River flows to the south through Huntersville State Forest at an average width of 184 ft (56 m). Expected environmental and flow conditions throughout the year for Shell River/ Crow Wing River are provided in Table 5-6.

Maps of the predicted downstream trajectory and mass balance tables of CLB (Figure 6-9) and Bakken Crude (Figure 6-10) seasonal scenarios for the Shell River to Twin Lakes release site are provided at the beginning of the following subsections.

6.1.4.1 Cold Lake Blend Scenarios

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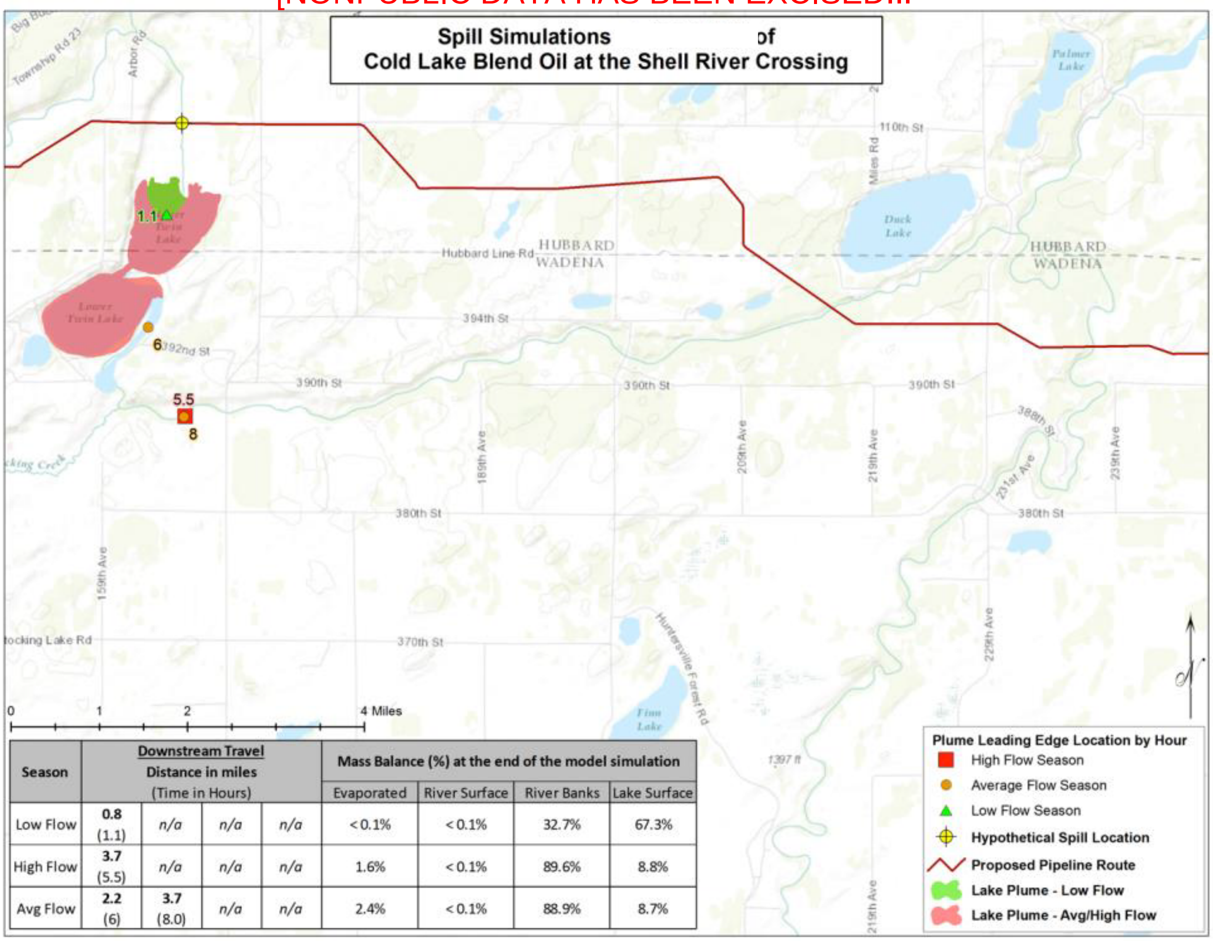

Season	Downstream Travel Distance in miles (Time in Hours)				Mass Balance (%) at the end of the model simulation: Evaporated	River Surface	River Banks	Lake Surface
Low Flow	0.8 (1.1)	n/a	n/a	n/a	< 0.1%	< 0.1%	32.7%	67.3%
High Flow	3.7 (5.5)	n/a	n/a	n/a	1.6%	< 0.1%	89.6%	8.8%
Avg Flow	2.2 (6)	3.7 (8.0)	n/a	n/a	2.4%	< 0.1%	88.9%	8.7%

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Figure 6-9 Predicted Downstream Transport of CLB Oil at the Shell River Release Location

6.1.4.1.1 Trajectory and Fate Results for High River Flow (Spring)

Flow rates for Shell River during the spring (April) result in peak average river velocities ranging between 0.85 and 2.26 mph (0.38 and 1.01 m/s). The OILMAP Land model transported oil downstream with these velocities to a point where all oil had evaporated and/or adhered to the shoreline.

Under high river flow, CLSB as predicted to travel a total of approximately 3.7 miles (6.0 km) downstream, within 5.5 hours of the release. At this time there was no CLSB on the river surface as the model predicted that the oil would have been lost from the water surface by this point in time. The CLSB was predicted to be transported down the Shell River 0.6 miles (0.97 km), then spread, covering the surfaces of both Upper and Lower Twin Lakes (for total area of 0.75 miles^2 or 1.94 km^2) to a thickness of 0.1 mm (Table 5-8), and then continue another 1.8 miles (2.9 km)down the Shell River. Approximately 89.6% of the CLSB was predicted to adhere to the shorelines of Shell River, 8.8% to have spread over the surface of Upper and Lower Twin Lake, and 1.6% to have evaporated into the atmosphere.

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

Flow rates for Shell River during the summer and fall result in average river velocities during August ranging between 0.58 and 1.3 mph (0.26 and 0.62 m/s). These river velocities were approximately 68% of that of the high flow condition.

As in the high river flow condition, CLSB under average river flow was predicted to travel a total of approximately 3.7 miles (6.0 km) downstream. However, under average river flow conditions with lower stream velocities, it took approximately 8.0 hours to reach this same distance. At this time there was no CLSB on the river surface as the model predicted that the oil would have been lost from the water surface by this point in time. The CLSB was predicted to be transported down the Shell River 0.6 miles (0.97 km), then spread covering the surfaces of both Upper and Lower Twin Lake (for total area of 0.75 miles^2 or 1.94 km^2) to a thickness of 0.1 mm (Table 5-9), and then continue another 1.8 miles (2.9 km) down the Shell River. Approximately 88.9% of the CLSB was predicted to adhere to the shorelines of Shell River, 8.7% to have spread over the surface of Upper and Lower Twin Lake, and 2.4% to have evaporated into the atmosphere.

Relative to the high river flow condition, more of the CLSB was predicted to evaporate. This was partially due to the higher temperatures in the summer conditions, but mainly due to the longer time required for the CLSB to move down stream due to the lower stream velocities. The slight reduction in oil remaining on the river shoreline and lake surface in the average river flow condition was the result of this increase in evaporation.

6.1.4.1.3 Trajectory and Fate Results for Low River Flow (Winter)

Under winter conditions (March), it was assumed that Shell River and Twin Lakes would be frozen over completely (100% coverage of ice). Additionally, it was assumed that CLWB would be released directly into the river from the pipeline under the river bottom, and remained trapped under the ice. The ice cover would prevent any evaporation to the atmosphere. Flow rates for

Shell River during these winter conditions resulted in minimum river velocities during March with a value of 0.56 mph (0.25 m/s). These river velocities were approximately 55% that of the high flow conditions.

Under low river flow conditions, the CLWB was predicted to be transported down the Shell River for 0.6 miles (0.97 km), and then spread under the ice to a thickness of 10.6 mm (Table 5-9; Section 5.3.2.6). CLWB was predicted to be transported a total of 0.8 miles (1.29 km) downstream, within 1.1 hours of the release. The oil was predicted to spread under the ice covering an area of 0.054 miles^2 (0.140 km^2) of Upper Twin Lake. Approximately 32.7% of the CLWB was predicted to adhere to the shorelines of Shell River, and the remaining 67.3% to spread under the ice within the lake. Relative to the high and average river flow conditions, the CLWB was predicted to be transported 2.9 miles (4.7 km) less downstream. This was due to the increased capacity for the ice to trap CLWB (10.6 mm) under the frozen surface of the lake.

6.1.4.2 Bakken Crude Scenarios

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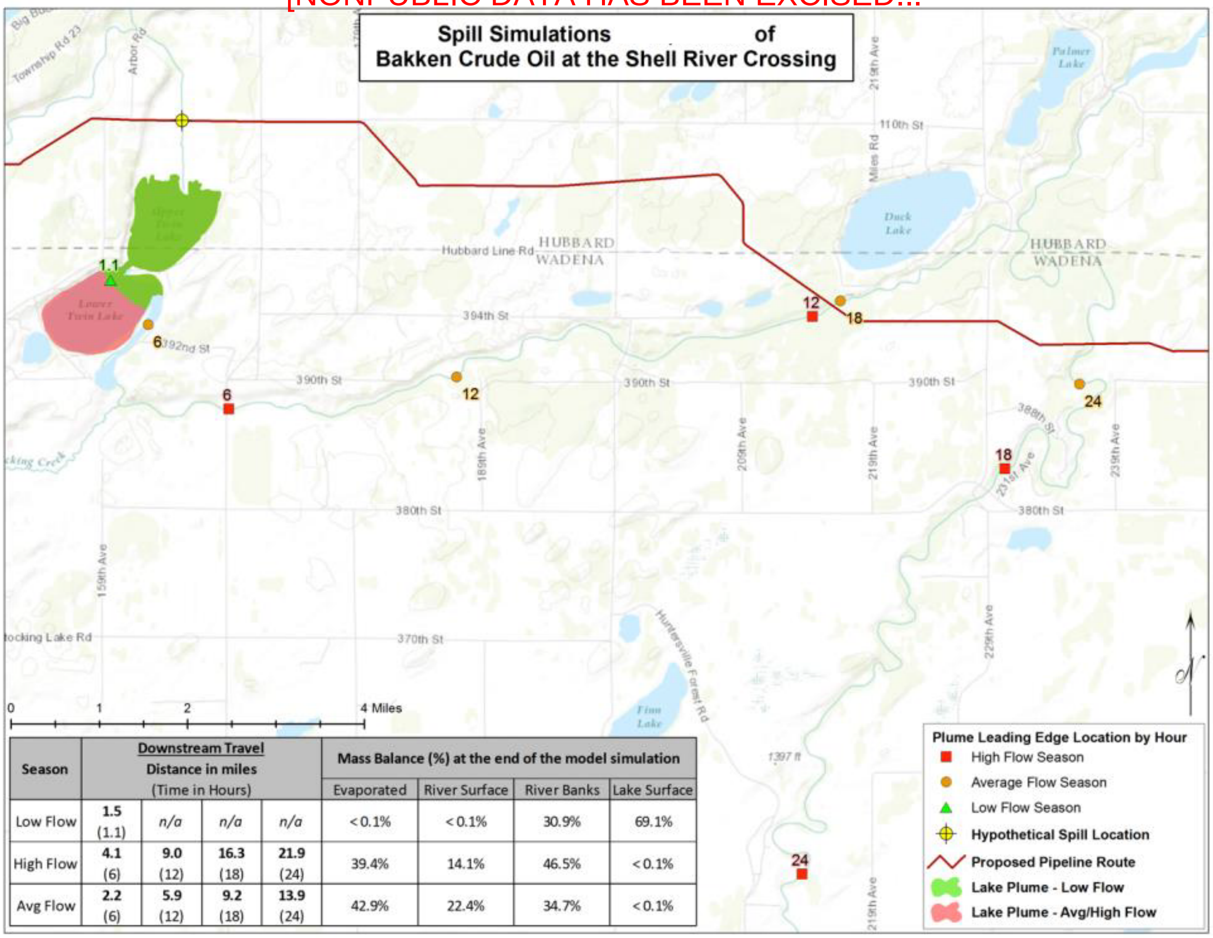

Season	Downstream Travel Distance in miles (Time in Hours)				Mass Balance (%) at the end of the model simulation			
					Evaporated	River Surface	River Banks	Lake Surface
Low Flow	1.5 (1.1)	*n/a*	*n/a*	*n/a*	<0.1%	<0.1%	30.9%	69.1%
High Flow	4.1 (6)	9.0 (12)	16.3 (18)	21.9 (24)	39.4%	14.1%	46.5%	<0.1%
Avg Flow	2.2 (6)	5.9 (12)	9.2 (18)	13.9 (24)	42.9%	22.4%	34.7%	<0.1%

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Figure 6-10 Predicted Downstream Transport of Bakken Crude Oil at the Shell River Release Location

6.1.4.2.1 Trajectory and Fate Results for High River Flow (Spring)

Under high river flow (April), Bakken crude was predicted to be transported approximately 21.9 miles (35.2 km) downstream, over the full 24-hour modeled period. The Bakken crude was predicted to be transported down the Shell River, and then spread covering the surfaces of both Upper and Lower Twin Lake (for total area of 0.75 miles^2 or 1.94 km^2) to a thickness of 0.001 mm (Table 5-9). It was then able to continue another 20.0 miles (32.2 km) down Shell River and Crow Wing River. Approximately 46.5% of the Bakken crude was predicted to oil the shorelines of Shell River and Crow Wing River, less than 0.1% would have spread over the surface of Upper and Lower Twin Lake, 39.4% to have evaporated into the atmosphere, and 14.1% to remain on the river surface at the end of the 24 hour simulation. If left unmitigated, the remaining Bakken crude on the river surface after 24 hours would be expected to continue downstream, weathering and oiling of shorelines until all the oil was removed from the water surface.

The Bakken crude was predicted to result in oiling 18.2 miles (29.3 km) further downstream than the CLSB (3.9 miles) under high flow river conditions. The difference in the extent of downstream transport was primarily the result of the differences in the shoreline and lake surface oil retention between the two oil types. Because of its higher viscosity and other parameters, CLSB would be expected to strand upon shorelines and spread on a lake surface more thickly than Bakken crude oil, resulting in larger amounts of CLSB along the shore and lake surface. In contrast, the same amount of Bakken crude would oil longer lengths of shoreline and more lake surface with a reduced thickness. While this result is logical, it is based upon the assumption of 100% shoreline oiling coverage (i.e., all shoreline up to that point is oiled to its maximum holding capacity) as oil makes its way downstream, and the assumption that oil would spread evenly within lake. In the event of an actual release, the downstream extents of CLSB and Bakken crude may be more similar, and the effects of CLSB may extend farther downstream than presented, with patchy coverage.

Bakken crude was predicted to evaporate nearly 25 times more (39.4%) than the CLSB (1.6%). This was partially due to the lighter nature and higher volatile content of the Bakken crude. Additionally, the Bakken crude was predicted to oil further downstream, which took more time and resulted in more surface area with oil. The additional time for downstream transport and oiled surface area allowed for more oil to evaporate to the atmosphere.

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

Under average river flow (August), Bakken crude was predicted to be transported approximately 13.9 miles (22.4 km) downstream, over the full 24-hour modeled period. The Bakken crude was predicted to be transported down the Shell River, and then spread covering the surfaces of both Upper and Lower Twin Lake (for total area of 0.75 miles^2 or 1.94 km^2) to a thickness of 0.001 mm (Table 5-9). It then continued another 12.0 miles (19.3 km) down the Shell River and Crow Wing River. Approximately 34.7% of the Bakken crude was predicted to adhere to the shorelines of Shell River and Crow Wing River, less than 0.1% to have spread over the surface of Upper and Lower Twin Lake, 42.9% to have evaporated into the atmosphere, and 22.4% to remain on the river surface at the end of the 24 hour simulation. If left unmitigated, the remaining Bakken crude on the river surface after 24 hours would be expected to continue downstream.

The Bakken crude was predicted to be transported 8 miles (12.9 km) less under average river flow conditions (13.9 miles or 22.4 km), when compared to the high river flow conditions (21.9 miles or 35.2 km). The lower river velocities of the average river flow condition prevented the oil from being transported as far within the 24 hour simulation period. The Bakken crude evaporated more under the average flow conditions (42.9%) than the high flow conditions (39.4%) due to the higher air temperatures. The higher air temperature causes the Bakken crude to evaporate more in the same 24 hour period despite the surface area being oiled being higher in the high river flow condition.

When compared to the CLSB under average river flow conditions (3.7 miles or 6.0 km), the Bakken crude is transported 10.2 miles (16.4 km) further downstream before reaching the 24 hour model limit. Additionally 22.4% of the Bakken crude was remaining on the river surface at the end of the simulation. The Bakken crude was able to travel further downstream, under the same river velocities due to the differences in the shoreline and lake surface oil retention between the two oil types.

6.1.4.2.3 Trajectory and Fate Results for Low River Flow (Winter)

Under low river (March) flow conditions, with oil released underneath 100% ice cover, Bakken crude was predicted to be transported a total of 1.5 miles (2.4 km) downstream, within 1.1 hours of the release. The Bakken crude was predicted to be transported down the Shell River for 0.6 miles (0.97 km), and then spread under the ice to a thickness of 1.9 mm (Table 5-9). The oil was predicted to spread under the ice covering an area of 0.42 miles^2 (1.09 km^2) including all of Upper Twin Lake and a portion of Lower Twin Lake. Approximately 30.9% of the Bakken crude was predicted to oil the shorelines of Shell River, and the remaining 69.1% to spread under the ice within the lake.

When compared to the CLWB under low river flow conditions (32.7%), 1.8% less of the Bakken crude remained on the river shorelines under the ice. This was due to the lower shoreline oil retention for Bakken crude oil, compared to CLWB. For this reason 1.8% more oil was able to spread under the ice surface in Upper and Lower Twin Lake for the Bakken release. The Bakken crude was also able to spread in the lakes under the ice to a greater extent (0.42 miles^2) than the CLWB (0.054 miles^2 or 0.140 km^2) due to the reduced capacity of the ice to trap the Bakken crude.

6.1.5 Unmitigated Hypothetical Release Case 5—Red River

The Red River is located along the border of Minnesota and North Dakota, and runs to the north into Canada. The pipeline crossing is located approximately 3 miles (4.82 km) due east of Bowesmont, North Dakota and 9 miles (14.48 km) southwest of Hallock, Minnesota adjacent to Route 16. At the proposed pipeline crossing location and downstream, the Red River is a large, wide (150-400 ft) river that flows north along a well-defined sinuous channel. The Red River passes the communities of Pembina, North Dakota and St. Vincent, Minnesota approximately 32 river miles downstream from the crossing location, and crosses into Canada approximately 34.5 miles downstream. The communities of Emerson and West Lyme, Manitoba are located on the Canadian side of the international border.

This modeling site captures a large, low-gradient (dropping approximately 6 ft in 35 river miles) watercourse, with a sinuous channel that is subject to flooding. The shore types are predominantly vegetated, often with shrubs and trees above the level of ice-scour. These waters are known to be a major area for recreation use, and also pass through or adjacent to sensitive ecosystems. The riparian banks are generally well vegetated, including some trees. Patches of forest are often present where the river meanders, although the surrounding land use is primarily agricultural. The Red River is subject to moderate to extreme flooding, particularly in the spring. Under low or average flow conditions, the stream banks are a combination of grass and soil. Under higher flow conditions the river can overtop the banks and spread into the surrounding farm and grassland. Expected environmental conditions throughout the year for the Red River are provided in Table 5-6.

The predicted downstream trajectory and mass balance tables for CLB (Figure 6-11) and Bakken crude (Figure 6-12) seasonal scenarios for the Red River release location are provided.

6.1.5.1 Cold Lake Blend Scenarios

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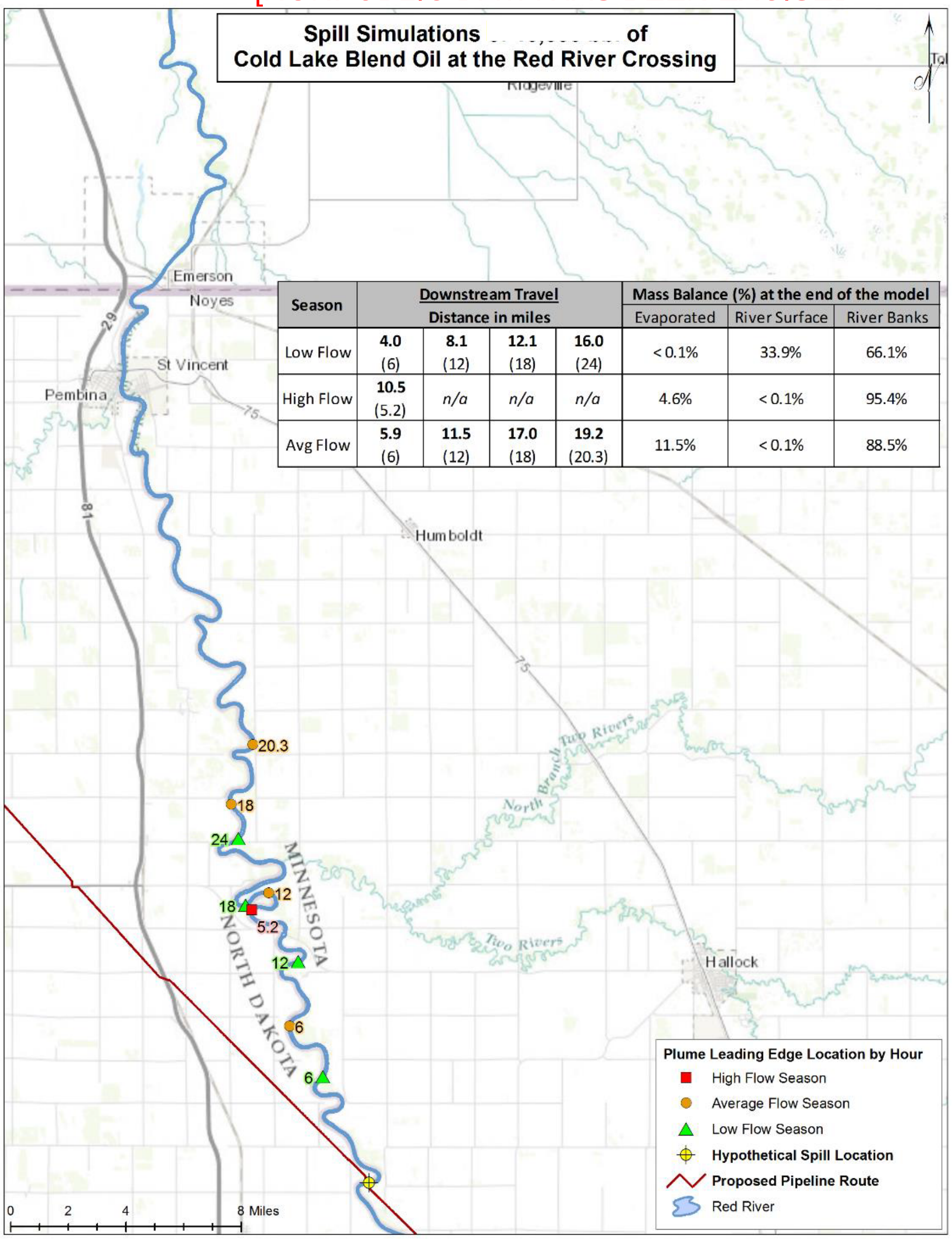

Season	Downstream Travel Distance in miles				Mass Balance (%) at the end of the model		
					Evaporated	River Surface	River Banks
Low Flow	**4.0** (6)	**8.1** (12)	**12.1** (18)	**16.0** (24)	< 0.1%	33.9%	66.1%
High Flow	**10.5** (5.2)	*n/a*	*n/a*	*n/a*	4.6%	< 0.1%	95.4%
Avg Flow	**5.9** (6)	**11.5** (12)	**17.0** (18)	**19.2** (20.3)	11.5%	< 0.1%	88.5%

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Figure 6-11 Predicted Downstream Transport of CLB Oil at the Red River Release Location

6.1.5.1.1 Trajectory and Fate Results for High River Flow (Spring)

Flow rates for the Red River during the spring result in peak average river velocities during April ranging from 1.97 and 4.12 mph (0.88 and 1.84 m/s). The OILMAP Land model transports oil downstream with these velocities to a point where all oil has evaporated and/or adhered to the shoreline.

Under high river flow, CLB was predicted to travel a total of approximately 10.5 miles (16.9 km) downstream, within 5.2 hours of the release. At this time, there was no CLB on the river surface as the model predicted that the oil would have been lost from the water surface by this point in time. After this distance, the oil would have been transported to the north through agricultural lands, stopping before the confluence with the Two Rivers. Approximately 95.4% of the CLB would be predicted to oil the shorelines of the Red river, and the remaining 4.6% would have evaporated into the atmosphere.

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

Flow rates for the Red River during the summer (August) and fall resulted in average river velocities ranging between 0.94 and 1.81 mph (0.42 and 0.81 m/s). These river velocities were approximately 43% of that of the high flow condition.

Under average river flow, CLB was predicted to travel a total of approximately 19.2 miles (30.9 km) downstream, within 20.3 hours of the release. At this time there would be no CLB on the river surface as the model predicted that the oil would have been lost from the water surface by this point in time. After 19.2 miles (30.9 km) the oil would have been transported to the north, passed the confluence with the Two Rivers to roughly a point just north of 310th Street in Minnesota, where County Ditch Number 26 enters the Red River. Approximately 88.5% of the CLB was predicted to oil shorelines of the Red River, and 11.5% to evaporate into the atmosphere.

Relative to the high river flow condition, the CLB was predicted to travel further downstream under average flow conditions. Under average flow conditions the stream shorelines are predominantly a mixture of grass and soil. Under high flow conditions all of the stream shorelines are assumed to be underwater and the shore type would be grass. The soil shorelines are capable of retaining 15 m^3 of CLB per kilometre of river, while the grass shoreline is capable of retaining 125 m^3 of CLB per kilometre of river. In the average river flow condition, less of the CLB would have adhered to the soil shorelines, allowing it to be transported further downstream. The volume of oil retained on the shoreline was less under the average flow conditions because more of the CLB was able to evaporate. This was partially due to the higher temperatures in the summer/fall conditions, but mainly driven by the longer time the CLB was able to move downstream and the greater surface area containing oil that was able to evaporate.

6.1.5.1.3 Trajectory and Fate Results for Low River Flow (Winter)

The lowest river flow winter conditions for the Red River occurs in February. To maximize downstream oiling potential, it was conservatively assumed that the Red River would be frozen over completely (100% coverage of ice). It was assumed that CLWB would be released directly into the river from the pipeline, which was under the river bed, and that all oil would remain trapped under the ice. The ice cover would prevent any evaporation to the atmosphere. Flow rates for the Red River during these winter conditions resulted in river velocities that ranged between 0.65 and 1.21 mph (0.29 and 0.54 m/s).

Under low river flow conditions, CLWB was predicted to be transported a total of 16.0 miles (25.7 km) downstream, over the full 24-hour modeled period. Approximately 66.1% of the CLWB was predicted to oil shorelines of the Red River, and the remaining 33.9% to remain in the river below the ice at the end of the 24 hour simulation. If left unmitigated, the remaining CLWB in the river after 24 hours would be expected to continue downstream, oiling shorelines until all of the oil was removed from the water surface. At the end of the 24-hour model period the CLWB was predicted to reach just north of 290th Street in Minnesota.

Relative to the high river flow conditions, the CLWB was predicted to be transported 5.5 miles (8.9 km) further downstream. Relative to the average river flow condition, the CLWB was predicted to be transported 3.2 miles (5.1 km) fewer downstream. Under low river flow conditions, the shore types were assumed to be the same as the average flow conditions. With the oil being transported at a lower velocity, 24 hour modeled time limit was reached at a shorter distance than the average river flow condition. With the CLWB below the ice of the river, no oil was evaporating from the surface.

6.1.5.2 Bakken Crude Scenarios

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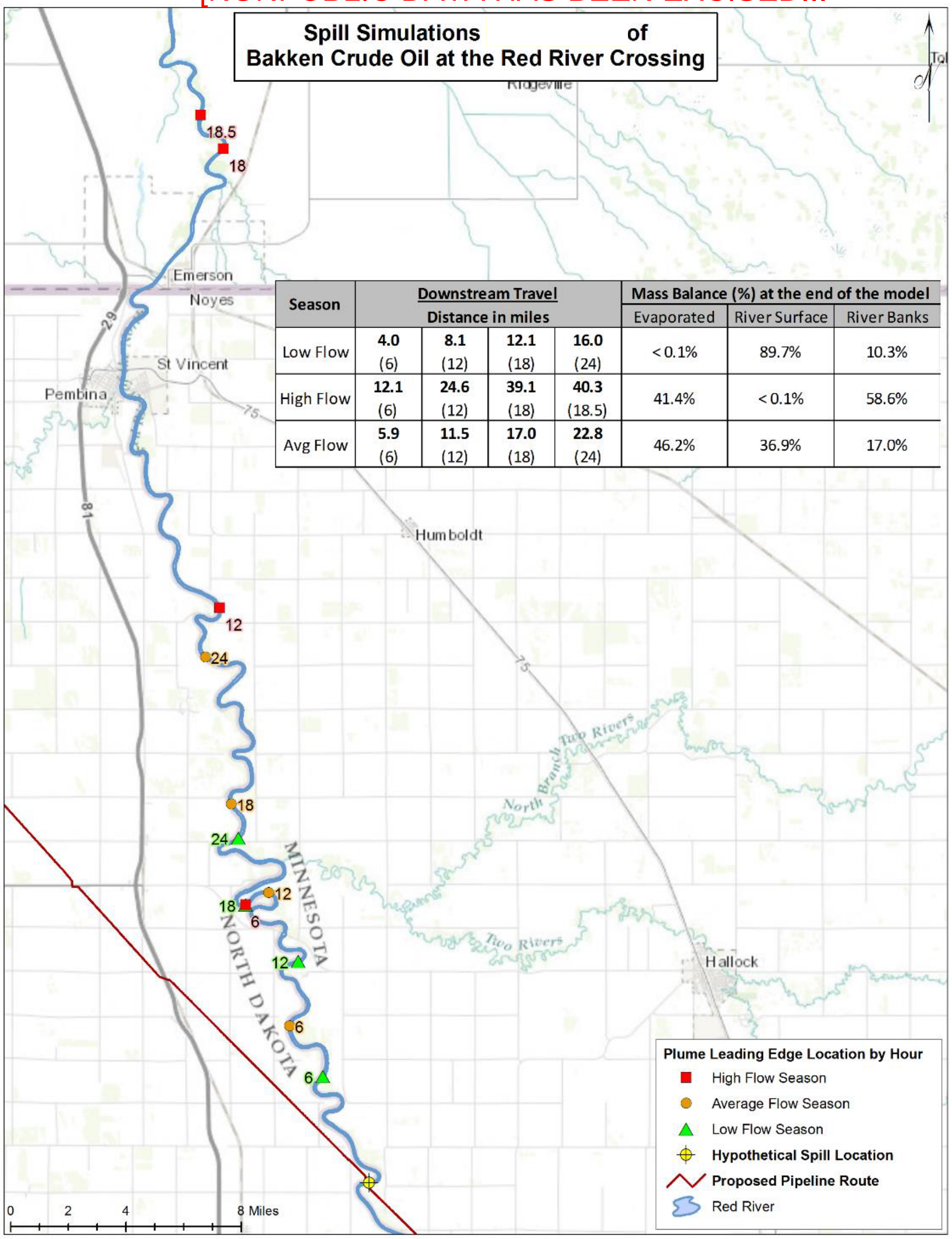

Season	Downstream Travel Distance in miles				Mass Balance (%) at the end of the model		
					Evaporated	River Surface	River Banks
Low Flow	4.0 (6)	8.1 (12)	12.1 (18)	16.0 (24)	< 0.1%	89.7%	10.3%
High Flow	12.1 (6)	24.6 (12)	39.1 (18)	40.3 (18.5)	41.4%	< 0.1%	58.6%
Avg Flow	5.9 (6)	11.5 (12)	17.0 (18)	22.8 (24)	46.2%	36.9%	17.0%

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Figure 6-12 Predicted Downstream Transport of Bakken Crude Oil at the Red River Release Location

6.1.5.2.1 Trajectory and Fate Results for High River Flow (Spring)

Under high river flow, Bakken crude was predicted to be transported approximately 40.3 miles (64.9 km) downstream, within 18.5 hours of the release. At this time there was no Bakken crude on the river surface as the model predicted that the oil would have been lost from the water surface by this point in time. After 40.3 miles (64.9 km) the oil has been transported to the north, past Pembina, into Canada, past Emerson and the confluence of the Joe River and terminating before the Ginew Roseau River Reserve. Approximately 58.6 of the Bakken crude was predicted to oil shorelines of the Red River and 41.4% to evaporate into the atmosphere.

The Bakken crude was predicted to result in oiling 29.8 miles (48.0 km) further downstream than the CLB (10.5 miles or 16.9 km) under high flow river conditions. The difference in the extent of downstream transport was the result of the differences in the shoreline oil retention between the two oil types. Because of its higher viscosity and other parameters, CLB was expected to strand upon shorelines more thickly than Bakken crude oil, resulting in larger amounts of CLB along the shore. In contrast the same amount of Bakken crude would oil longer lengths of shoreline with a reduced thickness. While this result is logical, it is based upon the assumption of 100% shoreline oiling coverage (i.e. all shoreline up to that point is oiled to its maximum holding capacity) as oil makes its way downstream. In the event of an actual release, the downstream extents of CLB and Bakken crude may be more similar, and the effects of CLB may extend farther downstream than presented, with patchy coverage.

Bakken crude was predicted to evaporate approximately 9 times more (41.4%) than the CLB (4.6%). This was partially due to the lighter nature and higher volatile content of the Bakken crude. Additionally, the Bakken crude was predicted to oil further downstream, which took more time and resulted in more surface area with oil. The additional time for downstream transport and oiled surface area therefore allowed for more oil to evaporate to the atmosphere.

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

Under average river flow, Bakken crude was predicted to be transported approximately 22.8 miles (36.7 km) downstream, over the full 24-hour modeled period. After this distance, the oil would have been transported to the north to a point between the entry of the Two Rivers and Pembina, close to 101st Street NE in North Dakota. Approximately 17% of the Bakken crude was predicted to oil the shorelines of the Red River, 46.2% to have evaporated to the atmosphere, and 36.9% to remain on the river surface at the end of the 24 hour simulation. If left unmitigated, the remaining Bakken crude oil on the river surface after 24 hours would be expected to continue downstream, weathering and oiling shorelines until all of the oil was removed from the water surface.

The Bakken crude was predicted to be transported 17.5 miles (28.2 km) less under average river flow conditions, when compared to the higher river flow conditions. The lower river velocities of the average river flow condition prevented the oil from being transported as far within the 24 hour simulation period. The Bakken crude evaporated more under the average flow conditions (46.2%) than the high river flow condition (41.4%) partially due to the higher air temperatures.

Additionally, under the average river flow condition the oil was transported downstream for the full 24 hours, as opposed to the high river flow condition that ends after 18.5 hours. This longer time allowed the Bakken crude to evaporate more before the end of the simulation.

When compared to the CLB under average river flow conditions, the Bakken crude was transported 3.6 miles (5.8 km) further downstream before reading the 24 hour model limit. Additionally 36.9% of the Bakken crude was still remaining on the river surface at the end of the simulation. The Bakken crude was able to travel further downstream, under the same river velocities, due to the lower shoreline oil retention value for Bakken, when compared to CLB.

6.1.5.2.3 Trajectory and Fate Results for Low River Flow (Winter)

Under low river flow, Bakken crude was predicted to be transported approximately 16.0 miles (25.7 km) downstream, over the full 24-hour modeled period. Approximately 10.3% of the Bakken crude was predicted to oil shorelines of the Red River, and the remaining 89.7% to remain in the river below the ice at the end of the 24 hour simulation. If left unmitigated, the remaining Bakken crude in the river after 24 hours would be expected to continue downstream, oiling shorelines until all the oil was removed from the water surface.

Relative to the high river flow condition, the Bakken crude was predicted to be transported 24.3 miles (39.1 km) fewer downstream. Relative to the average river flow conditions, the Bakken crude is predicted to be transported 6.8 miles (10.9 km) fewer downstream. Under low river flow conditions, the shore types were assumed to be the same as the average flow condition. With the oil being transported at a slow velocity, the 24 hour time limit was reached, resulting in a shorter distance oiled than that average river flow condition. With the Bakken crude below the ice of the river, no oil was allowed to evaporate from the surface.

When compared to the CLWB under low river flow conditions, 55.8% less of the Bakken crude remained on the river shorelines under the ice. This was due to the differences in the shoreline oil retention between the two oils. For this reason, 55.8% more oil was able to be transported downstream under the ice.

6.1.2 Summary of OILMAP Land Trajectory and Fate Results

The most important factor driving the transport of released oil in a river is the volume (discharge) of water and resulting velocity moving downstream. Typically, higher flow rates result in further downstream transport and more extensive shoreline oiling (Table 6-1). Based upon the river velocities at each location, the furthest downstream release extent is expected for the Red River. In some cases, changing shoreline types with the range of seasons did result in further downstream transport under low or average river flow conditions, when compared to high river flow conditions.

Table 6-1 Downstream Distance (miles) Maximum Oil Flow at the End of the Simulations

Location	Oil Type	Season / River Flow		
		Low	Average	High
Mosquito Creek	Bakken Crude	0.8	9.7	10.5
	Cold Lake Blend	0.8	3.5	3.5
Mississippi River at Ball Club (assumed grass shore type)	Bakken Crude	6.5 (6.5)	5.7 (15.9)	6.4 (23.0)
	Cold Lake Blend	1.3 (6.5)	1.3 (8.0)	1.3 (8.1)
Sandy River	Bakken Crude	6.0	9.1	12.2
	Cold Lake Blend	6.0	7.8	8.1
Shell River to Twin Lakes	Bakken Crude	1.5	13.9	21.9
	Cold Lake Blend	0.8	3.7	3.7
Red River	Bakken Crude	16.0	22.8	40.3
	Cold Lake Blend	16.0	19.2	10.5

Under winter conditions, snow and ice may significantly affect the predicted transport and fate of oil. Snow has the potential to slow downslope oil transport, with high absorbency. For releases at Mosquito Creek, snow cover under winter conditions prevented the releases from entering the water course, which did occur during summer and spring conditions. Ice has the potential to prevent oil from entering a waterway if the oil is released on land. However, if oil were to be released under ice, the in-water effects could be substantially greater due to the "capping" of the river, which would prevent evaporative losses and result in substantially more dissolution of hydrocarbons into the water column.

Two main differences between oil fates were observed when the CLB results were compared to those of the Bakken crude oil releases. Of primary importance, CLWB and CLSB have a higher density and viscosity, relative to the Bakken. This affects its shoreline oil retention values and results in more extensive shoreline oiling (thicker) for CLWB and CLSB, relative to the Bakken. In most scenarios, this results in further downstream transport of Bakken. In the event of an actual release, the downstream extents of CLSB and Bakken Crude may be more similar, and the effects of CLSB may extend farther downstream than presented, with patchy coverage. This is most important under high and average flow conditions, where the transport is directly limited by shoreline retention, as opposed to the downstream extent in low flow conditions predominantly being controlled by the low velocity. Of secondary importance is the volatile content, which controls the amount and rate of evaporation. More Bakken is expected to evaporate and at a higher rate, compared to CLWB and CLSB.

OILMAP Land is not able to provide detailed predictions of 3-D oil fate and transport. This includes processes such as entrainment of oil into the water column, dissolution of soluble fractions of hydrocarbons, emulsion formation, potential biological effects from exposure to oil, and other complex interactions. While these processes were not modeled for these five sites, they were modeled at the Mississippi River at Palisade and Little Falls using the SIMAP model application. These results are discussed in Section 6.2.

6.2 DESCRIPTION OF SIMAP MODEL OUTPUTS

This section provides modeled predictions of the expected trajectory and fate of hypothetical releases of two crude oils at two hypothetical releases located along the Mississippi River at Little Falls and Palisade and under multiple environmental conditions. Trajectory and fate results are depicted for each combination of season (high, average, and low river flow) for releases of both CLB and Bakken Crude oil types. A set of figures is provided for each of the twelve modeled scenarios.

The hydrocarbon trajectory provides a history of oil transport throughout the modeled domain in both time and space. Components of the oil are tracked as entrained droplets of oil within the water column, dissolved aromatics, floating surface oil, stranded oil on shorelines, oil in the sediment, and that which evaporated or decayed. The following points describe the types of figures produced through the modeling process and the information portrayed. Summary figures of trajectory and fate are provided for each location, season, and release volume. Mass balance information at the end of the 24-hour simulation is provided in tables for each of the release scenarios in terms of percent of oil spilled.

1. **Mass Balance Plots**: Provide an estimate of the weathering and fate of oil for a specific run for the entire model duration as a fraction of the oil spilled up to that point. Components of the oil tracked over time include the amount of oil on the water surface, the total entrained hydrocarbons in the water column, the amount of oil on shore, the oil evaporated into the atmosphere, the oil in sediments, and the amount of oil that has decayed (accounts for both photo-oxidation and biodegradation).
2. **Hydrocarbon Trajectory Maps:** Show the history of each individual particle of oil throughout the modeled domain in both time and space. Components of the oil were tracked as entrained droplets of oil, dissolved aromatic constituents, floating surface oil, and stranded shoreline oil. Trajectory maps are provided for 6, 12, and 24 hours after the initial release.
3. **Surface Oil Thickness Maps:** Depict the footprint of maximum floating surface oil and the associated oil thicknesses (mm) of each individual spill simulation at 24 hours.
4. **Water Column Concentration Maps:** Depict the footprint of the vertical maximum water column concentration of dissolved aromatics (µg/l or ppb) at 24 hours for each individual spill simulation. Dissolved aromatics are the portion of the oil having the greatest potential to affect water column biota, and the footprints were typically smaller than the extent of total oil contamination in the water column. Water column contamination figures show only concentrations ≥ 1 ppb. Concentrations below 1 ppb are considered low and result in little water column impact.

5. **Shoreline and Sediment Impact Maps:** Depict the total mass of oil deposited onto the shoreline and on sediments. Note that 1 μm thickness is roughly equivalent to 1 g/m^2.

6.2.1 Unmitigated Hypothetical Release Case 6—Mississippi River at Palisade

The Mississippi River passes to the south and east of the town of Palisade, Minnesota. The pipeline route crosses the Mississippi River 1.08 miles (1.74 km) to the south-south west of Palisade and to the southern edge of Great River Road (Rt. 10). At this location the Mississippi River flows to the south and west through a low energy and sinuous channel that passes through mainly agricultural lands with forested banks. Approximately 11 miles (17.7 km) to the south west of the hypothetical release location, the main stem of the Mississippi River continues to the south and west before continuing to the north and then west towards Wolford. At this point, the Aitkin Low Head Dam may be found with its flood diversion channel that flows due west along Great River Road (Rt. 21), 400th Lane, and then 400th St (Rt. 11) before rejoining the main stem of the Mississippi River. This flood diversion channel was only hydraulically connected to the Mississippi River during the modeled high river flow conditions. The width of the Mississippi River averages approximately 200-250 ft (61-76 m) in this area. Expected environmental and flow conditions used in modeling for the Mississippi River at Palisades are provided in Figure 5-5 and Tables 5-13 and 5-14.

6.2.1.1 Cold Lake Blend Scenarios

The Mississippi River at Palisade scenarios represent a low energy environment for the SIMAP analysis. Hypothetical releases of CLB at the Mississippi River at Palisade under high flow conditions resulted in oil that was transported downstream approximately 4, 8, and 17.5 miles (6.4, 12.8, and 28.2 km) after 6, 12, and 24 hours, respectively (Figure 6-15, Figure 6-16, and Figure 6-17). Under average river flow conditions, the release had a maximum extent of approximately 14 miles (22.5 km) after 24 hours (Figure 6-22, Figure 6-23, and Figure 6-24). During low river flows, the majority of the release was trapped at the ice-water interface within 1.5 miles (2.4 km) of the hypothetical release point, while the maximal extent of oil was approximately 2.5 miles (4.0 km) (Figure 6-37, Figure 6-38, and Figure 6-39). Table 6-2 provides a summary of the mass balance information at the end of the 24-hour simulation, while Figure 6-13 provides the furthest predicted downstream extent of whole oil.

Table 6-2 Summary of the CLB (CLSB or CLWB) Mass Balance Information at the Mississippi River at Palisade Release Location at the End of the 24-Hour Simulation [1]

Scenario	Surface (%)	Evaporated (%)	Water Column (%)	Sediment (%)	Ashore (%)	Decayed (%)
CLSB—High Flow (Spring)	71.3	19.7	<0.1	<0.1	8.1	0.8
CLSB—Average Flow (Summer-Fall)	70.3	21.1	<0.1	<0.1	7.8	0.8

Table 6-2 Summary of the CLB (CLSB or CLWB) Mass Balance Information at the Mississippi River at Palisade Release Location at the End of the 24-Hour Simulation [1]

Scenario	Surface (%)	Evaporated (%)	Water Column (%)	Sediment (%)	Ashore (%)	Decayed (%)
CLWB—Low Flow (Winter)	97.7	0.4	0.6	<0.1	0.3	1.0

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

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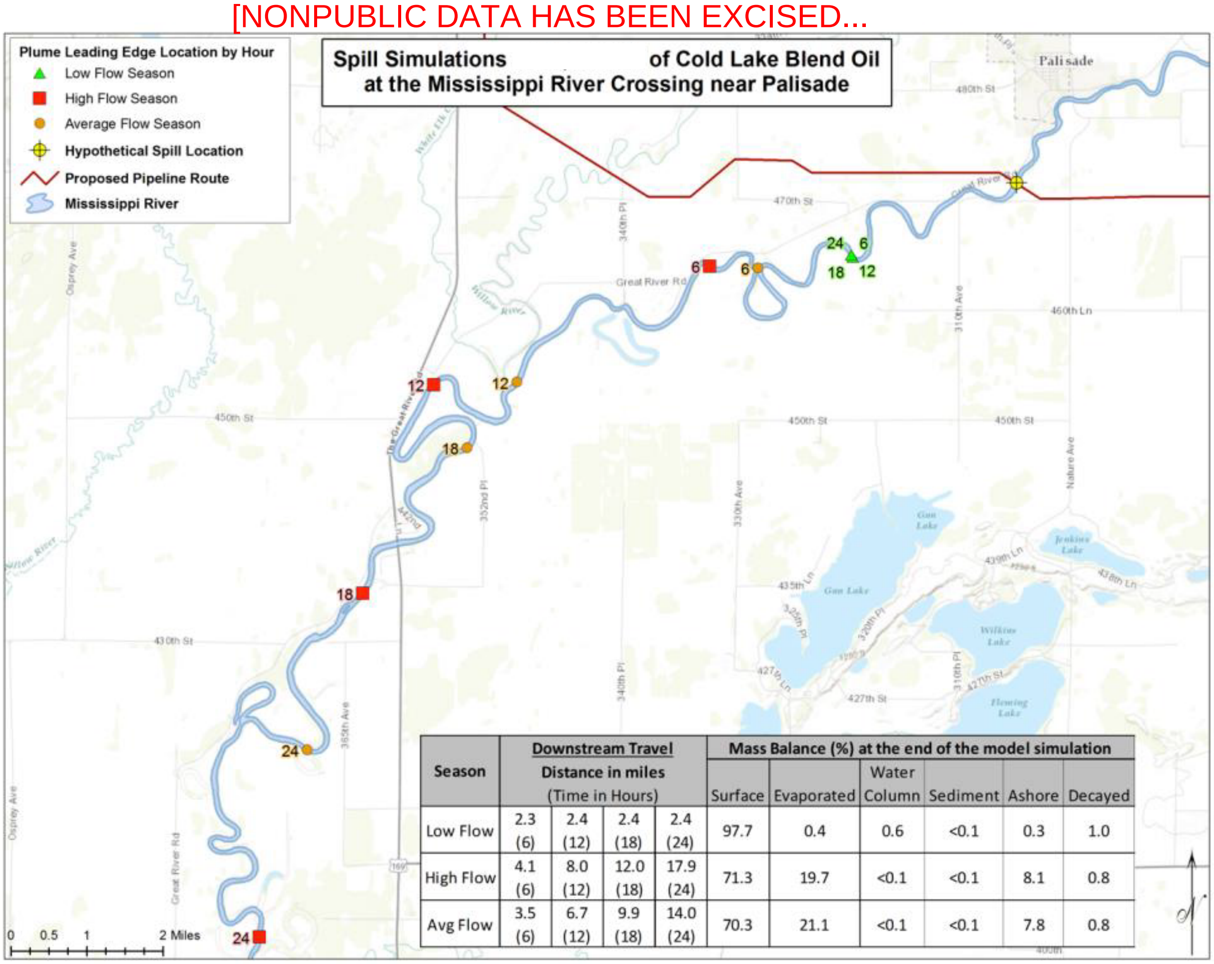


Season	Downstream Travel Distance in miles (Time in Hours)				Mass Balance (%) at the end of the model simulation					
					Surface	Evaporated	Water Column	Sediment	Ashore	Decayed
Low Flow	2.3 (6)	2.4 (12)	2.4 (18)	2.4 (24)	97.7	0.4	0.6	<0.1	0.3	1.0
High Flow	4.1 (6)	8.0 (12)	12.0 (18)	17.9 (24)	71.3	19.7	<0.1	<0.1	8.1	0.8
Avg Flow	3.5 (6)	6.7 (12)	9.9 (18)	14.0 (24)	70.3	21.1	<0.1	<0.1	7.8	0.8

...NONPUBLIC DATA HAS BEEN EXCISED]

Figure 6-13 Predicted Downstream Transport of CLB 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 6-18 and Figure 6-25). 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 oil). The presence of extensive surface slicks resulted in significant evaporation, with approximately 20% of the total release ending up in the atmosphere (Table 6-3).

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 6-20) and 14.5 miles (23.3 km) under average river flow conditions (Figure 6-27).

Surface oil evaporated rapidly over the 24-hour simulation (Figure 6-14, Figure 6-21, and Table 6-2). This natural weathering resulted in increased viscosity of the CLSB, which further reduced the likelihood of potential entrainment into the water column. 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 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 1 and 100 ppb (Figure 6-19). Of the oil that made its way into the water column, a portion did interact with SPM (also referred to as Total Suspended Solids or TSS). THCs on the sediment were generally less than 0.01 g/m², with small segments as high as 1 g/m2 (

Figure 6-20 and Figure 6-27). The concentrations on the shore were primarily greater than 500 g/m². 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 2.5 miles (4 km) from the spill location (Figure 6-31). Under low river flow conditions the

100% surface coverage of ice kept the entrained oil in the water column at the ice/water interface (97.7%) (Figure 6-31 and Figure 6-32). Patchy oiling along river banks was observed, however the majority of the oil remained trapped under the ice (Table 6-2). Concentrations on the shore were primarily greater than 500 g/m^2, with some segments less than 1 g/m^2 (Figure 6-34). A large portion of the soluble portion of the CLWB dissolved into the water column and was transported downstream, resulting in elevated dissolved aromatic concentrations within the water column (Figure 6-33). 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 6-33). 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 6-32). There was no floating surface oil less than 0.1 mm thick (black oil). Small amounts of sediment oiling did extend down to approximately 2.5 miles (4 km) (Figure 6-34), although the total hydrocarbon concentrations on the sediment were generally less than 0.01 g/m^2. There was very little decay from any of the three hypothetical releases within the timeframe modeled.

6.2.1.1.1 Trajectory and Fate Results for High Flow (Spring)

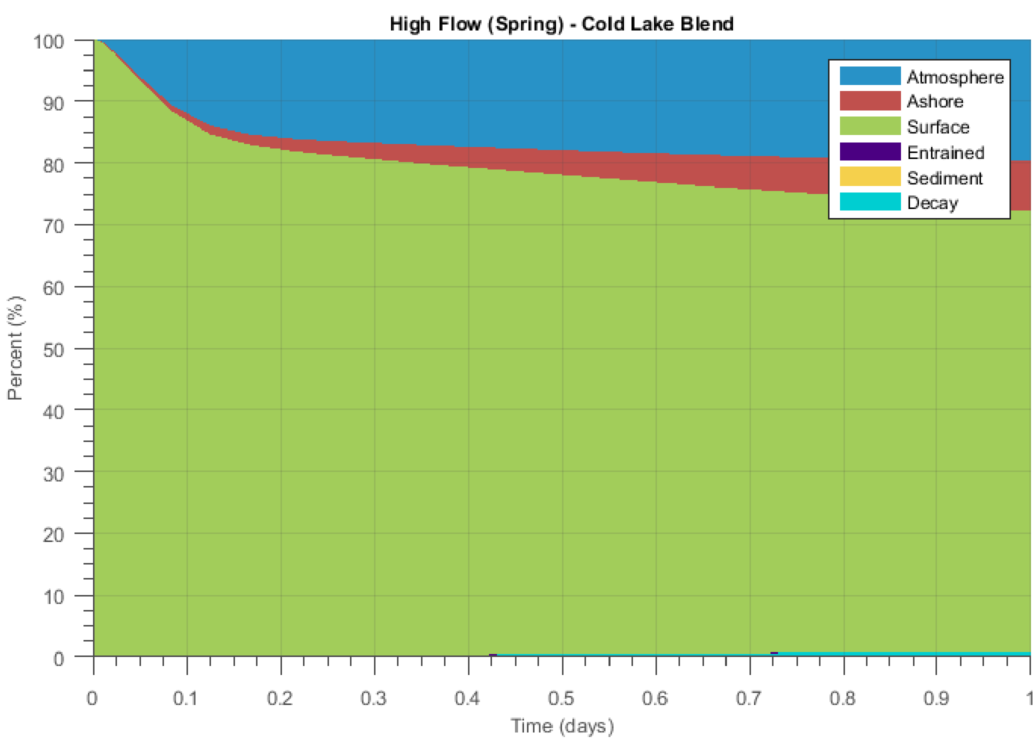
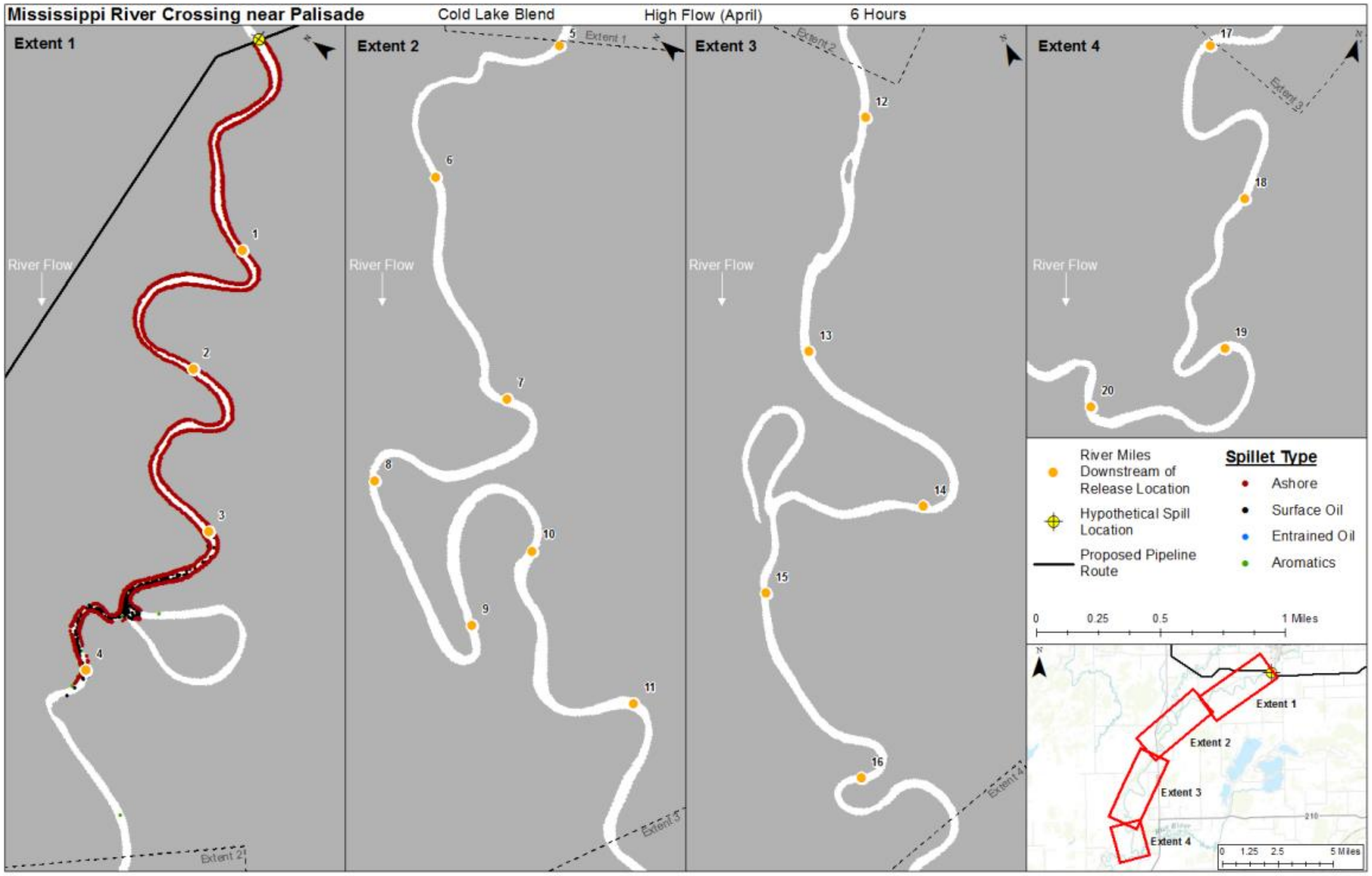


Figure 6-14 Oil Mass Balance Graph for the Release of CLB at the Mississippi River at Palisade Release Location During the High Flow (Spring) Season


Mississippi River Crossing near Palisade
Cold Lake Blend
High Flow (April)
6 Hours
Extent 1
Extent 2
Extent 3
Extent 4
River Flow
River Miles Downstream of Release Location
Hypothetical Spill Location
Proposed Pipeline Route
Spillet Type
Ashore
Surface Oil
Entrained Oil
Aromatics
0
0.25
0.5
1 Miles
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
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20

Figure 6-15 Oil Trajectory at 6 Hours for the Release of CLB at the Mississippi River at Palisade Release Location During the High Flow (Spring) Season

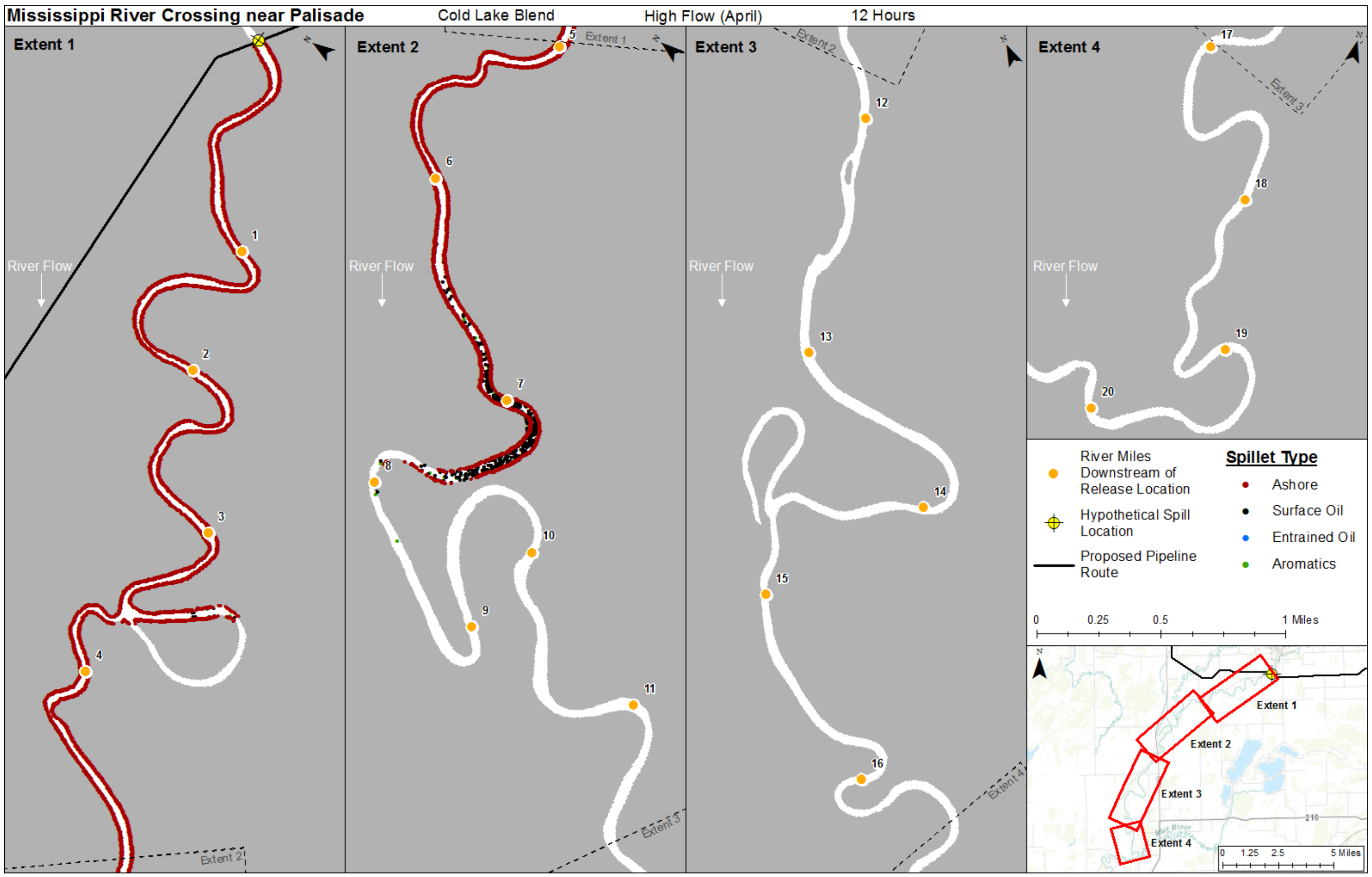

Figure 6-16 Oil Trajectory at 12 Hours for the Release of CLB at the Mississippi River at Palisade Release Location During the High Flow (Spring) Season

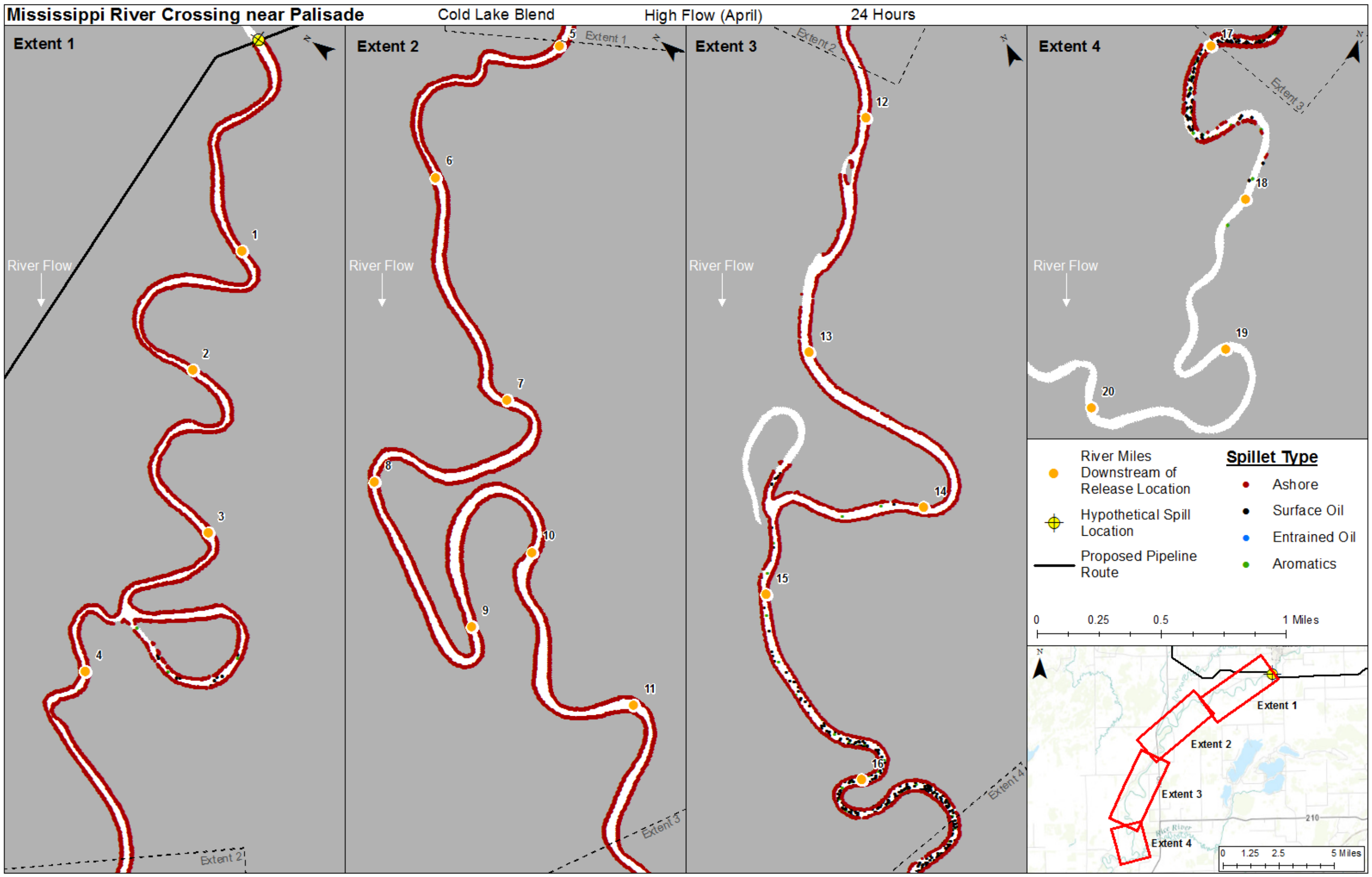

Figure 6-17 Oil Trajectory at 24 Hours for the Release of CLB at the Mississippi River at Palisade Release Location During the High Flow (Spring) Season

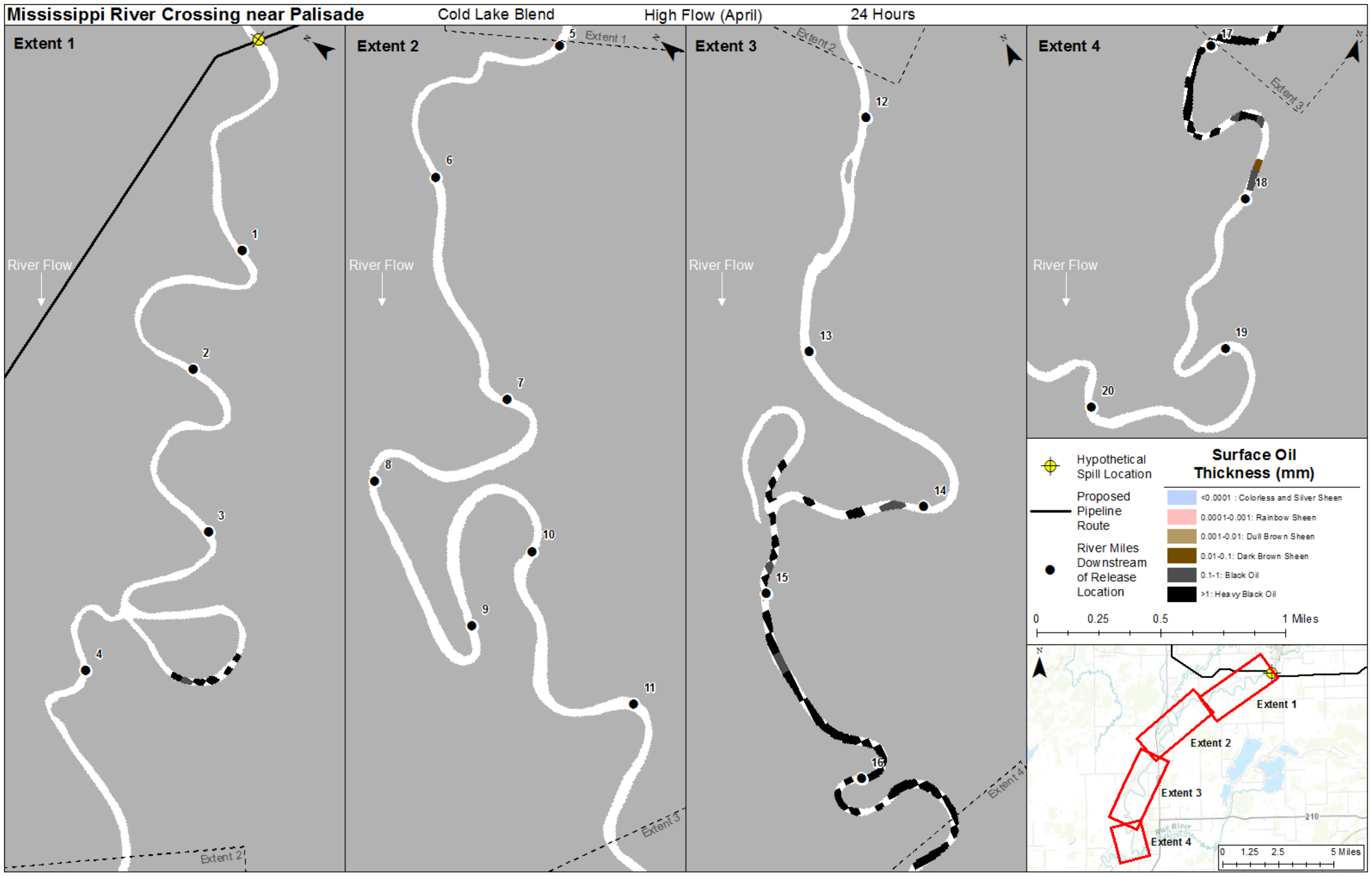

Figure 6-18 Maximum Floating Surface Oil Thickness at 24 Hours for the Release of CLB at the Mississippi River at Palisade Release Location During the High Flow (Spring) Season

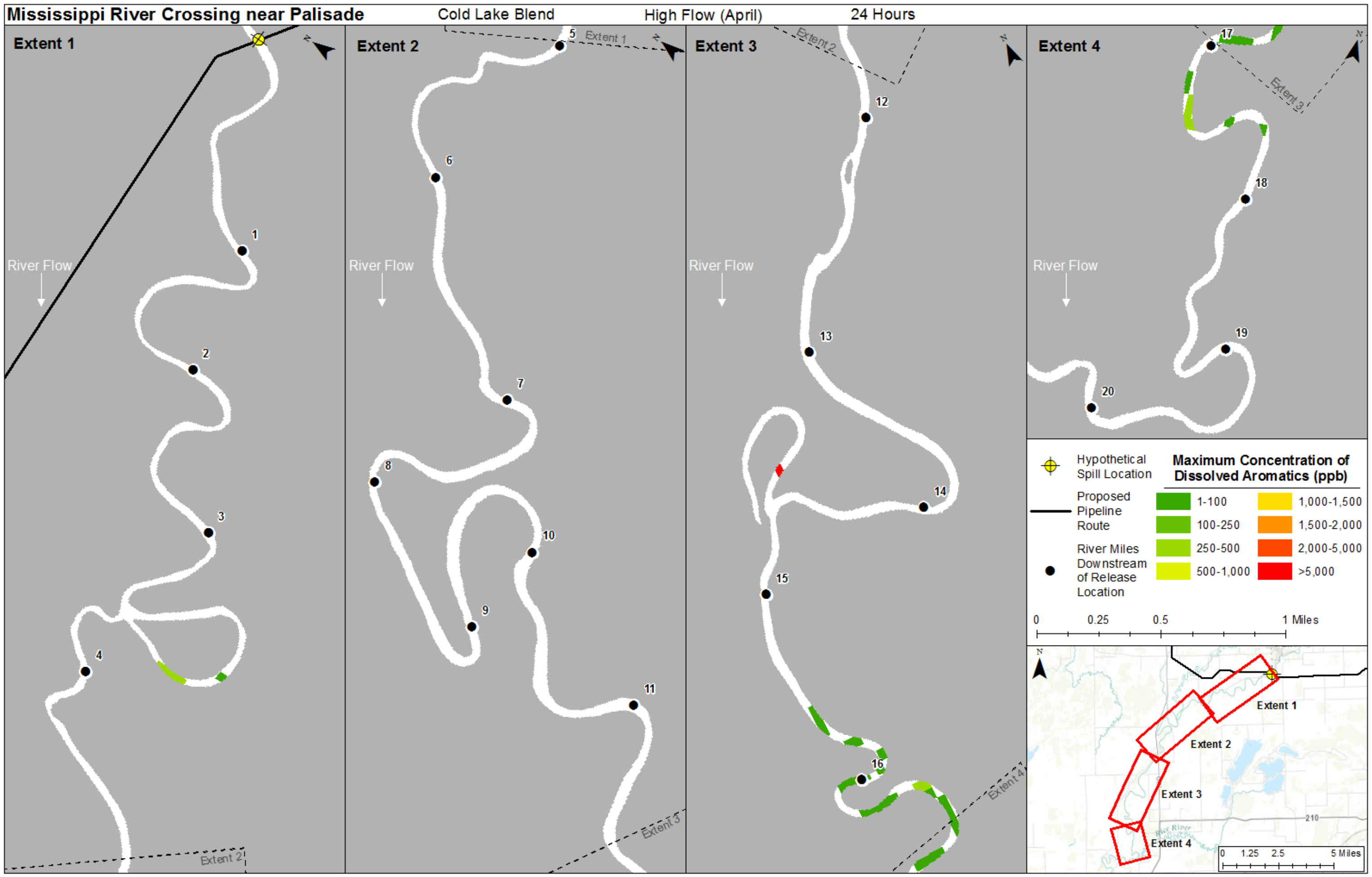

Figure 6-19 Maximum Total Dissolved Aromatic Concentration at 24 Hours for the Release of CLB at the Mississippi River at Palisade Release Location During the High Flow (Spring) Season

Figure 6-20 Maximum Total Hydrocarbon Mass on the Shore and on Sediments at 24 Hours for the Release of CLB at the Mississippi River at Palisade Release Location During the High Flow (Spring) Season

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

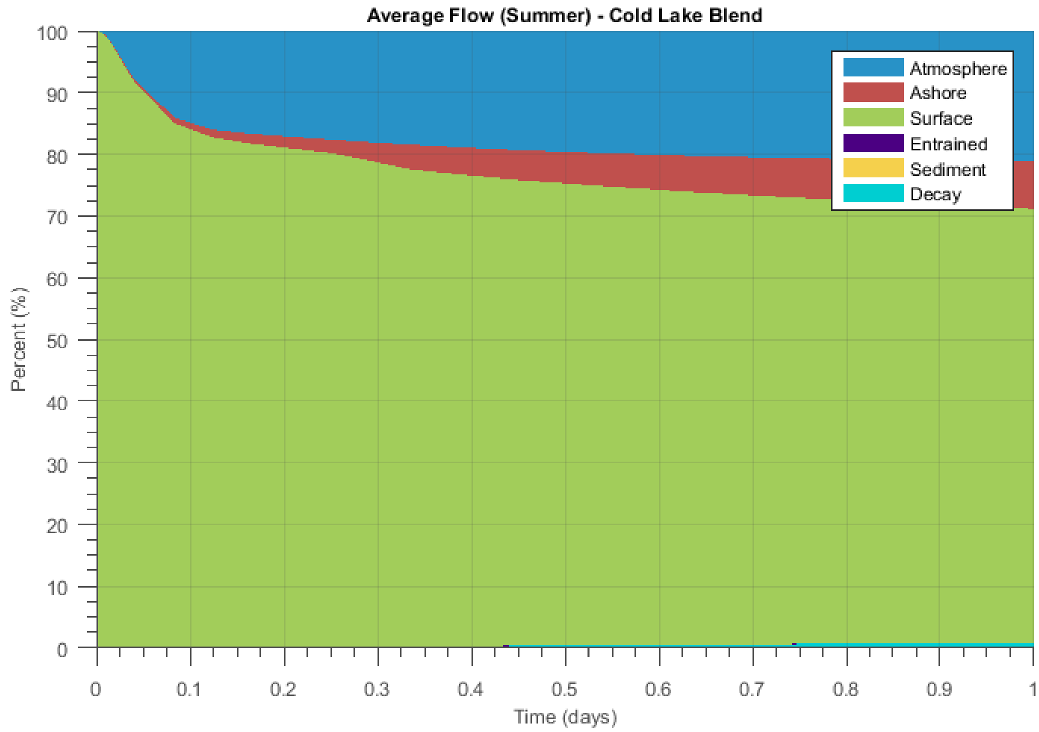

Figure 6-21 Oil Mass Balance Graph for the Release of CLB at the Mississippi River at Palisade Release Location During the Average Flow (Summer-Fall) Season

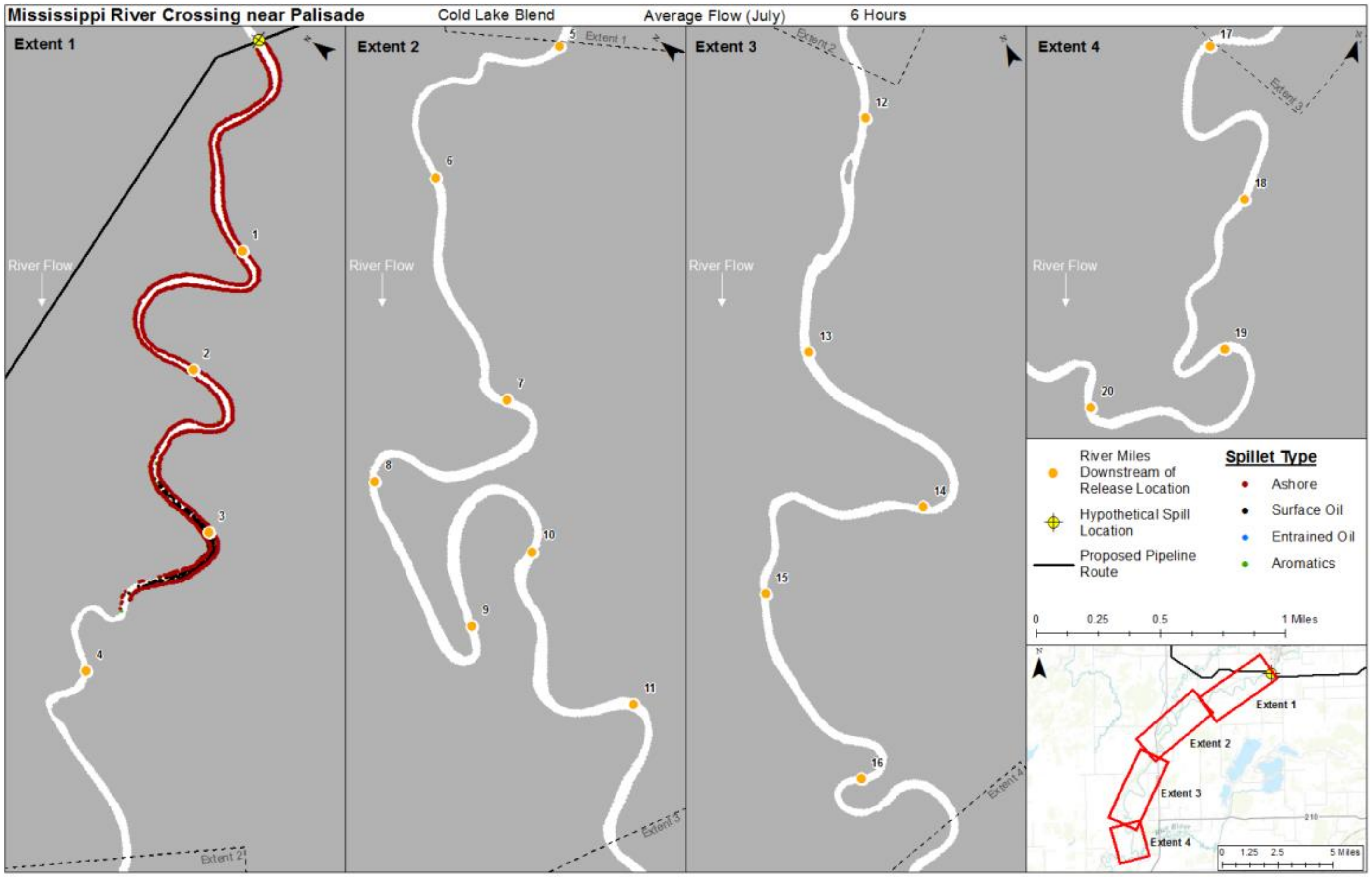

Figure 6-22 Oil Trajectory at 6 Hours for the Release of CLB at the Mississippi River at Palisade Release Location During the Average Flow (Summer-Fall) Season

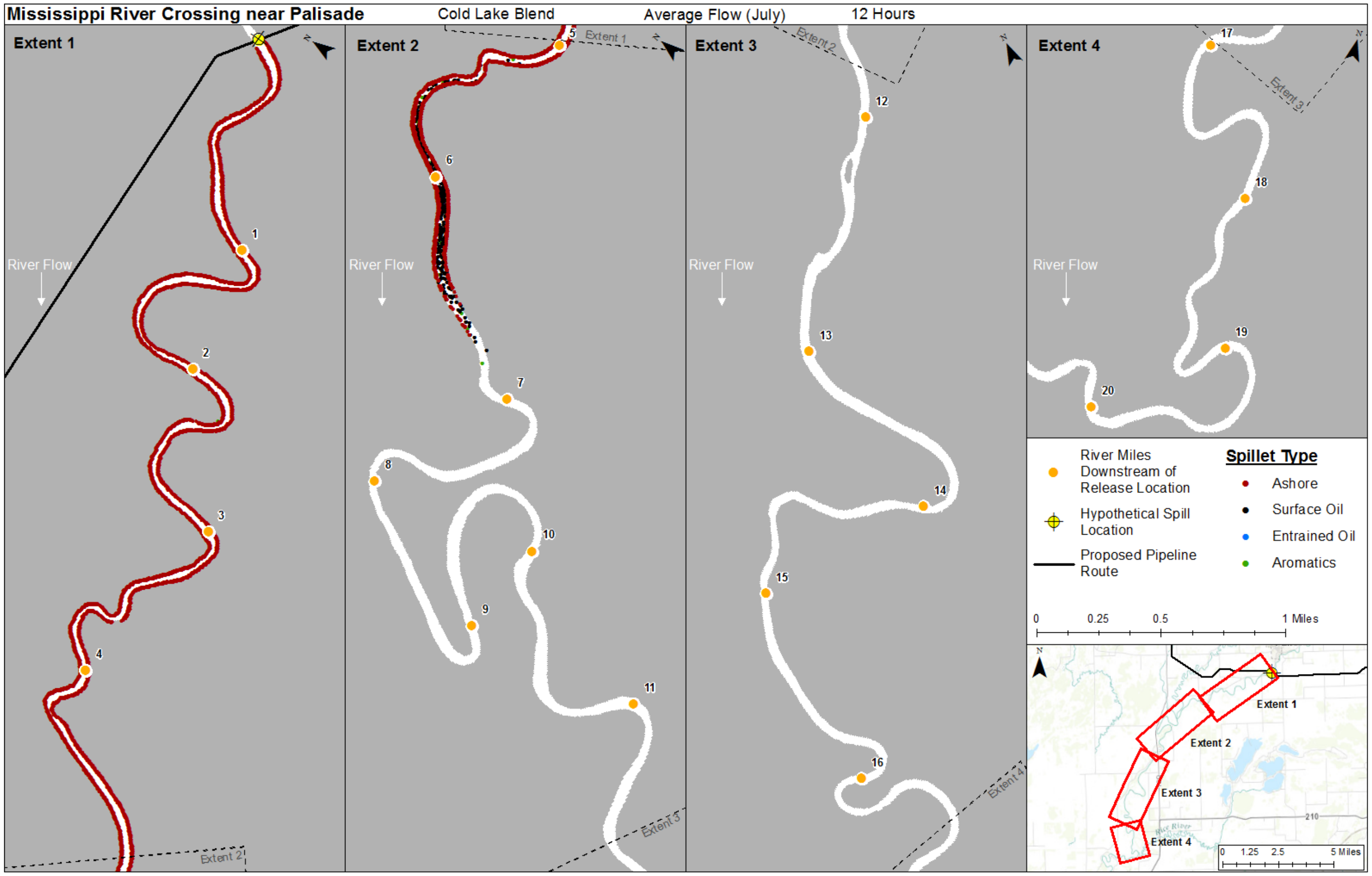

Figure 6-23 Oil Trajectory at 12 Hours for the Release of CLB at the Mississippi River at Palisade Release Location During the Average Flow (Summer-Fall) Season

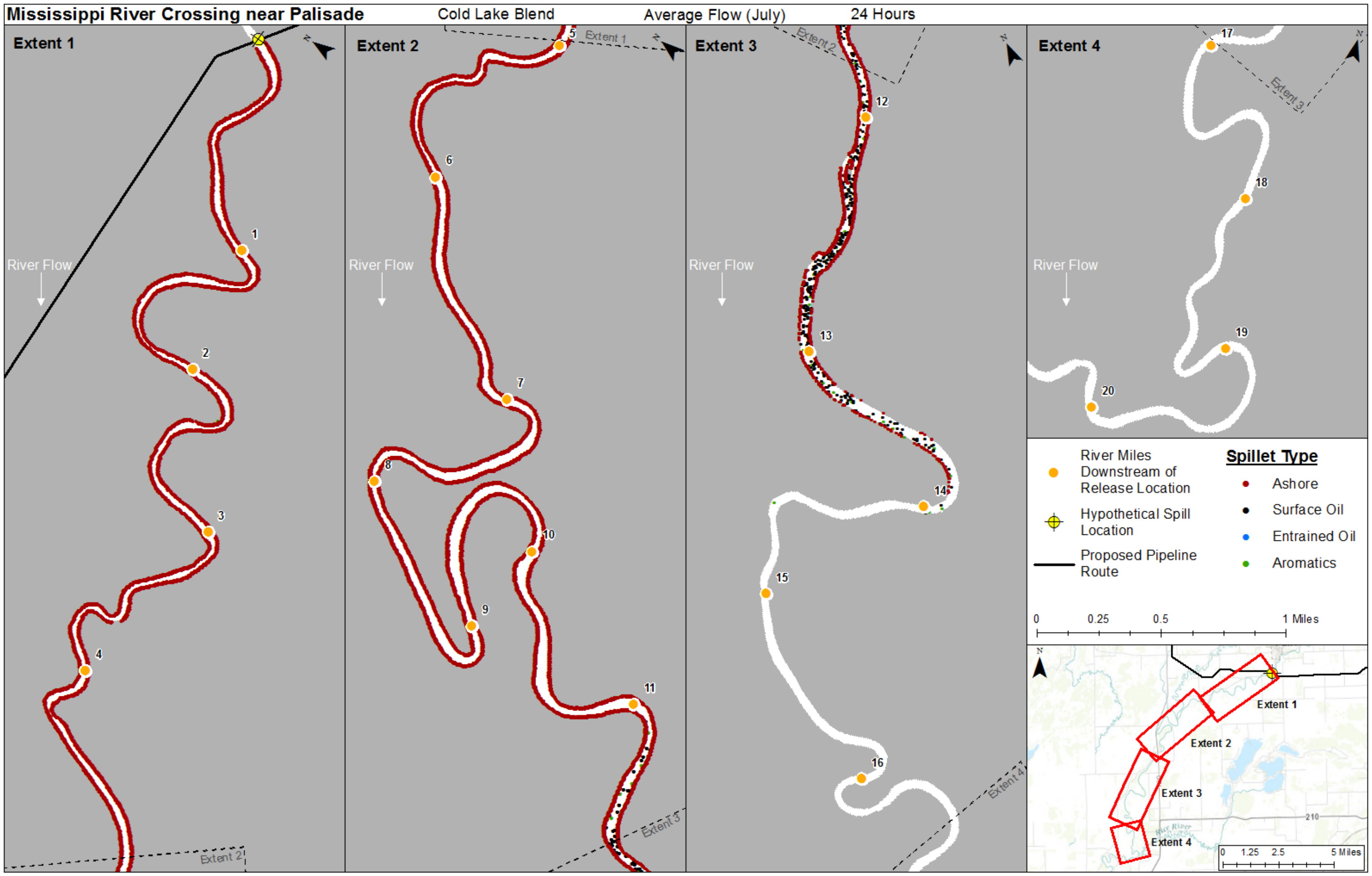

Figure 6-24 Oil Trajectory at 24 Hours for the Release of CLB at the Mississippi River at Palisade Release Location During the Average Flow (Summer-Fall) Season

Figure 6-25 Maximum Floating Surface Oil Thickness at 24 Hours for the Release of CLB at the Mississippi River at Palisade Release Location During the Average Flow (Summer-Fall) Season

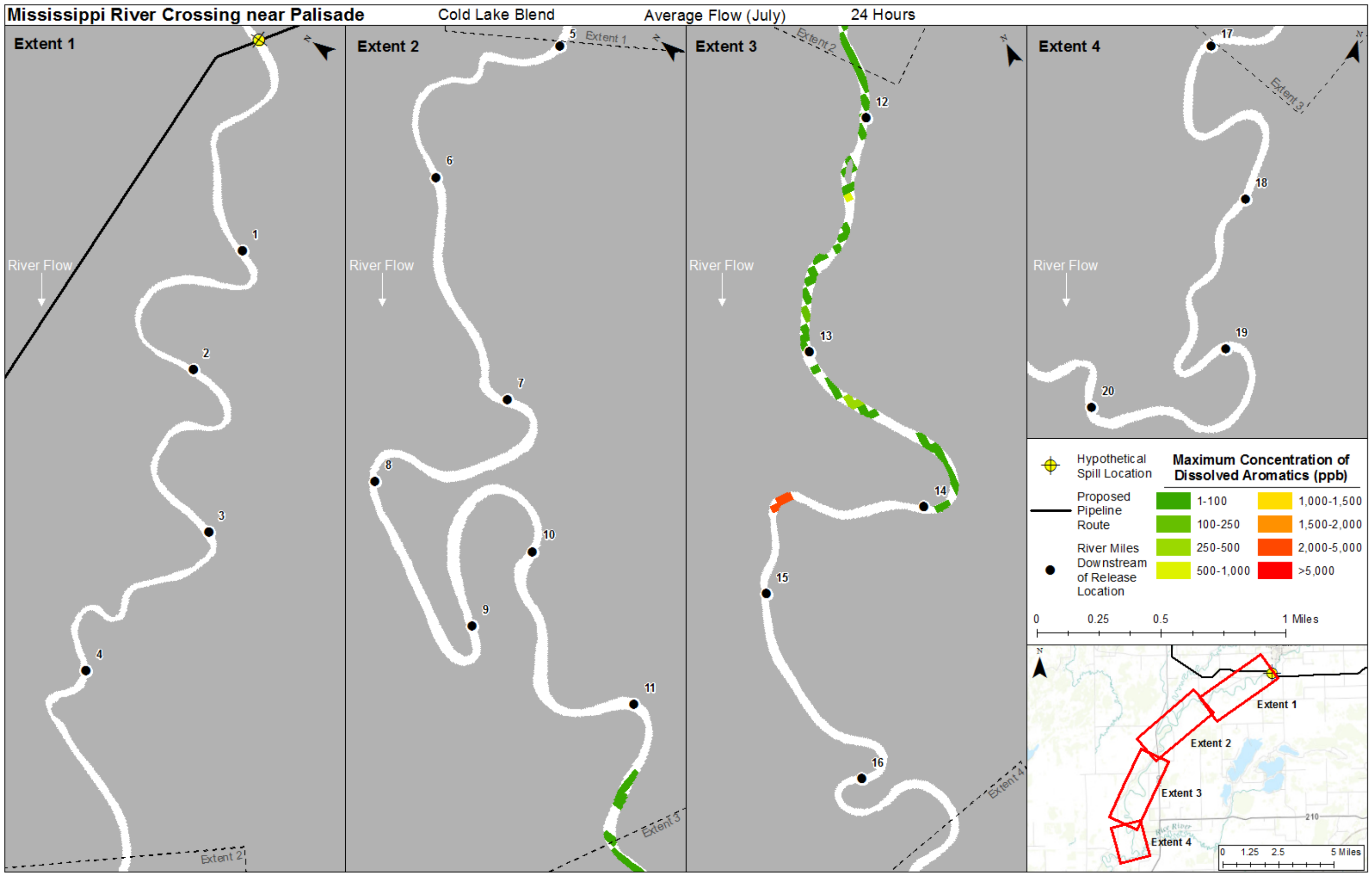

Figure 6-26 **Maximum Total Dissolved Aromatic Concentration on the Shore and on Sediments at 24 Hours for the Release of CLB at the Mississippi River at Palisade Release Location During the Average Flow (Summer-Fall) Season**

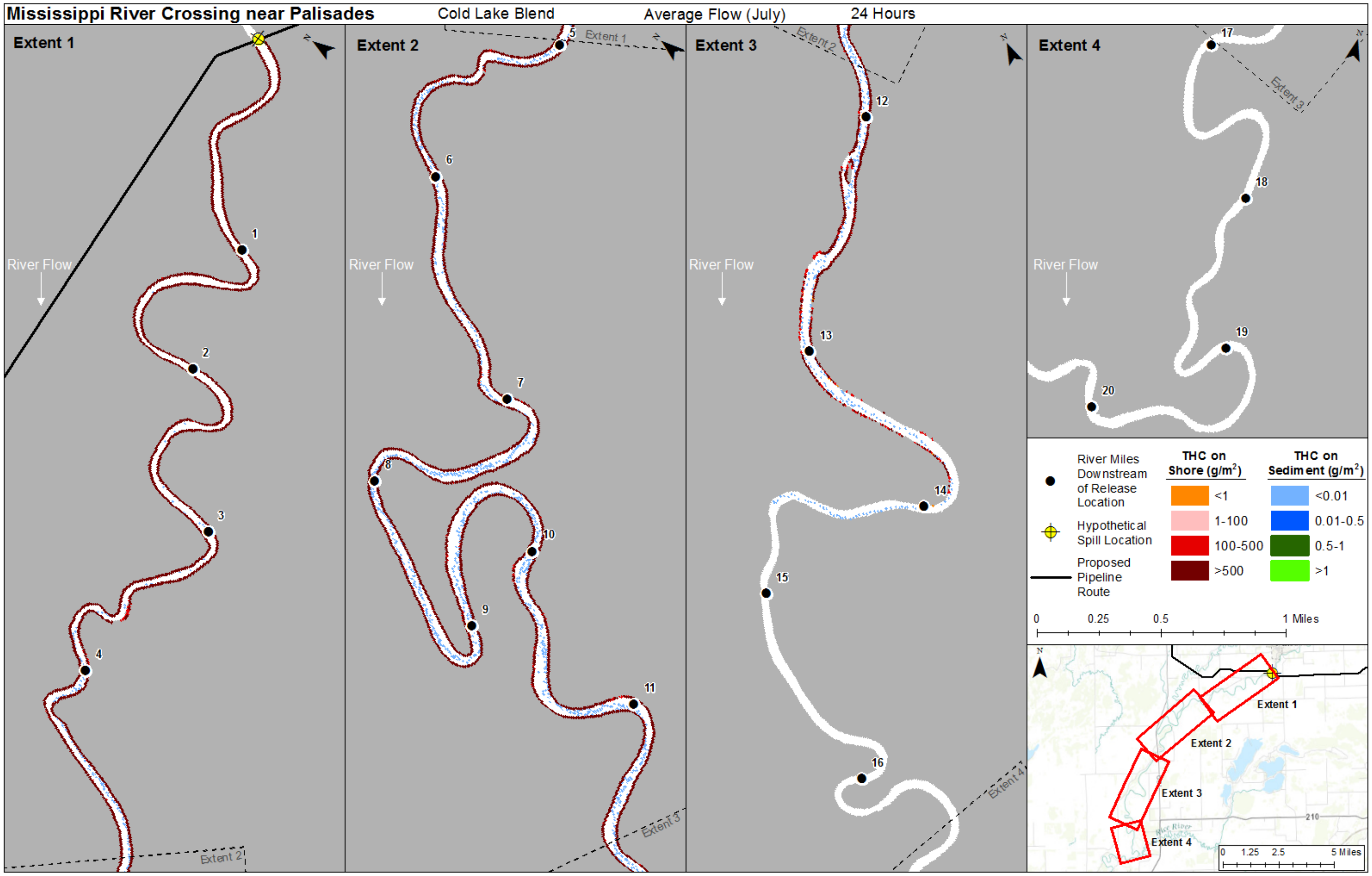

Figure 6-27 Maximum Total Hydrocarbon Mass on the Shore and on Sediments at 24 Hours for the Release of CLB at the Mississippi River at Palisade Release Location During the Average Flow (Summer-Fall) Season

6.2.1.1.3 Trajectory and Fate Results for Low Flow (Winter)

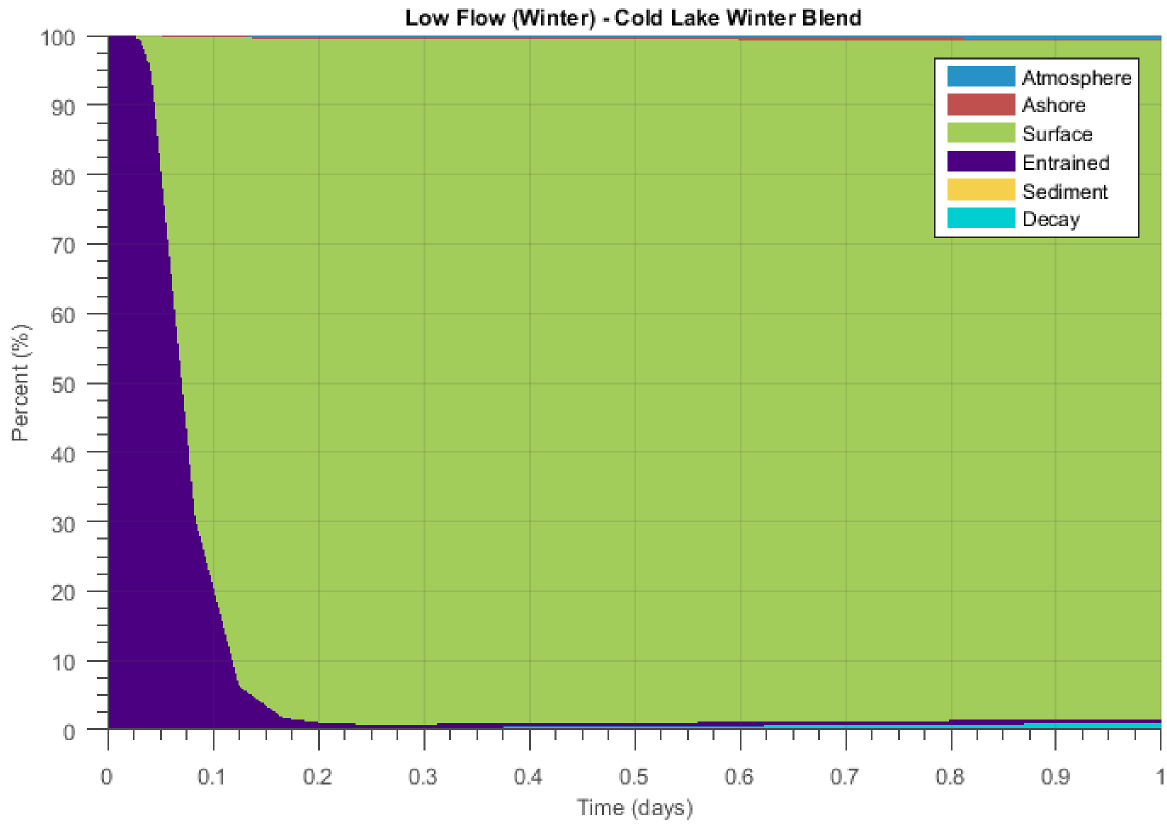

Figure 6-28 Oil Mass Balance Graph for the Release of CLB at the Mississippi River at Palisade Release Location During the Low Flow (Winter) Season

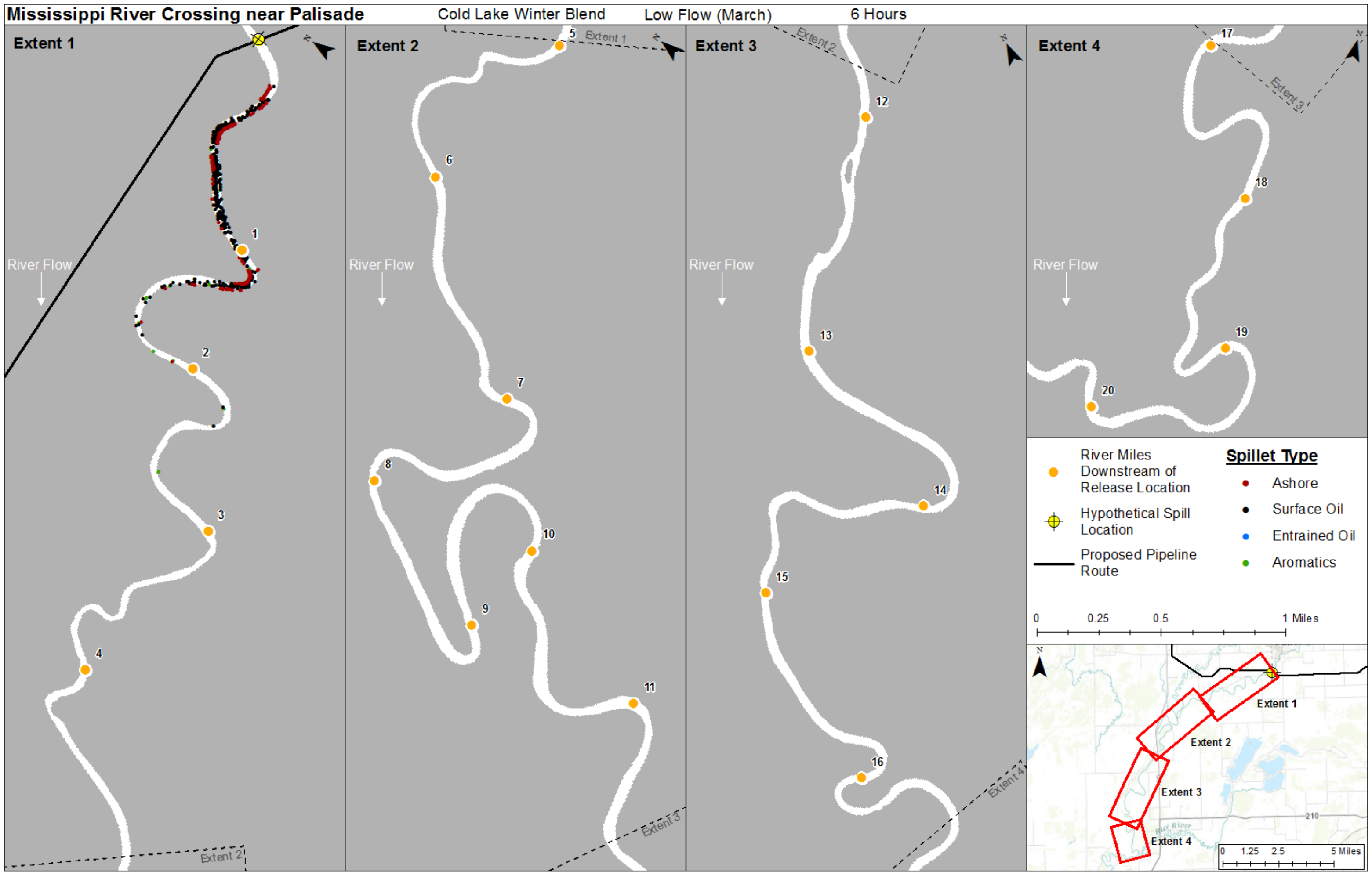

Figure 6-29 **Oil Trajectory at 6 Hours for the Release of CLB at the Mississippi River at Palisade Release Location During the Low Flow (Winter) Season**

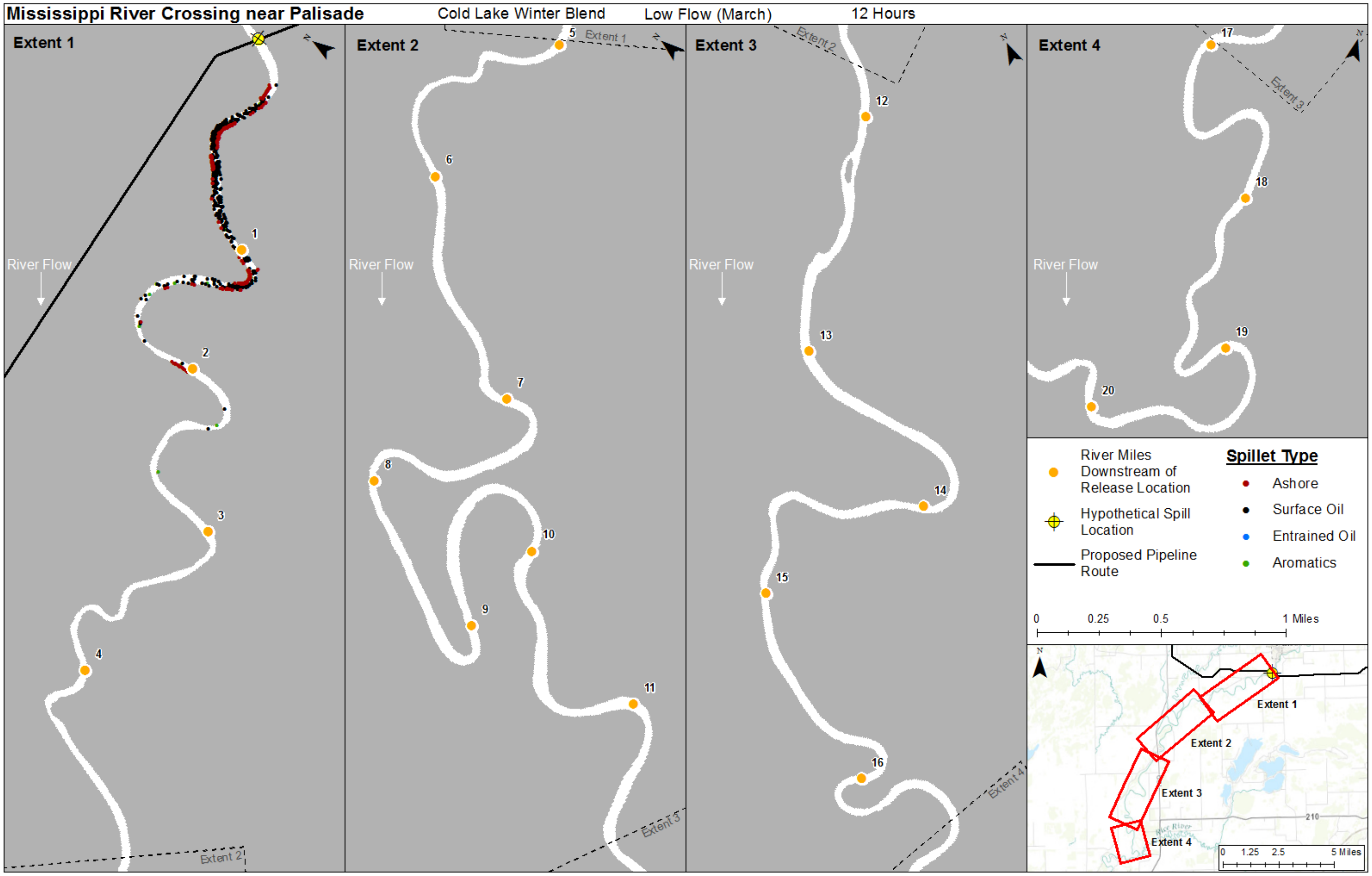

Figure 6-30 Oil Trajectory at 12 Hours for the Release of CLB at the Mississippi River at Palisade Release Location During the Low Flow (Winter) Season

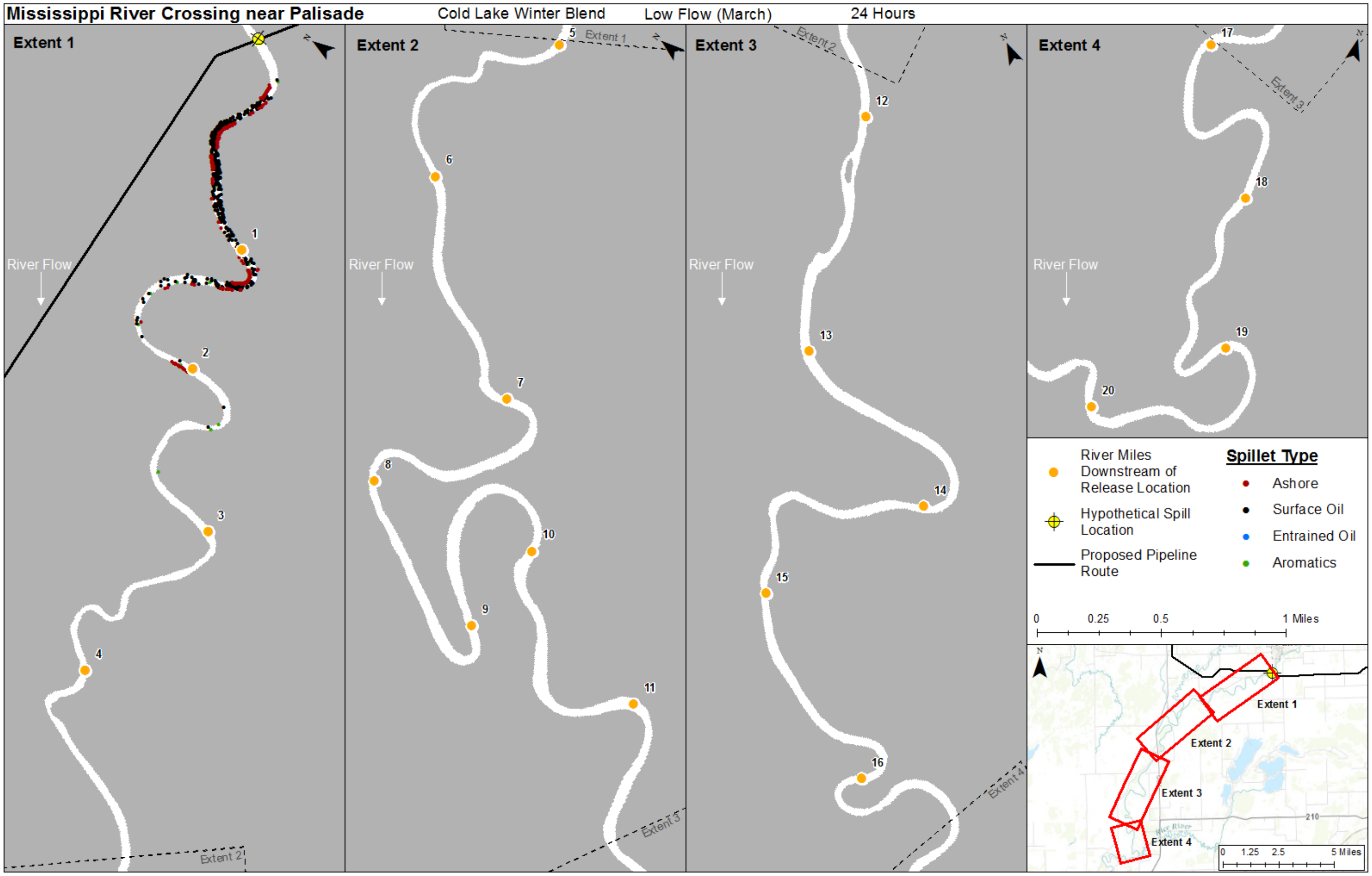

Figure 6-31 Oil Trajectory at 24 Hours for the Release of CLB at the Mississippi River at Palisade Release Location During the Low Flow (Winter) Season

Figure 6-32 Floating Surface Oil Thickness at 24 Hours for the Release of CLB at the Mississippi River at Palisade Release Location During the Low Flow (Winter) Season

Figure 6-33 Maximum Total Dissolved Aromatic Concentration at 24 Hours for the Release of CLB at the Mississippi River at Palisade Release Location During the Low Flow (Winter) Season

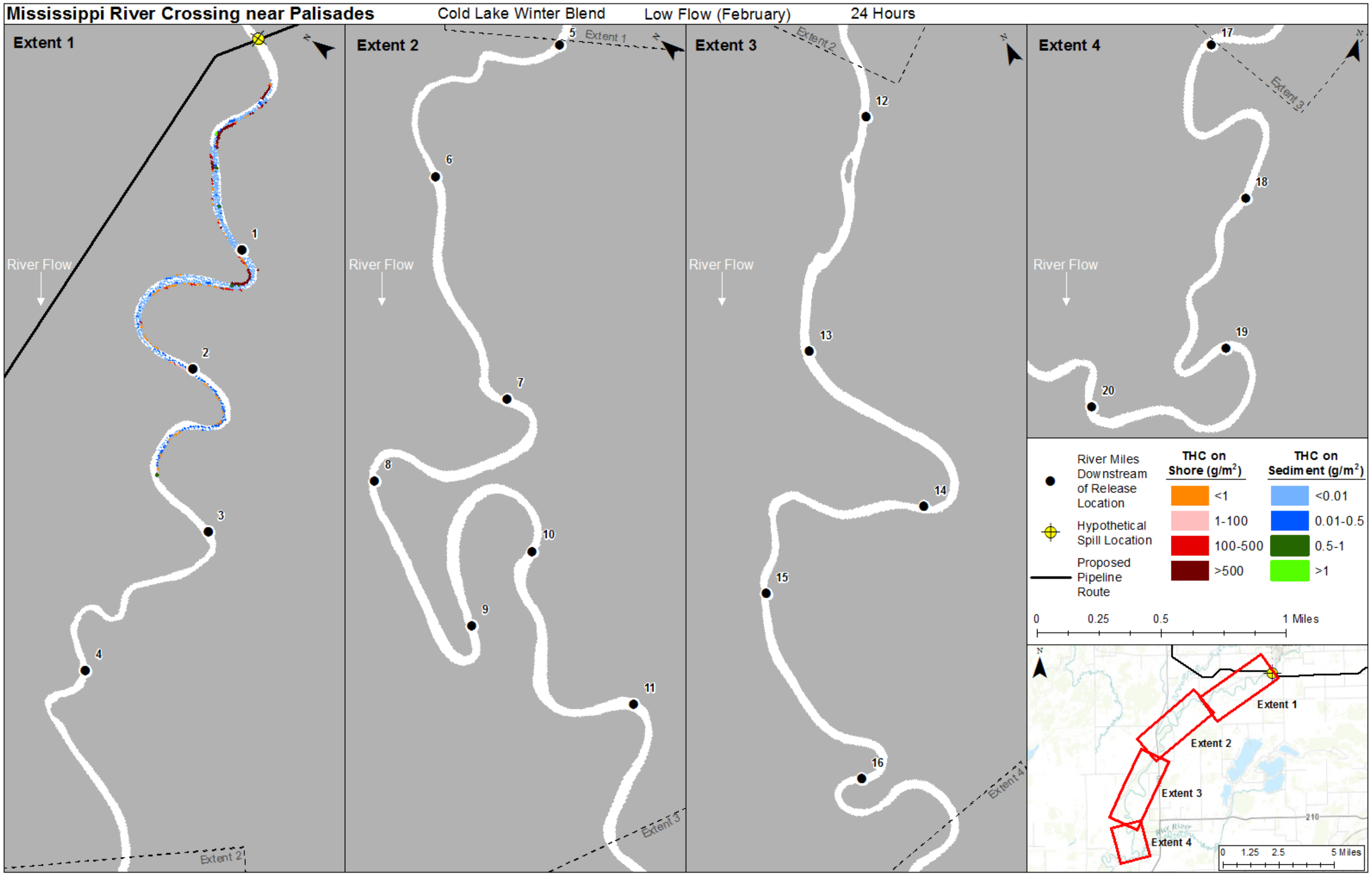

Figure 6-34 Maximum Hydrocarbon Mass on the Shore and on Sediments at 24 Hours for the Release of CLB at the Mississippi River at Palisade Release Location During the Low Flow (Winter) Season

6.2.1.2 Bakken Crude Scenarios

The Mississippi River at Palisade scenarios represent a low energy environment for the SIMAP analysis. Hypothetical releases of Bakken crude at the Mississippi River at Palisade resulted in the same downstream transport as the CLB. This was due to the released oil experiencing the same environmental forcing. Under high flow conditions predicted downstream transport was 4, 8, and 17.5 miles (6.4, 12.8, and 28.2 km) downstream after 6, 12, and 24 hours, respectively (Figure 6-37, Figure 6-38, and Figure 6-39). Under average river flow conditions, the release had a maximum extent of approximately 14.3 miles (23.0 km) after 24 hours (Figure 6-44, Figure 6-45, and Figure 6-46). During low river flows, the majority of the release was trapped at the ice-water interface within 1.5 miles (2.4 km) of the hypothetical release point, while the maximal extent of oil was approximately 2.8 miles (4.51 km) (Figure 6-51, Figure 6-52, Figure 6-53). Any slight differences between the downstream distance of Bakken versus CLB scenarios is the result of the effects of randomized dispersion. This does not significantly affect the downstream distance, but rather the exact location of each Lagrangian element (i.e., discretized spill) at each time step. Table 6-3 provides a summary of the mass balance information at the end of the 24-hour simulation, while Figure 6-35 provides the furthest predicted downstream extent of whole oil.

Table 6-3 Summary of the Bakken Crude (BAK) Mass Balance Information at the Mississippi River at Palisade Release Location at the End of the 24-Hour Simulation [1]

Scenario	Surface (%)	Evaporated (%)	Water Column (%)	Sediment (%)	Ashore (%)	Decayed (%)
BAK—High Flow (Spring)	35.8	52.2	<0.1	<0.1	11.4	0.6
BAK—Average Flow (Summer-Fall)	35.1	55.3	<0.1	<0.1	9.0	0.5
BAK—Low Flow (Winter)	98.7	<0.1	0.2	<0.1	0.1	1.0

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