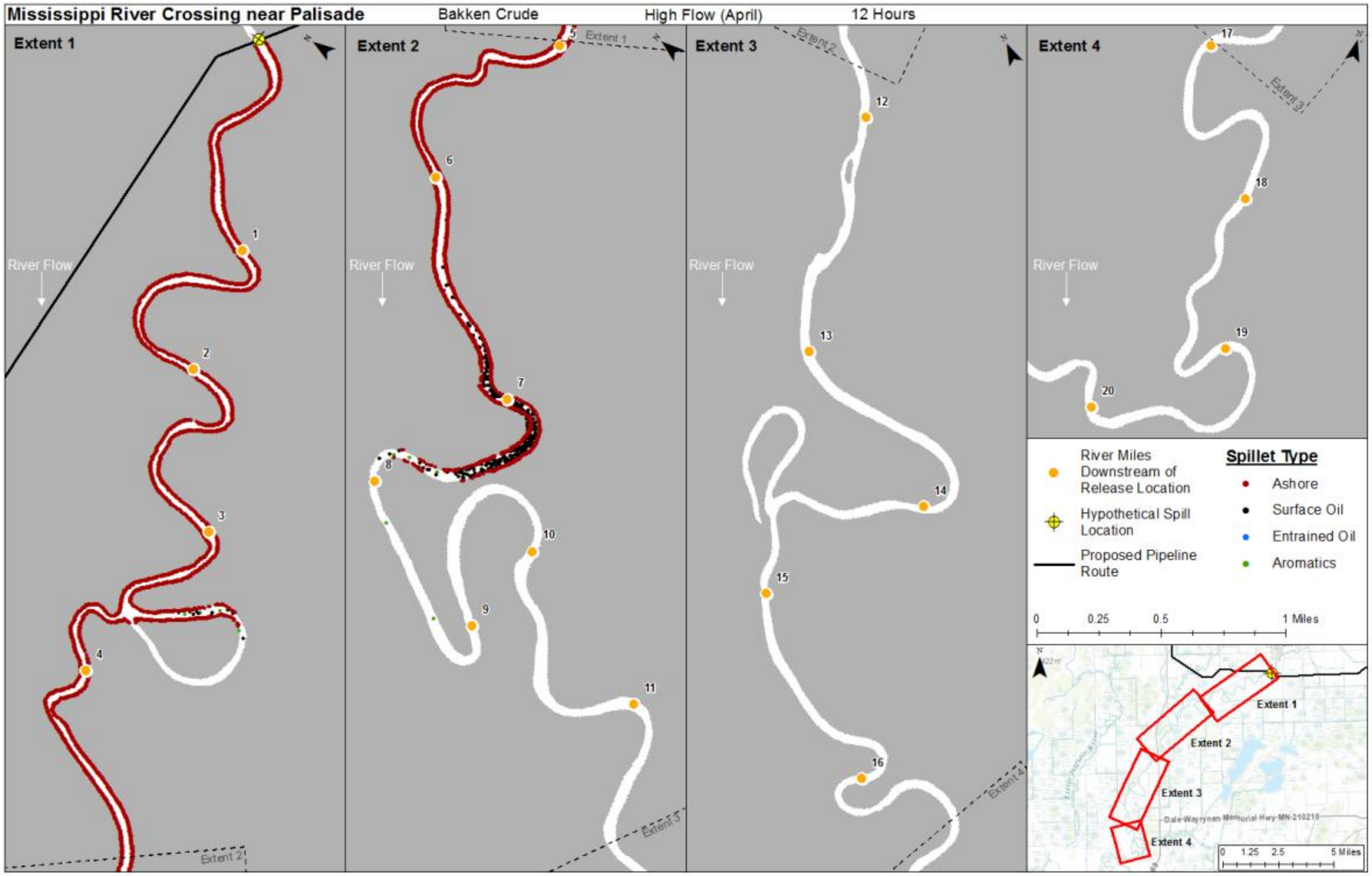

Figure 6-38 Oil Trajectory at 12 Hours for the Release of Bakken Crude at the Mississippi River at Palisade Release Location During the High Flow (Spring) Season

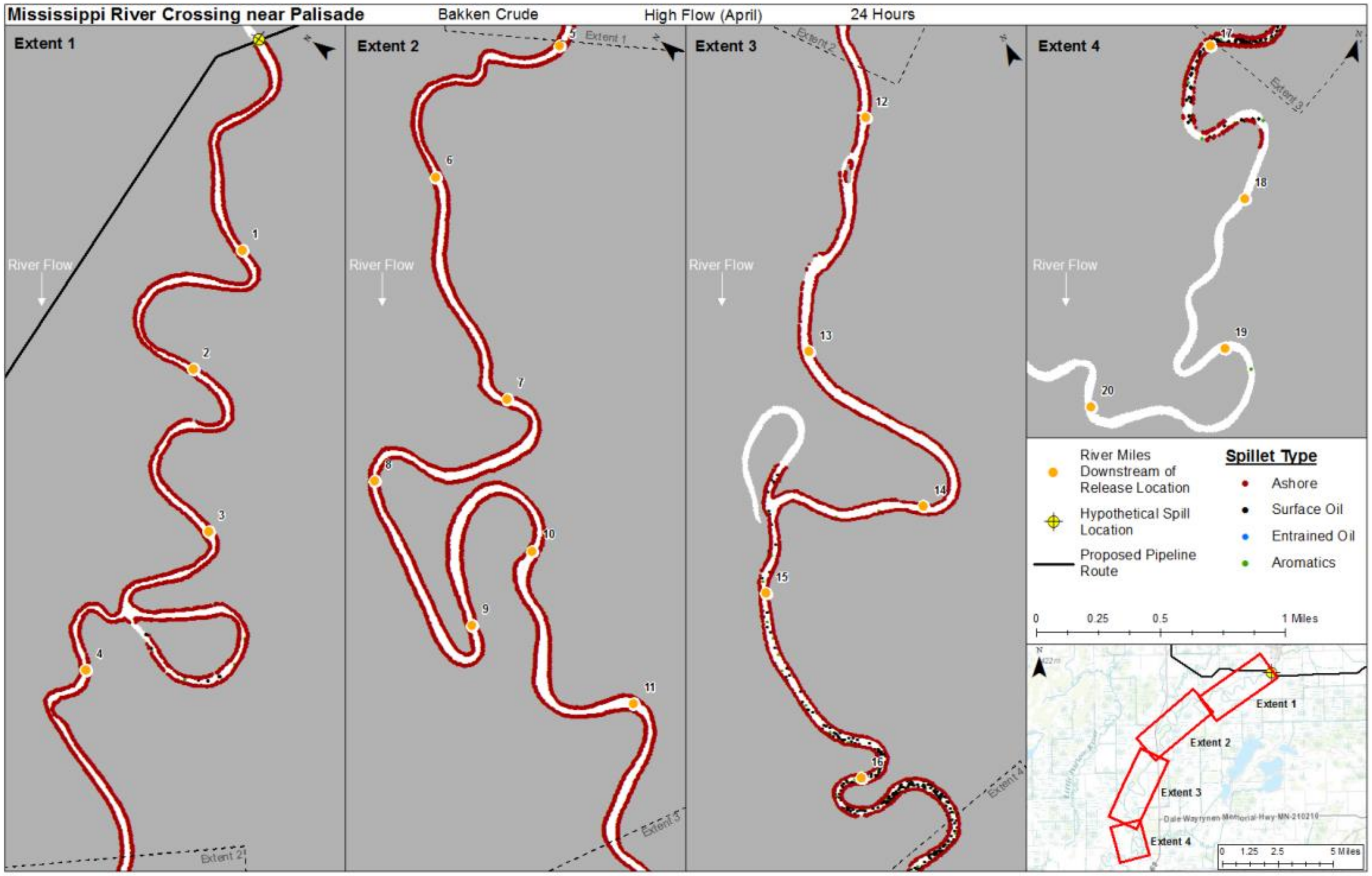

Figure 6-39 Oil Trajectory 24 Hours for the Release of Bakken Crude at the Mississippi River at Palisade Release Location During the High Flow (Spring) Season

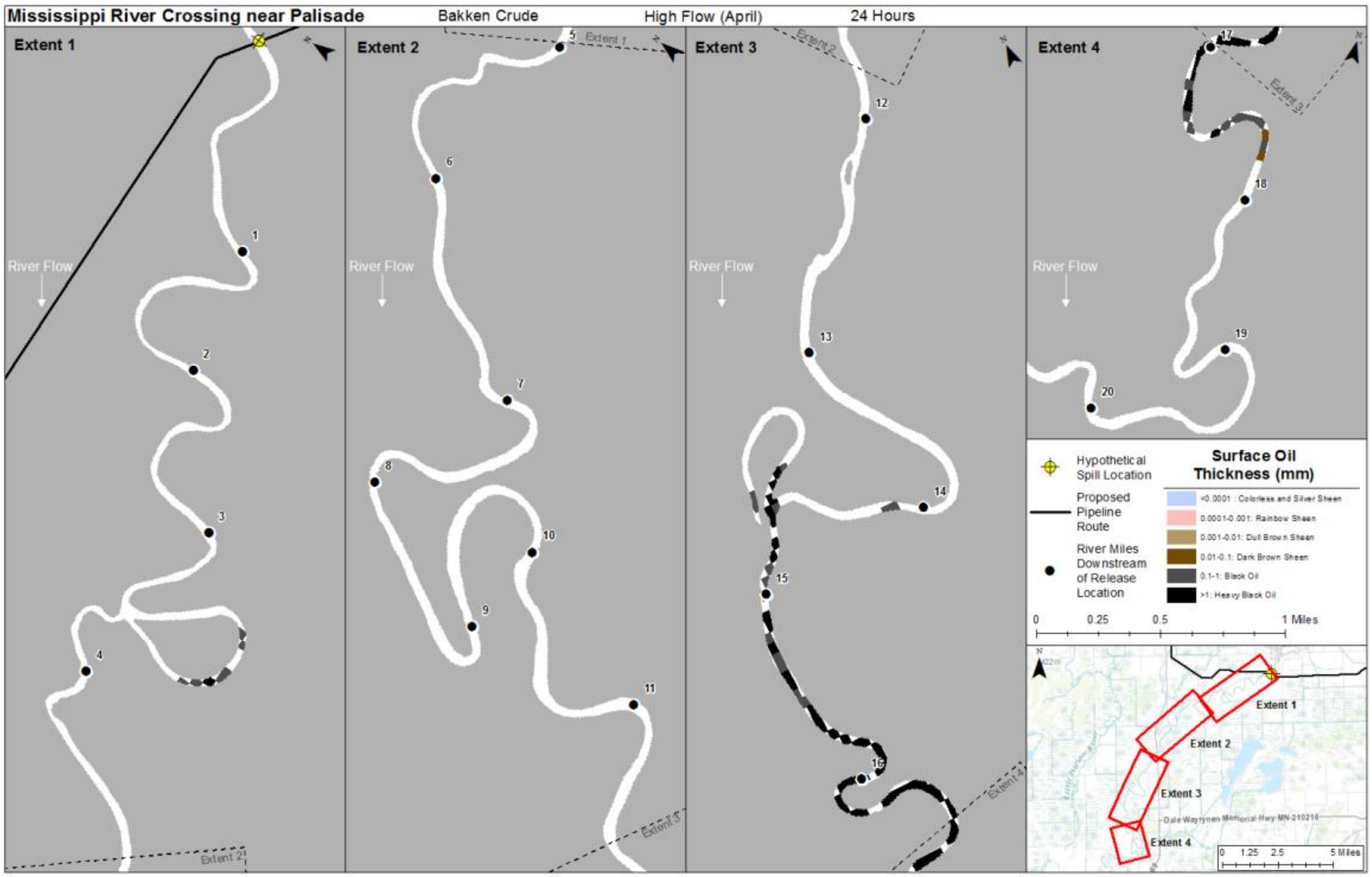

Figure 6-40 Maximum Floating Surface Oil Thickness at 24 Hours for the Release of Bakken Crude at the Mississippi River at Palisade Release Location During the High Flow (Spring) Season

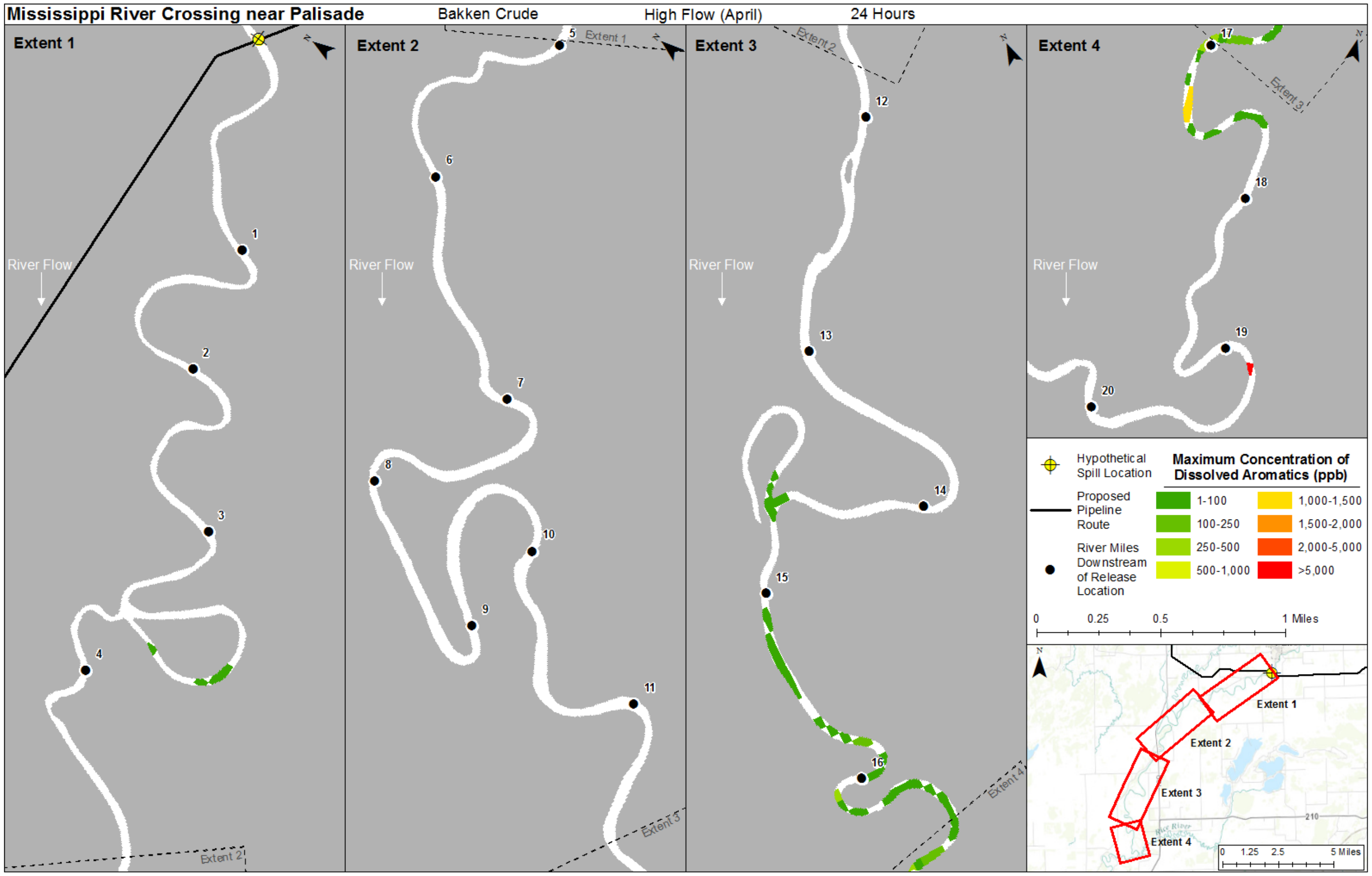

Figure 6-41 Maximum Total Dissolved Aromatic Concentration at 24 Hours for the Release of Bakken Crude at the Mississippi River at Palisade Release Location During the High Flow (Spring) Season

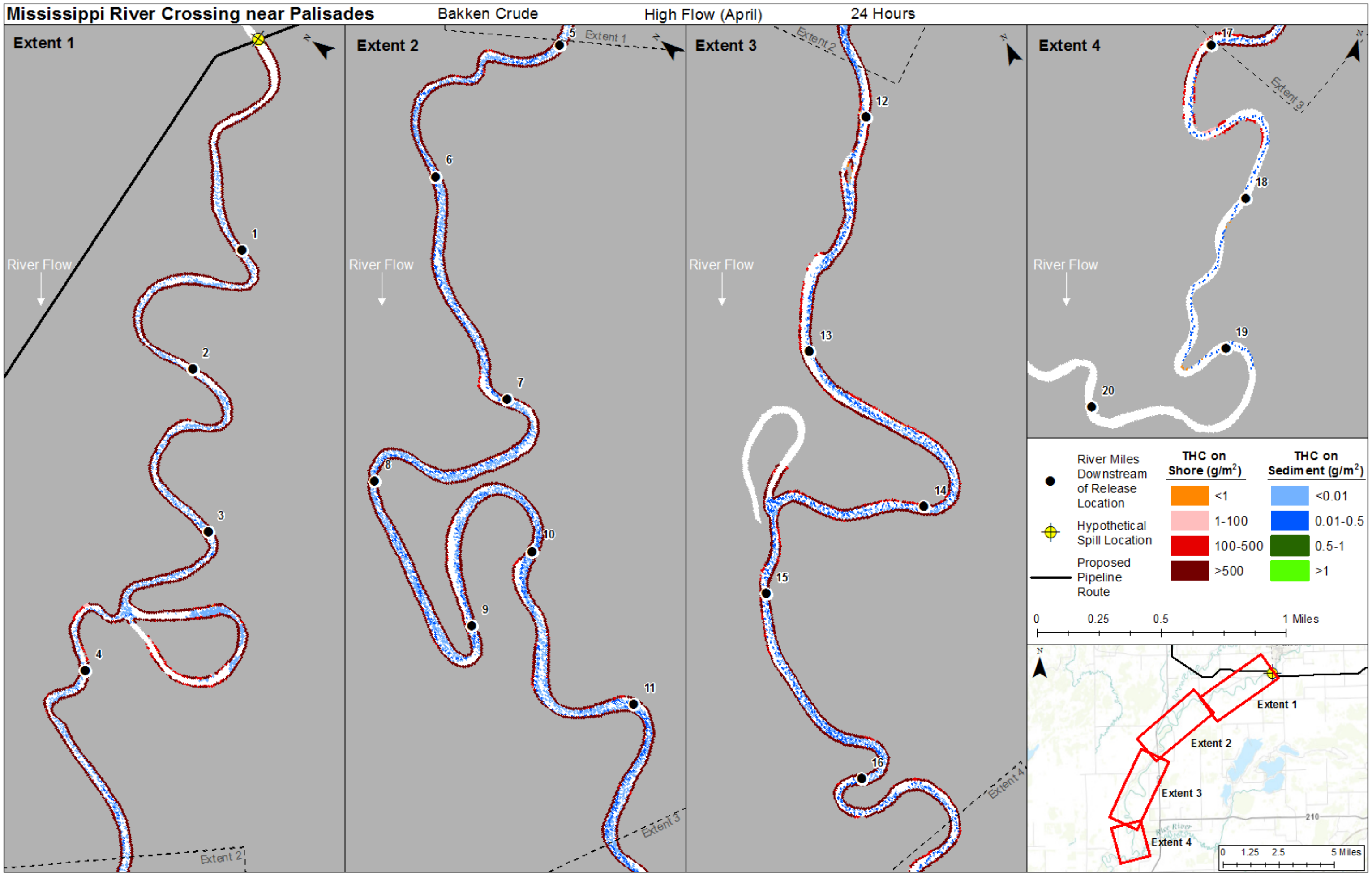

Figure 6-42 Maximum Total Hydrocarbon Mass on the Shore and on Sediments at 24 Hours for the Release of Bakken Crude at the Mississippi River at Palisade Release Location During the High Flow (Spring) Season

6.2.1.2.2 Trajectory and Fate Results for Average Flow (Summer-Fall)

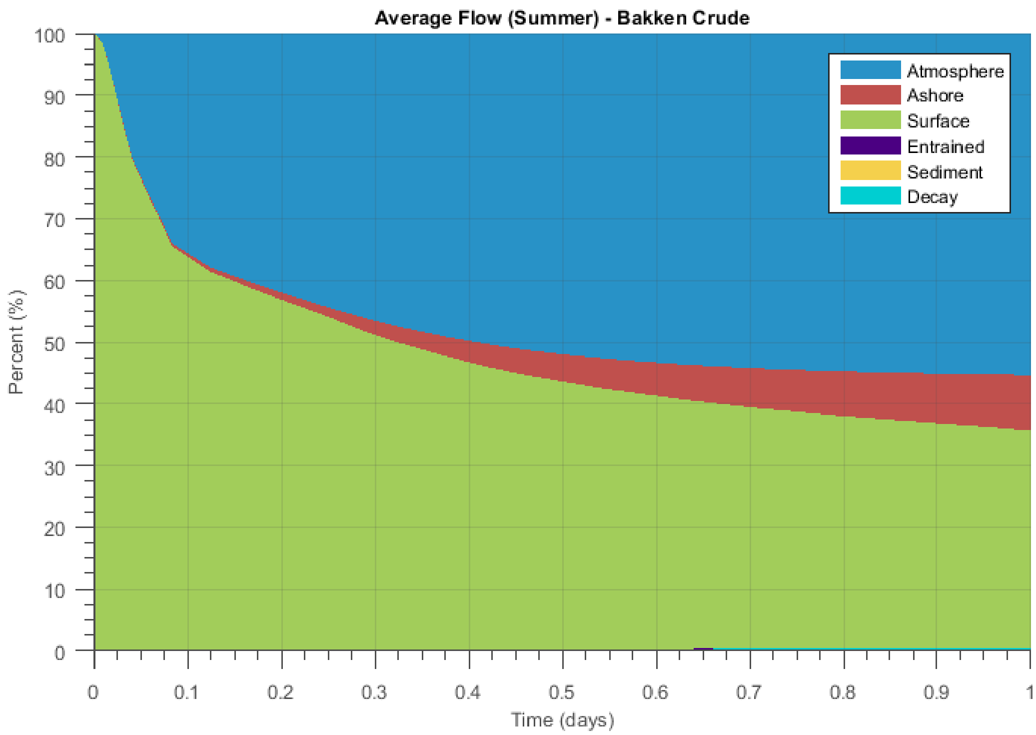

Figure 6-43 Oil Mass Balance Graph for the Release of Bakken Crude at the Mississippi River at Palisade Release Location During the Average Flow (Summer-Fall) Season

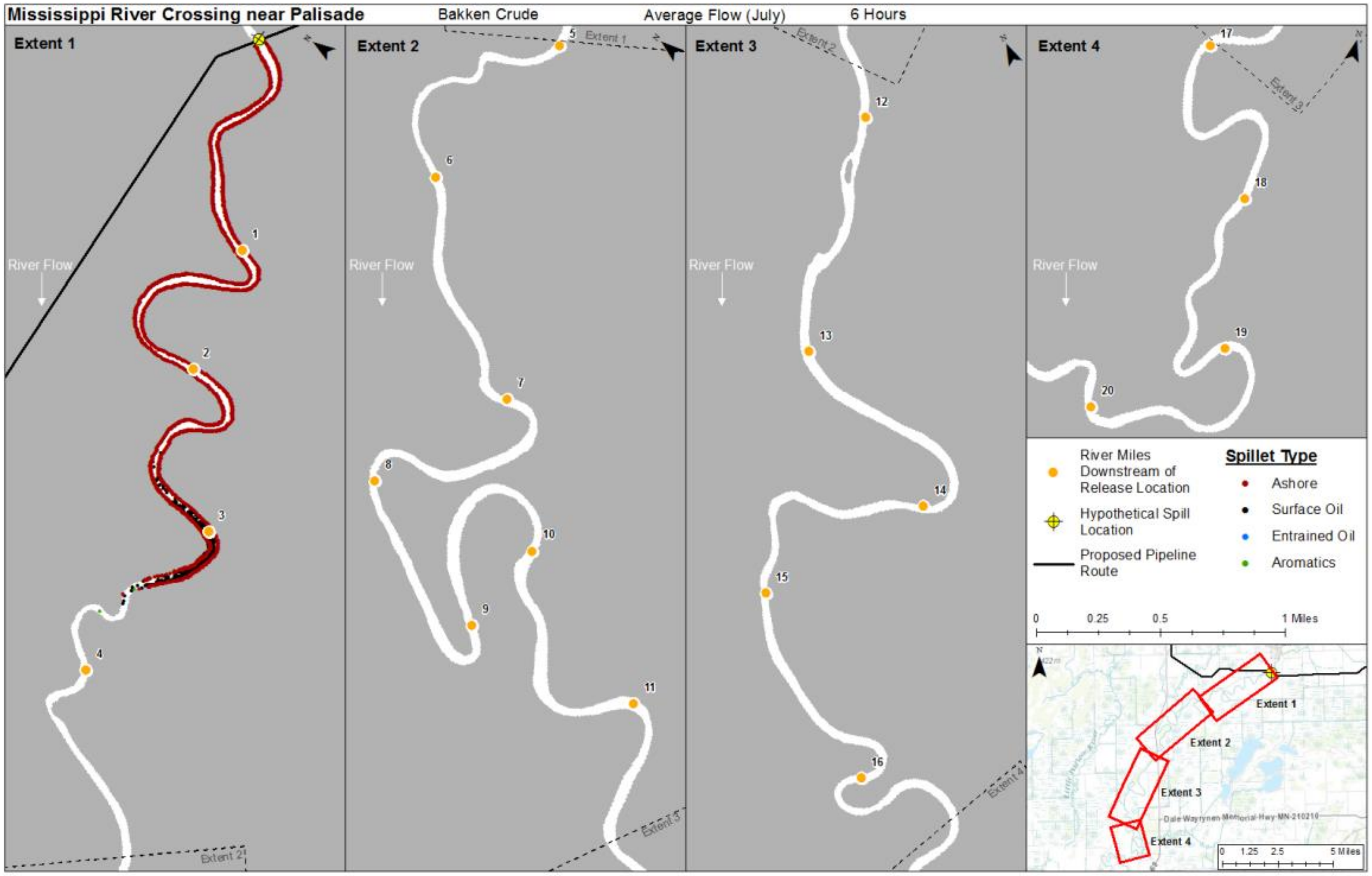

Figure 6-44 Oil Trajectory at 6 Hours for the Release of Bakken Crude at the Mississippi River at Palisade Release Location During the Average Flow (Summer-Fall) Season

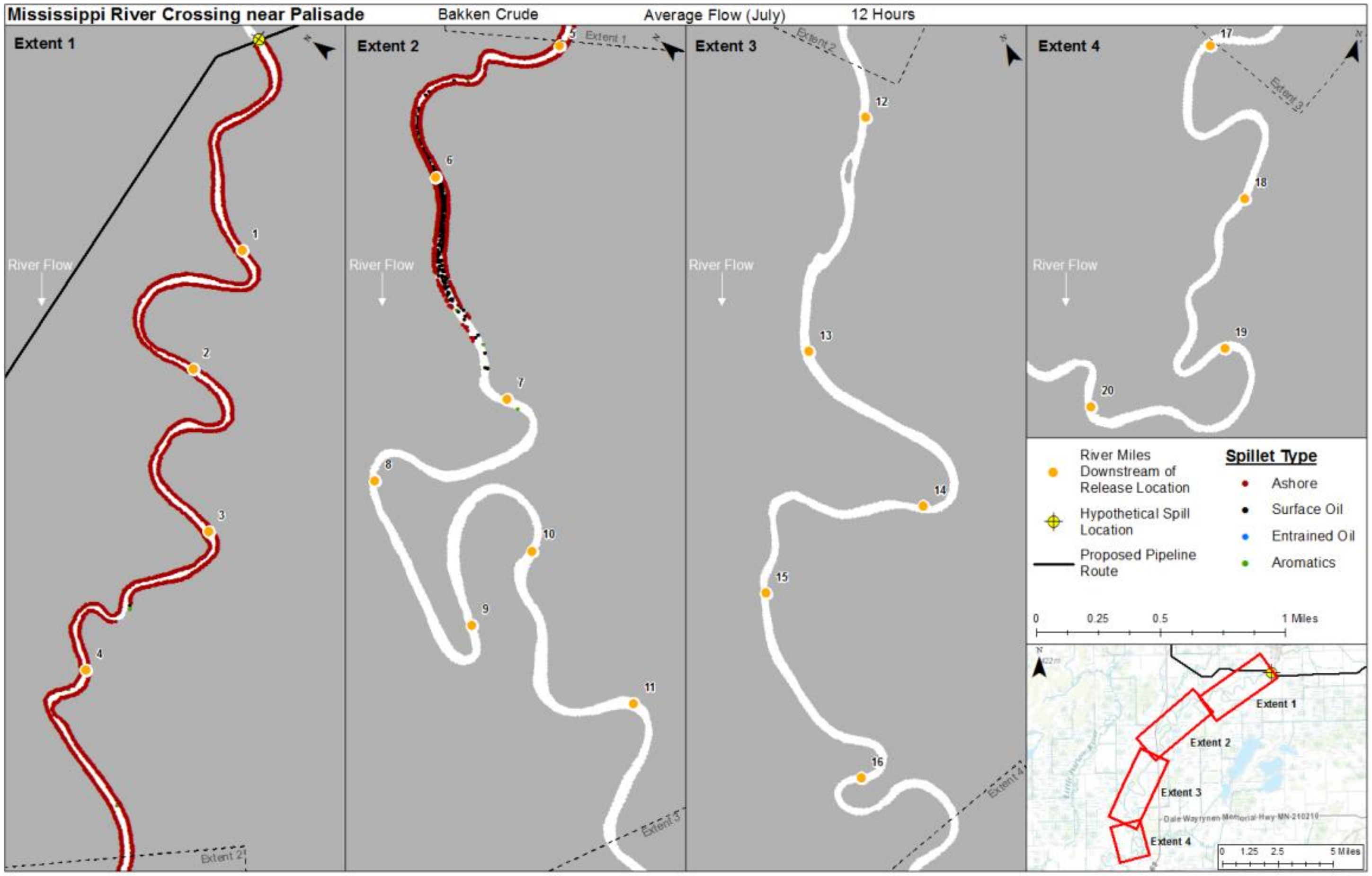

Figure 6-45 Oil Trajectory at 12 Hours for the Release of Bakken Crude at the Mississippi River at Palisade Release Location During the Average Flow (Summer-Fall) Season

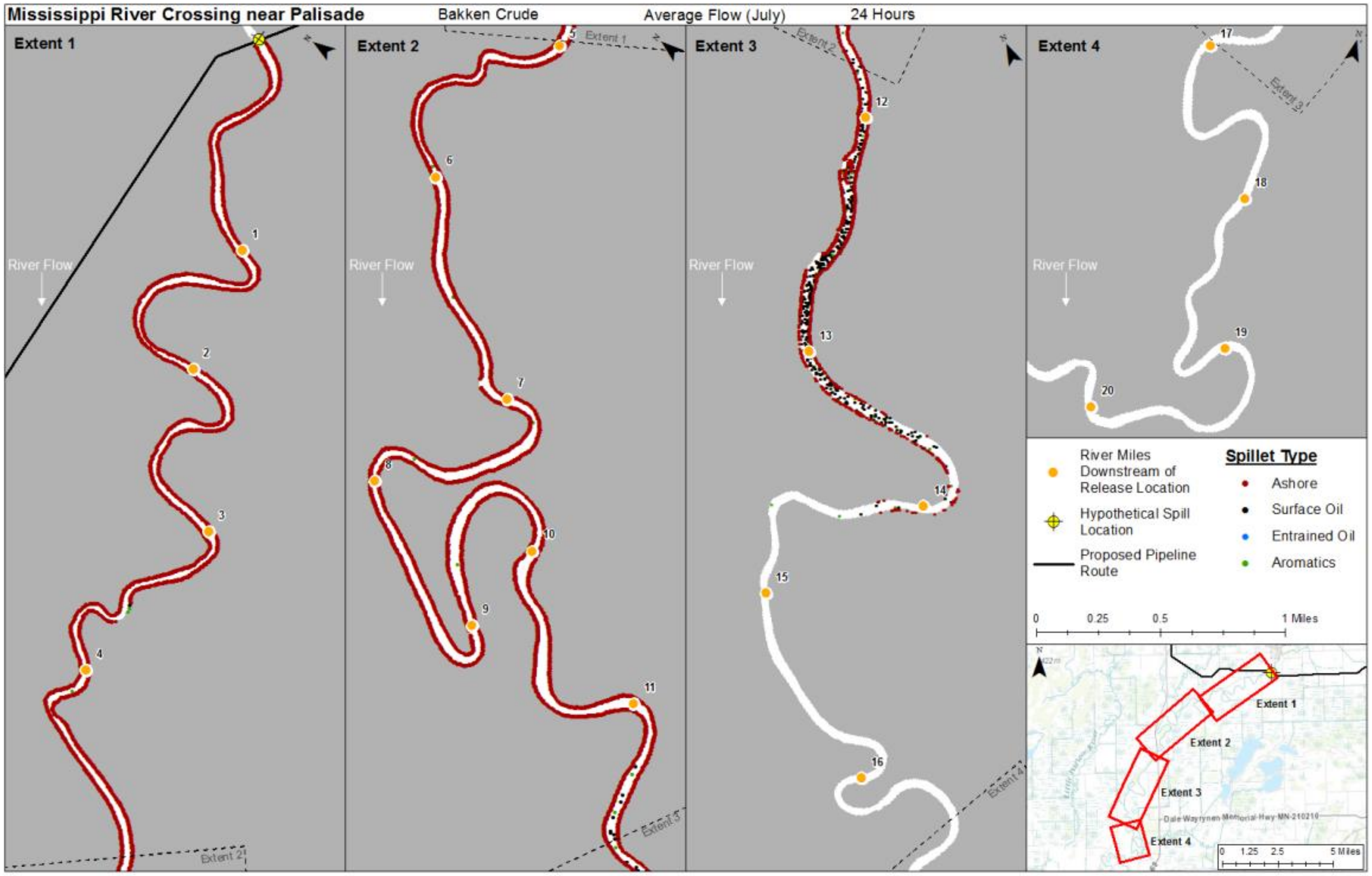

Figure 6-46 Oil Trajectory at 24 Hours for the Release of Bakken Crude at the Mississippi River at Palisade Release Location During the Average Flow (Summer-Fall) Season

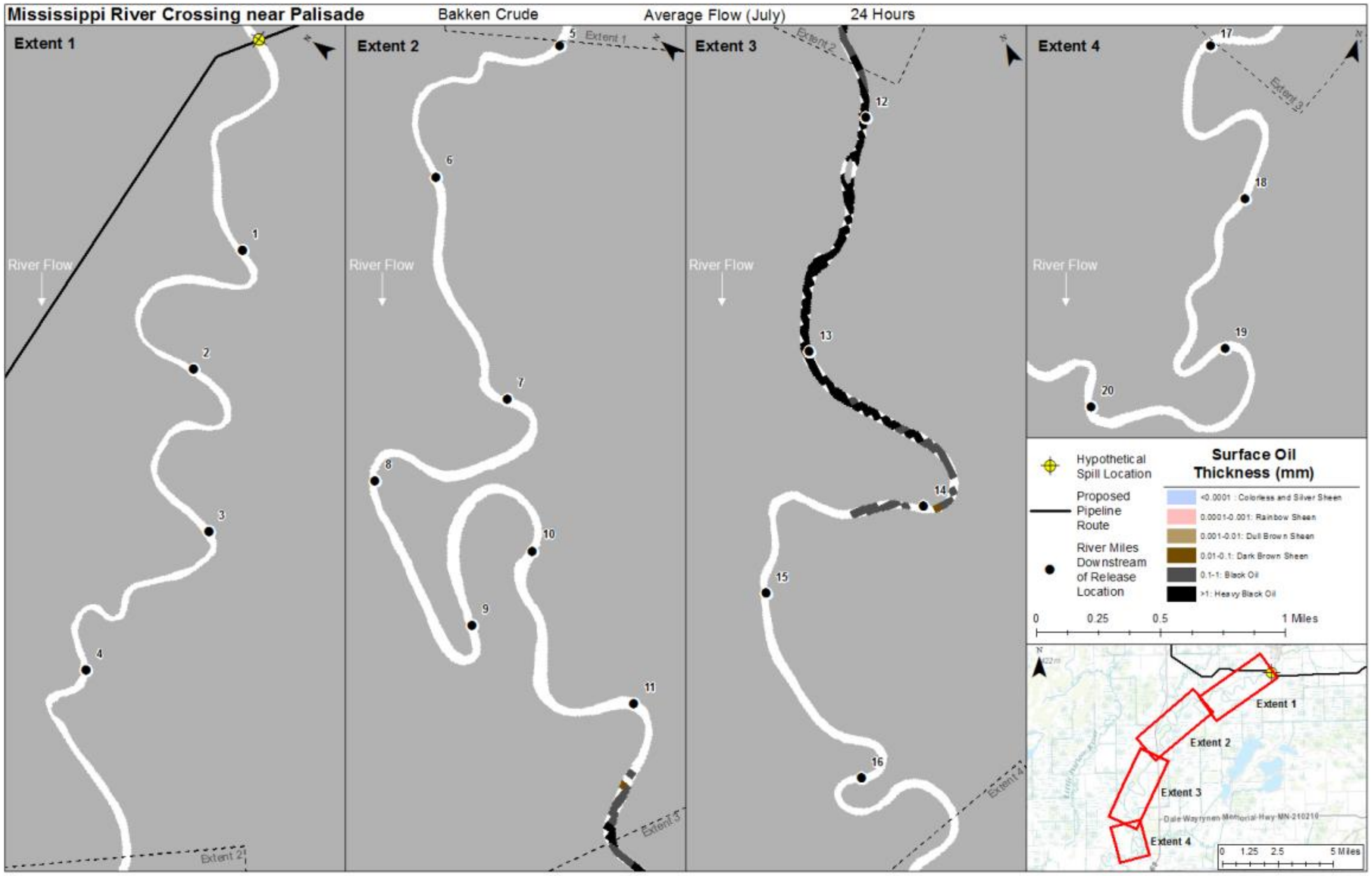

Figure 6-47 Maximum Floating Surface Oil at 24 Hours for the Release of Bakken Crude at the Mississippi River at Palisade release Location During the Average Flow (Summer-Fall) Season

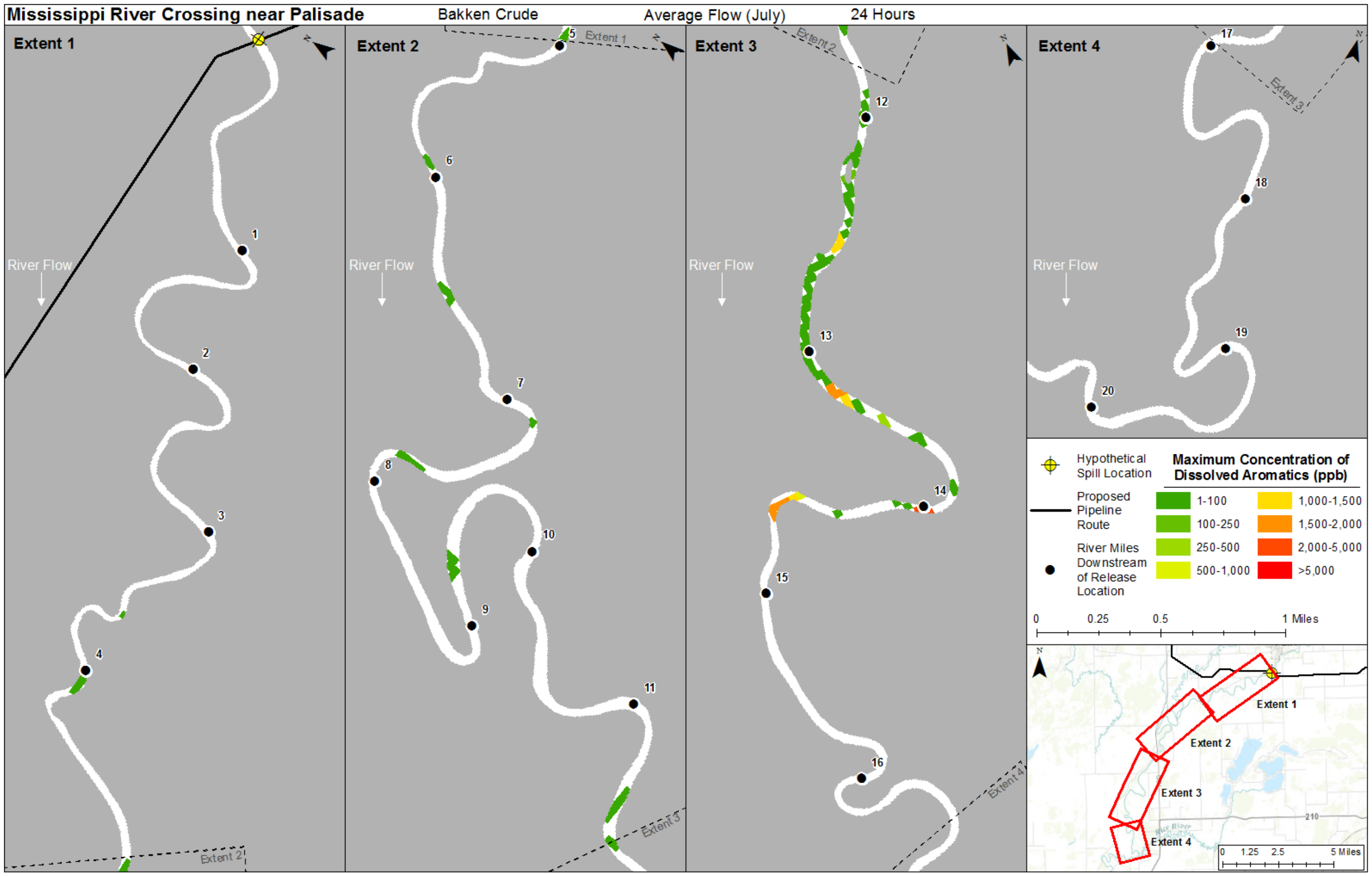

Figure 6-48 Maximum Total Dissolved Aromatic Concentration at 24 Hours for the Release of Bakken Crude at the Mississippi River at Palisade Release Location During the Average Flow (Summer-Fall) Season

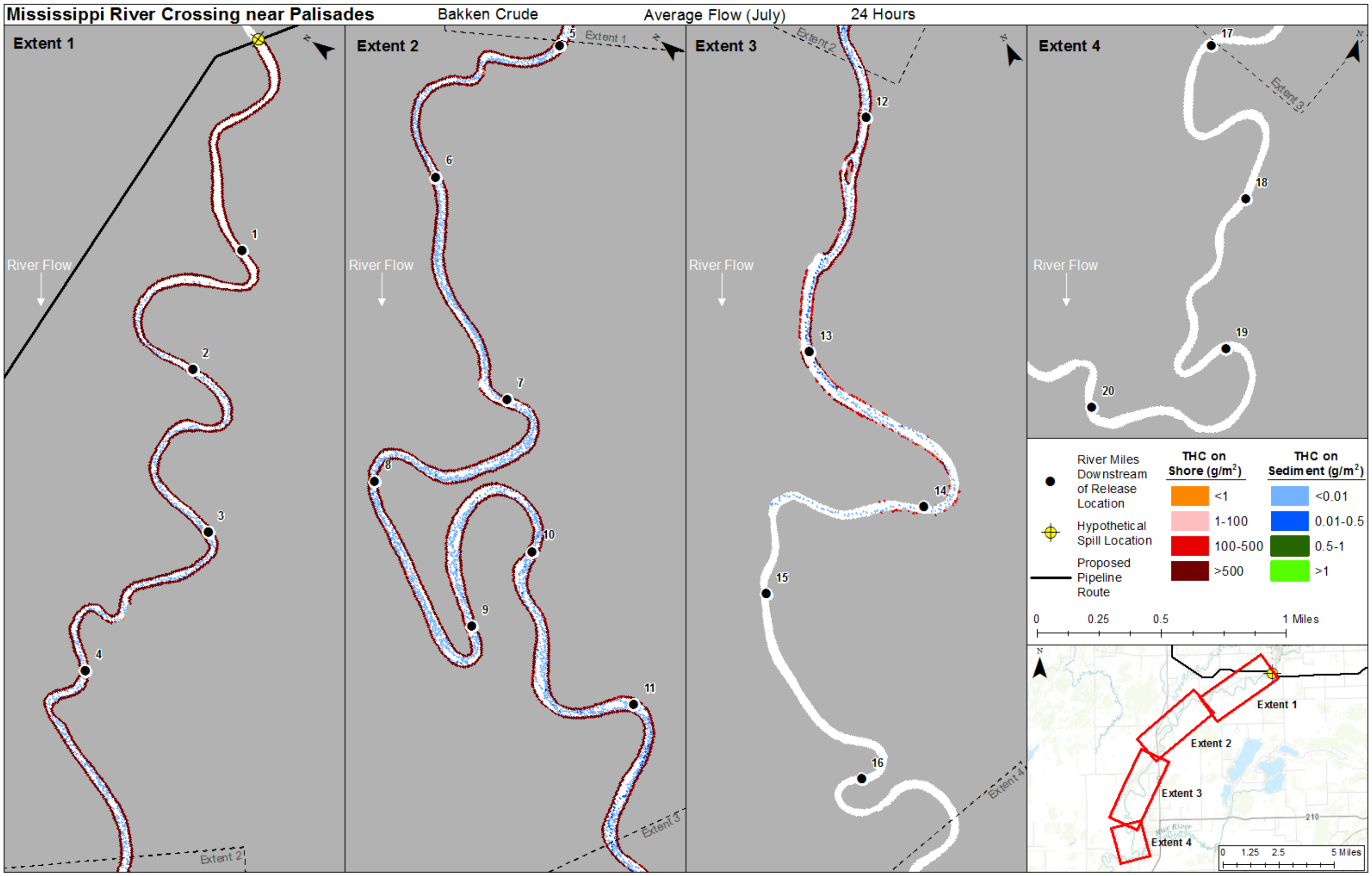

Figure 6-49 Maximum Total Hydrocarbon Mass on the Shore and on Sediments at 24 Hours for the Release of Bakken Crude at the Mississippi River at Palisade Release Location During the Average Flow (Summer-Fall) Season

6.2.1.2.3 Trajectory and Fate Results for Low Flow (Winter)

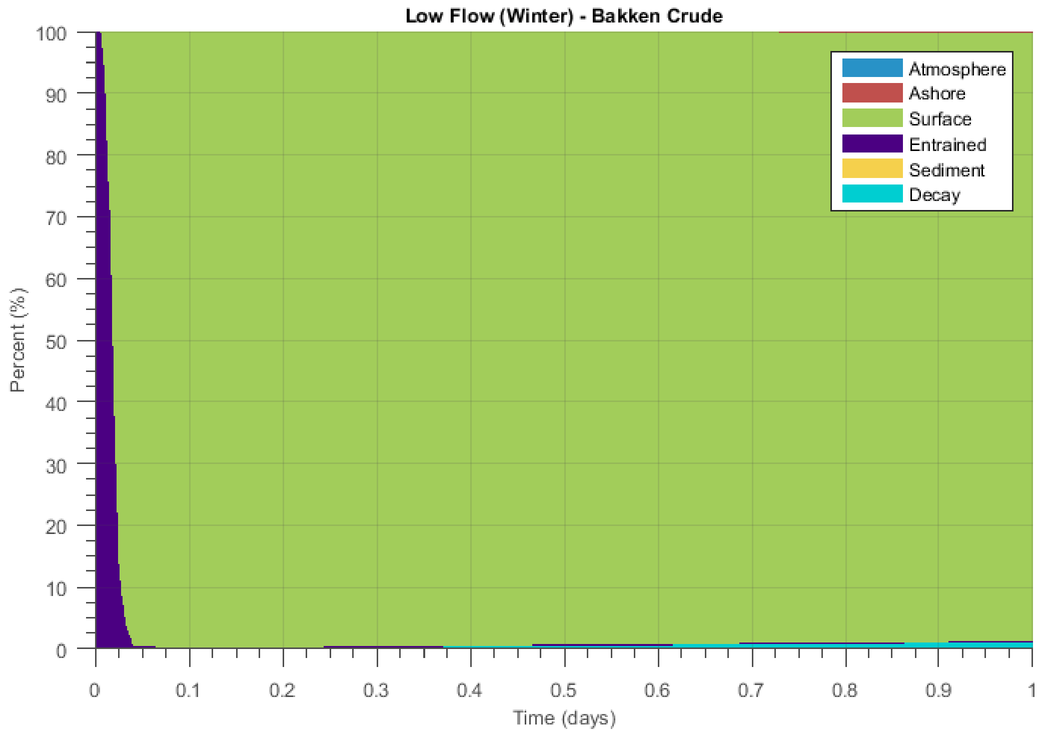

Figure 6-50 Oil Mass Balance Graph for the Release of Bakken Crude at the Mississippi River at Palisade Release Location During the Low Flow (Winter) Season

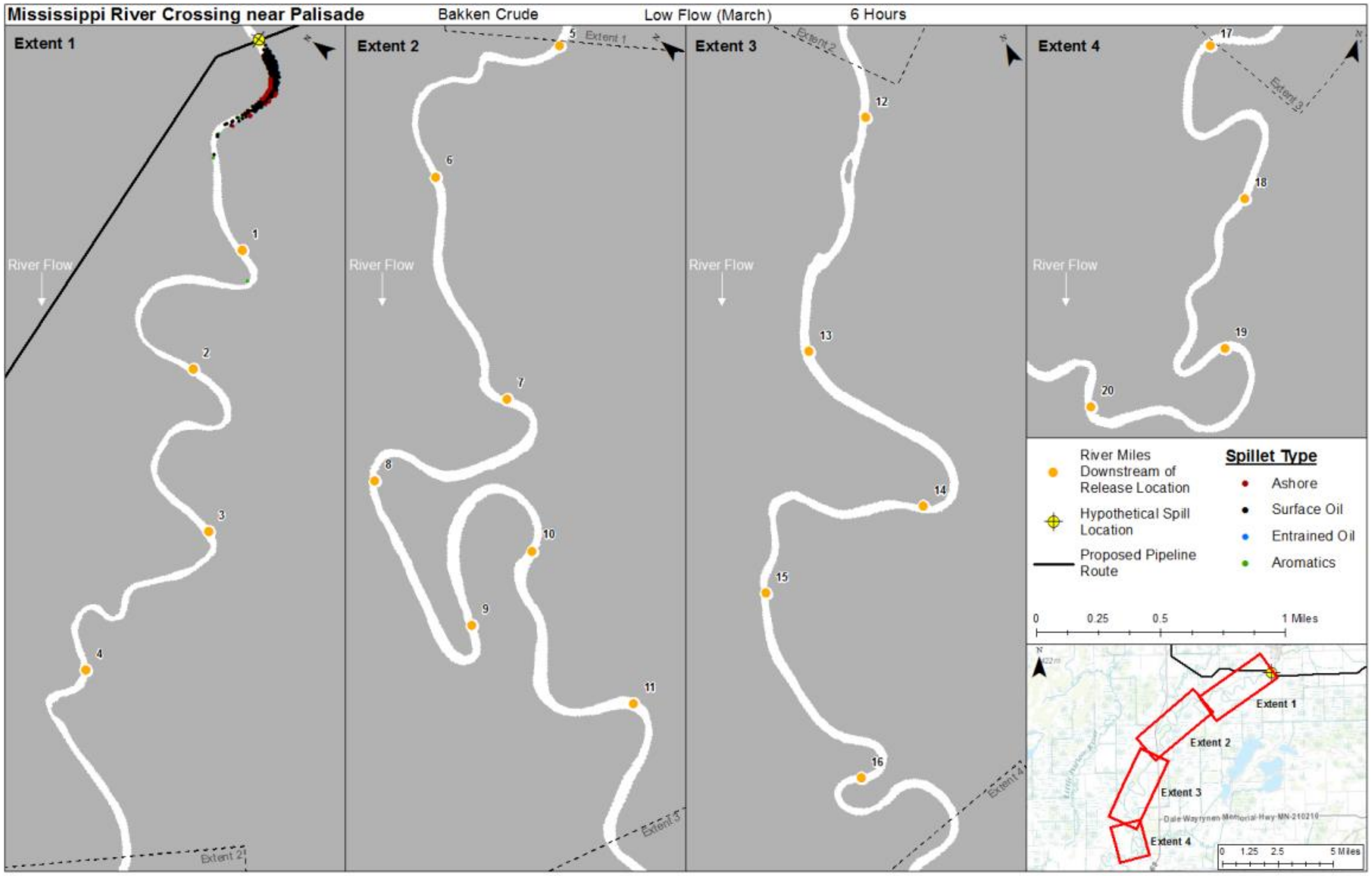

Figure 6-51 Oil Trajectory at 6 Hours for the Release of Bakken Crude at the Mississippi River at Palisade Release Location During the Low Flow (Winter) Season

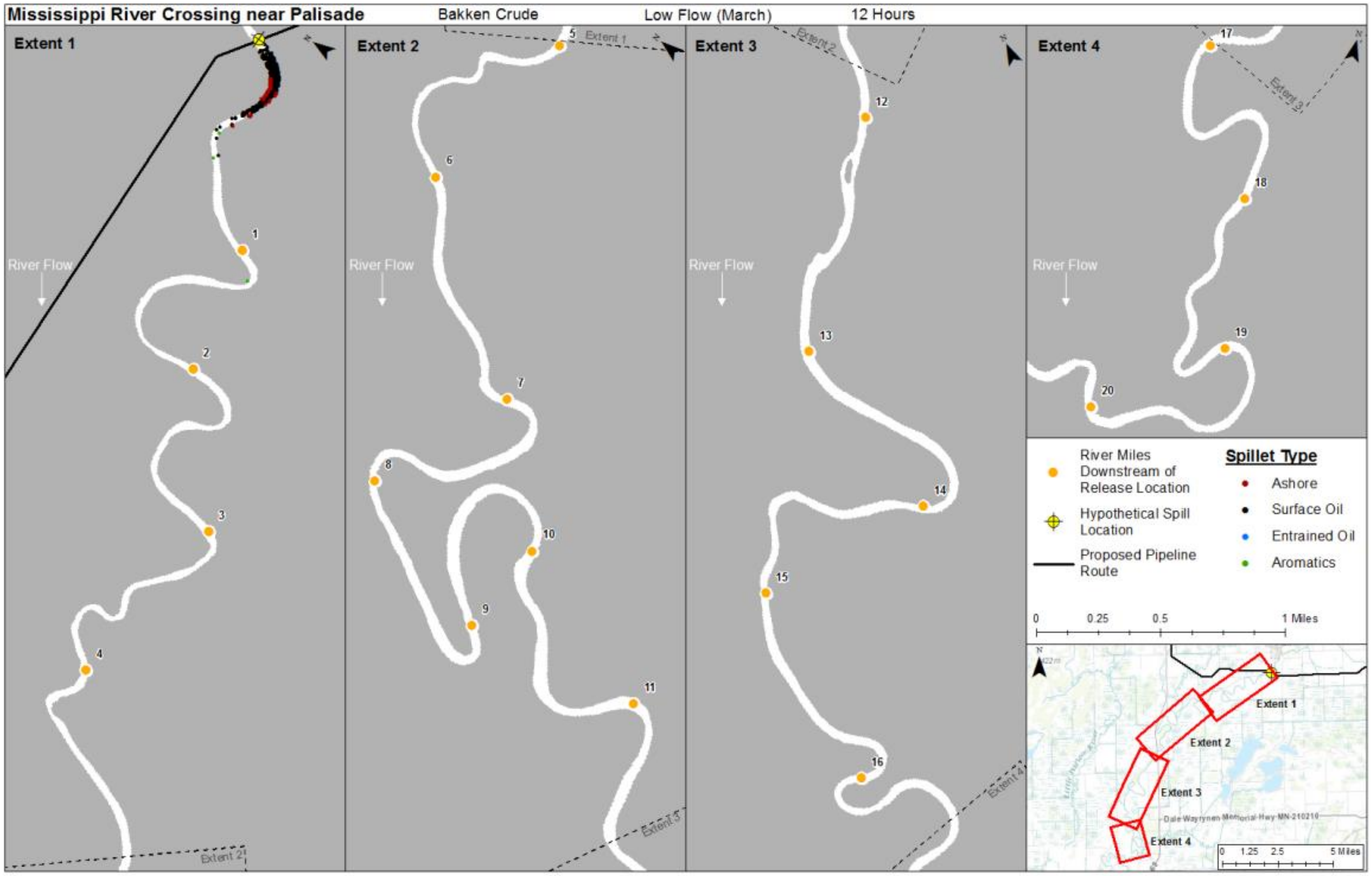

Figure 6-52 Oil Trajectory at 12 Hours for the Release of Bakken Crude at the Mississippi River at Palisade Release Location During the Low Flow (Winter) Season

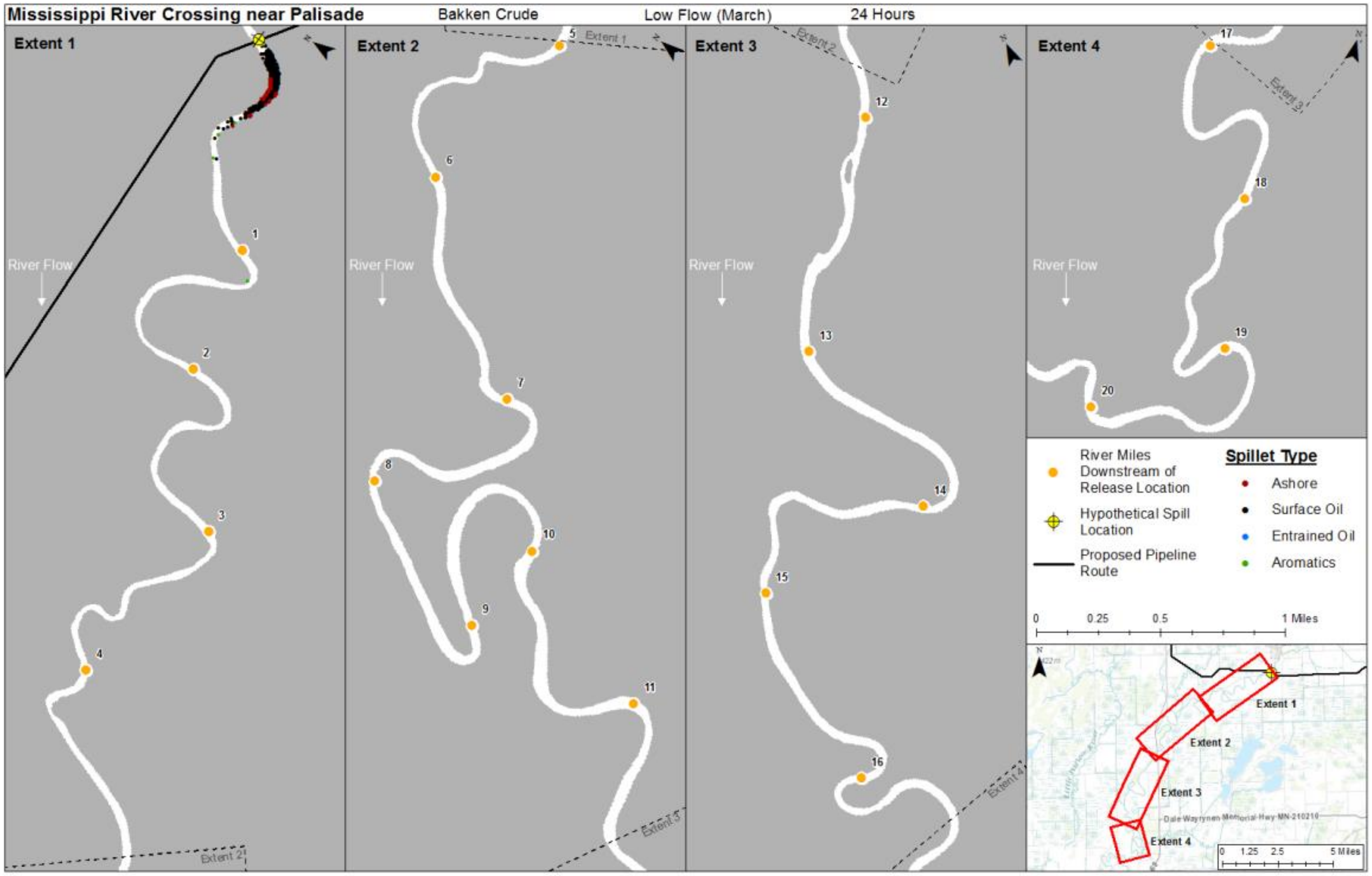

Figure 6-53 Oil Trajectory at 24 Hours for the Release of Bakken Crude at the Mississippi River at Palisade Release Location During the Low Flow (Winter) Season

Figure 6-54 Maximum Floating Surface Oil at 24 Hours for the Release of Bakken Crude at the Mississippi River at Palisade Release Location During the Low Flow (Winter) Season

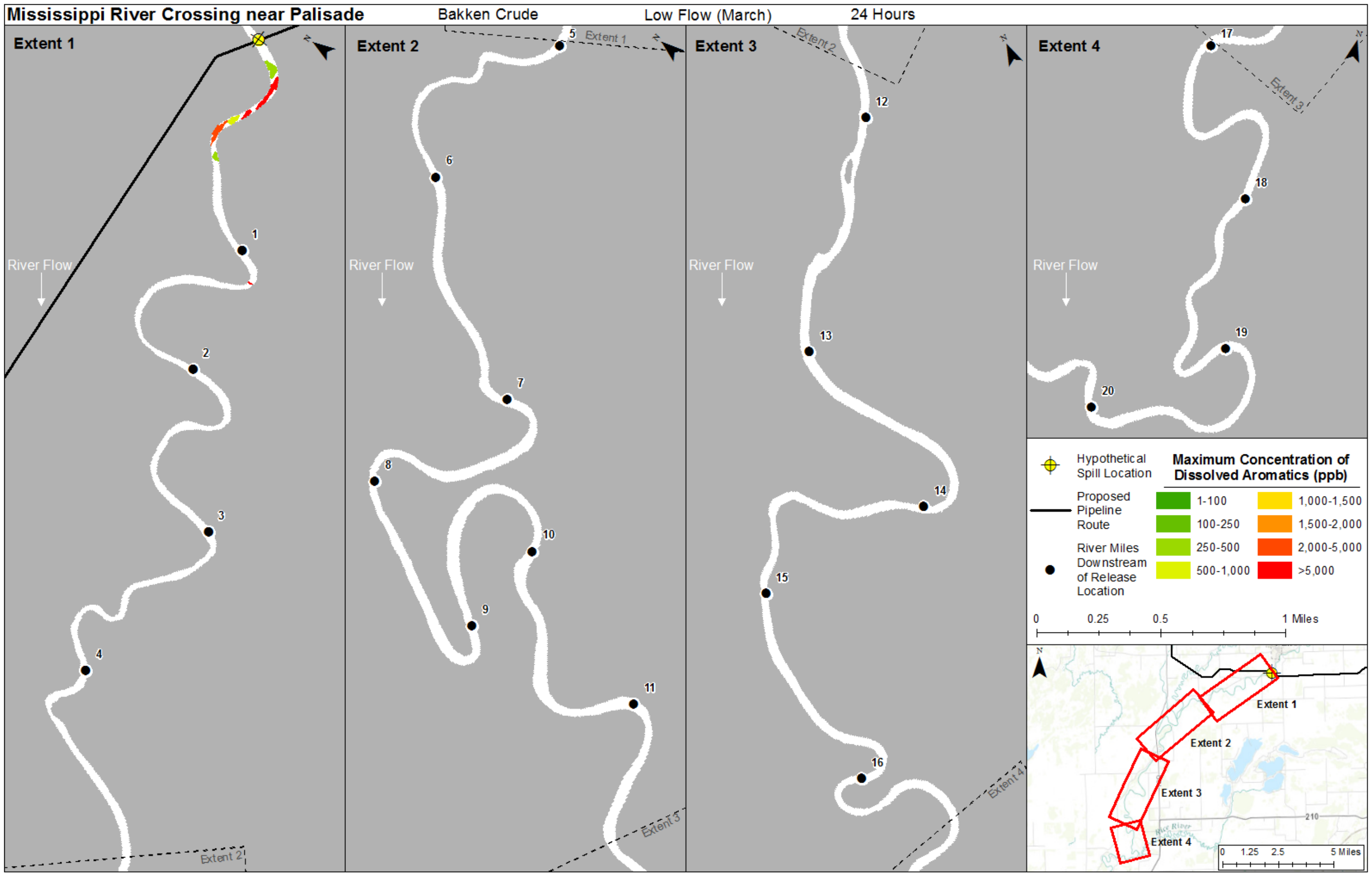

Figure 6-55 Maximum Total Dissolved Aromatic Concentration at 24 Hours for the Release of Bakken Crude at the Mississippi River at Palisade Release Location During the Average Flow (Summer-Fall) Season

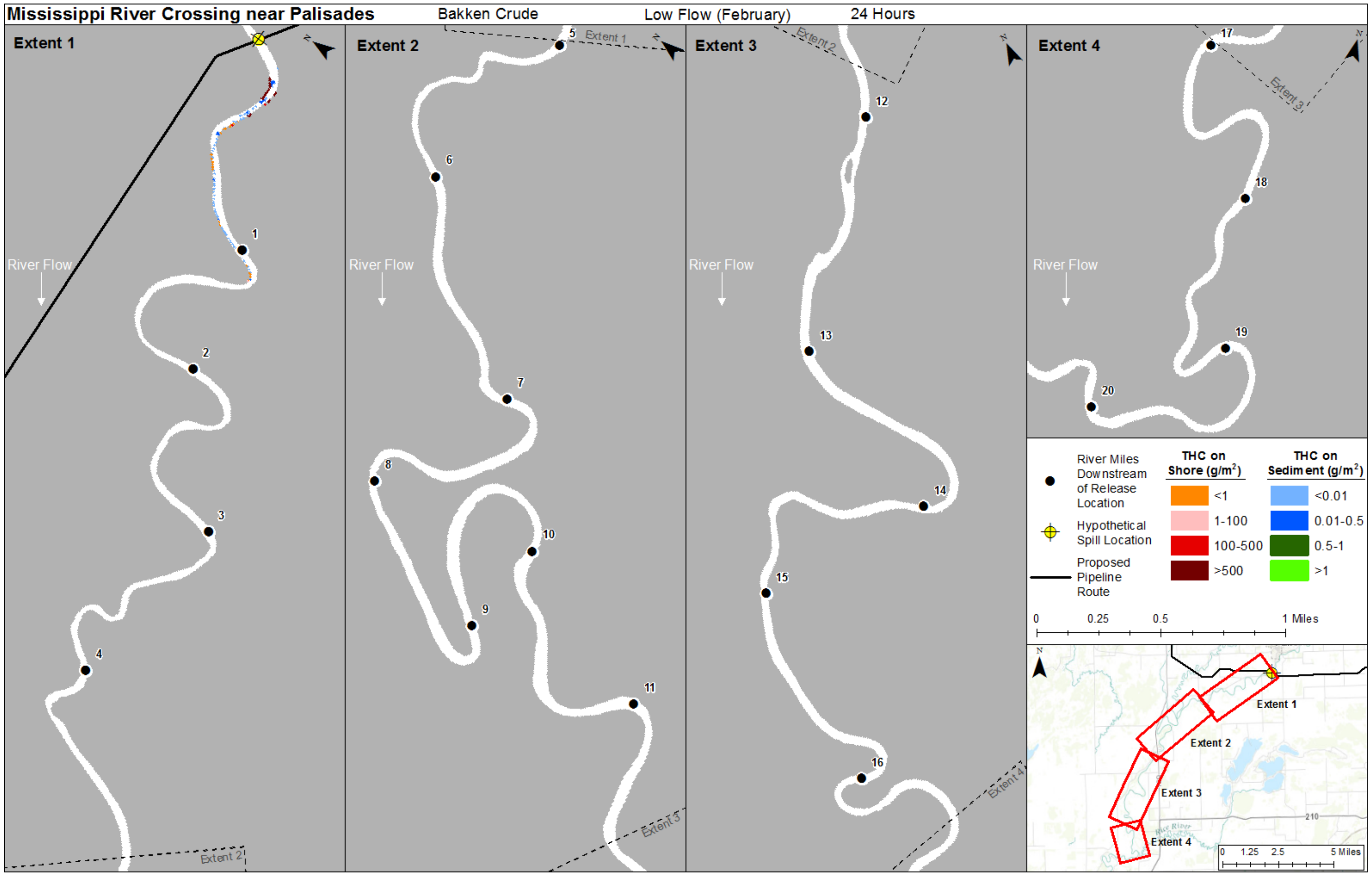

Figure 6-56 Maximum Total Hydrocarbon Mass on the Shore and on Sediments at 24 Hours for the Release of Bakken Crude at the Mississippi River at Palisade Release Location During the Average Flow (Summer-Fall) Season

6.2.2 Unmitigated Hypothetical Release Case 7—Mississippi River at Little Falls

The pipeline route crosses the Mississippi River approximately 4.89 miles (7.87 km) to the north of Little Falls, Minnesota, at Island Forty Eight. At this location the river is much larger, with a width of approximately 820 ft (250 m), as it travels through a relatively straight channel to the south. There are a number of wooded islands in this portion of the Mississippi River that range in size from a few hundred feet (100 m) to half a mile (0.8 km). Rather than being sinuous and marshy, like previously modeled reaches, this wide channel is lined with forested banks, passing through agricultural lands and by larger cities such as Little Falls and St. Cloud. Approximately 5.2 miles downstream of the hypothetical release location, the Mississippi River passes over the Little Falls Dam, a hydroelectric dam that is approximately 24 ft (7.3 m) tall. This concrete dam has a number of chutes or spillways that can create a tremendous amount of turbulence as water passes over top. Another 10 miles downstream, the Blanchard Dam may be found to the east of Great River Road (Rt. 24), west of Rt. 305, and at the Soo Line All-Terrain Vehicle Trail. This concrete dam is the tallest dam on the Mississippi at 46 ft (14.0 m) tall and is another hydroelectric station. The large amounts of turbulence at the dams and at the rapids downstream were modeled. Expected environmental and flow conditions used in modeling for the Mississippi River at Palisades are provided in Figures 5-41 to 5-43, and Tables 5-13 and 5-14.

6.2.2.1 Cold Lake Blend Scenarios

The Mississippi River at Little Falls scenarios represent a high energy environment with several waterfalls for the SIMAP analysis. Hypothetical releases of Cold Lake under high flow conditions resulted in oil that was transported downstream 10, 17, and 30 miles (16.1, 27.4, and 48.2 km) after 6, 12, and 24 hours, respectively (Figure 6-59, Figure 6-60, and Figure 6-61). Under average river flow conditions, the release had a maximum extent of approximately 30 miles (48.3 km) after 24 hours (Figure 6-69). During low river flows, the majority of the release was trapped at the ice-water interface within 4.0 miles (6.4 km) of the hypothetical release point, while the maximal extent of oil was approximately 5.5 miles (8.9 km) (Figure 6-76). Table 6-4 provides a summary of the mass balance information at the end of the 24-hour simulations, while Figure 6-57 provides the furthest predicted downstream extent of whole oil.

Table 6-4 Summary of the CLB (CLSB or CLWB) Mass Balance Information for the Mississippi River at Little Falls Release Location at the End of the 24-Hour Simulation [1]

Scenario	Surface (%)	Evaporated (%)	Water Column (%)	Sediment (%)	Ashore (%)	Decayed (%)
CLSB—High Flow (Spring)	37.9	19.1	4.2	0.5	37.5	0.8
CLSB—Average Flow (Summer-Fall)	31.1	20.7	2.8	0.3	44.2	0.8
CLWB—Low Flow	97.0	1.0	0.6	0.3	0.2	1.0

Table 6-4 Summary of the CLB (CLSB or CLWB) Mass Balance Information for the Mississippi River at Little Falls Release Location at the End of the 24-Hour Simulation [1]

Scenario	Surface (%)	Evaporated (%)	Water Column (%)	Sediment (%)	Ashore (%)	Decayed (%)
(Winter)						

NOTE:
[1] All values represent a percent of the total spilled oil

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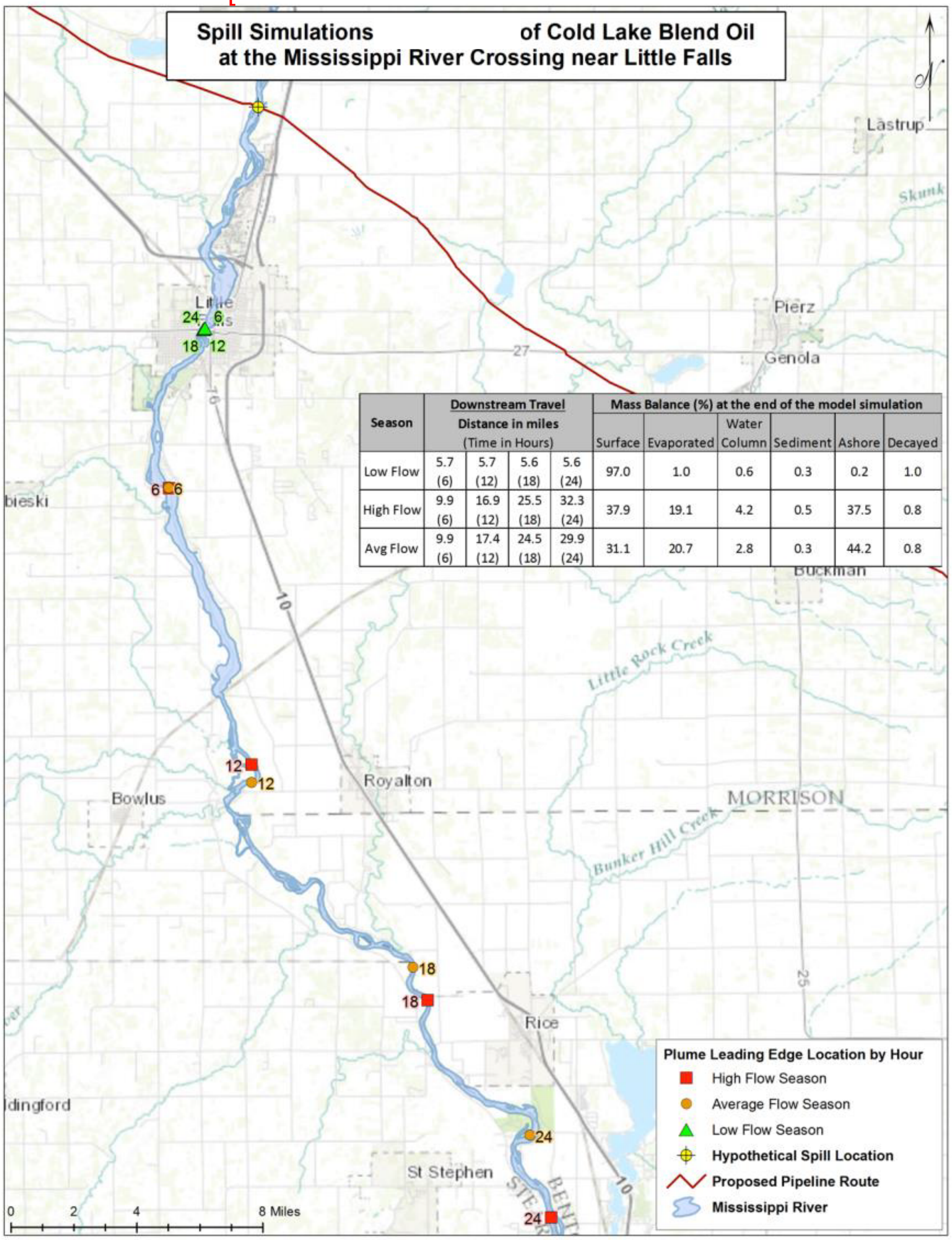

Season	Downstream Travel Distance in miles (Time in Hours)				Mass Balance (%) at the end of the model simulation					
					Surface	Evaporated	Water Column	Sediment	Ashore	Decayed
Low Flow	5.7 (6)	5.7 (12)	5.6 (18)	5.6 (24)	97.0	1.0	0.6	0.3	0.2	1.0
High Flow	9.9 (6)	16.9 (12)	25.5 (18)	32.3 (24)	37.9	19.1	4.2	0.5	37.5	0.8
Avg Flow	9.9 (6)	17.4 (12)	24.5 (18)	29.9 (24)	31.1	20.7	2.8	0.3	44.2	0.8

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Figure 6-57 Predicted Downstream Transport of CLB Oil at the Mississippi River at Little Falls Release Location

During high and average river flow conditions, the relatively calm waters upstream and downstream of the Little Falls Dam and Blanchard Dam resulted in large amounts of floating oil, which formed thick surface slicks over much of the river (Figure 6-62 and Figure 6-70). Surface slicks for the Mississippi River at Little Falls were in general, thinner and more extensive than those of the Mississippi River at Palisade. This was the result of more rapid and turbulent river flow at Little Falls. At the end of the 24-hour simulation, floating oil thicknesses between 0.1-1 mm (heavy black oil) remained on the water surface, with localized areas exceeding 1 mm. There was no floating surface oil less than 0.01 mm thick (dark brown sheen). The presence of extensive surface slicks resulted in significant evaporation, with approximately 20% of the total release ending up in the atmosphere (Table 6-4).

Extensive shoreline oiling was observed for approximately 29 miles (46.7 km) of the river below the release location under high river flow conditions (Figure 6-64) and average river flow conditions (Figure 6-72). The concentrations of CLB on the shore were primarily greater than 500 g/m^2, with some segments between 100 and 500 g/m^2.

Mass balance information for the high and average river flow conditions, depict two points of interest approximately 0.2 and 0.6 days (4.8 and 14.4 hours) into the average and high river flow releases (Figure 6-58 and Figure 6-66). Two "humps" or increases in the mass balance were identified representing a large amount entrained oil. These increases in entrained oil were observed, as the oil passed over the Little Falls Dam and then the Blanchard Dam, along with the associated rapids downstream (Figure 6-61 and Figure 6-69). Entrained oil droplets in the water column then rose to the surface over subsequent quiescent reaches of the river, where entrained oil rose back to the surface. A depiction of the dissolved aromatic concentration and total hydrocarbon concentration within the water column at the Little Falls Dam is presented at a time when a portion of the release was above and below the dam (Figure 6-65). Above the dam, note that there are no observed total hydrocarbon concentrations, the oil is floating on the water surface. A portion of this surface oil is dissolving into the surface water column (100 ppb), but is mainly evaporating. However, immediately downstream of the dam, the total hydrocarbon concentration increases (greater than 25 ppm) and dissolved aromatic concentration within the water column increases (100–1,000 ppb), as the whole oil droplets are now in the water column where the soluble portions dissolve into the water. The total hydrocarbon concentration decreases in the water column as distance downstream of the dam increases due to the buoyant rise of whole oil droplets to the surface in the relatively quiescent waters downstream.

When oil is mixed through the water column by turbulent mixing processes such as waterfalls at dams, there is a high potential for oil-SPM interactions with the possibility of "sinking oil." Substantial oiling of the sediment was observed in both the high and average river flow scenarios, with concentrations between 0.01–0.5 g/m^2 along approximately 24 and 30 miles (38.6 and 48.2 km) of river bottom below Little Falls Dam (Figure 6-64 and Figure 6-72). In patchy and localized portions of the Mississippi River downstream of the waterfalls, sediment concentrations are predicted to exceed 500 g/m^2. However, the majority of sediment oiling is much lower in concentration over the larger area with any amount of potential oil on the sediments. Between 0.3 and 0.5% of the CLB release is predicted to be found in the sediments under ice-free conditions. Higher sediment oiling is predicted under high river flow rates due to the increased turbulence and higher suspended sediment load within the water column. The lowest sediment concentrations and smallest areas with sediment oil were predicted for low flow conditions (Figure 6-78).

The maximum concentration of dissolved aromatics was greater than 5,000 ppb in small regions within the spill extent; however, most of the dissolved aromatic concentrations ranged between 25 and 150 ppb (Figure 6-63 and Figure 6-71). The enhanced dissolved aromatic concentrations were due to dissolution of the soluble portion of the CLWB into the water column. While this may be expected to cause higher concentrations (as observed in the Palisade case), it is important to consider that in the Little Falls scenarios, vertical mixing results in more uniform concentrations throughout the water column, as opposed to a localized or thin layer with elevated concentrations at the surface for the scenarios at Palisade.

For the low river flow scenario, the hydrocarbon trajectory at the end of the 24-hour simulation extended 4.0 miles (6.4 km) from the hypothetical release location, while the maximal extent of oil was approximately 5.5 miles (8.9 km) downstream (Figure 6-77). The downstream extent is further in this scenario than for those at Palisade due to the higher river velocity which transports oil more rapidly as it rises through the water column. In addition the water column is deeper at this release point, relative to Palisade. Finally, the CLWB has a higher density than the Bakken and therefore rises at a slower rate, being transported further downstream before sticking to the underside of the ice. Under low river flow conditions the 100% surface coverage of ice kept the entrained oil in the water column at the ice/water interface (97.0%) (Figure 6-73 and Figure 6-76). Patchy shoreline oiling along river banks was observed between miles 1 and 2 (1.6 and 3.2 km) downstream from the release point. However, the majority of the oil remained trapped under the ice (Table 6-4). Concentrations on the shore were predominantly 1–100 g/m^2, with some segments of the shoreline with values between 100–500 g/m^2 and others exceeding 500 g/m^2 (Figure 6-79).

The soluble portion of the CLWB would dissolve into the water column and be transported downstream, resulting in elevated dissolved aromatic concentrations within the water column (Figure 6-78). Dissolved aromatic components traveled downstream from the initial release location with maximum concentrations greater than 5,000 ppb in the region between 1–3 miles (1.6 to 4.8 km) of release location at hour 24.

At the end of the 24-hour simulation, floating oil under the ice had a thickness greater than 1 mm thick (heavy black oil) (Figure 6-77). There was no floating surface oil less than 0.01 mm thick (dark brown sheen). Small amounts of sediment oiling did extend down to approximately 8.5 miles (13.7 km) (Figure 6-79), although the total hydrocarbon concentrations on the sediment were generally less than 0.01 g/m^2 due to the small amount of SPM in the water column.

There was very little decay from any of the three hypothetical releases within the timeframe modeled (Table 6-4).

6.2.2.1.1 Trajectory and Fate Results for High Flow (Spring)

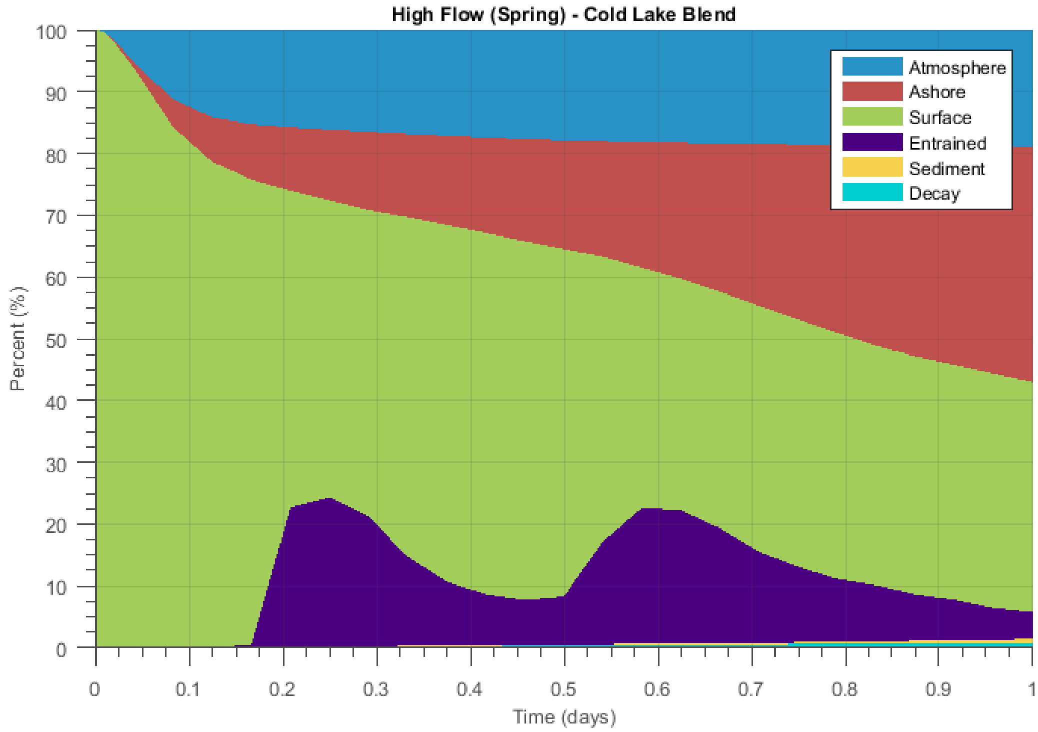

Figure 6-58 Oil Mass Balance Graph for the Release of CLB at the Mississippi River at Little Falls Release Location During the High Flow (Spring) Season

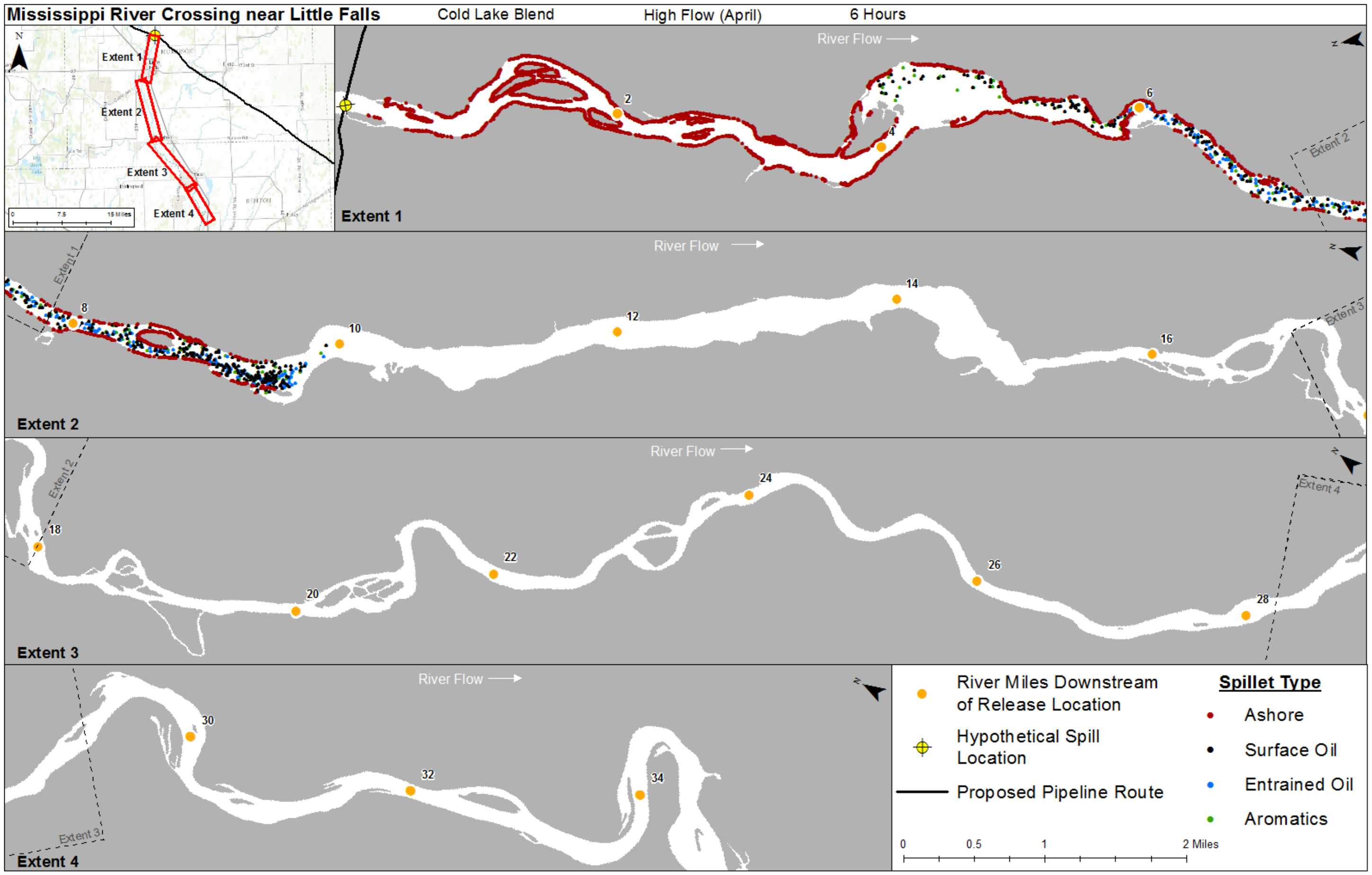

Figure 6-59 Oil Trajectory at 6 Hours for the Release of CLB at the Mississippi River at Little Falls Release Location During the High Flow (Spring) Season

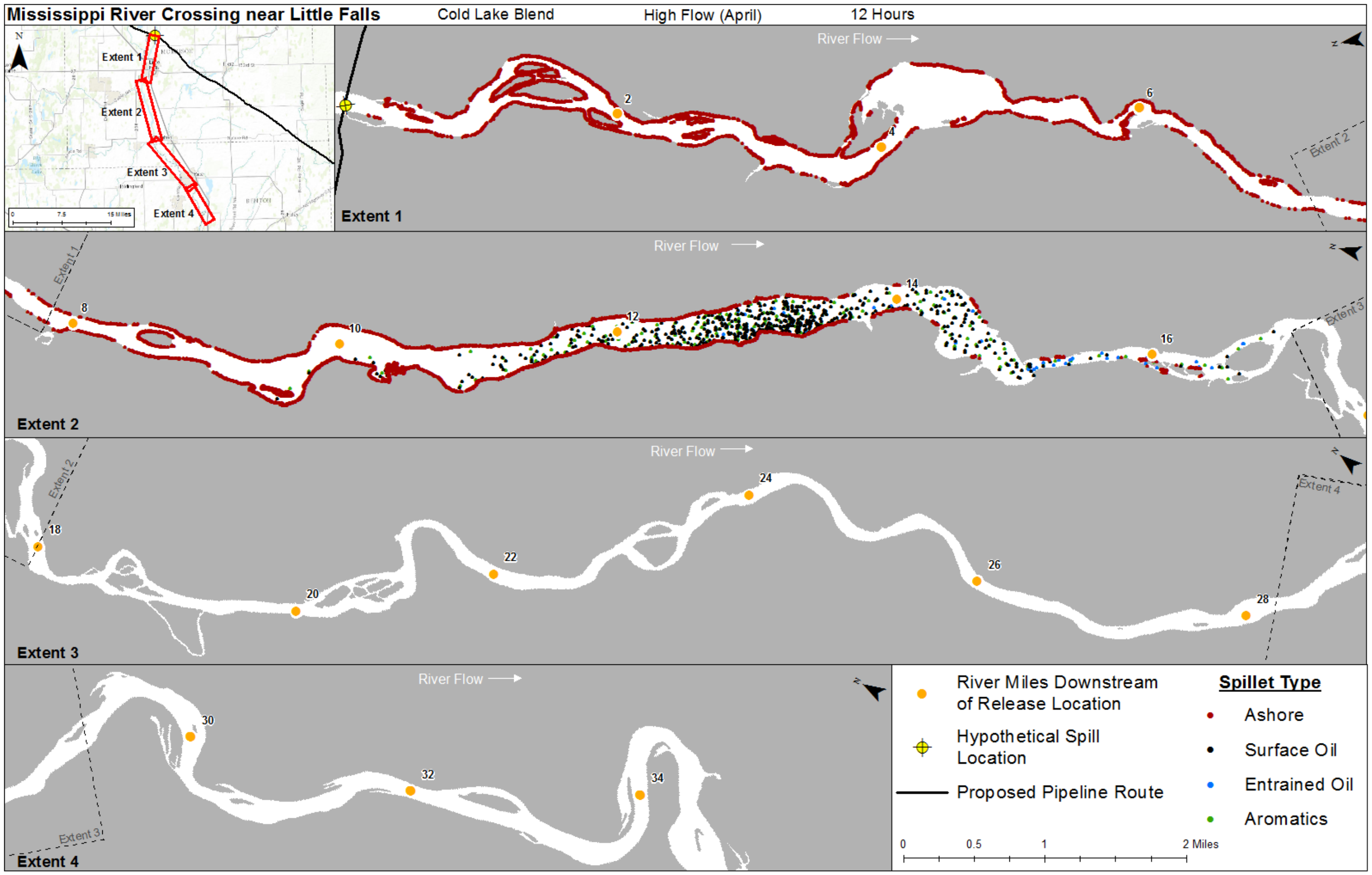

Figure 6-60 Oil Trajectory at 12 Hours for the Release of CLB at the Mississippi River at Little Falls Release Location During the High Flow (Spring) Season

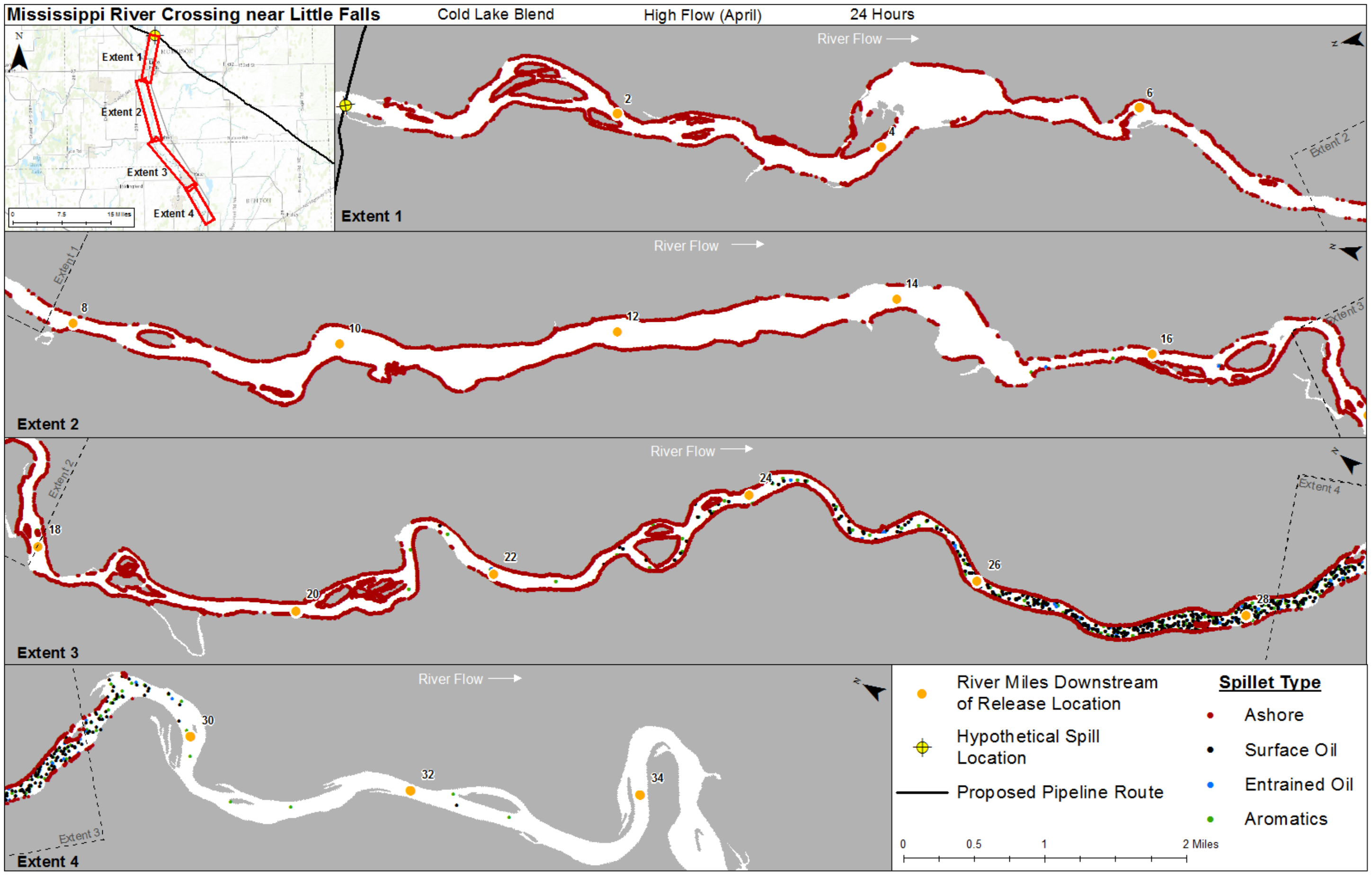

Figure 6-61 Oil Trajectory at 24 Hours for the Release of CLB at the Mississippi River at Little Falls Release Location During the High Flow (Spring) Season

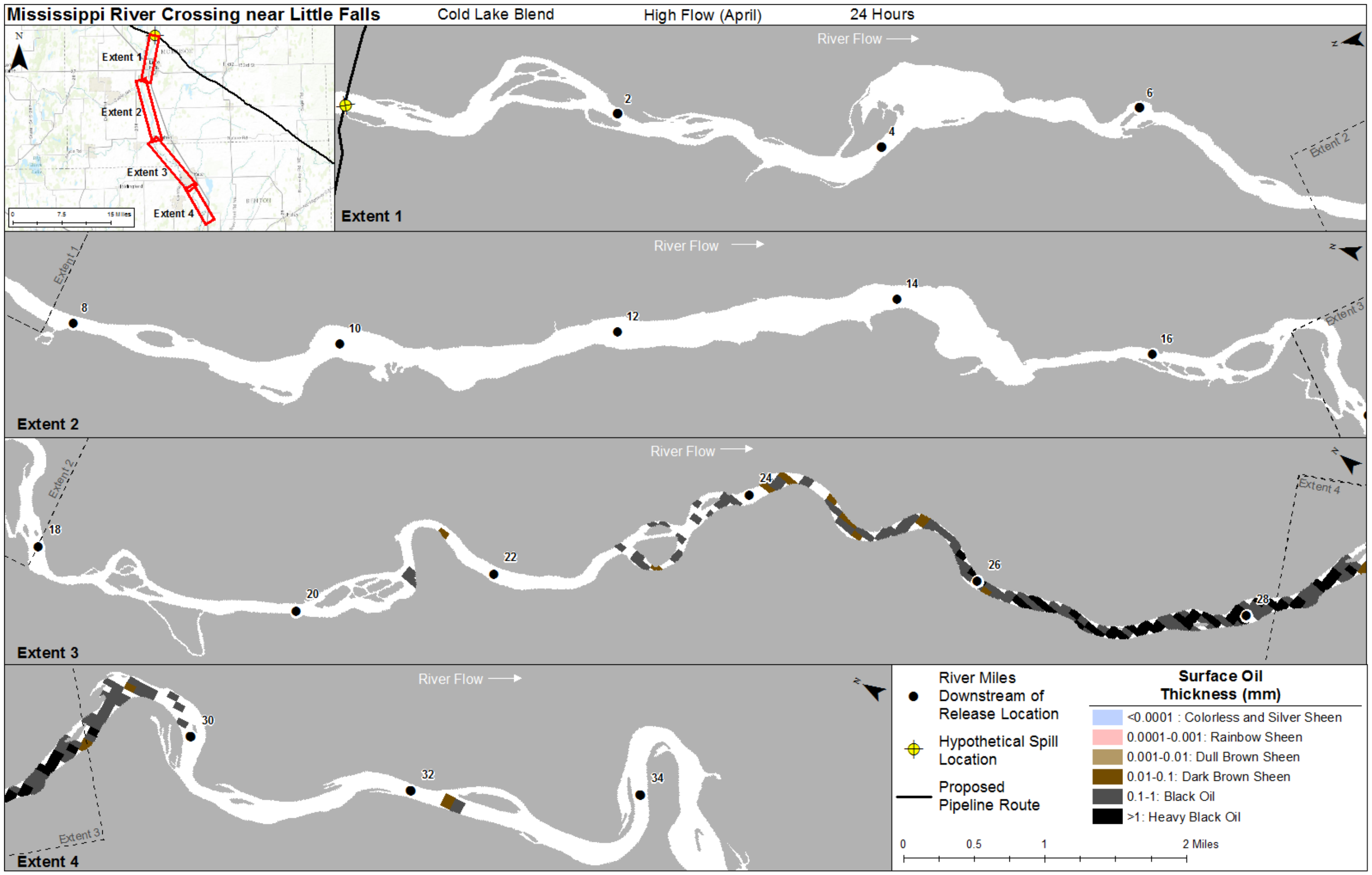

Figure 6-62 Maximum Floating Surface Oil at 24 Hours for the Release of CLB at the Mississippi River at Little Falls Release Location During the High Flow (Spring) Season

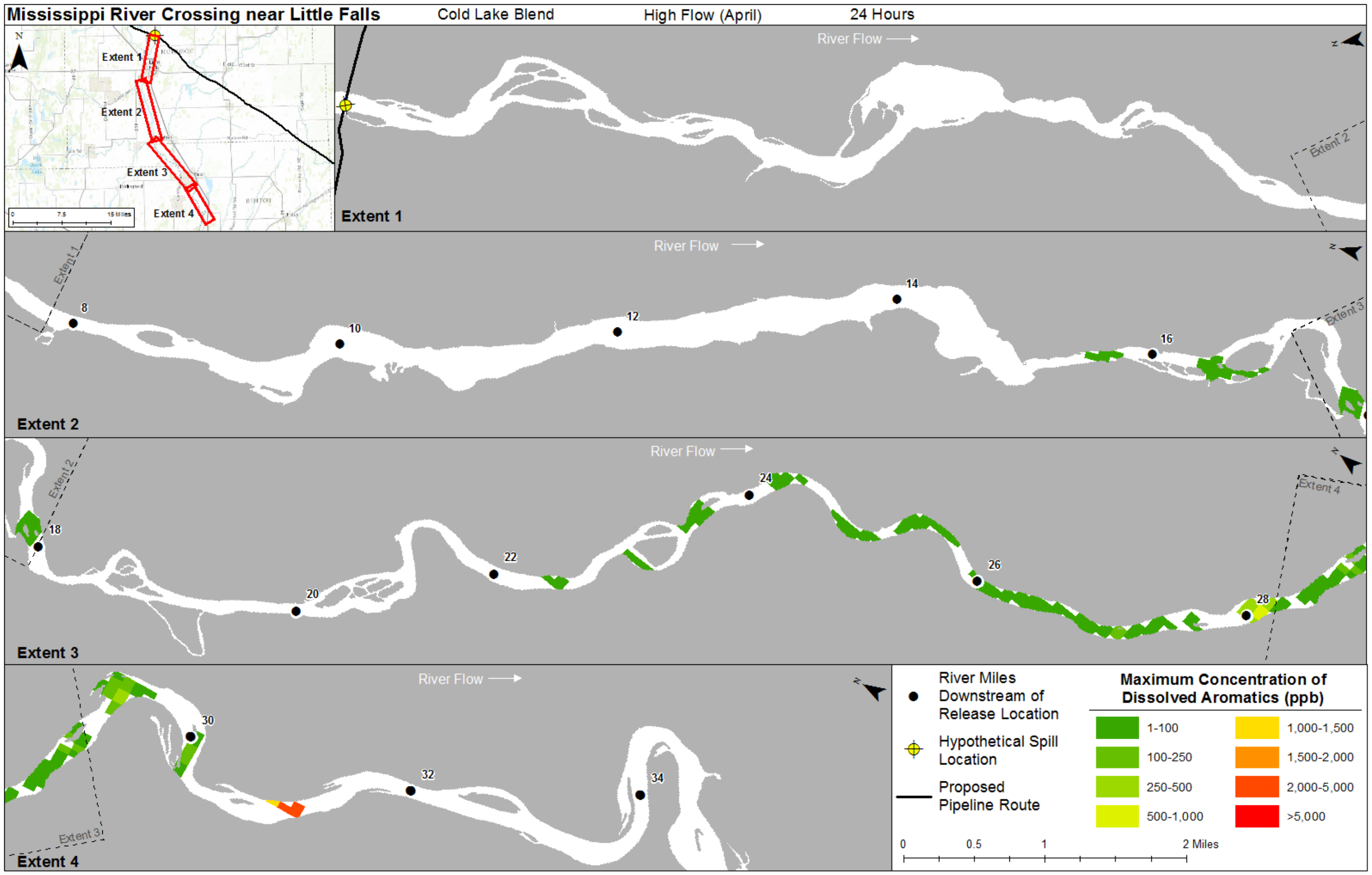

Figure 6-63 Maximum Total Hydrocarbon Mass on the Shore and on Sediments at 24 Hours for the Release of CLB at the Mississippi River at Little Falls Release Location During the High Flow (Spring) Season

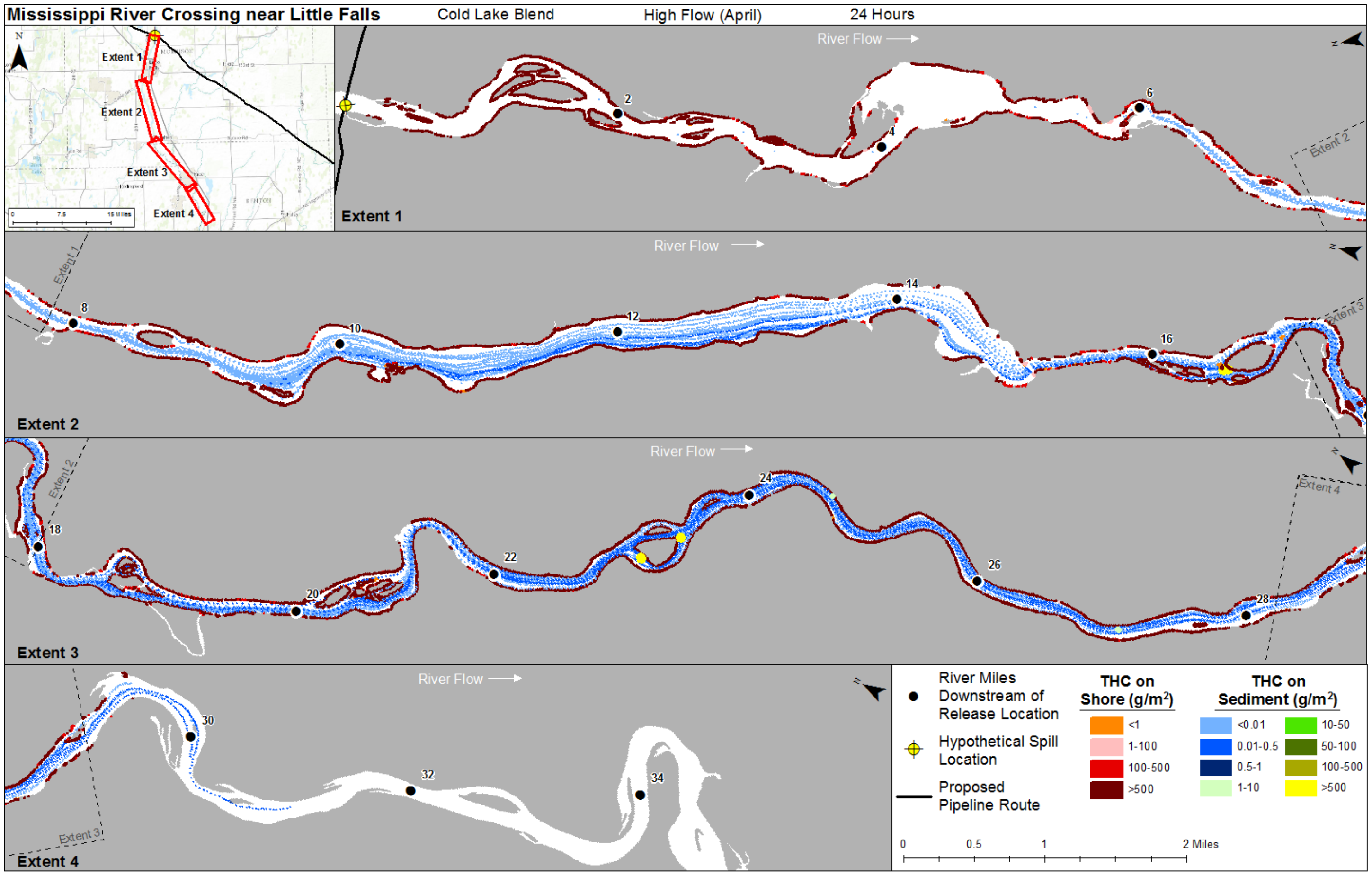

Figure 6-64 Maximum Total Hydrocarbon Mass on the Shore and on Sediments at 24 Hours for the Release of CLB at the Mississippi River at Little Falls Release Location During the High Flow (Spring) Season

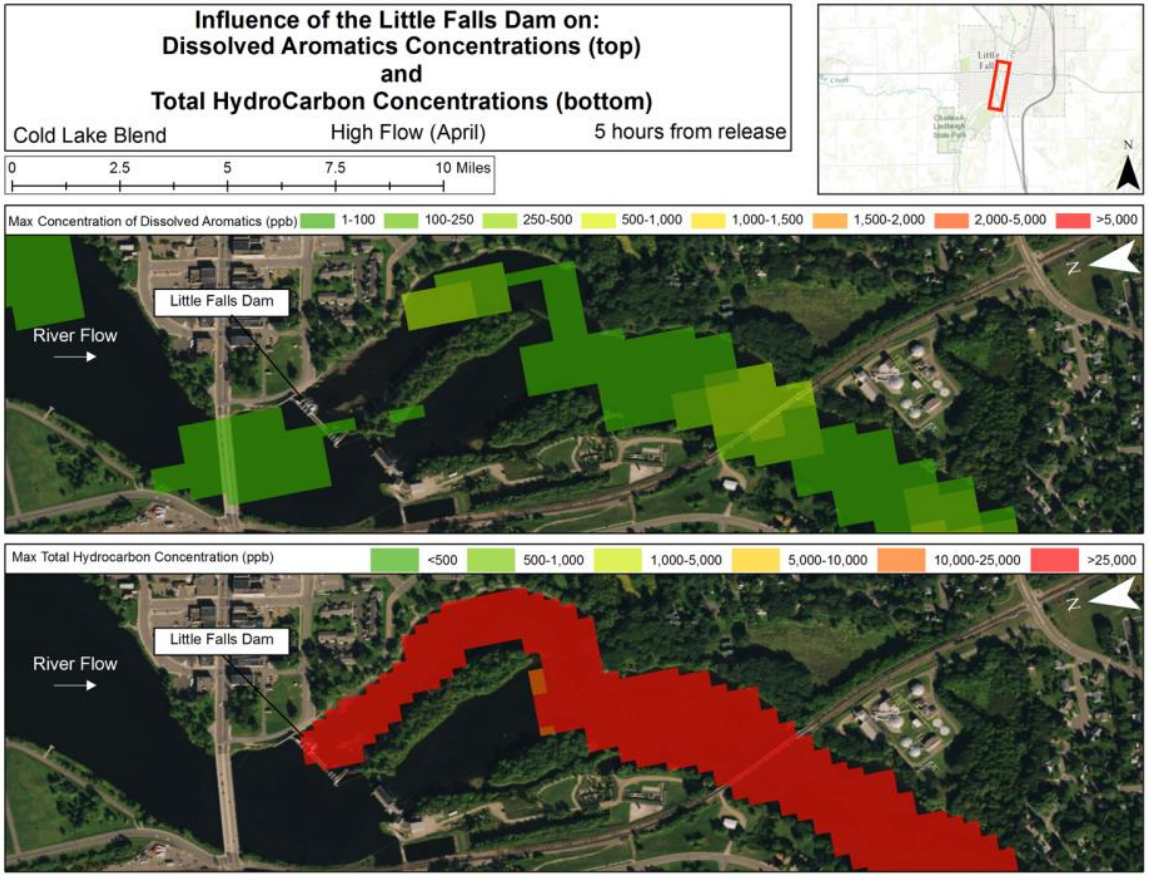

Figure 6-65 Maximum Total Dissolved Aromatic Concentration (top) and Maximum Total Hydrocarbon Concentration in the Water Column (bottom) at Little Falls Dam 24 Hours After the Release of CLB at the Mississippi River at Little Falls Release Location During the High Flow (Spring) Season

6.2.2.1.2 Trajectory and Fate Results for Average Flow (Summer-Fall)

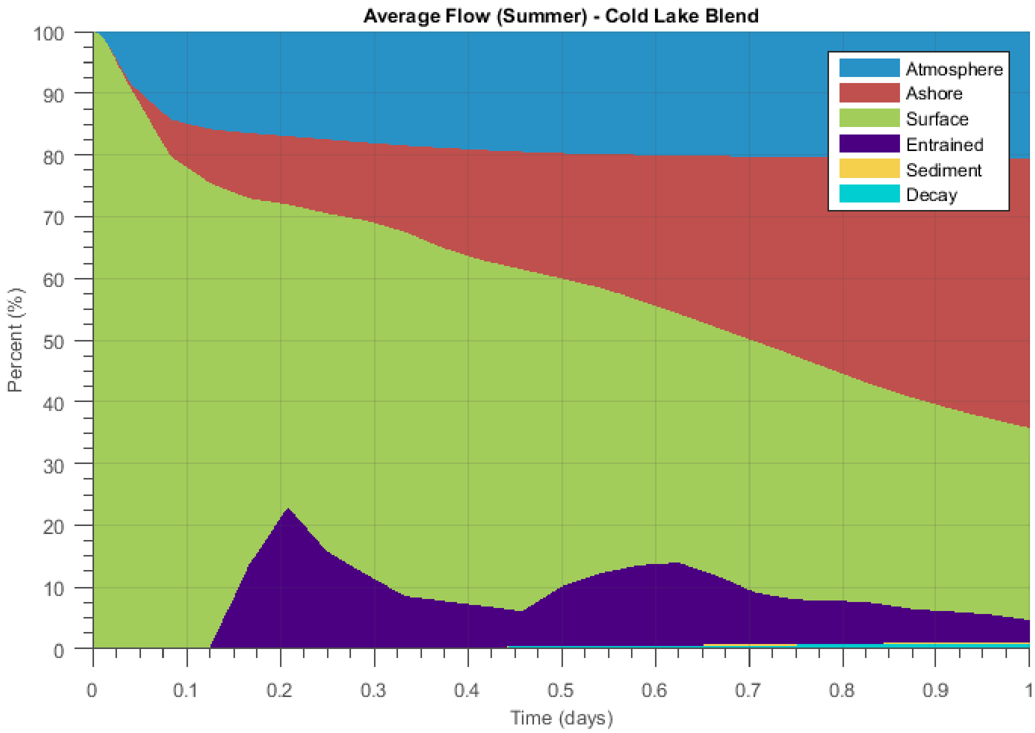

Figure 6-66 Oil Mass Balance Graph for Release of CLB at the Mississippi River at Little Falls Release Location During the Average Flow (Summer-Fall) Season

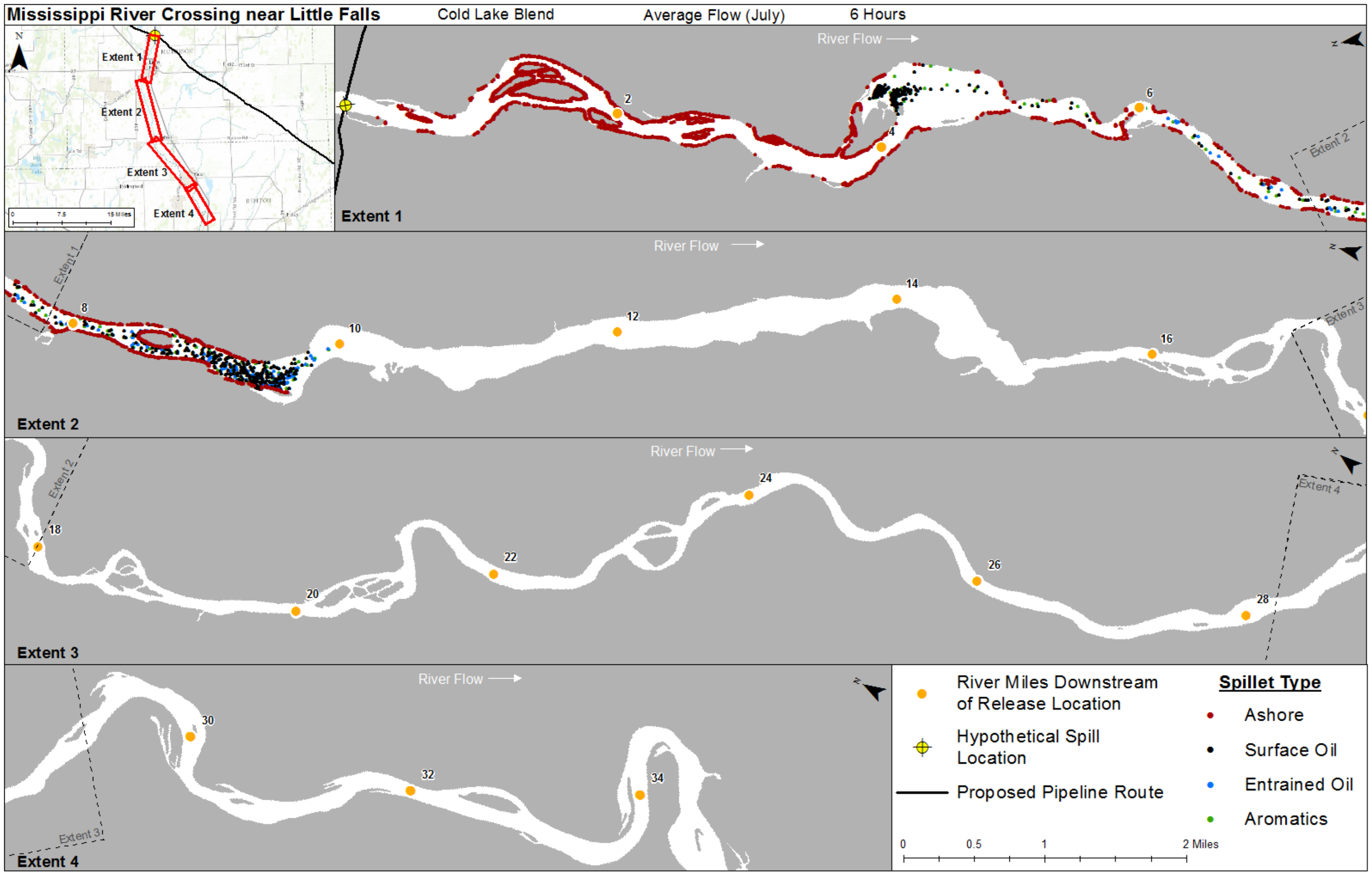

Figure 6-67 Oil Trajectory at 6 Hours for the Release of CLB at the Mississippi River at Little Falls Release Location During the Average Flow (Summer-Fall) Season

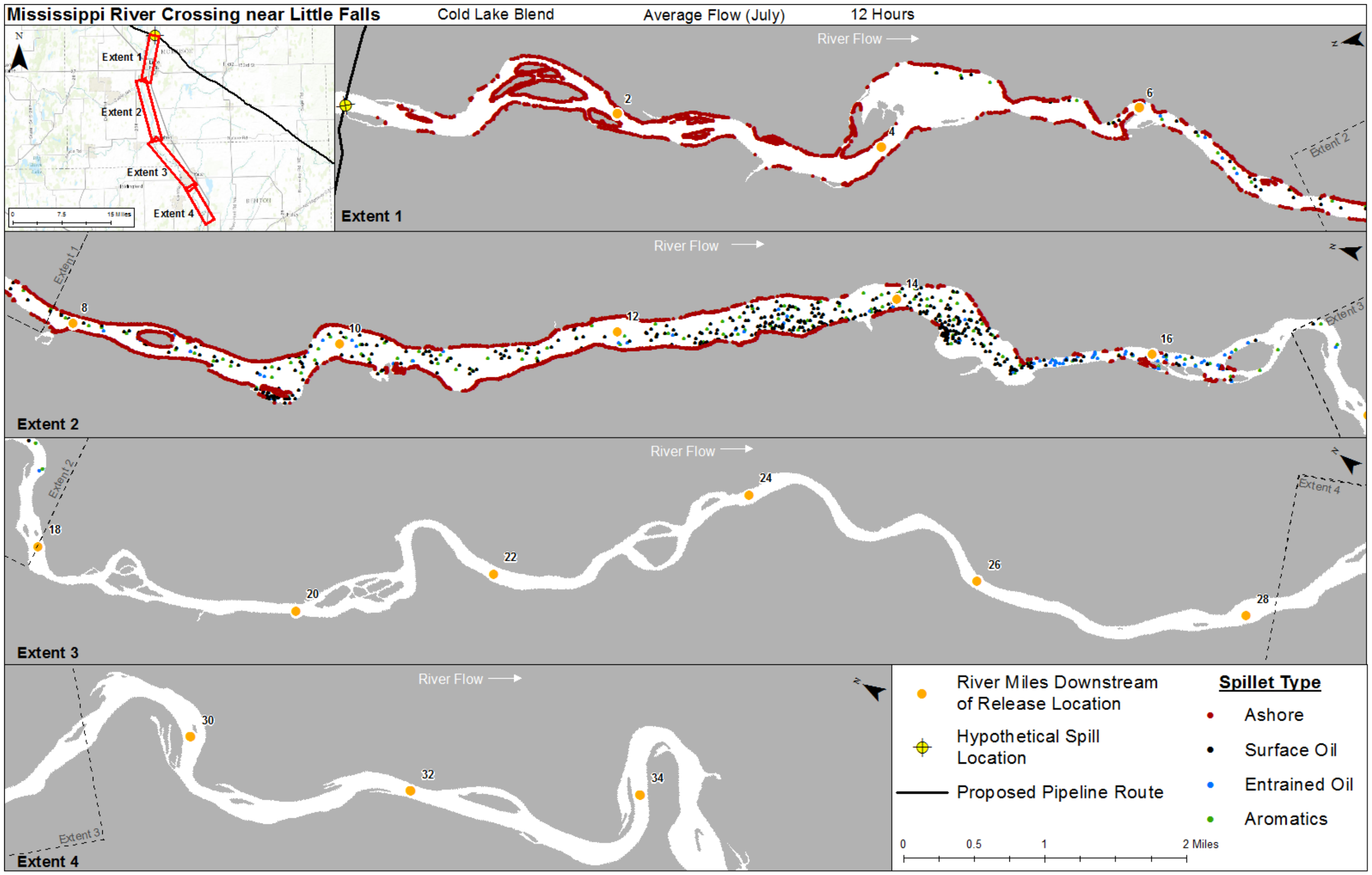

Figure 6-68 Oil Trajectory at 12 Hours for the Release of CLB at the Mississippi River at Little Falls Release Location During the Average Flow (Summer-Fall) Season

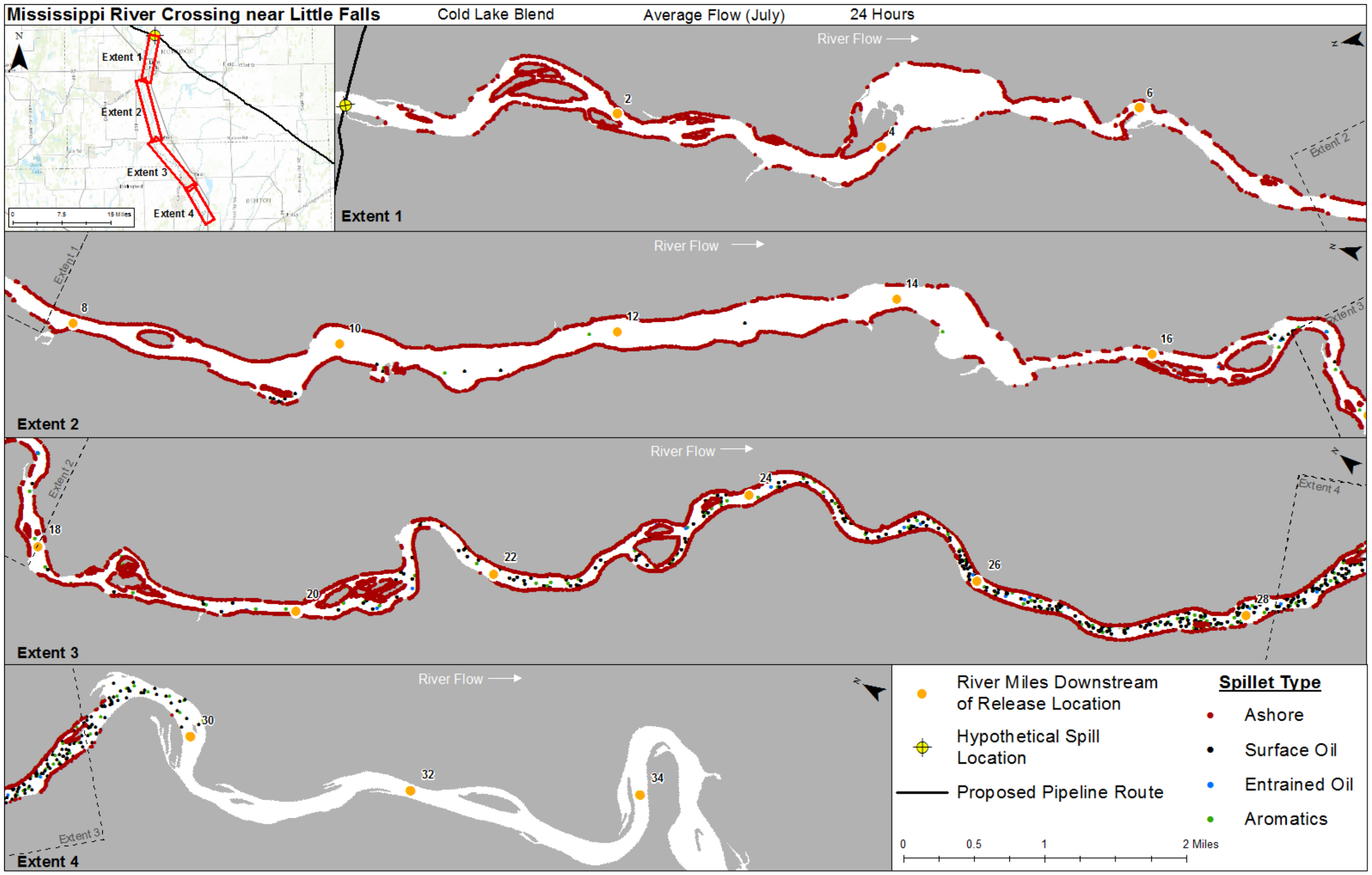

Figure 6-69 Oil Trajectory at 24 Hours for the Release of CLB at the Mississippi River at Little Falls Release Location During the Average Flow (Summer-Fall) Season

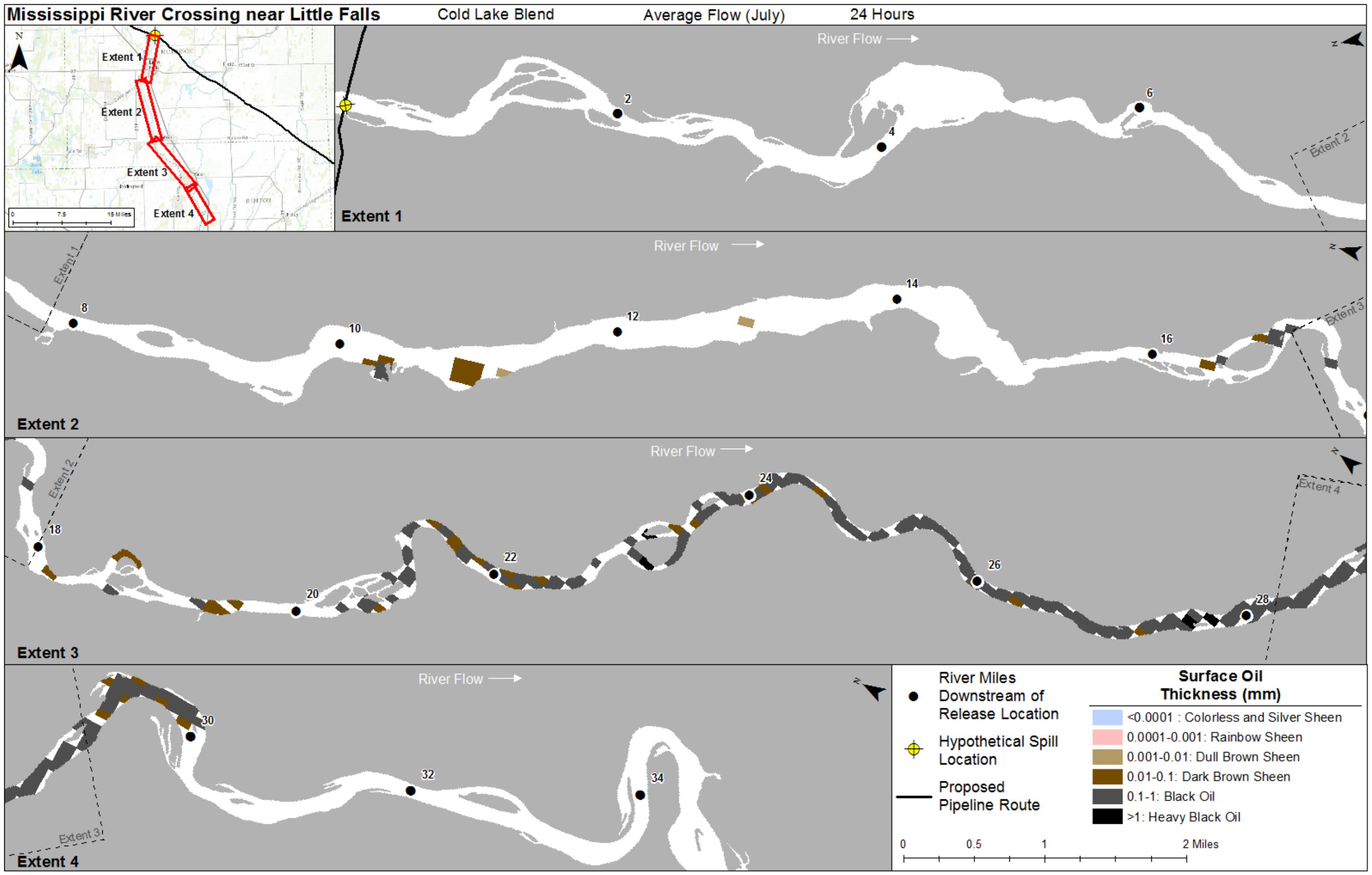

Figure 6-70 Maximum Floating Surface Oil at 24 Hours for the Release of CLB at the Mississippi River at Little Falls Release Location During the Average Flow (Summer-Fall) Season

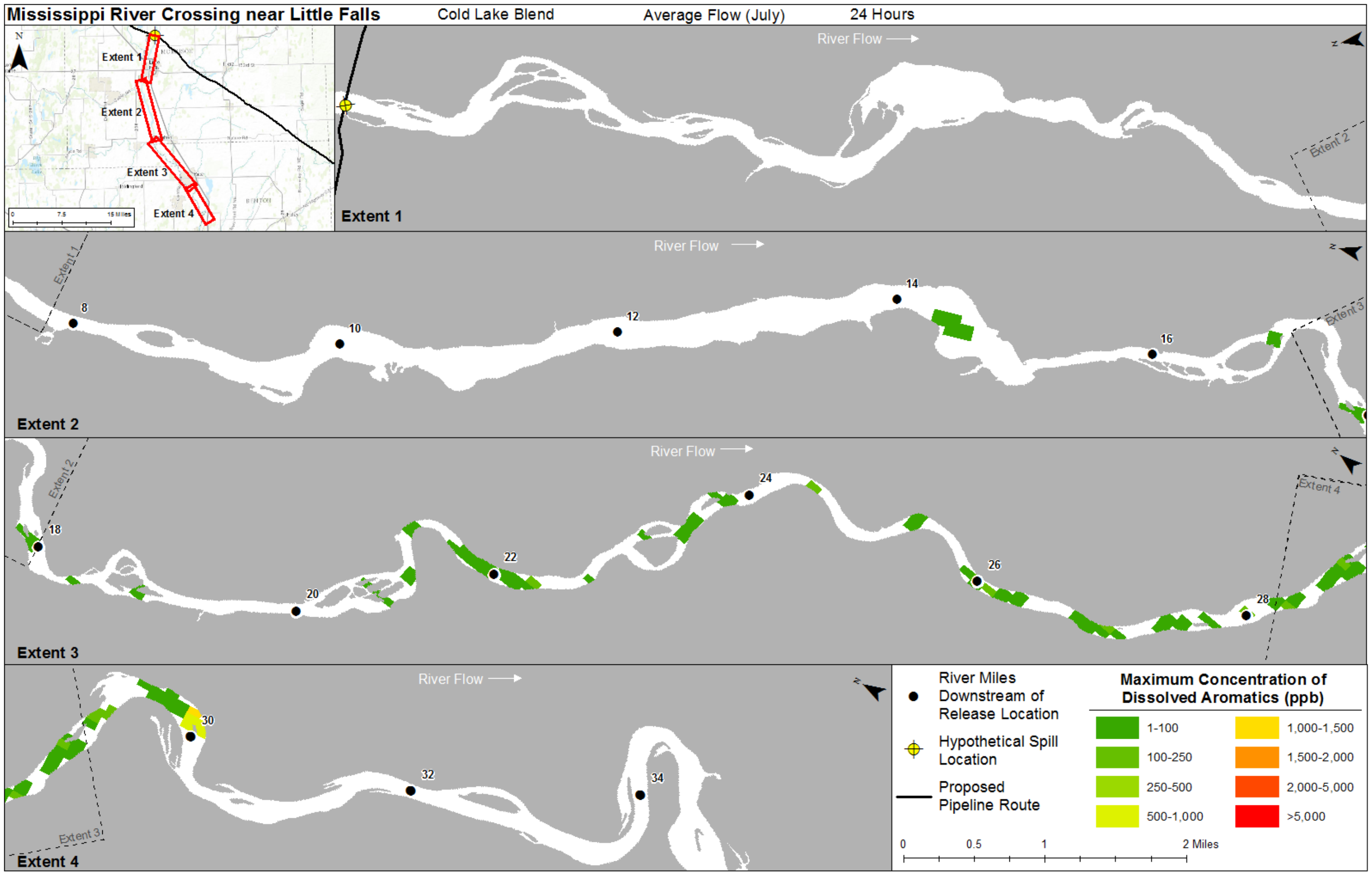

Figure 6-71 Maximum Total Dissolved Aromatic Concentration at 24 Hours for the Release of CLB at the Mississippi River at Little Falls Release Location During the Average Flow (Summer-Fall) Season

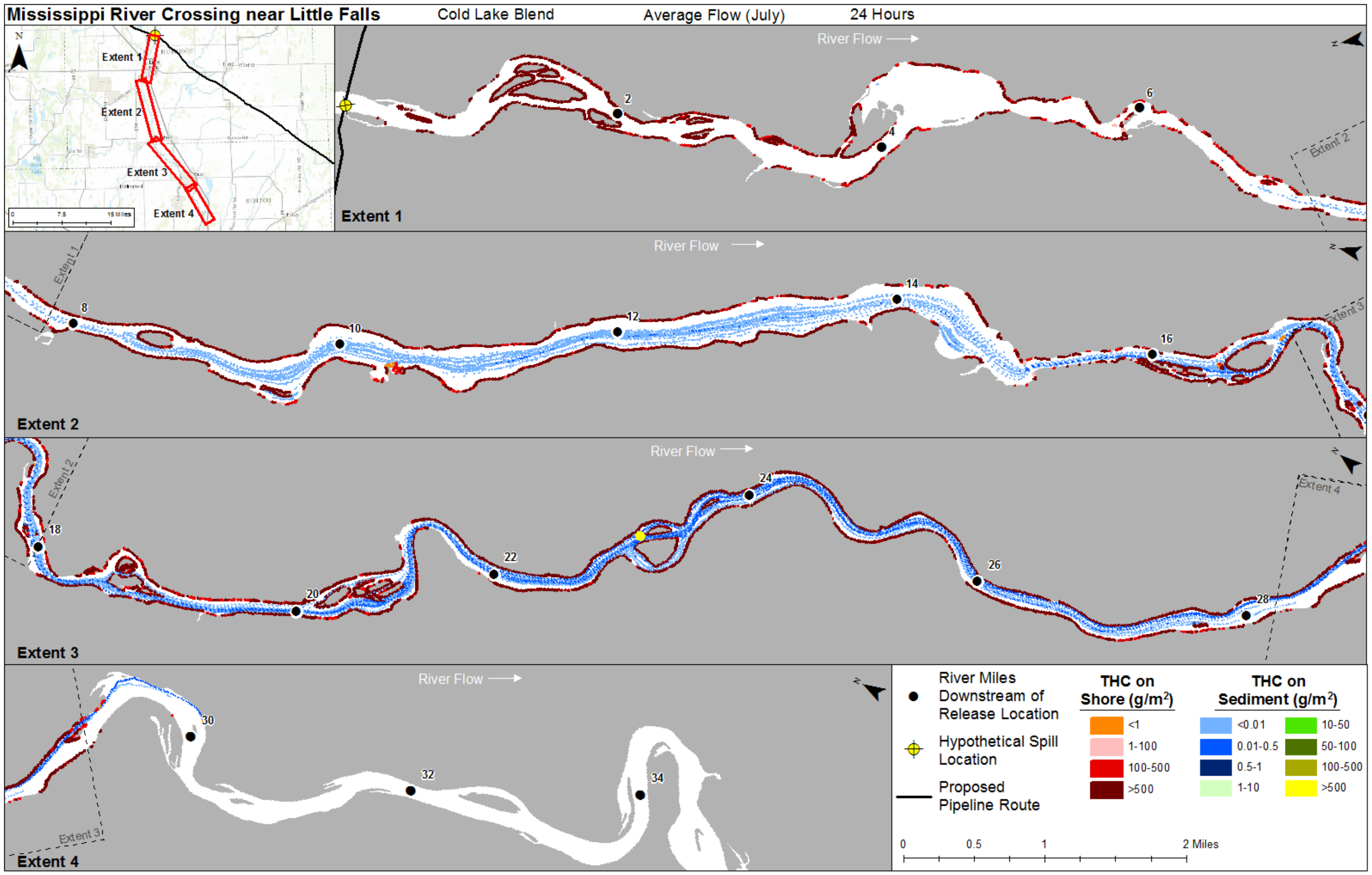

Figure 6-72 Maximum Total Hydrocarbon Mass on the Shore and on Sediments at 24 Hours for the Release of CLB at the Mississippi River at Little Falls Release Location During the Average Flow (Summer-Fall) Season

6.2.2.1.3 Trajectory and Fate Results for Low Flow (Winter)

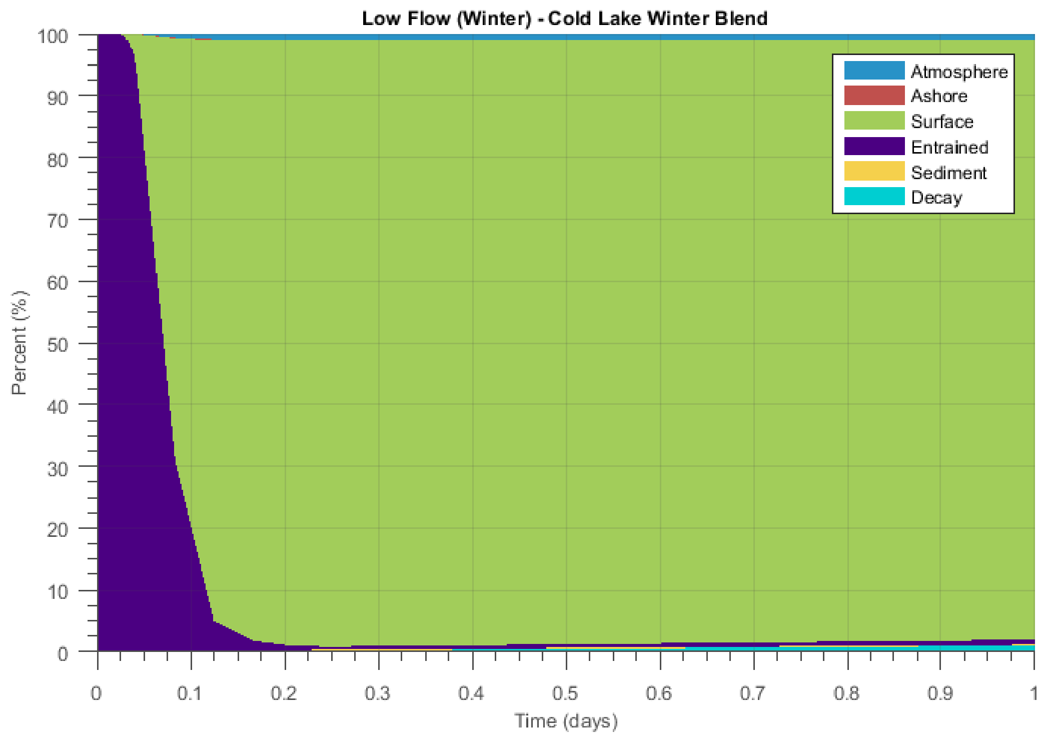

Figure 6-73 Oil Mass Balance Graph for Release of CLWB at the Mississippi River at Little Falls Release Location During the Low Flow (Winter) Season

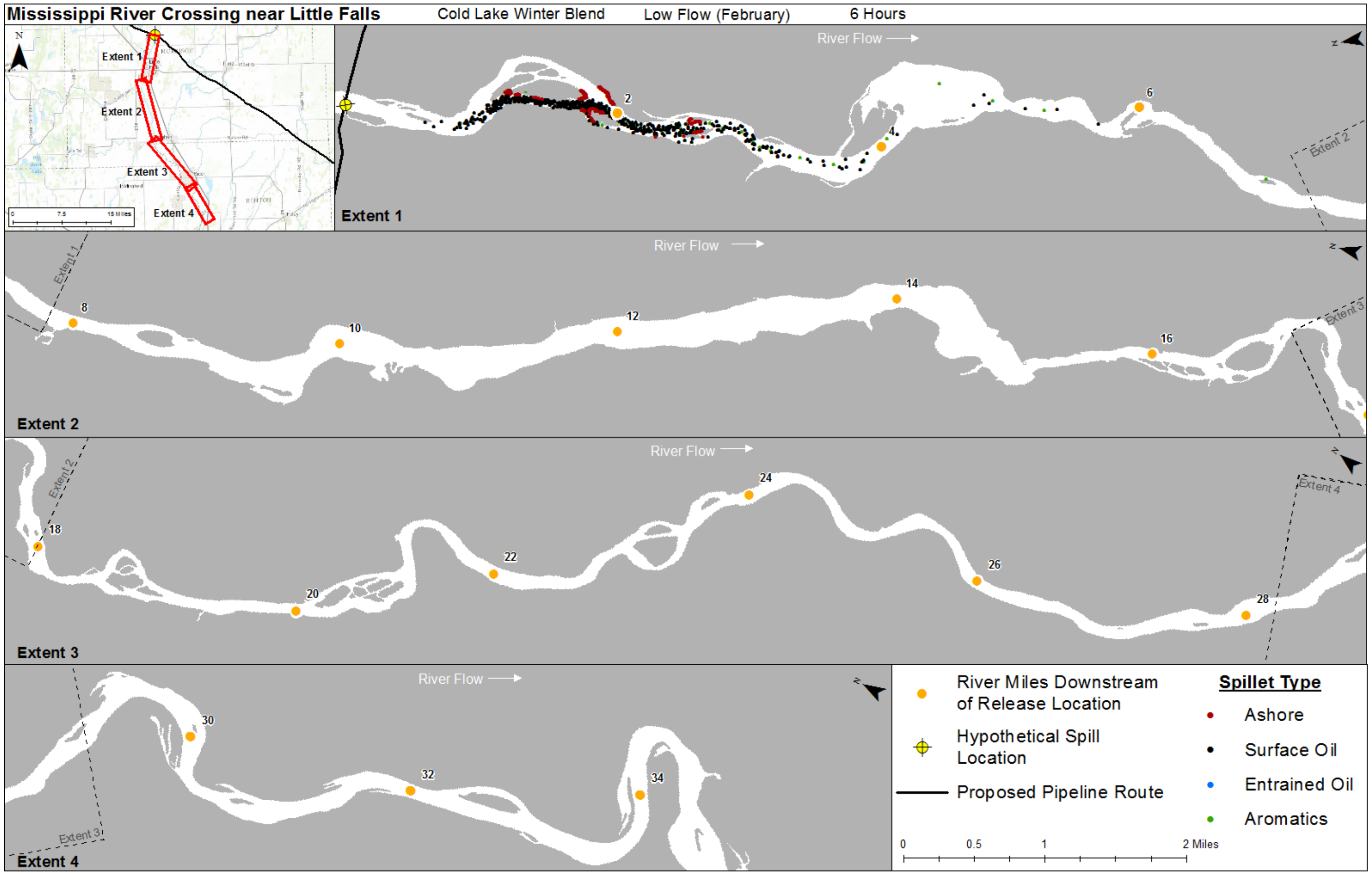

Figure 6-74 Oil Trajectory at 6 Hours for the Release of CLWB at the Mississippi River at Little Falls Release Location During the Low Flow (Winter) Season

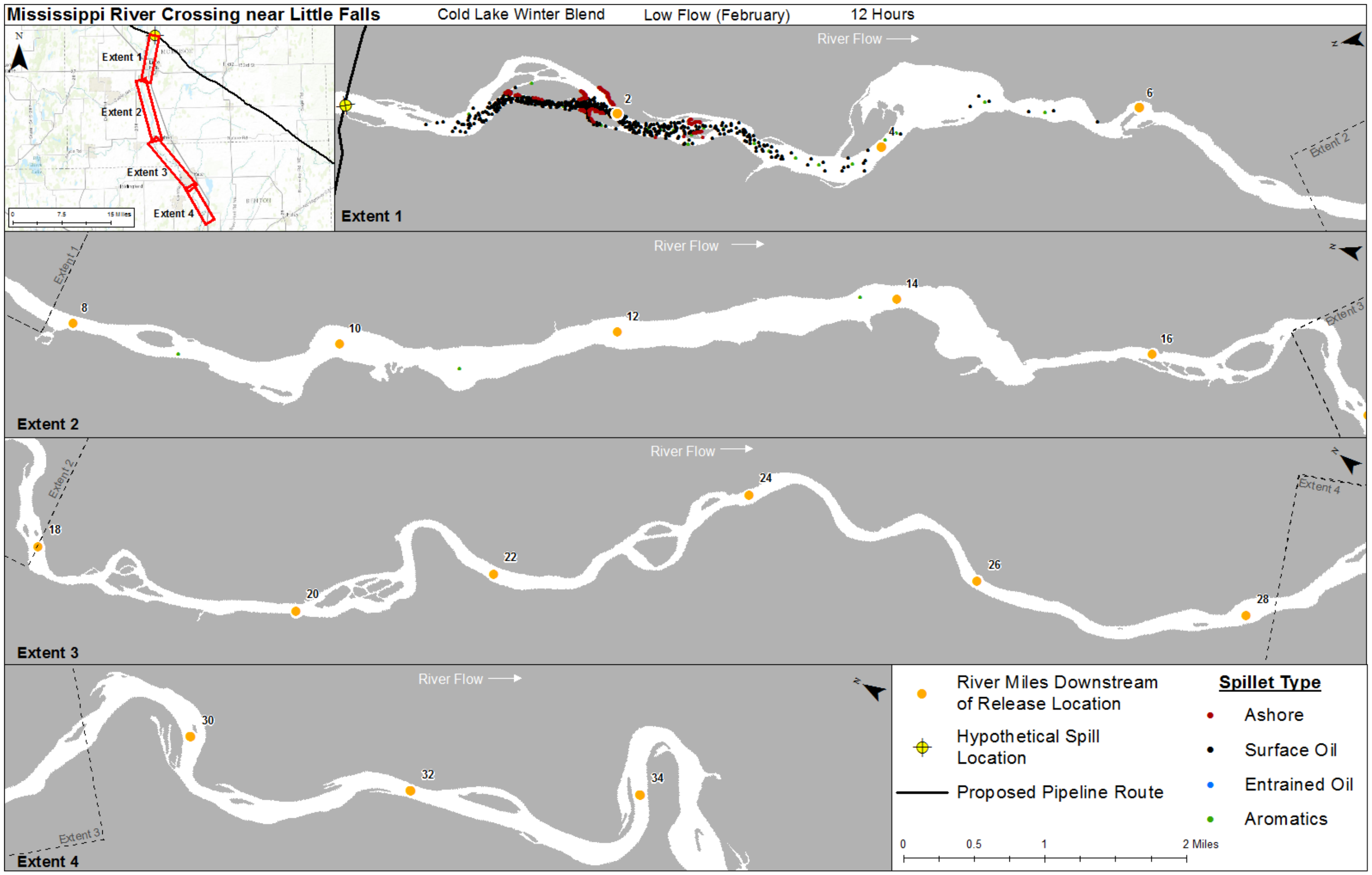

Figure 6-75 Oil Trajectory at 12 Hours for the Release of CLWB at the Mississippi River at Little Falls Release Location During the Low Flow (Winter) Season

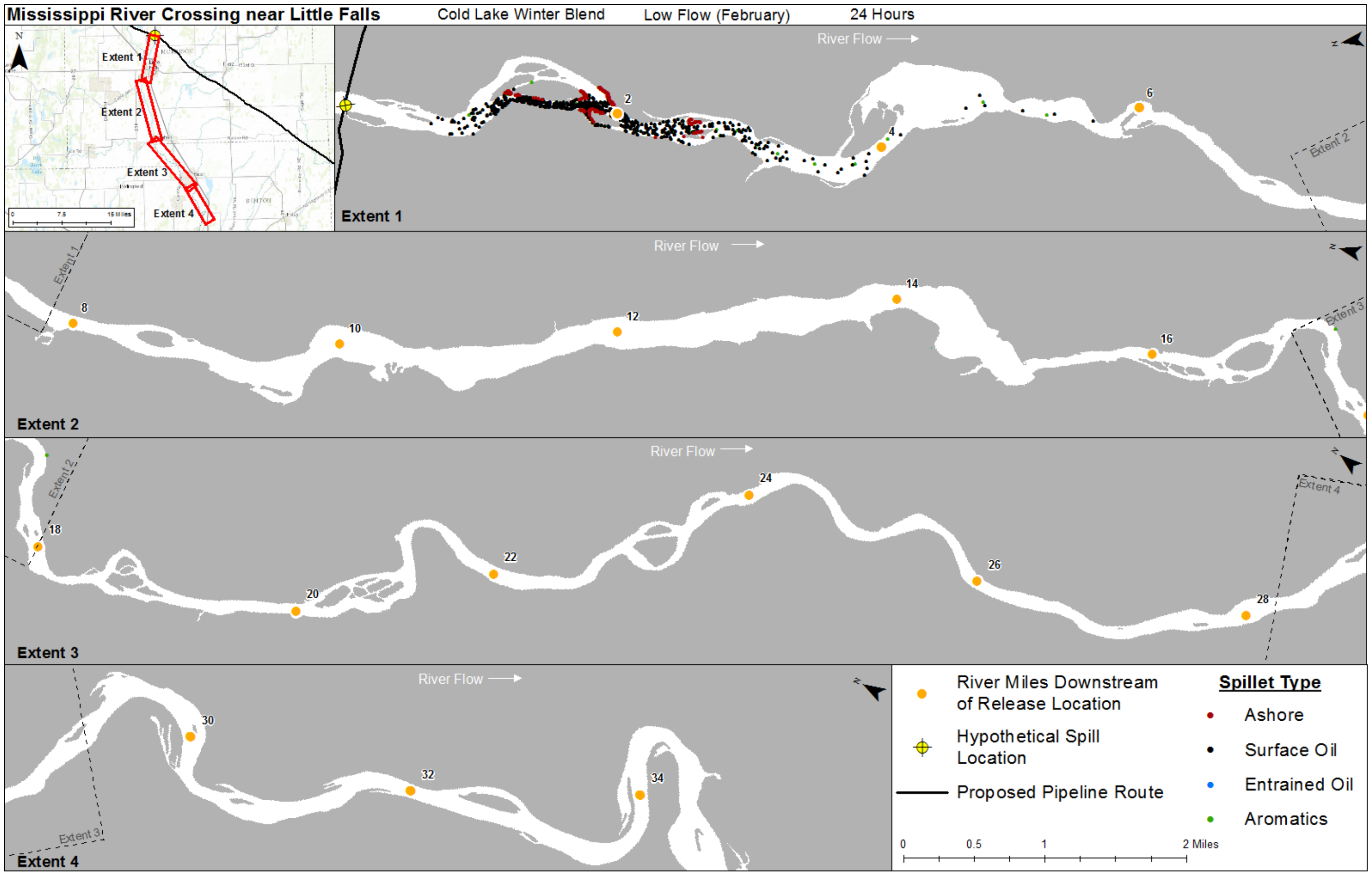

Figure 6-76 Oil Trajectory at 24 Hours for the Release of CLWB at the Mississippi River at Little Falls Release Location During the Low Flow (Winter) Season

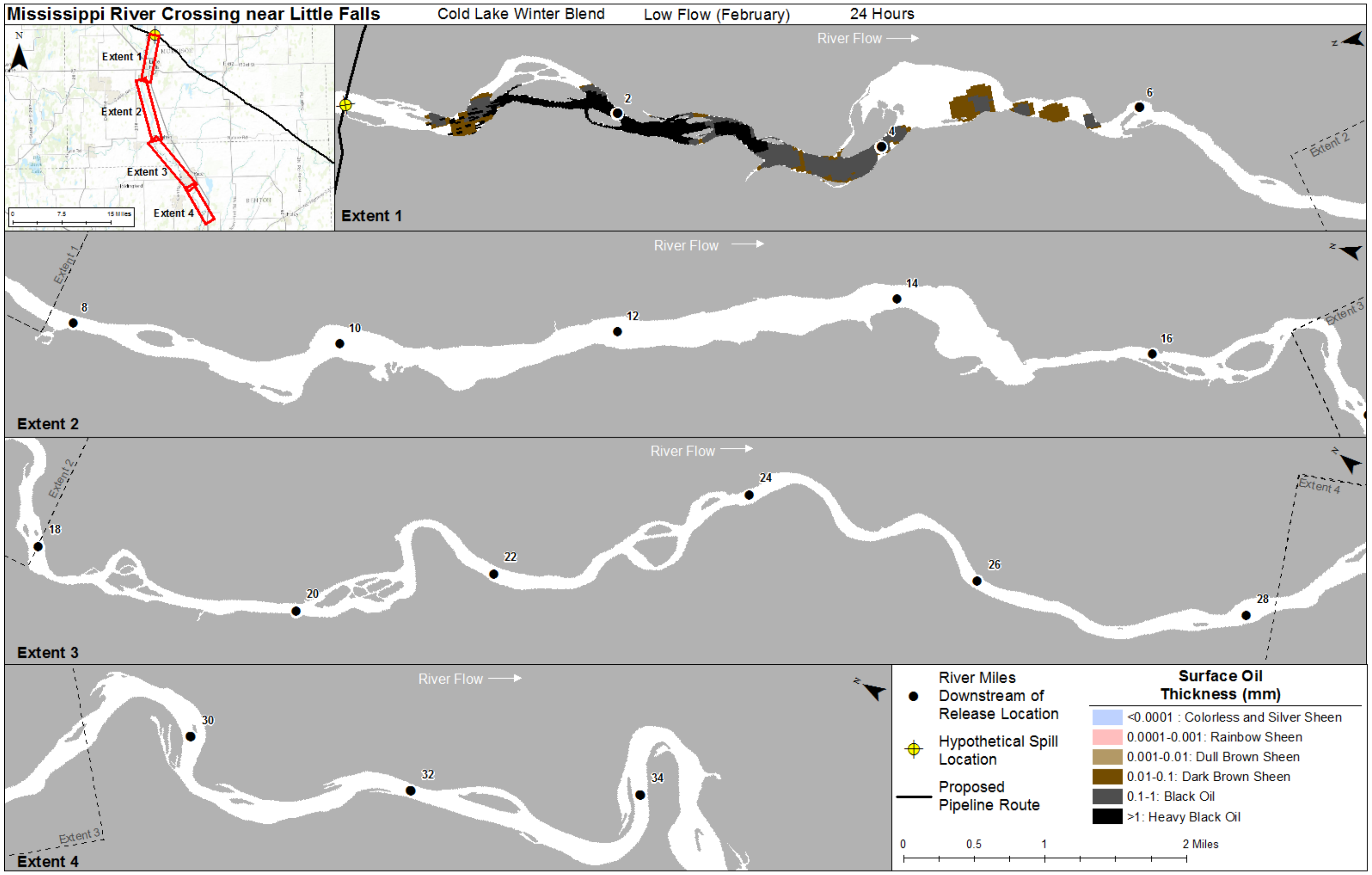

Figure 6-77 Maximum Floating Surface Oil at 24 Hours for the Release of CLWB at the Mississippi River at Little Falls Release Location During the Low Flow (Winter) Season

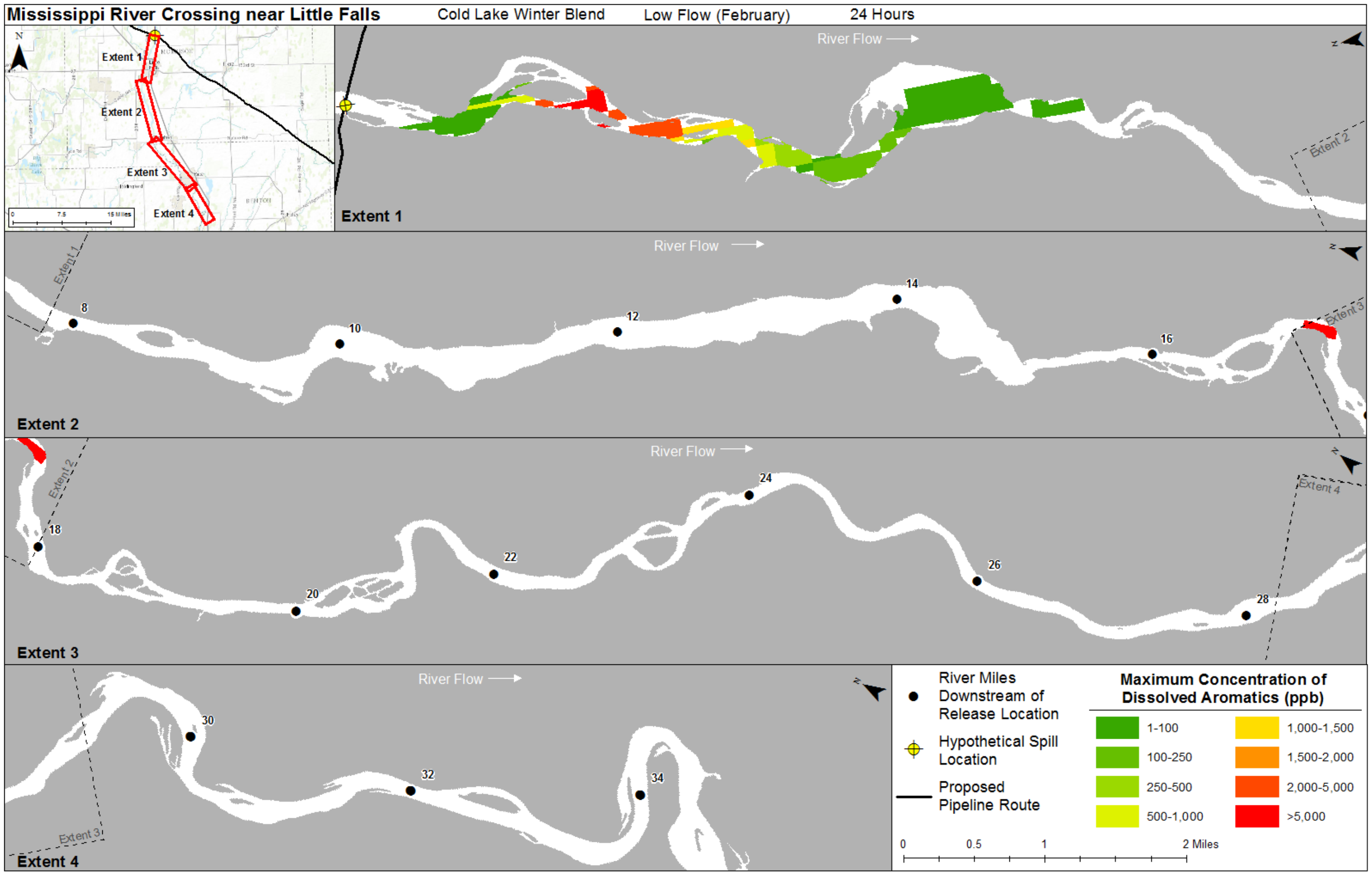

Figure 6-78 Maximum Total Dissolved Aromatic Concentration at 24 Hours for the Release of CLWB at the Mississippi River at Little Falls Release Location During the Low Flow (Winter) Season