ENBRIDGE LINE 5 WISCONSIN SEGMENT RELOCATION PROJECT
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Operations Assessment: Oil Spill Report

Enbridge Line 5 Segment
Relocation Project
Wisconsin

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OIL SPILL REPORT
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Preface

RPS Group PLC (RPS) and DNV GL USA, Inc. (DNV) were retained by Enbridge Energy, Limited Partnership (Enbridge) to prepare an operations assessment focused on potential oil spills associated with the Line 5 Wisconsin Segment Relocation Project (L5WSRP). This assessment included a risk assessment that assessed the likelihood of and potential for effects following hypothetical releases of crude oil associated with the L5WSRP. In addition, the assessment included a route alternatives analysis focused on comparing the risks of each pipeline route alternative relative to one another.

Purpose

The purpose of this Oil Spill Report and supporting appendices is to provide quantitative information that contextualizes a preferred route for the L5WSRP as well as an analysis that frames and bounds the risks associated with failures during operation (i.e., the likelihood and potential consequences of an oil spill).

Risk is defined most concisely as the ‘chance of loss’. Accordingly, in the context of the risk associated with L5WSRP, the term ‘risk’ is used as a joint expression of chance (e.g., the probability of incurring a rupture on the Line 5 pipeline) and loss (e.g., the consequences associated with such a rupture).

A probability analysis was conducted to quantify the likelihood of different release volumes that could occur on each of the pipeline routes, with the intent of putting the release volumes used in the consequence assessment into context. A route alternatives analysis of the Existing, Proposed, and Route Alternatives (RA-01, RA-02, and RA-03) used computational oil spill modeling to assess the range of predicted overland and downstream movement of oil following hypothetical releases along each route to quantify susceptible receptors and resources at risk to enable direct comparisons between routes. Finally, a comprehensive oil spill analysis was developed, using state-of-the-art computational oil spill modeling tools, to bound the potential for effects (i.e., consequences) associated with a range of several different accidental release volumes of crude oil and numerous environmental and river flow conditions over the course of the year, for both unmitigated and emergency response mitigated scenarios. These analyses bound the expected and accidental events and types of consequences that could result in a range of magnitudes and extents of potential effects.

Information from this range of modeling at numerous representative sites will be used to bound the potential range of consequences that are predicted across the region under a wide range of environmental conditions. Results can be used to understand the potential for effects that may occur at other locations with similar features among and across the proposed and alternative routes.

This material was prepared to supplement the draft Environmental Impact Statement (DEIS), issued December 2021 by the Wisconsin Department of Natural Resources.

Direction on Technical Work

RPS and DNV (referred to collectively as the Consulting Team) were retained by Enbridge. The Consulting Team was responsible for identifying potential approaches for assessing the risk (as both failure likelihood/probability and potential consequences) of a wide range of hypothetical scenarios. The approach used here was based upon a preferred approach used previously on the Line 3 Replacement Project (L3RP) that was developed in consultation with the Minnesota Department of Commerce, Energy Environmental Review and Analysis (DOC-EERA), who led the assessment, and numerous other state and federal agencies and their consultants that supported them. The Consulting Team used this preferred approach and undertook the technical work under its own direction.

A presentation outlining the technical work associated with this preferred approach was made to the Wisconsin Department of Natural Resources (WDNR) and the United States Army Corps of Engineers (USACE) prior to the work being undertaken. The Consulting Team then prepared this assessment, which was again presented to WDNR, USACE, the Pipeline and Hazardous Material Safety Administration (PHMSA), and the United States EPA (USEPA). Prior to this meeting, comments on the draft assessment were received by Enbridge. In response to these comments, revisions to the draft assessment were undertaken by the Consulting Team, but only where the Consulting Team deemed the changes to be appropriate. The work's technical conclusions were unchanged by the revisions accepted. A final report was prepared by the Consulting Team for final submission to WDNR and USACE.

Funding

Funding for the work undertaken by the Consulting Team was provided by Enbridge.

Authorship

This Operations Assessment was prepared by the Consulting Team. The Technical Lead for each section of the report was as follows:

Report Section	Technical Lead(s) Responsible
Oil Spill Report*	Matt Horn, Ph.D., RPS Hilary Robinson, P.E., RPS
Technical Appendix A: Probability Analysis	Lynsay Bensman, DNV John Godfrey, DNV
Technical Appendix B*: Hydrocarbon Trajectory, Fate, and Effects Assessment	Matt Horn, Ph.D., RPS Lisa McStay, RPS Hilary Robinson, P.E., RPS
Technical Appendix C: Hydrocarbon Route Assessment and HCA Analysis	Matt Horn, Ph.D., RPS Tara Franey, RPS

***Note:** As referenced in the text, Enbridge provided the Consulting Team with clear direction associated with their emergency response capabilities, equipment, contractors, response tactics, control points, and other necessary information for this assessment (outlined in this Report: Section 2.1 and Technical Appendix B: Section 3.10). Enbridge also provided the Consulting Team with an Integrated Contingency Plan (ICP) approved by PHMSA, their Emergency Response Plan (ERP).

Declaration

As the Technical Leads for the Operations Assessment associated with the Line 5 Wisconsin Segment Relocation Project (L5WSRP), we verify that we are responsible for leading and managing the preparation of the chapters of the report, as described in the above table. All technical analysis and all conclusions reflect our work and opinions. Modifications in response to verbal or written comments have not modified the technical aspects and results of our work or our conclusions.

Matt Horn, Ph.D., RPS

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Lisa McStay, RPS

Lynsay Bensman, DNV

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Executive Summary

Enbridge Energy, Limited Partnership (Enbridge) has proposed the Line 5 Wisconsin Segment Relocation Project (L5WSRP) to relocate the existing Line 5 pipeline (Line 5) around the Bad River Reservation ("the Reservation") in northern Wisconsin. This report (the "Oil Spill Report") was prepared by RPS to: (i) provide a probability assessment to quantify the likelihood of different release volumes that could occur on each of the routes; (ii) model the hydrocarbon trajectory, fate, and effects from a suite of release scenarios at certain crossing locations; and (iii) to simulate hypothetical releases along each pipeline route being studied to allow for a comparison of receptors. The quantitative analyses in the Oil Spill Report are laid out in a series of Technical Appendices.

A total of 13,665 hydrocarbon releases were modeled for the proposed pipeline and route alternatives, spanning a wide range of locations, environmental conditions, seasonality, type and volume of release, and emergency response mitigative measures. Together, the spill probability and consequence assessments convey the overall "risk" associated with the pipeline and allow for comparisons between route alternatives and an understanding of the range of potential effects from the Relocation's operation.

KEY POINTS

- Probability of Release is Extremely Remote: The probability of failure (POF) for the Proposed Route is 3.96×10^{-6} failures per mile per year for all release sizes, and 6.34×10^{-8} per mile per year for a Full-bore Rupture (FBR). This is equivalent to the extremely remote probability of a failure occurring somewhere on a given mile of pipe of 1 in 252,000 for any given year and an FBR of 1 in 15,700,000 for any given year. The POF of any size release at the Bad River crossing ranges from 1.25×10^{-7} to 4.59×10^{-7} depending on the route, and at the White River crossing ranges from 2.92×10^{-7} to 8.34×10^{-7} depending on the route. The overall POF for any release at a waterbody crossed by the Relocation is extremely remote, in all cases less than 1 in 6,990,000 in any given year.
- Downstream Movement and Potential for Effects Following a Release are Substantially Reduced by Emergency Response Activities: As modeled, the successful implementation of emergency response mitigation measures following a hypothetical release of oil substantially reduced the downstream progression of oil for even the largest volumes simulated (full bore ruptures of 9,874 bbl on the Bad River and 8,517 bbl on the White River). In these scenarios, between no oil and surface floating oil of a thickness no greater than a patchy and discontinuous dull brown (1-10 μm or microns) or rainbow sheen (0.1-1 μm) were predicted downstream for brief periods of time (less than a few hours). For comparison, a bacterium is 1-10 μm in size, a strand of spider web silk is 3-8 μm, and paper is 70-80 μm thick. Successful containment and collection of released oil would reduce the concentration and duration of exposure to contaminants, which reduced the potential for effects.
- A Route Assessment and Receptor Analysis Comparison, Identified the Proposed Route as Most Favorable: The Proposed Route is considered to be the most favorable route based upon the relatively low number of receptors with the potential for impact following a release, a relatively shorter construction length, and a reduced potential to impact key receptors including the Reservation, wild rice, Lake Superior, and populated areas.

OVERVIEW OF THE ANALYSIS

RPS used a suite of modeling tools to assess numerous hypothetical release scenarios. DNV GL USA, Inc. (DNV) examined the POF of the proposed routes utilizing its proprietary pipeline probabilistic risk model. OILMAPLand and SIMAP are two separate computational oil spill modeling tools that have been developed by RPS to predict the trajectory, fate, and potential acute effects of released hydrocarbons on land and into water. These models have been used extensively in the United States and internationally to assess the potential impacts of oil spills.

Probability Assessment (Technical Appendix A)

- The probability assessment helps contextualize the likelihood of hypothetical spills along each of the route alternatives. Publicly available failure data, as well as DNV's proprietary probabilistic risk model, were utilized to estimate the Probability of Failure (POF) along the mainline pipe for the Proposed Route, as well as each route alternative (RA-01, RA-02, and RA-03). The POF of pipeline failures that would result in hydrocarbon releases at water crossings that were horizontally directional drilled (HDD) crossings as well as open cut water crossings were also calculated.
- For all routes, the POF is extremely remote.
    - It is estimated that the POF, considering all commodities transported, for the Proposed Route of the L5WSRP is $3.96x10^{-6}$ failures per mile per year for all release sizes, and the POF of an FBR is $6.34x10^{-8}$ per mile per year. This is equivalent to the extremely remote probability of a failure occurring somewhere on a given mile of pipe of 1 in 252,000 for any given year and an FBR of 1 in 15,700,000 for any given year.
    - The POF of any size release at the Bad River crossing ranges from $1.25x10^{-7}$ to $4.59x10^{-7}$ depending on the route, and at the White River ranges from $2.92x10^{-7}$ to $8.34x10^{-7}$ depending on the route. The POF of any size release at any other water body crossed by the relocation using a shorter HDD is estimated to be lower than those predicted for these crossings. The POF of a release greater than 334 barrels at the Bad River Crossing ranges from $2.14x10^{-8}$ to $7.85x10^{-8}$ per year depending on route. The POF of a release greater than 334 barrels at the White River Crossing ranges from $4.99x10^{-8}$ to $1.43x10^{-7}$ per year depending on route. The overall POF for any release at a waterbody crossed by the Relocation is extremely remote, in all cases less than 1 in 6,990,000 in any given year.

Hydrocarbon Release Assessments (Technical Appendices B and C)

In Technical Appendices B and C, potential consequences were evaluated by simulating a range of hypothetical release volumes including 334 bbl (recent average release volume, or RARV), 1,911 bbl releases (historical accidental release volume, or HARV), and site-specific FBRs. The HARV was identified based on an analysis of the average release volume since 1985 from all pipelines that carry crude oil on the entire Enbridge Mainline System (PHMSA, 2017). The smaller-volume RARV was identified based on an analysis of release volumes of any reportable size (recorded as >5 gallons or >0.12 bbl) from 2010 to 2019 for all of Enbridge's liquids pipelines and a set of highly conservative assumptions intended to maximize hypothetical release volume. FBR volumes varied by location and route due to location-specific gravitational drain down, with the Existing route having a maximum value of 26,684 bbl, and the Proposed Route having a much smaller maximum value of 13,451 bbl.

Hydrocarbon Trajectory, Fate and Effects Assessment (Technical Appendix B)

- RPS used the SIMAP model to assess the range of downstream movement, behavior, timing, and potential for acute biological effects that may result from a full suite of hypothetical release scenarios where the Proposed Route crosses the Bad River and the White River. In total, a suite of 28 hypothetical release scenarios were evaluated in SIMAP. There was a specific focus on the potential for oil to reach the wild rice habitats in the vicinity of the Kakagon-Bad River Slough Complex and Lake Superior, which are located 22 river miles downstream of the White River crossing of the Proposed Route and 45 river miles downstream from the Bad River crossing.
- Generally, oil was predicted to be transported downstream as a large "slug" of oil that would evaporate quickly (totaling 35-50% of the released volume over the 4-day model simulation) and strand on both shorelines up to their holding capacity, where it would continue to evaporate, degrade, and be subject to Enbridge's Shoreline Cleanup and Assessment Technique (SCAT) program.
- Emergency response mitigation measures would be deployed at pre-identified (but flexible based upon the actual conditions at the time for any real-world event) Control Points on the White River and Bad River that would have the capacity to contain and collect oil.
    - As modeled, the successful implementation of emergency response mitigation measures following a hypothetical release of oil substantially reduced the downstream progression of oil for even the largest volumes simulated (full bore ruptures of 9,874 bbl on the Bad River and 8,517 bbl on the White River). In these scenarios, between no oil and surface floating oil of a thickness no greater than a patchy and discontinuous dull brown (1-10 μm) or rainbow sheen (0.1-1 μm) were predicted for brief periods of time (less than a few hours). For comparison, a bacterium is 1-10 μm in size, a strand of spider web silk is 3-8 μm, and paper is 70-80 μm thick.
    - The amount of oil on the surface of the water was predicted to be reduced to <0.1% of the release volume by the end of the 4-day simulations.
    - This generally prevented slicks from being able to reach the most downstream portions of the Bad River (north of Highway 2). Mitigation activities therefore limited the potential for oil to contact wetlands and wild rice habitats located in these downstream areas. Additionally, because surface oil was removed, downstream surface biological effects were substantially reduced in emergency response mitigated scenarios.
    - In a real-world response, any remaining surface oil sheens would further be addressed by an additional barrier (e.g., set up at Highway 2), which would allow for additional containment and skimming resources to be deployed, as well as additional tactics that were not modeled to minimize sheens (e.g., sorbents, pads, X-Tex fabric, pom-poms, etc.) and help capture submerged oil droplets.
- All scenarios (unmitigated and response mitigated) considering the smaller, though still conservatively large, release volumes of 334 bbl and 1,911 bbl at the Proposed Route crossings of the Bad and White Rivers were predicted to prevent whole oil (i.e., the insoluble fraction) from reaching the wild rice areas, Kakagon-Bad River Slough complex, and Lake Superior.
- Highly unrealistic unmitigated scenarios were modeled to illustrate baseline conditions where no response activities were considered or undertaken at all for a 4-day simulation. These artificial results provide hypothetical maximum extents of oil transport and contamination to provide a comparative

basis to assess the benefits of emergency response mitigation measures (e.g., reduced magnitude and extent of contamination, increased timing or prevention of contamination, and reduced potential for effects).

  - For these completely unmitigated scenarios in both the White River and Bad River, oil was predicted to take approximately 2 days, 3 days, or 4 days following a release for oil to reach Lake Superior under high, average, and low (wintertime, ice-covered) river flow conditions, respectively. Following a release, actual response mitigation activation would (as was modeled for the mitigated scenarios) begin at the pre-identified Control Points within 3.1 to 11 hours on the Bad River and 3.8-9.8 hours on the White River, based on Enbridge's maintained cache of available response equipment and tactics and conservative assumptions about the time needed to notify and activate trained responders, transport equipment and personnel and set up an active Control Point with containment and collection.

- Biological effects were assessed in SIMAP using the predicted trajectory and fate of hydrocarbon contamination to use the spatially and time-varying concentrations and duration of exposure to determine acute mortality following a release.

- Most of the surface and shoreline effects were predicted to occur in upstream areas, closer to the release locations, where the surface oil slicks were thickest and more continuous and caused the greatest potentials for shoreline exposure as well. From a risk perspective, following a release of oil, the largest consequences (i.e., greatest predicted magnitude, extent, and potential for biological effects) were associated with the lowest probability (i.e., least likely) spill volume (i.e., FBR releases) during unfavorable environmental conditions, where the spill was unrealistically allowed to continue for four days without any emergency response mitigation measures. Predicted effects were substantially reduced for smaller volume releases (more likely events, while still being unlikely) and when response mitigation was included at pre-arranged locations from Enbridge's emergency response plans (a more likely scenario than a completely unmitigated release). The most likely (and lowest consequence) release volumes (i.e., less than 10 bbl) were not assessed in this study.

Hydrocarbon Route Assessment and HCA Analysis (Technical Appendix C)

- RPS conducted a comparative ranking assessment of pipeline routes based upon high consequence areas (HCAs) and other areas of interest (AOIs) for each route alternative.

- A total of 10,088 hypothetical crude oil releases were simulated in OILMAPLand. This included 5,029 larger, FBR releases under high river flow conditions and 5,029 smaller, RARV releases under low river flow conditions. The hypothetical releases were simulated at 100-meter increments (and at every watercourse crossing) along each pipeline route to assess the overland and downstream movement and behavior of oil. Results of these simulations were used to determine whether specific receptors of concern (HCAs and AOIs) within the Project Area, would potentially be reached by any release. These results allowed for a direct comparison of routes to one another, based upon the numbers of susceptible receptors that have the potential to be impacted following a release and the total length of pipeline that may result in these impacts. The FBR analysis presented a conservative basis for assessing the upper range of susceptible resources (HCAs and AOIs), relevant for routing decisions, while the RARV analysis presented a lower range of potential impacts, relevant to contextualize more limited transport potential for smaller volume releases under lower river flow conditions.

  - The Proposed Route was considered the most favorable route based upon the relatively low number of receptors with the potential for impact following a release, a relatively shorter construction length, and a reduced potential to impact key receptors including the Reservation, wild rice, Lake Superior, and populated areas.
  - RA-02 was considered unfavorable because it had the highest-ranking score, which means that relative to the other routes, it had the highest potential to impact the largest number of HCAs and AOIs following a release along the pipeline.
  - RA-01 had the lowest overall ranking score. Although the route became less favorable when further consideration and weighting was applied for specific downstream receptors including the Reservation, wild rice areas, and Lake Superior, to which RA-01 is the closest route alternative.
  - RA-03 was considered unfavorable because of guaranteed and potential impacts to HCAs and AOIs. While the route alternative is outside of the Bad River watershed, potential impacts move to previously untouched HCAs and AOIs including populated areas, the largest number of wild rice areas outside the Reservation, and numerous State and Federal Lands (e.g., state forest and fishery areas, large portions of the Chequamegon-Nicolet National Forest, and the Saint Croix National Scenic Riverway). RA-03 also has the longest overall length of pipeline, which would 1) increase the likelihood of a release, 2) maximize the potential land surface susceptible to a release, 3) increase the total receptors that may be affected, and 4) maximize the guaranteed effects from construction activities including 86.5 km (53.7 mi or 52.3% of RA-03 total length) within the Chequamegon-Nicolet National Forest, because it would require the longest length of new pipe installation (163.4 km or 101.5 miles).
  - RA-03 has the longest overall length among the route alternatives, followed by RA-02, the Proposed Route, and finally RA-01, which would be the shortest
- A total of 3,579 additional hypothetical FBR crude oil releases were simulated in OILMAPLand. The hypothetical releases were simulated at 10-meter increments from the banks of the Bad River and White River inland for each route alternative crossing. This high-resolution segment analysis was conducted to determine the total length of pipeline at specific watercourse crossings that would have the potential for FBR releases to enter that crossing directly. The length of the potential impact segment for releases that reached the river at each crossing varied from 90-600 meters (295-1969 ft; sum of left bank and right bank) and was used in the Probability Assessment to determine the likelihood of a release at each watercourse crossing.

Contents

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List of Acronyms and Abbreviations

3D: Three dimensional, referring to the vertical and horizontal, as in x, y, and z directions

AL: In modeling terms, the aliphatic portion of the total hydrocarbon is modeled as a volatile but insoluble fraction within the SIMAP model and can therefore evaporate but will not dissolve.

AOI: Area of Interest

AR: In modeling terms, the aromatic portion of the total hydrocarbon is modeled as a volatile and soluble fraction within the SIMAP model and can therefore evaporate and dissolve.

ASCE: American Society of Civil Engineers

ASME: American Society of Mechanical Engineers

BAOAC: Bonn Agreement Oil Appearance Code

BBL: Barrel

BFGRID: a boundary fitted grid using an unstructured conforming grid for modeling that was developed by RPS

BFHYDRO: Boundary Fitted Hydrodynamic model, a boundary fitted hydrodynamic model developed by RPS

BFMASS: Boundary Fitted Mass Transport model, a single constituent mass transport model that was developed by RPS

BFWASP: Boundary Fitted Eutrophication Model, an eight-state variable water quality, eutrophication model that was developed by RPS

BTEX: Benzene, toluene, ethylbenzene, and xylene

CERC: Coastal Engineering Research Center

CERCLA: The U.S. Superfund or Comprehensive Environmental Response, Compensation, and Liability Act of 1980

CFR: United States Code of Federal Regulations

cm: centimeter

CNW: Commercially Navigable Waterways

COZOIL: Coastal Zone Oil Spill Model

cP: Described as a unit of dynamic viscosity, centipoise is the amount of force necessary to move a layer of liquid in relation to another liquid. Centipoise is considered the standard unit of measurement for fluids of all types. It is one hundredth of a poise, or one millipascal-second (mPa·s).

CP: A Control Point is a pre-defined location where emergency response activities may be undertaken to contain, collect, and/or remove oil in the event of a release. While they are specified ahead of time for emergency response and preparedness planning, other locations may be used in the event of a real-world release.

CUDEM: Continuously Updated Digital Elevation Model

DEIS: Draft Environmental Impact Statement

DEM: Digital elevation model

DHC: Dissolved hydrocarbon concentrations

DOC: Dissolved Oxygen Content

DSD: Droplet Size Distribution

DW: Drinking water

EA-100: Equivalent areas of 100% acute mortality. The SIMAP model uses concentration and duration of exposure to determine acute mortality within regions and by behavior group. While 100% mortality may be experienced in some localized regions, it is more likely that areas would experience only partial effects (e.g., 10% mortality). Because each simulation may have different trajectories (i.e., extents), concentrations, durations of exposure, and resulting mortality, the EA-100 is used to normalize predicted acute mortality between scenarios. The EA-100 would be the same (1 km^2) for a release that resulted in 100% mortality over 1 km^2, 1% mortality over 100 km^2, or 20% mortality over 5 km^2.

EIS: Environmental Impact Statement

Enbridge: Enbridge Energy Limited Partnership

EPA: Environmental Protection Agency

EROM: Extended Unit Runoff Method

ESA: Environmentally Sensitive Area

ESRI: Environmental Systems Research Institute

FBR: Full-bore rupture

ft: feet

g/cm^3: gram per cubic centimeter

GFS: The Global Forecast System (GFS) is a weather forecast model produced by the National Centers for Environmental Prediction (NCEP).

GIS: Geographic Information Systems

GPM: Gallons per minute

HARV: Historical accidental release volume

HCA: High Consequence Areas

HDD: Horizontal Directional Drill

HPA: High population area

H_2S: Hydrogen sulfide

ICP: Integrated Contingency Plan

km: kilometer

L5WSRP: Line 5 Wisconsin Segment Relocation Project

LC50: The lethal concentration at which 50% of exposed organisms will die, for a specified duration of exposure.

LiDAR: Light Detection and Ranging

m: meter

m^3: cubic meter

MAH: Monocyclic aromatic hydrocarbons (monoaromatic), with only one six-carbon ring

MAOP: Maximum Allowable Operating Pressure

mph: miles per hour

mg/kg: milligram per kilogram

MT: Metric ton

NCEP: National Center for Environmental Prediction

NED: National Elevation Database

NGL: Natural gas liquid

NHD: USGS National Hydrography Dataset

NHDPlus: EPA National Hydrography Plus Dataset

NLCD: The United States Multi-Resolution Land Characteristics Consortium (MRLC) National Land Cover Database

NOAA: United States National Oceanic and Atmospheric Administration

NRC: United States National Research Council

NRDA: Natural Resource Damage Assessment

NRDAM/CME: Natural Resource Damage Assessment Model for Coastal and Marine Environments

NRDAM/GLE: Natural Resource Damage Assessment Models for Great Lakes Environments

OilToxEx: Oil toxicity exposure model

OMA: Oil mineral aggregates

OML: OILMAPLand, an overland oil spill trajectory and fates model developed by RPS.

OPA: Oil particle aggregates

OSRO: Oil Spill Removal Organization

QA/QC: Quality Assurance / Quality Control

PAH: Polycyclic aromatic hydrocarbons (polyaromatic), with two or more six-carbon rings

PHMSA: Pipeline and Hazardous Materials Safety Administration

POF: Probability of Failure

PPM: Parts per million, as referring to concentration. Roughly equivalent to mg/L.

QSAR: Quantitative Structure Activity Relationship

RA: Route Alternative

RARV: Recent average release volume

ROW: Right-of-Way

RPS: RPS Group PLC

SCAPA: Subcommittee on Consequence Assessment and Protective Action

SCC: Stress Corrosion Cracking

SIMAP: Spill Impact Model Application Package, a 3D trajectory, fate, and effects model developed by RPS

SPM: Suspended particulate material

SVR: Small volume release

THC: Total hydrocarbon concentration

The Tribe: Bad River Band of the Lake Superior Tribe of Chippewa Indians

TNC: The Nature Conservancy

TPAH: Total Polycyclic Aromatic Hydrocarbons

TPH: Total Petroleum Hydrocarbon

TSS: Total suspended solids

µg/L: microgram per liter

USACE: United States Army Corps of Engineers

USEPA: United States Environmental Protection Agency

USCG: United States Coast Guard

USFWS: United States Fish and Wildlife Service

USGS: United States Geological Survey

WBD: National Watershed Boundary Dataset

WDNR: Wisconsin Department of Natural Resources

WQMAP: Water Quality Management and Analysis Package – a modeling package that contains the BFHYDRO gridding capabilities for hydrodynamic modeling developed by RPS.

1 INTRODUCTION

Enbridge Energy, Limited Partnership (Enbridge) has proposed the Line 5 Wisconsin Segment Relocation Project (L5WSRP), which is designed to relocate the existing Line 5 pipeline (Line 5) around the Bad River Reservation (Reservation) in northern Wisconsin to a more southerly route in Ashland, Bayfield, Douglas, and Iron Counties, Wisconsin. The draft Environmental Impact Statement (DEIS) for L5WSRP, which was prepared by the Wisconsin Department of Natural Resources (WDNR, 2021), provided a high-level analysis of potential environmental impacts from the Proposed Route of the pipeline and three Route Alternatives (RA-01, RA-02, and RA-03). This report (Oil Spill Report) seeks to supplement the DEIS with a set of quantitative analyses aimed at understanding:

- the likelihood of releases and the potential release volumes associated with them,
- the regions that may be susceptible to adverse effects following any hypothetical release of crude oil, and how this compares between various route alternatives, and
- the movement and behavior of numerous hypothetical crude oil release scenarios under a range of geographic and environmental conditions with varying degrees of emergency response to bound the range of contamination and potential for effects following a release.

These quantitative analyses were performed using a variety of computational modeling approaches that were used to assess the range of potential effects associated with accidental releases of oil along the pipeline, including numerous hypothetical releases along the Proposed Route and Route Alternatives. These varied analyses bound the types of consequence and magnitudes of effects that could result from discharges occurring along the proposed pipeline alternatives, depending on the environmental conditions, seasonality, and location, type, and volume of the release. These consequence analyses quantified the range of movement, behavior, and potential for effects following a full range of hypothetical releases. A probability assessment was also conducted to quantify the likelihood of spills of different volumes that might be expected to occur on each of the pipeline routes. Together, these spill probability and consequence assessments convey the overall “risk” associated with the pipeline and allow for comparisons between route alternatives, and an understanding of the potential effects, which can be used to enhance the DEIS.

The existing Line 5 is a 76 cm (30 in) diameter underground pipeline that was designed to transport hydrocarbon products approximately 1,038 km (645 mi), from Superior, WI to Sarnia, Ontario, Canada. The pipeline has been in operation for nearly 70 years and currently carries light crude oil, natural gas liquids (NGLs), and light synthetic crude oils (Enbridge, 2018a). The Proposed Route and each route alternative of the relocation project would divert a small portion of the Line 5 pipeline from the existing route through the Reservation and instead route the pipeline from a starting point west of the Reservation, south around the Reservation, and then back to the north to reconnect at another point farther east in Iron County. Depending on the route alternative, the relocation would involve the construction of between 50.5 km (31.4 mi) and 163.4 km (101.5 mi) of new pipeline. Depending on the route alternative, the relocation would therefore add between 24 km (15 mi) to 60 km (37 mi) to the total pipeline length. The relocated pipeline would carry the same products to the same ultimate Line 5 destination in Sarnia, Ontario, Canada. The Proposed Route and alternate routes RA-01 and RA-02 are all designed to bypass the Reservation to the south, and pass instead through the upper portions of the Bad River watershed. The much longer route alternative RA-03 would start farther west, travel farther south, and rejoin the existing line farther east, and would bypass the Bad River watershed entirely (Figure 1-1).

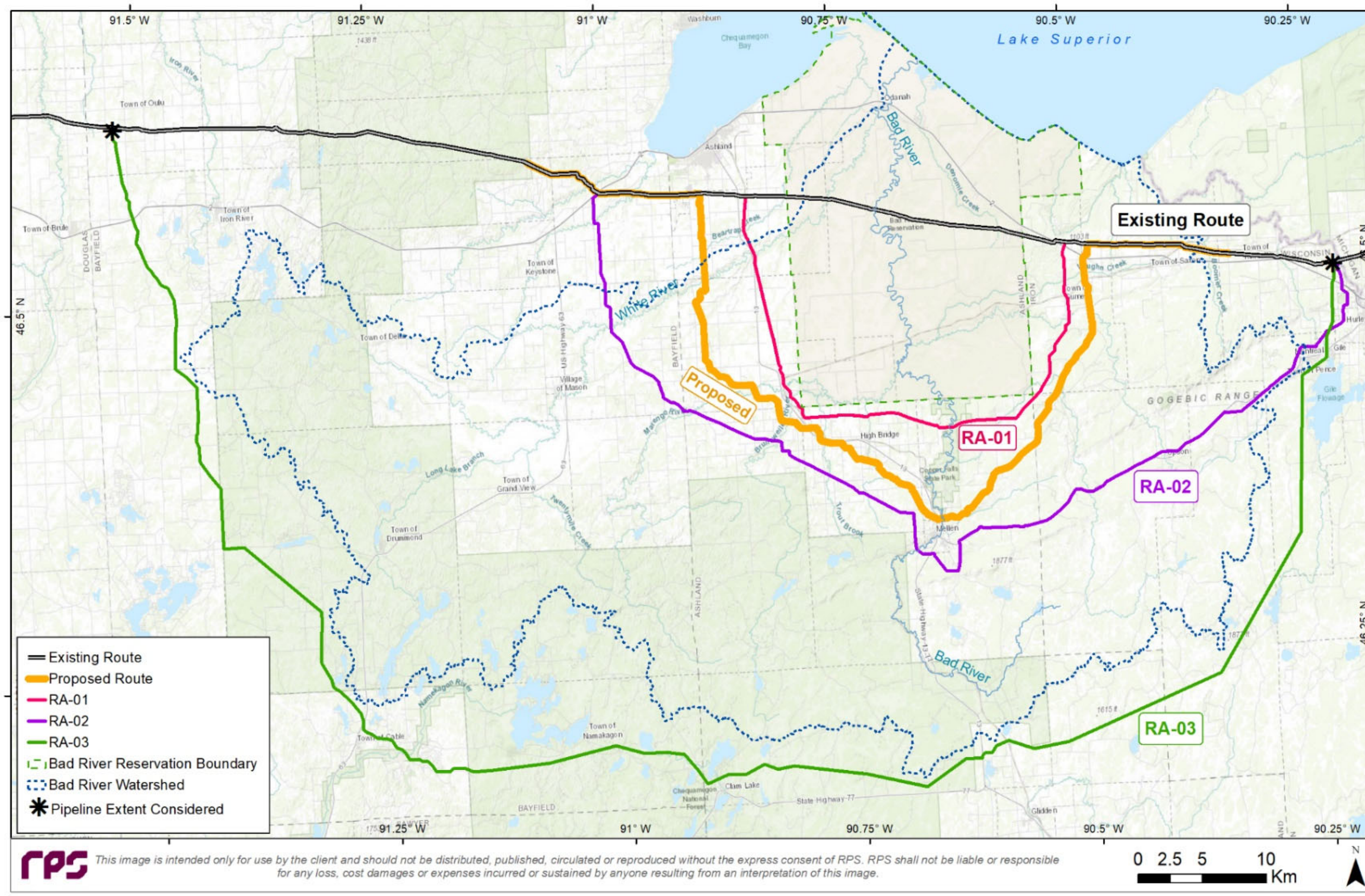

Figure 1-1. Map of proposed and alternative Enbridge Line 5 routes in the DEIS.

1.1 Purpose and Scope

Enbridge retained RPS to assist with its response to the DEIS and to contribute to further development of quantitative analyses of risk associated with the Proposed Route and Route Alternatives of Line 5 to inform decision makers about the proposed L5WSRP. The primary purpose of this Oil Spill Report is to provide information related to the operational risks associated with oil spills on the planned route alternatives along the L5WSRP. The intent is to quantify risk from several different perspectives, in order to enable one to make an informed decision about which route may be preferred. Risk is defined most concisely as the 'chance of loss.' Accordingly, in the context of the risks associated with operation of the Line 5 pipeline, the term 'risk' is used as a joint expression of chance (e.g., the annual probability of an event occurring on the pipeline) and loss (e.g., the consequences associated with such an event). One of the primary concerns focuses on the potential for a release of hydrocarbon product from Line 5, and what effects may be expected to humans and other environmental receptors.

This Oil Spill Report begins with a probability analysis (Appendix A) that evaluates the likelihood of a release occurring in the first place, as well as likely associated release volumes. Paired with this analysis are assessments of potential effects (i.e., consequences) associated with accidental large volume releases of crude oil (Appendices B and C) that use a suite of computational spill modeling tools and analyses to provide context and quantitative support for the analysis of route selection, risk, and environmental impact that were presented in the DEIS. Collectively, these analyses assess the potential environmental consequences of the L5WSRP, depending on the pipeline route selected, including the probability and the potential range of such consequences occurring, allowing for a fully quantitative assessment of risk. This report summarizes the general findings and overall conclusions of each of the various modeling studies, while each Technical Appendix contains details on model theory and design, inputs of environmental and release conditions, and full modeling results.

1.1.1 Probability Assessment (Technical Appendix A)

DNV was tasked by Enbridge with examining the POF of the 30-inch L5WSRP. The POF of the mainline pipe was calculated for the Proposed Route, as well as for the alternate routes. DNV calculated the POF based on the threats identified in American Society of Mechanical Engineers (ASME) Standard B31.8S. Additionally, the probability of a pipeline failure occurring at specific water crossings was determined for each pipeline route. The probability of release for various spill sizes was also calculated.

The probability of pipeline failure for all threats other than manufacturing defects and welding/fabrication defects was calculated based on DNV's proprietary pipeline probabilistic risk model. DNV's risk model takes into account the pipeline design (i.e., diameter, wall thickness, coating type, grade, etc.) and operating characteristics (i.e., operating pressure), as well as information regarding land use, crossings, etc. Various public data sources are used to populate threat variables such as earth movement, climatological impact, soil characteristics, and waterway characteristics. For time-based threats such as external corrosion, internal corrosion, and Stress Corrosion Cracking (SCC), a remaining life is calculated. A Weibull function analysis is then performed to convert expected remaining life to annual probabilities. The Weibull analysis incorporates a shape factor, which creates the shape of the failure distribution based on historic industry failure patterns.

For time-independent threats such as mechanical damage, weather-related and outside force, which can vary based on location and land use, the POF was calculated based on industry data and the estimated mileage of each land-use type.

DNV's risk model also takes into account preventive measures that are included in the pipeline design or planned in the Integrity Management Plan for each threat. These include but are not limited to additional pipe wall thickness, depth of cover, and coating selection.

For manufacturing defects and welding/fabrication defects, the POF was estimated using publicly available PHMSA reportable incident data for hazardous liquid pipelines. The data were sorted for similar pipeline configurations, vintage, size, and operation as the L5WSRP (e.g., sorted by modern, large diameter pipe). These data were utilized to establish a conservative or upper bound of a POF for modern pipeline construction. It must be noted that these POFs are not considered to be the actual failure rate as they do not necessarily account for all of the preventive measures that Enbridge may implement during the design, construction, and operation of the L5WSRP to prevent a failure, including measures taken under Enbridge's Integrity Management Plan.

The results from both DNV's proprietary model and those calculated using PHSMA data were then aggregated to determine a POF per mile per year. The overall POF for each of the proposed pipeline routes was calculated for the entire route. The POF is then converted to a per mile basis for direct comparison. The POF for each route includes the total number and type of all pipeline crossings along the route.

The probability for various spill volumes was calculated utilizing PHMSA data to calculate percentages of failures for different spill size ranges. These percentages were then applied to the calculated pipeline POF (as described in the previous section) in order to determine a probability for each range of spill volumes. The ranges of spill volumes considered correspond to Recent Average Release Volumes (RARV) and Historic Accident Release Volumes (HARV).

The POFs for the Bad and White River HDD crossings were calculated to provide an upper bound for a release that directly enters a large waterway. The probability range associated with other HDD watercourse crossings is dependent on the direct impact length of the crossing and is expected to be less than the POF at the Bad and White rivers. The length of HDD that crosses the waterway valley and can directly impact the waterway is different for each of the Bad and White River crossings; therefore, the POF varies for each route. Additionally, the POF was calculated for multiple lengths of an open cut waterbody crossing for comparison. The POF of individual crossings can be extrapolated from the HDD or open cut POF based on method of construction and relative length of each crossing.

1.1.2 Hydrocarbon Trajectory, Fate and Effects Assessment (Technical Appendix B)

RPS assessed the range of downstream movement, timing, and potential effects that may result from a set of hypothetical releases of crude oil along the Proposed Route and Route Alternatives, that spanned the range of:

- environmental conditions (e.g., river flow conditions, temperature, winds, and ice cover) present throughout the year;
- representative release volumes that could occur; and
- emergency response mitigation measures and associated timings and efficiencies for collection that may be undertaken following a release.

To undertake this analysis, RPS conducted a site-specific modeling study to characterize the range of downstream movement, behavior, timing, and potential for acute biological effects that may result from a full suite of hypothetical release scenarios (multiple release volumes, mitigation options, and biological effects thresholds) that span the range of environmental conditions present throughout the year. The modeling study used the SIMAP three-dimensional in-water model to bound the movement, behavior, and potential effects of releases of crude oil by accounting for site-specific and season-specific conditions including river flow and corresponding geographic and environmental conditions throughout the year, including complete ice cover during winter. This analysis focused on two locations where the Proposed Route crosses larger waterbodies in the Bad River watershed: the crossing of the Bad River (46.336 N, 90.649 W) and the crossing of the White River (46.502 N, 90.895 W).

Specific focus has been provided on the range of downstream movement, timing, and potential for effects related to the wild rice beds in the Kakagon-Bad River Slough Complex and Lake Superior. These areas in the Reservation are known to contain many sensitive aquatic receptors, including fish and wild rice that are harvested for human consumption and areas within the watershed that include spawning grounds for fish species. The Bad River and Kakagon Sloughs are located at the mouth of the watershed on Lake Superior and provide the last remaining extensive coastal wild rice wetlands in the Great Lakes Basin. These important receptors are located more than 72 river km (45 mi.) and 35 river km (22 mi.) downstream of the Proposed Route crossings of Line 5 with the Bad River and White River, respectively, which were the two water bodies assessed for the potential effects modeling conducted in this study.

Initially, hypothetical release scenarios were investigated as completely unmitigated releases, which provided an illustrative baseline of the maximum extents of oil that could physically occur, assuming no emergency response efforts were undertaken for the full 4-day model duration (highly unlikely to occur in any real-world release). As part of this site-specific study, emergency response mitigation activities were also assessed to quantify the reduction in the magnitude and extent of potential impacts during different environmental conditions (seasons), factoring in the variability in transport and fate of the released oil under different environmental conditions. To address the potential for adverse response conditions, RPS modeling included consideration of additional activation time for control points and reduced response effectiveness, that may be the result of seasonal/weather delays or any other situation that could impact collection. The hypothetical release scenarios (with varying volume and seasonality) provided a highly quantitative investigation of the range of downstream movement, behavior, timing, and potential for effects to a full suite of downstream receptors (based upon two sensitivity thresholds). The consideration of "difficult-to-access" areas was incorporated through this modeling, which included the potential for entrainment and sedimentation of oil, caused by waterfalls in Copper Falls State Park, and realistic deployment of response mitigation based on Enbridge's spill response inventory and planned activation times.

While not modeled here, RPS also considered a set of two scenarios previously modeled at the crossing of the Bad River for the Existing Route to understand the transport, fate, and effects of oil that could occur in the event of a spill during flood conditions (July 2016 flood event), with significant overbank flows (Horn, 2022). The results of those simulations (discussed further in Section 3.2.2.1) represented the shortest possible time for oil to reach Lake Superior (approx. 24 km or 15 mi downstream) and the extents and concentrations of oil contamination that could occur under those conditions. Any such release from the Proposed Route would have necessarily lower risk and potential to reach the Lake, due its being located an additional 54 km (33 mi) upstream of the Existing Route.

For the unmitigated releases modeled from the Existing Route, a portion of the floating (surface) oil was able to reach and enter Lake Superior. The previous modeling therefore included a set of simulations to predict how oil that reached the Lake might move and behave under a range of naturally variable environmental conditions that included winds and currents within Lake Superior (Horn, 2022). The results of this modeling are also described in Section 3.2.2.1 contextualizing as a worst-case how a spill might behave in Lake Superior without any form of emergency response mitigation being undertaken. However, for this unlikely event to happen, oil from a release along one of the route alternatives would need to be transported 64 to 80 km (or 40-50 mi) downstream (i.e., 40 to 59 km further to Lake Superior than from the Existing Route), which would take between 2-4 days to reach the Lake under the range of river flow conditions present throughout the year. Following any such unlikely event, Enbridge’s emergency response would occur within hours of the release occurring.

1.1.3 Hydrocarbon Route Assessment and HCA Analysis (Technical Appendix C)

A higher-level, quantitative route alternatives analysis and assessment was conducted to determine the potential downstream movement and behavior of hypothetical hydrocarbon releases from any point along each pipeline route to enter nearby waterways and the footprint that may be susceptible to potential effects. The intent was to use computational oil spill modeling to quantify the number and type of receptors, including Lake Superior and the Reservation, that may be susceptible to hypothetical releases of oil along the Existing Route, the Proposed Route, and each Route Alternative. Hypothetical full-bore rupture (FBR) release volumes under high river flow conditions were simulated at 100-meter intervals (328 ft) and at each watercourse crossed by the Existing Route, the Proposed Route, RA-01, RA-02, and RA-03. While the FBR results provide a conservative basis to make decisions for pipeline routing, smaller volume releases under low river flow conditions were also simulated at each release point to provide a lower bound prediction of movement/transport and potential for effects. The recent average release volume (RARV, 334 bbl) was used for these lower bound simulations. In total, 10,058 hypothetical crude oil releases were simulated. The simulations were modeled using the OILMAPLand two-dimensional overland and downstream model to assess the overland and downstream movement and behavior of oil from the hypothetical release points. Results of these simulations allowed for a direct comparison among routes, such as the number of spill plumes reaching watercourses and the length of pipeline over which spills could reach specific Areas of Interest (AOIs), including Lake Superior, the Reservation, wild rice areas, and public lands.

A high consequence area (HCA) assessment was also conducted to investigate receptors that may be impacted from each pipeline alternative using a "could-effect" analysis. The intent was to capture downstream HCAs that could be reached (via direct or indirect effects) from hydrocarbon releases occurring within the identified time frame from hypothetical FBR release scenarios along each pipeline route. Again, a route comparison was conducted across the route alternatives to quantitatively compare the HCAs potentially impacted, should an accidental release occur.

Finally, a higher-resolution (10-meter), segment analysis was conducted to determine the lengths of pipeline over which potential releases might directly enter the Bad River and White River crossing for the Proposed Route and Route Alternatives within the Bad River watershed. In total, 3,579 additional hypothetical FBR crude oil releases were simulated in OILMAPLand from the banks of the Bad River and White River inland for each route alternative crossing. These segment lengths were used in the probability assessment described in Technical Appendix A to quantify the likelihood of a release directly into each waterway.

1.2 Study Area

Line 5 originates near Superior, WI, passes through Michigan's Upper and Lower Peninsulas, and terminates in Ontario, Canada. Along this route, the pipeline transects the Bad River watershed, along the north shore of Wisconsin. The area is known to contain many sensitive aquatic receptors, including fish and wild rice that are harvested for human consumption, and areas within the watershed that include spawning grounds for fish species (TNC, 2020). The downstream reaches and mouth of the Bad River on Lake Superior provide the last remaining extensive coastal wild rice wetland in the Great Lakes Basin. In addition to federally designated HCAs (not depicted), several Areas of Interest (AOIs) have been defined for this study (Figure 1-2) to highlight the locations and key receptors in the Project Area. These AOIs include Lake Superior, the Reservation, Federal, State, and County/Local Lands[1] (WI DNR 2022), and wild rice areas (within the Reservation from Bad River Tribe, 2020; elsewhere in the region from WI DNR, 2020; 2023).

The Bad River watershed is depicted in Figure 1-3. Beartrap Creek, which drains into the Kakagon Slough, is also adjacent to the Bad River watershed (Bad River Watershed Association, 2021). To the west and east of the Bad River watershed, respectively, are the Beartrap-Nemadji and Montreal River watersheds. The Proposed Route and Route Alternatives RA-01 and RA-02 pass through portions of the Beartrap-Nemadji, Bad River, and Montreal River watersheds. RA-03 bypasses the Bad River watershed entirely, instead passing to the south through the St. Croix and Upper Chippewa basins that drain to the St. Croix and Chippewa Rivers in the greater Mississippi River watershed.

[1] While Federal and State lands are traditionally used in these assessments, additional lands associated with county/local government, as well as Forest Crop Law lands were included in the segment length analysis as a further conservative consideration, following consultation with Federal, State, and Tribal representatives. These lands were included because they are important to community, cultural, and ecological functions. Individual county and local land parcels that could be impacted, however, were not listed individually as unique AOIs because of the wide variety of land types and the overlapping nature of these resources between each dataset (e.g., contained within Federal and State lands).

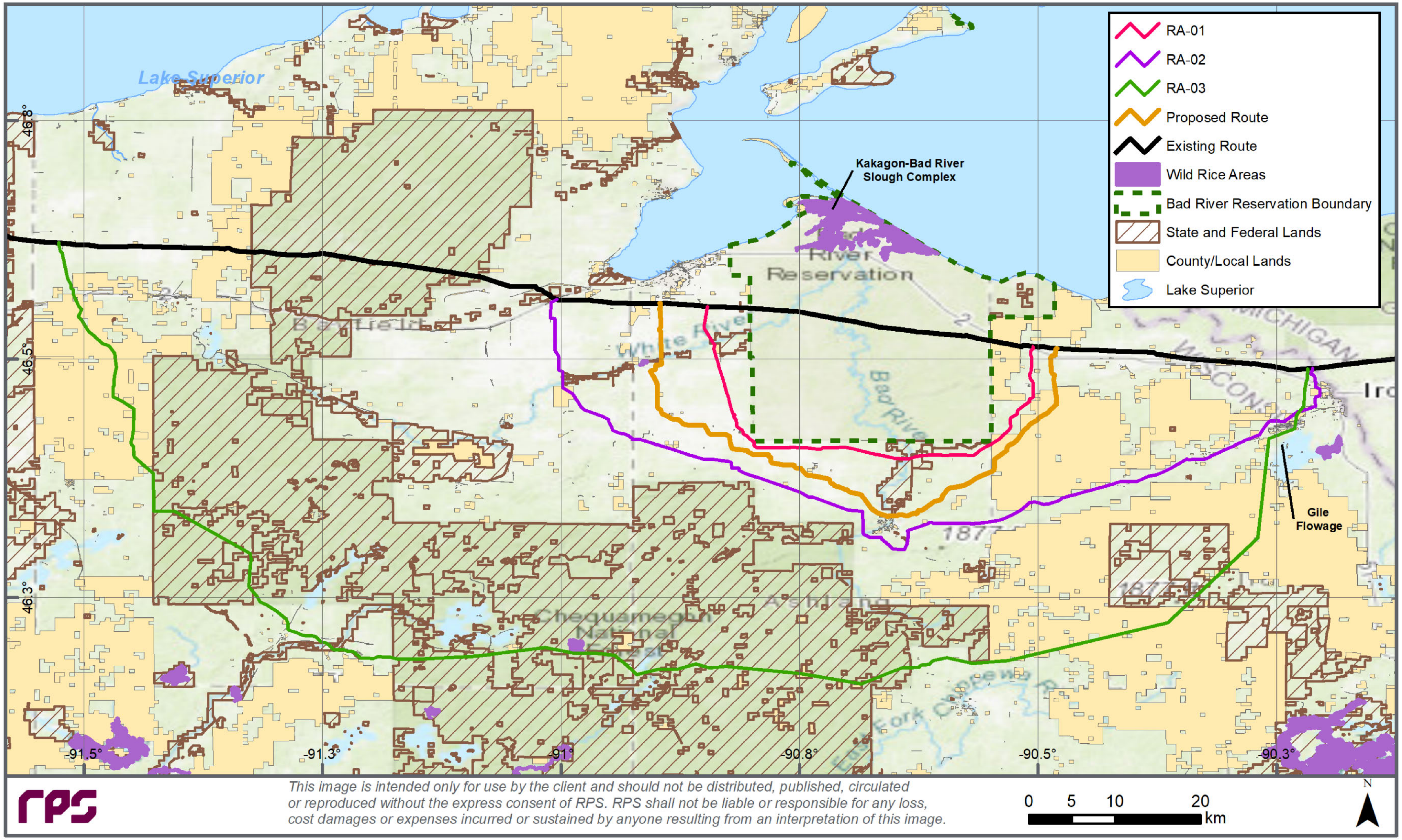

Figure 1-2. AOIs in the area of the route alternatives.

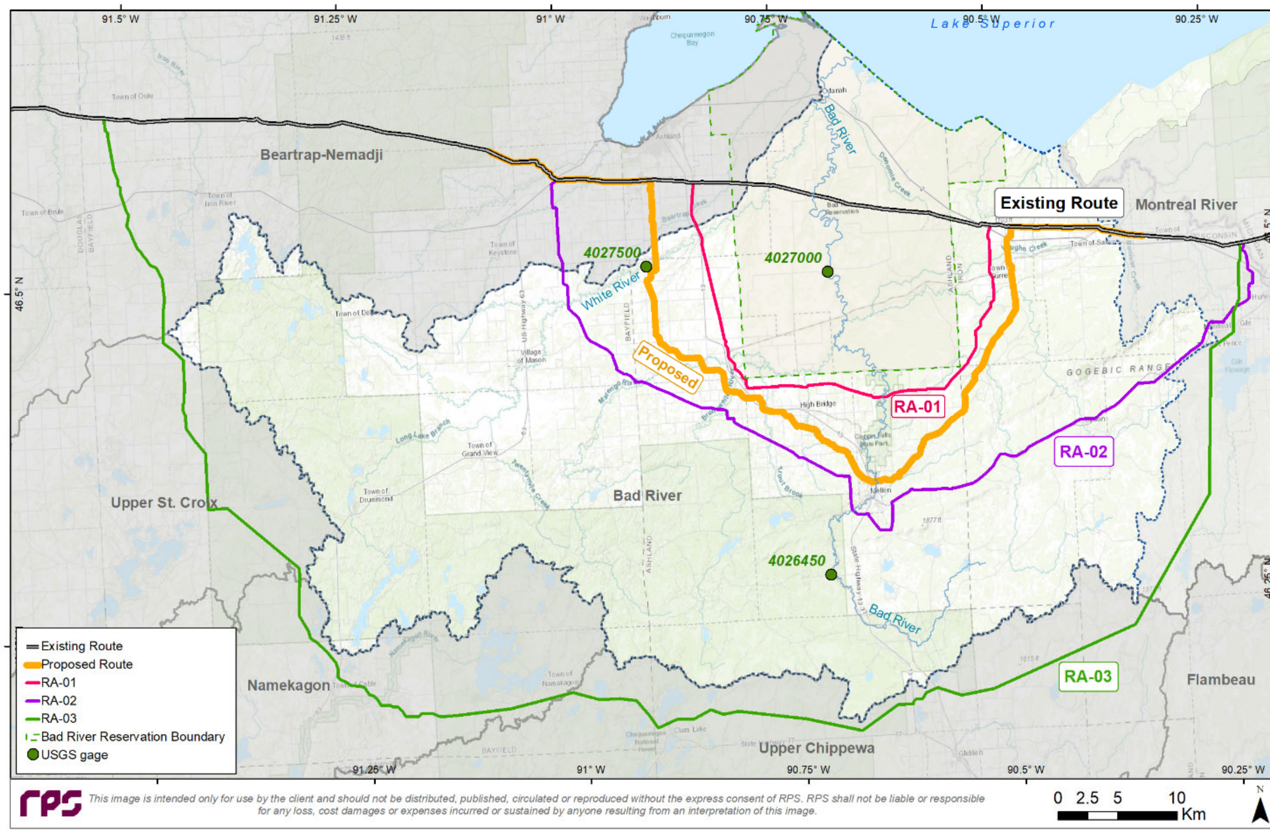

Figure 1-3. Map of proposed and alternative Enbridge Line 5 routes in the DEIS relative to the Bad River watershed.

For the purposes of this study, pipeline crossing locations on the Bad River and White River have been selected as representative large waterbody crossings for site-specific analysis of hypothetical hydrocarbon releases. The Bad River's headwaters are located at Caroline Lake, which is located approximately 40 km (24.9 mi) south of Lake Superior (straight-line distance). In total, the Bad River is approximately 125 km (77 mi) long, with a sinuous path that leads to the north, where it enters the Bad River Slough and Lake Superior. It has an average depth of 1.3 m (4.27 ft) under average river flow conditions (TNC, 2020). The SIMAP study boundary was terminated 78 km (48.5 mi) downstream (north) of the crossing, at the entrance to Lake Superior. The modeled area, referred to as the model domain, for the SIMAP simulations of releases into the Bad River extended between 90.61°W – 90.73°W and 46.33°N – 46.65°N.

The White River flows from the westernmost areas of the Bad River watershed, past Mason, Wisconsin, and joins the Bad River just south of Odanah, Wisconsin (SRWA, 2022). The Proposed Route would cross the White River just downstream of the White River Flowage, between Route 112 and Route 13 in Ashland County. The modeled area/domain for the SIMAP simulations of releases into the White River extended between 90.63°W – 90.92°W and 46.48°N – 46.65°N.

2 MODELING APPROACH

Several modeling approaches using a suite of technical models were taken to develop the different assessments conducted in this report. State-of-the-art computational spill models (SIMAP and OILMAPLand) were used for the modeling of hypothetical hydrocarbon (oil) releases into the environment. SIMAP and OILMAPLand are two separate oil spill modeling tools that have been developed by RPS to predict the trajectory, fate, and potential acute effects of released hydrocarbons on land and in water. Both models have been validated against real world releases and have been used extensively in the United States and internationally to meet regulatory requirements and other recommendations and guidelines. SIMAP and OILMAPLand are used frequently by industry, government, and academia. Underlying hydrodynamics used as inputs to the hydrocarbon assessments were modeled using RPS' BFHYDRO model and the Delft3D Flexible Mesh (FM) modeling suite.

The following sub-sections outline the modeling approaches and scenarios developed for each assessment, as well as a high-level description of the modeling tools used. The individual Technical Appendices to this report (Appendices B and C) provide further details of each model, including their design and usage, inputs used for modeling, and the scientific and mathematical basis behind the models.

For the assessments of hypothetical oil spills, Bakken crude oil was selected as the oil type modeled for all scenarios. Line 5 predominantly carries lighter hydrocarbons, including light crude oils through natural gas liquids (NGLs). Based upon its physical and chemical properties, a single Bakken crude oil type was therefore modeled. Bakken Crude Oil is produced in North Dakota, Montana, and the bordering Canadian provinces of Manitoba and Saskatchewan. Bakken is a relatively light crude oil with low density, low viscosity, and a high aromatic content. Bakken Crude Oil is similar to other light crudes and can be considered representative of many light crude oils, including many Canadian crudes, but is a conservative selection for this type of effects assessment as the high aromatic content has the potential to maximize the potential for impacts in the environment. This representative oil was conservatively selected to be a worst-case compound for in-water effects following a release because it would be more persistent than a NGL (which would evaporate rapidly and nearly completely) and it has a higher percentage (when compared to similar oil types) of BTEX compounds and other monocyclic aromatic hydrocarbons (MAHs), making up 2.5-4% of the total by mass, which would tend to maximize in water effects.

Hypothetical release volumes spanning three orders of magnitude (334 bbl up to 26,684 bbl on the existing route; or up to 13,451 bbl on the Proposed Route) including credible worst-case timing were selected for the crude oil modeling in consultation with Enbridge and RPS. Three types of release volumes were investigated including Full-Bore Rupture (FBR) volumes, which varied based on the hypothetical location of pipeline rupture, one Historical Accidental Release Volume (HARV), and one Recent Average Release Volume (RARV). FBR release volumes were used for both the route assessment using OILMAPLand and the site-specific assessments using SIMAP because they present highly conservative, worst-case events that entail complete breakage and open flow from the entire pipeline diameter. These FBR scenarios are presented as "credible worst-case" scenarios in this report because they portray a credible volume (from 5,417 up to 26,684 bbl depending on location and route) that could be released in the event of a highly unlikely, worst-case pipeline breakage.

FBR volumes for each hypothetical release location along the pipeline were provided to RPS by Enbridge on May 20, 2022 (Enbridge, 2022b) and depended on pipeline flow rate, shutdown time, the type of product being released, valve locations, and the elevation profile of the pipeline. FBR release volumes were calculated to include active pump out during a 13-minute identification of the rupture, analysis of the pipeline condition, pipeline shutdown and full valve closure in the affected pipeline section, as well as the gravitational drain down once the valves were closed. The maximum 13-minute duration of Control Center response time to valve closure is a standard for safe operations and leak detection for Enbridge. While 13 minutes is the maximum time, this is a conservative (i.e., worst-case) assumption, since an identification of a release and response to it through to valve closure would be expected to occur in less than 13-minutes (i.e., maximum allowable total time to shut down and isolation) in an FBR leak scenario.

For the site-specific assessments, release volumes of 1,911 bbl (HARV) and 334 bbl (RARV) were also used in the modeling to capture potential release scenarios other than the credible worst-case FBR. The HARV was identified based on an analysis of the average release volume since 1985 from all pipelines that carry crude oil on the entire Enbridge Mainline System from the Pipeline and Hazardous Materials Safety Administration (PHMSA) historical database (2017) of crude spills. Over this 33-year time period, there were 81 recorded releases that ranged from 0.01 bbl to 40,500 bbl. The smaller-volume RARV was identified based on an analysis of the average release volume of any reportable size (recorded as >5 gallons or >0.12 bbl) from 2010 to 2019 for all of Enbridge's liquids pipelines. The RARV still represents a conservatively high release volume because, since 2010, Enbridge has transported approximately 25% of the crude oil produced in North America in its pipelines and recorded only 122 total releases, of which 90% were less than 10 bbl, with both the mode and median of these release volumes being less than 1 bbl. In each release scenario, a constant release rate was assumed during the period of release.

Site- and season-specific geographic and environmental parameters were used for each modeling analysis (by scenario) based on datasets collected over multiple years. Data inputs for the modeling efforts were obtained from independent sources with well-documented quality standards. Geographical data, including habitat mapping and shoreline identification and classification, were obtained from multiple data sources, including the USGS gage in Odanah, WI (Station 04027000), the USGS gage near Ashland, WI (Station 04027500), aerial imagery, and the USGS NHD dataset. Bathymetry was based on field data, plan and response documentation, and records from the gage locations. Hydrodynamics for the Bad River were modeled using data inputs from USGS stream gages and the NHDPlus dataset. Wind data were obtained from the Ashland Kennedy Memorial Airport, and total suspended solids (TSS) concentrations within the water column were based on USGS gages and professional experience. Seasonally-appropriate values (and variability, where available) for all environmental parameters were characterized at each location based on the hypothetical release date. As an example, scenarios in wintertime conditions with low river flow aligned with low temperature, higher wind speeds, and low TSS, which are characteristics of that location under those specific seasonal conditions.

2.1 Oil Spill Emergency Response Mitigation

In the Midwest Region, Enbridge operates over 4,000 miles of pipeline through Minnesota, North Dakota, and Wisconsin. In accordance with federal (49 CFR 194) and state regulations, Enbridge has an Integrated Contingency Plan (ICP) approved by the PHMSA that fulfills the requirement for a response party to have an Emergency Response Plan (ERP) to ensure a safe, effective, and comprehensive response to all types of incidents to protect public health and safety, the environment, and infrastructure. PHMSA considers Enbridge's ICP to be an example of industry best practice for emergency response planning. Enbridge currently maintains a high state of readiness across all areas of operations, with trained personnel having the capability to deploy a cache of Enbridge-owned equipment and conducting routine maintenance on stored equipment. In addition, Enbridge has contracted with a number of different Oil Spill Response Organizations (OSROs) that would provide additional trained personnel, response equipment, and other resources in the event of a release.

As a supplemental guide to the ICP, Enbridge maintains core technical information references such as the Inland Spill Response Tactics Guide and the Incident Management Handbook (Enbridge, 2018b, 2019) that apply universally to field operations' tactical response and incident manage of a response. The Inland Spill Response Tactics Guide is an internal Enbridge document that can be used as a quick reference by Enbridge first-on-scene responses to select and implement containment and recovery tactics with Enbridge-owned oil spill response equipment during the first 72 hours of the response. It illustrates a collection of inland spill tactics that can be applied using obtainable resources to a liquid products release until additional resources and personnel arrive on-site. Enbridge conducts periodic reviews of this document, and adjusts its tactics based on internal lessons learned and lessons from external agencies.

It would be expected that in the event of a spill, Enbridge would utilize any and all of the equipment referenced below that may be necessary to access and respond to all areas including difficult-to-access regions where response activities would make sense. Enbridge has specific, pre-identified Control Point (CP) locations along hydrologically-connected watercourses that could be utilized in the event of a spill. A CP is a predetermined location from where spill containment and recovery operations may be conducted. Pre-established CPs reduce the response times and enhance effectiveness for containment and recovery of released products into a watercourse. It should be noted, however, that a response is not limited by these pre-established CPs. In the event of an actual release, containment and recovery/collection locations would be tailored to the environmental conditions and the specific location of the release to most effectively target containment and collection activities. This could result in Enbridge and its OSROs deploying at CPs and other locations.

This section describes Enbridge's emergency response capabilities in the project area and the available response tactics that could be used in the event of a release, tailored to the type of watercourse and conditions of release. Details of the site-specific response tactics that were simulated in the oil trajectory, fate, and effects modeling (Appendix B) are also provided. Enbridge provided RPS with a series of identified tactical CPs and response equipment information to assist with modeling emergency response mitigation capabilities of containment and collection. These response options were modeled at Modeled Control Points (MCPs) within the Bad River and White River for hypothetical releases at the watercourse crossings of the Proposed Route.

2.1.1 Emergency Response Capabilities

Enbridge maintains a large cache of spill response equipment that can be mobilized in the unlikely event of a release. All Enbridge response personnel are field safety and response trained to meet the requirements of 49 CFR 194.117. These training include HAZWOPER, Incident Command System (ICS), Tabletop Exercises, Full

Scale Equipment Deployment Exercises, Dryland Equipment Training, Boat Operation, Oil Spill Response, and Winter/Ice Tactics. Winter tactics include the prevention of oil moving downstream using physical barriers (e.g., ice slotting and the insertion of plywood barriers) to form collection areas/points. Contracted OSROs have similar qualifications.

Additionally, Enbridge maintains ER equipment at locations along its Right-of-Ways (ROWs). Major equipment available in Enbridge's Midwest Region includes:

- Command Post Trailers
- Response Boats
- Air Boats
- Amphibious Vehicles
- All-Terrain Vehicles
- Fixed-Wing Aircraft (Enbridge Enterprise-owned)
- Helicopters (Enbridge Enterprise-owned)
- Portable ATV Vacuum Units
- Heavy Construction Equipment
- Spill Response Trailers (includes winter equipment such as chainsaws, augers, plywood, etc.)
- Wildlife Response Trailers
- Containment Boom (Multiple sizes)
- Oil Skimmers (Multiple types and sizes)
- Temporary Storage Tanks
- WaterGate™
- Vacuum Trucks

Recovery capacity volumes and effectiveness for various response equipment (e.g., oil skimmers and boom) employed by Enbridge have been rigorously tested at the Oil and Hazardous Materials Simulated Environmental Test Tank (Ohmsett) in Leonard, New Jersey. The National Oil Spill Response Research & Renewable Energy Test Facility provides independent and objective performance testing of full-scale oil spill response equipment and helps improve technologies through research and development. Ohmsett uses American Society for Testing and Materials standards F-2084—01 Standard Test for Determining Nameplate Recovery Rate of Stationary Oil Skimmer Systems. Data has been compiled into a "World Catalog of Oil Spill Response Products" published by SL Ross Environmental Research Limited (SLRoss, 2013; 2017).

In addition to the ER equipment owned by the company, Enbridge also has OSROs under contract to support an Enbridge response both in the field and managing the incident. OSROs have the ability to add equipment to the response and provide the required capacity to scale the response efforts for the conditions encountered.

In addition to have an OSRO of record (a PHMSA requirement), OSROs typically employed by Enbridge include:

- Marine Spill Response Corporation
- The Response Group (for ICS)
- SWAT
- Bay West
- Beltrami Industrial
- T&T Marine
- Marine Pollution Control
- Minnesota Limited

2.1.2 Response Tactics

In the unlikely event of a release, there are a range of tactics that Enbridge and its contracted OSROs can deploy based on the conditions of the various sites. Tactical response measures for containment and recovery/collection of released product from within watercourses can vary depending on the specific conditions present at the time of release including: watercourse depth, flow speeds and type, substrate of the watercourse, access, product type and amount, weather conditions, etc. Generally, the response options used would be tailored to the watercourse and conditions: small watercourse response (for the many small tributaries), watercourse response (Bad River and White River), high velocity and turbulent water response (sections of the Bad River through Copper Falls State Park), submerged oil response, and a smaller potential need for open water response (Lake Superior). Emergency response activities would be managed by identified individuals within Enbridge that specialize in response management and coordination and have trained to be liaisons during an incident.

2.1.2.1 Recovery Methods

Generally, there are three main types of oil spill response methods: mechanical recovery, non-mechanical recovery, and manual recovery.

- Mechanical recovery: oil is contained using a conventional boom, physical barrier or within a hydraulic stall, and mechanical skimmers are used to remove the released product from the surface of the water.
- Non-mechanical recovery: in-situ burning or biological remediation are used to degrade an oil slick.
- Manual recovery: the use of shovels, rakes, buckets, nets and other means to remove the oil.

Mechanical recovery of released product has been determined to be the most effective and appropriate response method for the unlikely release of product from the relocated Line 5 that would affect a watercourse. While response conditions can vary, Enbridge has equipment to address each of these conditions, plus the addition of available OSRO equipment if required.

Descriptions of available response equipment using mechanical recovery tactics that have been used for the modeling in this study are summarized below:

- Containment Boom – a long and continuous floating physical barrier to oil. They are typically made of plastic, metal, or other materials, which slow the spread of oil and keep it contained. Because they only extend a few inches/feet into the water column they may become less effective under high wind or wave conditions, where oil may move over/under the barrier (NOAA, 2016). The containment boom was simulated within the response modeling to have an efficiency of 99%.

Figure 2-1. Example of a river containment boom in the process of being set up (Enbridge, 2022*a*).

- Smooth Drum Skimmer – a floating oleophilic drum oil skimmer designed for continuous duty in an oil spill. As the floating drum rotates, oil adheres to the surface separating it from the water. Wiper blades remove the oil from the drums, depositing it into the collection trough where it is pumped to a storage location. This technology is designed to operate in shallow near-shore environments such as those potentially found in the Bad River. The nameplate recovery rates of the smooth drum skimmers were reported to be 20-77 gpm across various models with differing size (Enbridge 2022a).

Figure 2-2. Elastec smooth drum skimmer (Elastec, 2020)

- Grooved Drum Skimmer – a floating oleophilic drum oil skimmer designed for continuous duty in an oil spill (identical in methodology to a smooth drum skimmer). Because of the larger surface area of a grooved oleophilic drum, collection rates are higher than smooth drum skimmers. Grooved drums have a higher recovery rate efficiency with viscous oils than do smooth drum skimmers. This technology is designed to operate in shallow near-shore incidents such as those potentially found in the Bad River. The nameplate recovery rates of the grooved drum skimmers were reported to be 90-356 gpm across various models with differing size (Enbridge, 2022a).

Figure 2-3. Elastec grooved drum skimmer (Enbridge, 2022a).

- Weir Skimmer – a floating oil skimmer designed for continuous duty in an oil spill. Oil flows into the central hopper where it's pumped to storage. Weir skimmers have a higher removal capacity than do smooth drum or grooved drum skimmers. This technology is designed to operate in shallow near-shore incidents such as those potentially found in the Bad River. The nameplate recovery rates of the weir skimmers were reported to be 300-520 gpm across various models with differing size (Enbridge, 2022a).

Figure 2-4. Elastec Seaskater weir skimmer (Elastec, 2022).

Winter recovery tactics generally follow the same mechanisms of containing and collecting oil, but additional tools such as ice augers and cutting saws (e.g., for ice slotting and the insertion of plywood barriers) would be used to access oil and create spaces for skimmers (Figure 2-4). In addition, there may need to be options for heating equipment and personnel to ease oil collection and maintain safety. The winter response mitigation modeled here assumes the same equipment availability as other seasons, but makes accommodations for potential delays and reduced efficacy (described in the next section). Ice-handling equipment would be deployed from the same staging areas to be used as needed at the various CPs.

Several other response tactics and equipment have not been modeled here but would be available and implemented as determined useful during the course of a response. For example, equipment like sorbent booms, pom-pom snares, and X-Tex skirts are part of Enbridge's CPs for certain locations in the White River and Bad River. Although they would provide lesser overall mitigation than containment booms and skimmers, as a percentage of the total release volume, such tactics can minimize sheens and help capture submerged oil droplets downstream of turbulent waters. The tactic of burning was also not considered.

Figure 2-5 Winter response equipment and tactics including an ice auger (left) used to locate subsurface oil and a sled-mounted chainsaw (right) that is used to slot ice (Enbridge, 2022a).

2.1.2.2 Small Watercourse Response (tributaries)

Small watercourses, as described in the Inland Spill Response Tactics Guide, are usually characterized by a combination of shallow depth (< 1.6 ft), narrow width (< 33 ft), and low current velocity (< 1 knot) (Enbridge, 2018b). Tactics that are typically implemented in small watercourses rely on man-made fixtures that either halt the flow of surface water while allowing underflow to continue, or in extreme cases can halt the entire flow of the watercourse by completely blocking the flow. Tactics that are successful in containment and recovery of small watercourses for which Enbridge has the equipment available for deployment include the following:

- Stream Dams: Water Bags, AquaDams™, Tiger Dams™, WaterGate™ and earthen material.
- Weirs: Inverted Weir dams, Board Weirs, Turner Valley Gates, Culvert Weirs and filter fence.
- Boom: Creek Boom.

The simplest form of a stream dam involves placing earthen material (typically clay) within a small watercourse to block the entire flow of the watercourse. Water bags are made from a non-permeable fabric bladder, filled with water and held in place across a watercourse. AquaDams™ are made of multiple parallel chambers called fill tubes which give the dam more stability against shifting within a watercourse. Similar to an AquaDam™ a Tiger Dam™ utilizes multiple water tubes for increased freeboard and resistance to sliding, but unlike the AquaDam™, a Tiger Dam™ can use individual units which are strapped together after placement. A WaterGate™ is an open self-filling barrier that relies on the hydrostatic pressure differential to provide a bottom seal to the substrate.

Weirs installed within a watercourse allow for subsurface flow of water. Due to the specific gravity and chemical properties of released liquid hydrocarbons, the released product tends to float on the upper surface of the water column. A weir stalls the flow within the upper surface of the watercourse while allowing the subsurface flow to proceed past the weir. This tactic allows for control of the watercourse flow and height which can prevent back flooding within the watercourse. Inverted weir dams can be created with earthen material (or prefabricated weirs) to create the channel block and underflow pipes are installed during construction to allow for subsurface flow. Board Weir's, Turner Valley Gates, and culvert weirs operate in a similar manner by placing an impermeable membrane within the upper surface of the water column while allowing subsurface flow to continue. In areas where the concentration of oil is limited, a filter fence can be employed as a tactic to contain small quantities of released product within a small watercourse. A filter fence is constructed using a semi-permeable membrane or sorbent materials that allows for oil to adhere to the membrane while permitting water to flow through.

Conventional boom is specifically engineered in various sizes, including smaller boom designed specifically for use in smaller watercourses. Boom can be efficiently and effectively deployed rapidly within small watercourses due to the limited personnel and equipment requirements for deployment.

Enbridge would respond at the planned CPs and in any locations (or smaller watercourses) that would be found suitable to implement the tactics described above. The Inland Spill Response Tactics Guide (Enbridge, 2018b) further describes and illustrates each of these tactics. The goal of these efforts would be to ensure the containment and recovery of oil prior to its movement downstream where it may reach turbulent or fast moving waters and potentially enter Lake Superior.

2.1.2.3 Watercourse Response (e.g., Bad River and White River)

Larger watercourses are those where any combination of water depth, watercourse width, or current velocity would make the installation of bottom-founded or rigid structures impractical. The tactics for larger watercourses rely on the installation of flexible, floating barriers to redirect or divert surface contamination from sensitive areas or toward areas of hydraulic stalls where slower velocities allow for collection of the product. Shoreline protection will also typically be employed using shoreline booming tactics.

Skimmers are used as a mechanical recovery tactic in larger watercourses, whereby they remove the oil from the surface of the water. Skimmers can be grouped into two main categories (oleophilic and non-oleophilic). Oleophilic skimmers are manufactured using materials in which the oils have an affinity toward the boom, while non-oleophilic skimmers are typically weir-type skimmers that are adjusted to function just below the interface between the oil and water. The Inland Spill Response Tactics Guide (Enbridge, 2018b) provides additional description and illustrations of these tactics.

2.1.2.4 High Velocity and Turbulent Water Response (Copper Falls State Park)

In areas with high velocity and turbulent water, response tactics are employed only in locations where watercourse characteristics permit safe and effective containment and recovery. Exclusionary (or deflection) booming along sensitive areas is typically used to prevent released product from entering particularly sensitive areas, with the intent to contain and recover the released product farther downstream where conditions are more favorable. The goal of exclusionary booming is to divert surface oil away from sensitive areas and recover the released product downstream at low-velocity and turbulent areas such as back eddies where it can be successfully contained and recovered.

2.1.2.5 Submerged Oil Response

Line 5 does not carry heavy crude oil, which can submerge due to its greater density relative to water following natural weathering. However, portions of all oils, including light crude oils, can interact with suspended sediments in the water column which results in the formation of negatively buoyant oil mineral aggregates that have the potential to result in sunken oil. In the unlikely event of a release that could lead to submerged and/or sinking oil, Enbridge would implement its Submerged Oil Management Program (SOMP). The aim of this program is to limit and/or completely avoid oil from submerging into the water column and/or avoid submerged oil from falling out of the water column and onto sediment. This Program would be used in conjunction with the Inland Spill Response Tactics Guide (Enbridge, 2018b).

The early implementation of submerged oil tactics can greatly limit the amount of oil that sinks to the sediment layer, if there is a concern that conditions will cause sinking to occur. Submerged oil tactics capture submerged oil out of the water column before it sinks, which can eliminate or decrease the amount of potential dredging needed for remediation and thereby materially reduce the resources and time necessary to remediate a release. As shown in the SOMP, some of the specific tactics include the use of Filter Fences or Gabion Baskets filled with sorbent materials, and/or the addition of filter curtains (X-Tex material) attached to the bottom of boom. This equipment, along with others, is staged in Enbridge's Submerged Oil Response trailers that are found in each region in the U.S. and Canada. The containment and recovery techniques established in the Enbridge SOMP align with the American Petroleum Institute (API) technical report for sunken oil recovery (API, 2016).

Enbridge would manage the response to a submerged oil incident like any other response, using ICS with potentially a Submerged Oil Branch formed as part of the Operations Section. The Submerged Oil Branch is comprised of response personnel who would focus their efforts on deployment of applicable tactics to locate and capture submerged oil.

2.1.2.6 Open Water Response (Lake Superior and Sloughs)

In the unlikely event that floating surface oil were able to reach the downstream waters of Lake Superior and the Kakagon-Bad River Slough complex, an assortment of open water containment and recovery tactics can be employed for large open water systems. Further analysis of the potential for spills to reach open water is discussed in Section 3.2 and Appendix B. Methods for open water response include containment utilizing lake boom and open water skimming tactics. Lake boom is specifically designed for oil containment in large open water systems. Open water skimming responses utilize lake boom, skimmers, and various boat configurations to perform sweeps throughout the slick to contain and recover the released product. In addition to conventional sweep tactics, specialized equipment such as a NOFI Current Buster® can be used. A Current Buster® is currently the most effective oil spill response equipment for towing in open water sweeps at speeds up to 5 knots. Current Busters®, which are part of Enbridge's equipment inventory, are suitable for a wide variety of oil types and are uniquely suited to large inland waterways and open water. These tactics are further described and illustrated in the Inland Spill Response Tactics Guide (Enbridge, 2018b).

The waters in the vicinity of the pipeline route alternatives (i.e., leading up to and entering Lake Superior) are suitable for deployment of Open Water, Large Watercourse, and some Small Watercourse Response tactics. In addition to the pre-established CPs, numerous areas within this stretch (e.g., widening rivers and sloughs) could be utilized as containment and recovery locations, such as the small bays, inlets, and potentially manmade structures, to corral, contain, and recover oil before it reaches Lake Superior.

2.1.2.7 Response Management, Coordination, & Liaison

All Enbridge operational regions have multiple individuals identified for key leadership positions on the Incident Management Teams that are trained in the ICS positions for which they are assigned. The use of ICS allows Enbridge to work together with local, tribal, state, and federal agencies within a unified command structure to ensure any emergency is carefully coordinated and planned, and with input from all participating agencies. The employment of ICS also ensures Enbridge is able to inform the public on what is occurring via a Public Information Officer and a Liaison Officer, with the latter liaising with all potentially impacted third party agencies not part of unified command (e.g., tribal agencies, water treatment, nearby municipalities, etc.).

2.1.2.8 Recovery Timing and Effectiveness

The three response mitigation factors having the largest influence on the geographic extent and magnitude of effects following a release of oil are the amount of time required to set up an active CP, the amount of oil that is able to be contained, and the rate of removal or collection. In the most ideal situation following a release, CPs would be set up as rapidly as possible and collection efficiencies would be maximized.

As described in Section 2.1.1 recovery capacity volumes and effectiveness for various response equipment (e.g., oil skimmers and boom) to be employed by Enbridge are variable, but have been rigorously tested at Ohmsett to develop nameplate recovery rates following ASTM standards. Nameplate capacities are thought to be unrealistic in many real-world oil spill cases due to circumstances or environmental conditions that may be far from optimal operational conditions and therefore could reduce collection efficiency. This accounts for variables such as degree of emulsification, weather conditions, sea state, available daylight hours, fouling of gear with ice/debris, and any number of other factors that could reduce collection efficiency. Therefore, the United States Coast Guard (USCG) typically derates the nameplate capacity by 80% (i.e., collection is assumed to be 20% of nameplate recovery rate) or more in estimating a recovery capacity for planning purposes (Table 2-1). For this modeling study, RPS used the USCG recommendation and conservatively derated all nameplate capacities by 80% (or 20% efficiency collection rate) for all scenarios simulated under non-winter conditions. For winter conditions, the response equipment was further derated to 85% of nameplate capacity (or 15% efficiency collection rate). This additional reduction (to three-quarters the collection rate of the previously-derated values) reflects the uncertainty around other winter-specific limitations that could be encountered, such as weather conditions causing temporary work stoppage; unsafe ice conditions; limitations on plywood J-slotting technique; slow work caused by bulky winter clothing; slow work caused by slip trip fall risks; and equipment issues or maintenance needs due to winter conditions.

Table 2-1. Derated recovery rates for each piece of modeled skimmer equipment at downstream CPs (Enbridge, 2022a).

Response Options	Nameplate Capacity (gpm)	Standard Non-winter conditions: 20% Efficiency* Collection Rate (gpm)	Extreme Winter conditions: 15% Efficiency* Collection Rate (gpm)
Elastec TDS 118	35	7	5.3
Elastec TDS 118G	90	18	13.5
Elastec TDS 136	77	15.4	11.6
Elastec TDS 136G	170	34	25.5
Elastec Magnum 100	251	50.2	37.7
Elastec Magnum 200	356	71.2	53.4
Elastec SeaSkater ES400	520	104	78
SkimPak 1800	300	60	45
Elastec Mini-Max	20	4	3
Elastec Shovelhead**	43	8.6	6.5

*20% efficiency is equivalent to 80% derating from nameplate capacity; 15% efficiency is equivalent to 85% derating.

** Based on similar Manta Ray unit from Lamor.

Collection capabilities under real-world spill conditions could be greater than the highly conservative assumed collection efficiencies of 20% (non-winter) and 15% (wintertime) nameplate capacity simulated in this study. More favorable conditions could include calm winds and favorable seasonal conditions, safe and easy access, daylight conditions, etc. Therefore, the potential effects (i.e., acute mortality) predicted in the response mitigated scenarios within this study are likely greater than the likely effects of any release scenario that might occur during favorable environmental conditions. Should environmental conditions become unfavorable to the point where response effectiveness was less successful, the potential effects would approach those predicted herein for the response mitigated scenarios. Should environmental conditions further deteriorate to the point where response efforts were not possible (i.e., cessation of all response activities), the potential effects would approach those simulated for the completely unmitigated scenarios.

2.1.3 Site-specific Response Tactics to be Simulated

In the event of a real-world release into the Bad River or White River, a list of response equipment, tactics, and pre-identified CPs would be available and provided to responders by Enbridge (2022a). For this assessment, seven CPs were pre-identified by Enbridge at locations downstream of the Proposed Route crossing at the Bad River (Figure 2-6, Figure 2-7). Six CPs were pre-identified downstream of the Proposed Route crossing at the White River (Figure 2-8, Figure 2-9). As described above, a CP represents a predetermined location from where spill containment and recovery operations may be conducted with the expectation of a high degree of success. However, containment and recovery/collection would be tailored to the environmental conditions and exact location of the oil in the event of any specific spill. CP information sheets recommend an effective set of equipment and deployment techniques for a location, considering site-specific information such as access, river flow, water depth, and other factors assessed by field crews that specialize in emergency response that assessed visited the locations and trained response specialists conducting a desktop study. Individual information sheets outlining response equipment, placement, and timing for each CP are included in Appendix B. The CP locations were designated by Enbridge as part of spill contingency planning for the Project. Deployment of different or additional resources at new locations beyond those planned at the CPs would have the potential to increase the amount of oil that could be contained and collected, thereby further reducing the potential for effects.

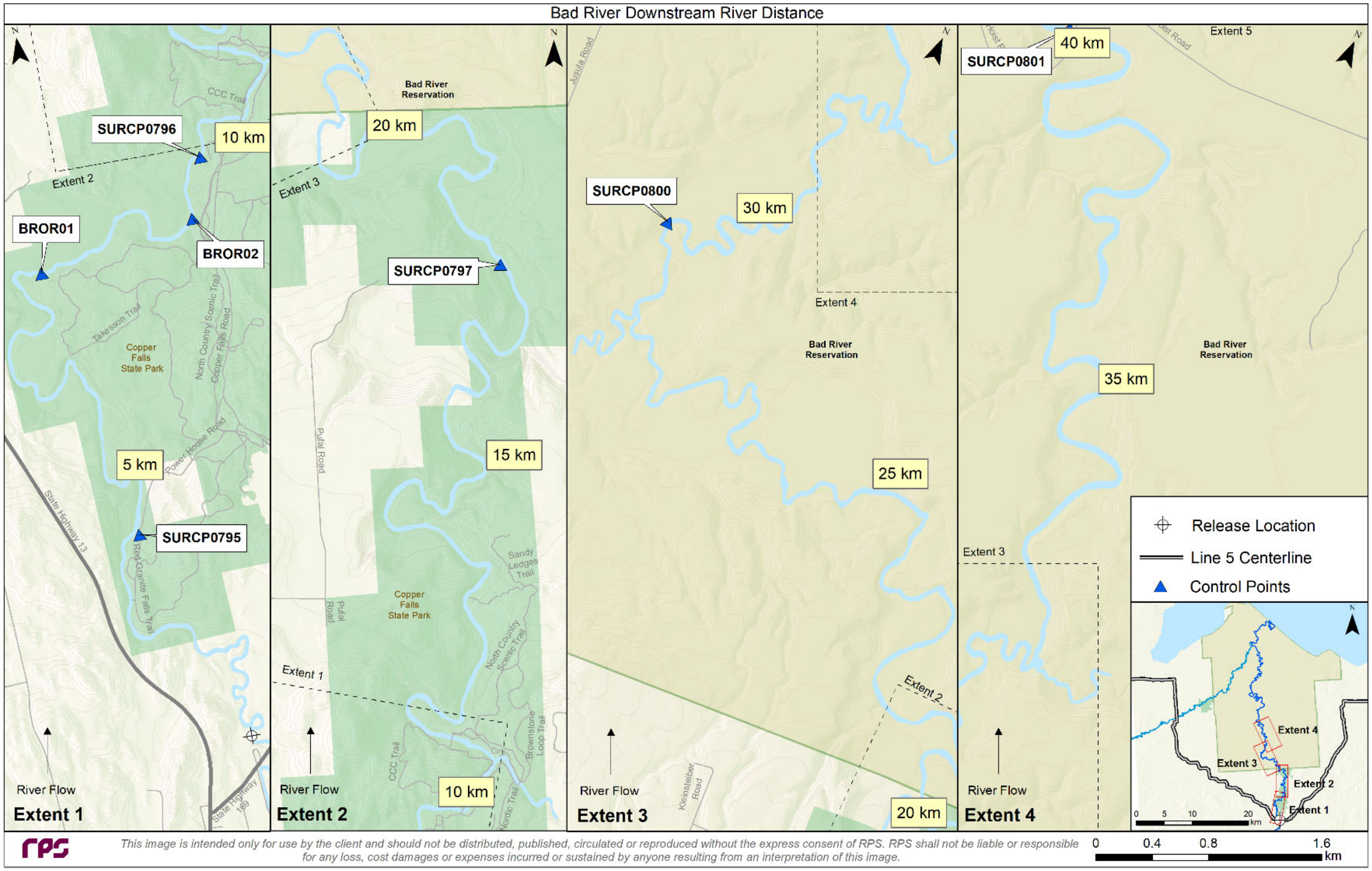

Figure 2-6. MCP locations modeled on the Bad River (upstream portion).

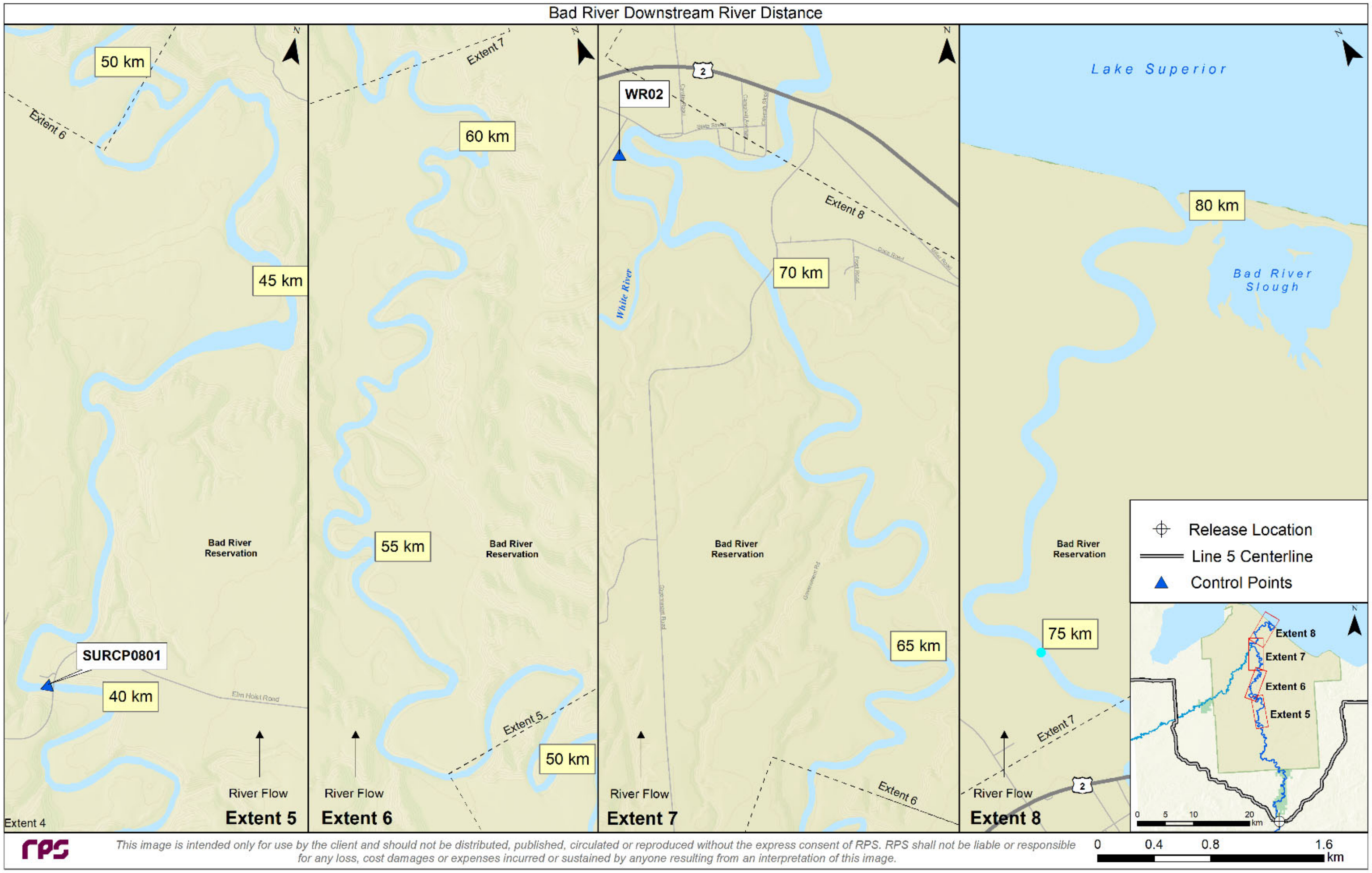

Figure 2-7. MCP locations modeled on the Bad River (downstream portion).

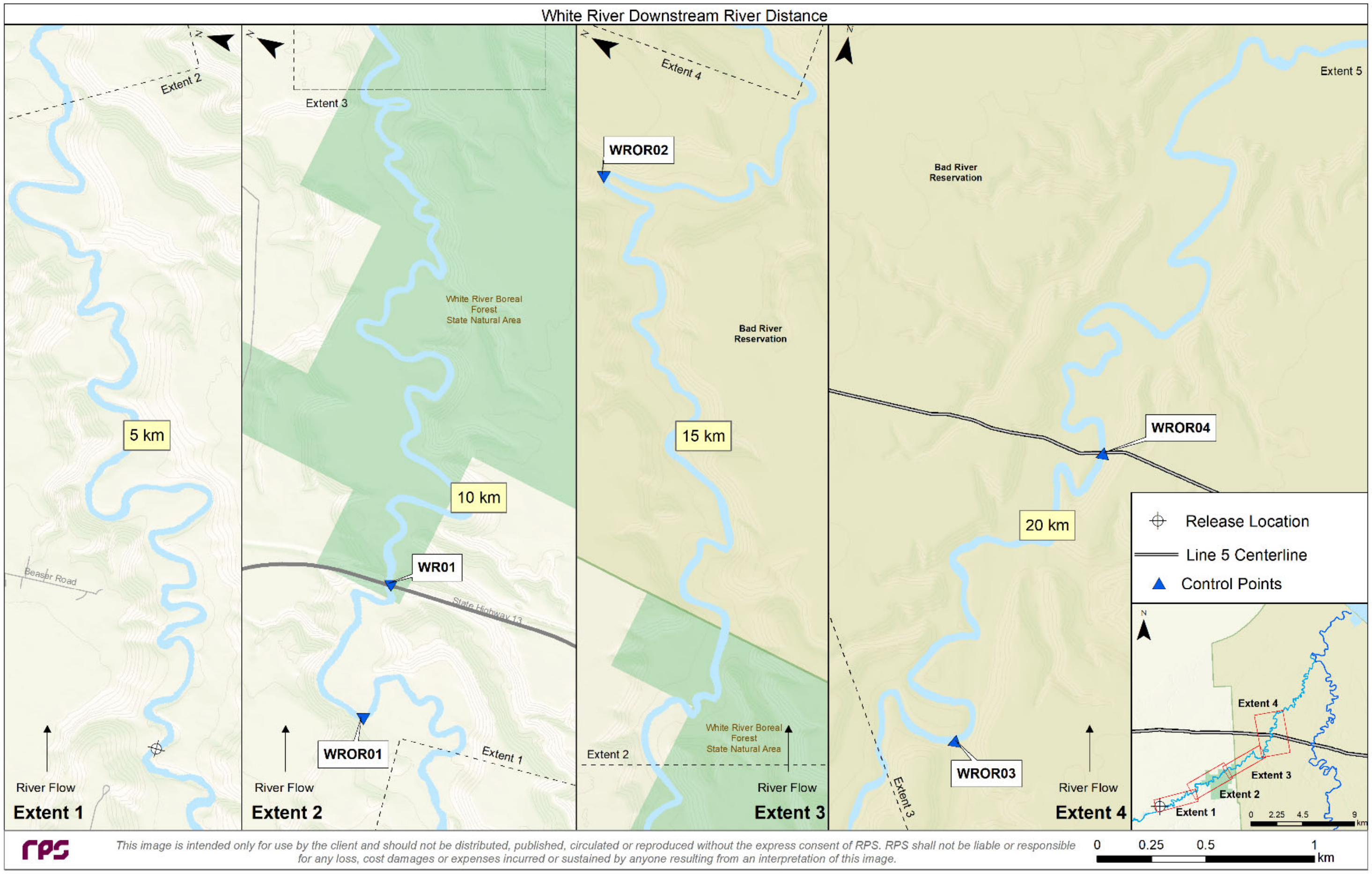

Figure 2-8. MCP locations modeled on the White River (upstream portion).

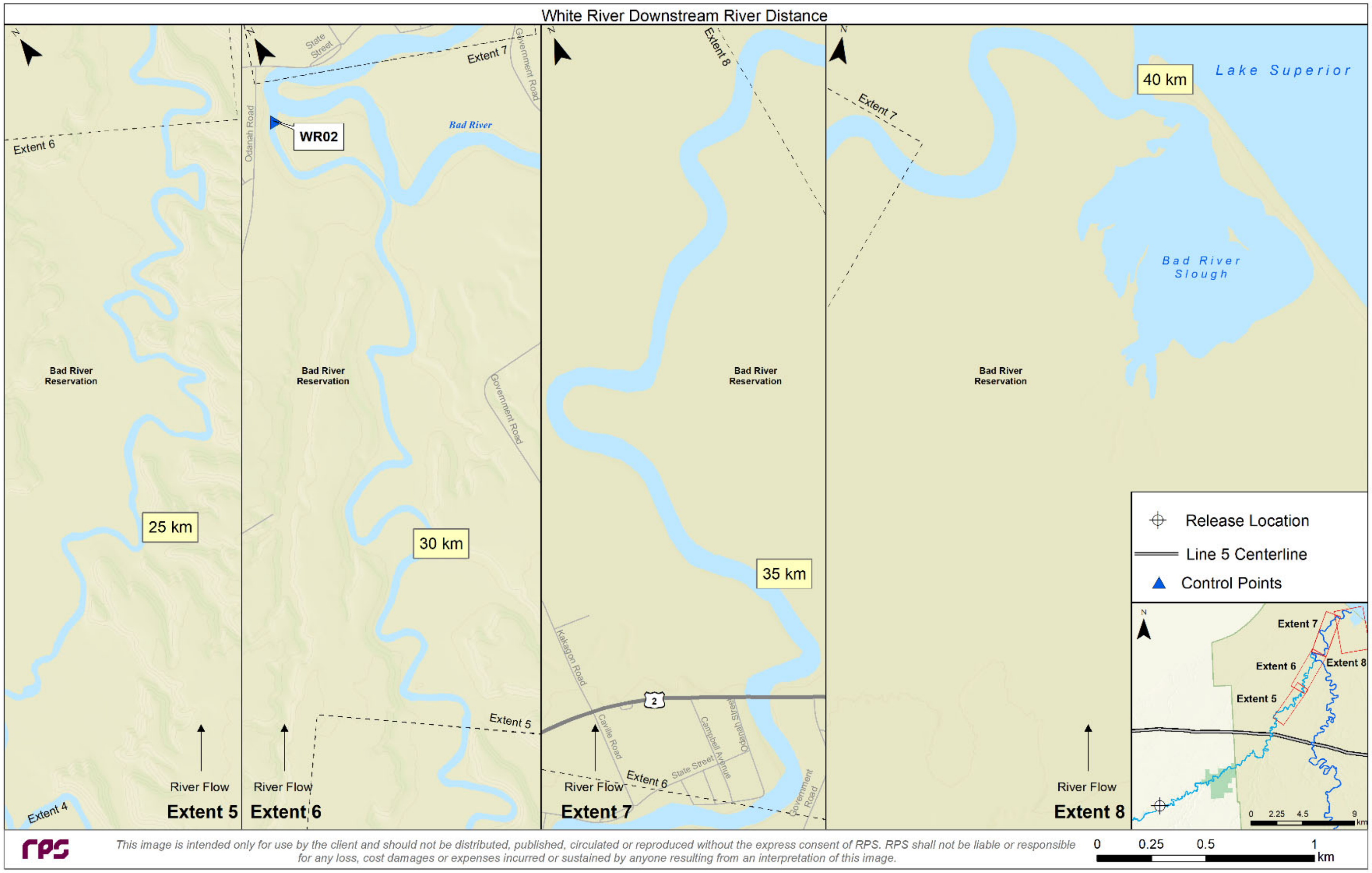

Figure 2-9. MCP locations modeled on the Bad River (downstream portion).

Collectively, the information provided by Enbridge on the CPs was developed into a series of inputs that were used in the emergency response mitigation modeling scenarios, including varying lengths of containment booms, a number of different skimmer resources, specific equipment layouts, and varying times for activation. This information was used to develop the Modeled Control Points (MCPs) along the White River and Bad River that were used as modeling inputs (Table 2-2 and Table 2-3). The distinction between CPs and MCPs is important because the CPs are designed to be flexible based on the exact circumstances of the spill, which will also vary through time. Changes or modifications to each CP (e.g., adding equipment, moving booms, activating/deactivating additional locations) would be made throughout the course of a real response based upon the variable conditions. However, the MCPs in this study were not simulated to change through time.

Containment booms were modeled at each of the downstream MCPs along with various skimmer resources that would be available from nearby staging locations, including smooth drum, grooved drum, and weir skimmers. The amount of equipment and timing to activate varied by MCP based upon the equipment that would be available and the associated times to mobilize, access, and setup (Table 2-2 and Table 2-3). The response equipment that was modeled is based upon planning data and conservative assumptions provided by Enbridge (2022a), along with conservatively long times to respond from Enbridge's staging locations.

Table 2-2. Modeled response equipment at each CP on Bad River.

CP	Latitude °N	Longitude °W	Downstream Distance (km)	Active Collection/ Containment (hr)*	Collection Equipment	Length of Containment Boom (ft)
Bad River CPs						
SURCP0795	46.34928	90.65998	2.8	3.1	1 Skimmer Elastec 136 1 Skimmer TDS118 1 Skimmer TDS118G	450
BROR01	46.36586	90.66346	6.4	5.6	1 Skimmer TDS 136G	150
				5.8	1 Skimmer TDS118G	150
BROR02	46.36700	90.64784	7.8	5.1	1 Skimmer TDS 136 1 Skimmer TDS118G	300
				5.5	1 Skimmer TDS118	500
SURCP0796	46.37048	90.64574	8.2	5.1	2 Skimmer TDS118 1 Skimmer Sea Skater 1 Skimmer Manta Ray X-Tex Fabric (not modeled)	800
				5.3	1 Skimmer TDS118G 1 Skimmer TDS136G	150
				6.0	Pom poms (snare) (not modeled)	100
SURCP0797	46.40475	90.63425	16.1	9.6	1 Skimmer Mini-max 1 Skimmer TDS118 1 Skimmer TDS118G	200
				10.1	1 Skimmer TDS118	200
SURCP0800	46.44060	90.69298	27.9	9.1	1 Skimmer TDS136G	200
				10.1	1 Skimmer TDS1118G X-Tex Fabric (not modeled)	200
SURCP0801	46.48723	90.69595	38.9	10.0	1 Skimmer TDS136G 1 Skimmer SkimPak 1800	500
				11.0	1 Skimmer TDS118	3800

* An initial time of 15 minutes was added to the response modeling to accommodate the maximum period in which a release is identified and communication of the spill is relayed to the response organization.

The activation time at each CP was modeled from the time of initial boom placement, as that activity would trigger the containment of oil behind booms (limiting its transport downstream) for subsequent collection using skimmers.

Table 2-3. Modeled response equipment at each CP on White River.

CP	Latitude °N	Longitude °W	Downstream Distance (km)	Active Collection/ Containment (hr)*	Collection Equipment	Length of Containment Boom (ft)
White River CPs						
WROR01	46.51532	90.85121	7.1	5	1 Skimmer TDS118G	600
WR01	46.51672	90.84281	8.1	3.8	3 Skimmer TDS136 1 Skimmer TDS118 1 Skimmer TDS118G 1 Skimmer Mini-Max	2500
				9.0	1 Skimmer TDS118G 2 Skimmer TDS136G 1 Skimmer Magnum 100 2 Skimmer Magnum 100	-
				5	X-Tex Fabric (not modeled)	950
WROR02	46.53942	90.77940	16.3	5.5	1 Skimmer TDS136G	500
WROR03	46.53807	90.76218	18.9	8.6	3 Skimmer TDS136G 2 Skimmer TDS118 1 Skimmer TDS118G X-Tex Fabric (not modeled)	1000
WROR04	46.54992	90.75499	21.3	9.6	1 Skimmer TDS136G	500
WR02	46.60732	90.70327	35.7	9.8	3 Skimmer TDS118 3 Skimmer TDS118G 4 Skimmer TDS136	5200

* An initial time of 15 minutes was added to the response modeling to accommodate the maximum period in which a release is identified and communication of the spill is relayed to the response organization.

The activation time at each CP was modeled from the time of initial boom placement, as that activity would trigger the containment of oil behind booms (limiting its transport downstream) for subsequent collection using skimmers.

The MCP activation times reflect conservative assumptions that lengthen the amount of time allowed in the model to set up and begin collecting oil. A 2-hour notification time was assumed for all MCPs, as well as a travel time based on a 35 miles per hour (mph) speed average for transportation from the staging location to the point of access. Enbridge's internal response capabilities are actually designed to accommodate a 1-hour notification time, but a 2-hour notification time (which is the standard for OSRO-owned equipment) was applied here as a more conservative assumption. The use of a 35-mph speed average reflects OSRO guidance for potentially adverse travel conditions (e.g., winter snow, severe storm) that might impact the ability to access a CP location. For the purposes of modeling, an additional 15 minutes was added to MCP activation to accommodate for the amount of time following a release to identify that a release had occurred and communicate that with Enbridge responders and OSROs.

Activation timing and tactics of response were not adjusted for flooding (or overbank) conditions. In the event of a release under these conditions, Enbridge would consider condition-specific access and response needs, which may differ from those outlined here. Staging sites may be accessed by several different types of vehicles (e.g., tracked vehicles, helicopters, etc.) with the capacity to transport a wide range of response equipment including, but not limited to, additional boom for wider river deployments. The trailers at staging sites are already equipped with longer boom lengths than required for normal flow conditions to accommodate wider-than-normal, high flow conditions.

Together, the conservatively-based recovery rates and timing used in this modeling depict scenarios where emergency response efforts and success could be reasonably lower than might occur in real-world circumstances. The modeling is further conservative because it also does not account for full-scale OSRO deployment, dynamic readjustment of CP layouts or locations, or emergency response mitigation techniques other than direct containment through skimming (e.g., submerged oil recovery techniques, sorbent or protective booming, shoreline cleanup).

The modeling, notably, does not account for the establishment of an "additional barrier" (as part of overall tactical response planning) that would be used to limit impacts into a watercourse at a point downstream of the expected near-term oil trajectory. In a real-world release, the location of an additional barrier and associated tactics would be determined based on field observations and input from the ICS Operations Sections Chief and Unified Command (Enbridge, 2022c). Resources beyond those modeled in this Technical Appendix would be mobilized, not subtracting from mitigation efforts otherwise available at the upstream CPs. An additional barrier strategy is planned (Enbridge, 2022c) as follows:

- Contains sufficient reserve resources for containment and recovery of larger amounts of surface oil in the unlikely event that a loss of containment from an upstream CP occurred;
- Addresses sheens and micro surface oils through the use of sorbents including; sorbent pads, Pillows, Sorbent Sweeps, Pom-poms/snares, sorbent socks;
- Includes tactics that would address entrained and submerged oils that may resurface through the use of filter fences and filter fabrics; and
- May include protective and exclusionary booming for environmentally sensitive areas or areas of high consequence (equipment includes vinyl river boom, vinyl creek boom, vinyl shore seal boom, AquaDams™, Tiger Dams™, Water-Gate dams, etc.). The Inland Spill Response Tactics Guide (Enbridge, 2018) is an internal Enbridge document that can be used to select and implement such equipment from a cache of Enbridge-owned oil spill response equipment during the first 72 hours of the response.

Based on the trajectory modeling conducted in this assessment, oil would be predicted to reach Highway 2 between 44 hours and 87 hours after release, depending on the release location and river flow conditions. The resources for an additional barrier could therefore be positioned into an area downstream of Highway 2 and upstream of the entry point to the Bad River Slough complex and Lake Superior; the exact location would be determined and adjusted based on real-time observations of the watercourse characteristics at the time of release. These resources were not modeled here due to the dynamic and spill-specific nature of the potential deployment, as well as the variety of equipment that might be used to address very small quantities of oil on the surface (e.g., sheens) or in the water column (i.e., entrained oil). However, such resources would likely be able to stop small amounts of oil (e.g., sheens, which are less than 1/1,000th the thickness of heavy black oil) from transporting beyond this point in the event of a real release from the pipeline.

2.2 Hydrocarbon Trajectory, Fate, and Effects Assessment using SIMAP

2.2.1 SIMAP Model Description

The SIMAP modeling system is a comprehensive modeling system that was developed by RPS over the last roughly forty years to provide an understanding of the movement, behavior, and potential effects of crude oil for releases into the water (Figure 2-10). This modeling system allows for an in-depth understanding of the behavior of oil in the environment. SIMAP provides three-dimensional trajectory and fate information through time and with seasonal considerations (such as ice cover), as well as anticipated biological effects. SIMAP provides measurements of the oil thickness on the water surface, concentration of hydrocarbons in the water column, and length of shorelines contaminated. It is also used to assess the exposure to toxic compounds within the water column following a release of oil to inform the potential for acute impacts to aquatic organisms. Using the exposure and effects modules, SIMAP can also be used to assess the potential effects (i.e., acute mortality, represented as "Equivalent Areas of 100% Acute Mortality" by receptor group or EA-100) that releases of oil may have on various biological receptors in the freshwater environment (Figure 2-11). Mortality is calculated as percent loss within specific areas (i.e., each grid cell), and is translated into the equivalent area of 100% loss (i.e., EA-100) to allow for results from each scenario (which include fractional percent mortality by grid cell and vary spatially and through time) to be compared to one another.

The schematic in Figure 2-10 depicts the various oil fate processes simulated in the SIMAP model for near shore and in riverine environments. Each of these processes is discussed in more detail in Appendix B. Because oil contains many chemicals with varying physical-chemical properties and the environment is spatially and temporally variable, the oil rapidly separates into different compartments within the environment including:

- Surface oil
- Emulsified oil (mousse) and tar balls
- Oil droplets suspended in the water column
- Oil adhering to suspended particulate matter in the water
- Dissolved lower molecular weight components (MAHs, PAHs, and other soluble components) in the water column
- Oil on and in the sediments
- Dissolved lower molecular weight components (MAHs, PAHs, and other soluble components) in the sediment pore water
- Oil on and in the shoreline sediments and surfaces

Further details of the SIMAP model theory, approach, and effects assessment are provided in Appendix B.

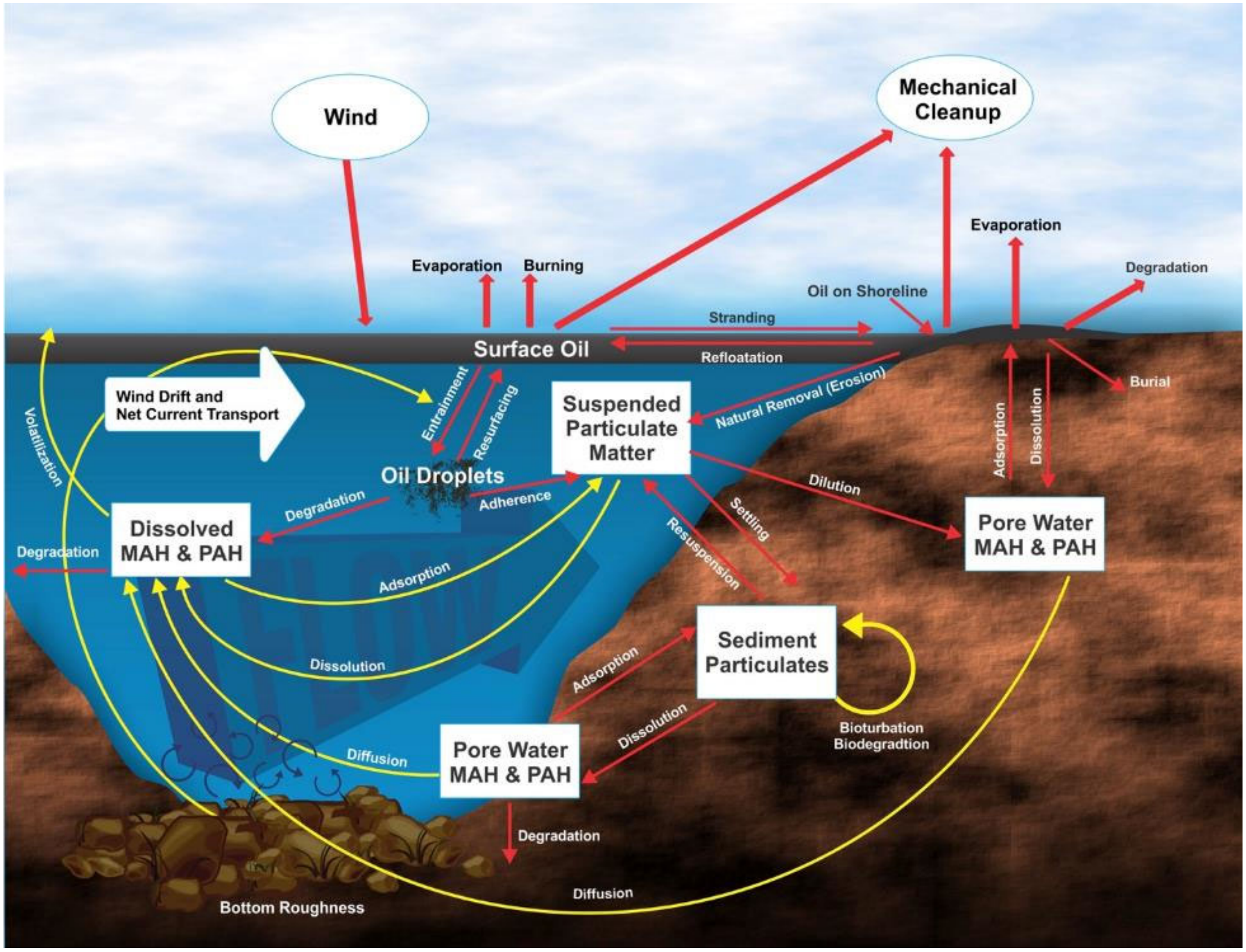

Figure 2-10. Simulated SIMAP oil fate processes in lakes and rivers.

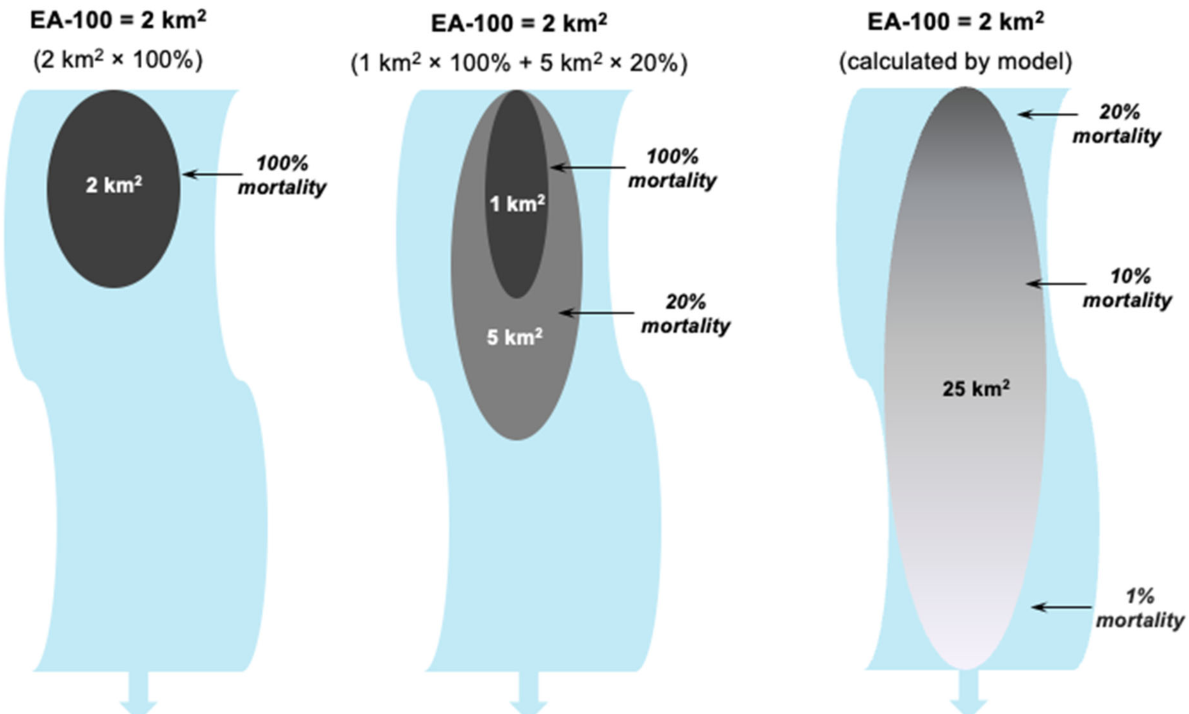

Figure 2-11. Examples of EA-100 calculations (simplified, unrealistic schematics provided for example purposes). The left highlights the unrealistic and extremely unlikely scenario where the presence of any amount of oil would result in 100% mortality of all organisms within the area of contamination. The center highlights greater areas of exposure to oil and the simplification of two fixed fractions killed (either 20% or 100). The right highlights a more realistic (though still highly simplified) scenario with fractional mortality over a much greater area. This later example is closest to what is carried out within the SIMAP model over each grid cell within the entire model domain. In each of these examples, the EA-100 would be the same value of 2 km^2.

2.2.2 Modeling Approach

Oil spill trajectory, fate, and effects modeling and analyses were performed to support evaluation of the risks resulting from hypothetical releases of light crude oil from Line 5, focused on site-specific assessments at the crossings of the Proposed Route with the Bad River and the White River. SIMAP was used at the two crossings to assess the site-specific and season-specific movement and behavior of released oil in unmitigated and emergency response-mitigated release scenarios. SIMAP was also used to determine the potential biological effects using an exposure analysis to determine acute mortality and the EA-100s for a set of biological receptors.

To understand the range of potential environmental variability and the effect that this would have on the trajectory, fate, and potential effects of a release, three environmental conditions were investigated separately, based upon river flow conditions, which is the major driver of oil trajectory in a watercourse. The seasons modeled include low river flow wintertime conditions with 100% ice cover (which prevented evaporation of subsurface oil), average river flow summer or fall conditions, and high river flow springtime conditions (Table 2-4). To account for changes in oil adherence to shorelines under varying water levels, different shore types were considered at each downstream point within the Bad and White Rivers for each environmental condition. Under low river flow wintertime conditions, all shorelines were considered to be completely frozen/ice, with very little potential for oil adherence. Under average river flow conditions, shorelines included predominantly sand and mud banks with some wetland, with some gravel or rock banks with intermediate retention potential. Under high river flow conditions, shore type was predominantly vegetated, based upon bankfull conditions, with a high potential to adhere oil to shorelines. The intent of the modeling was to provide multiple representative release scenarios, based on site-specific and season-specific parameters for each single release event, to provide an understanding of the range of predicted movement, behavior, and potential biological effects that may be possible under different geographic and environmental conditions. All three conditions (high, average, and low) assumed within-bank flow for the hydrodynamics.

Table 2-4. Average water temperature and wind speed for each seasonal condition modeled in SIMAP.

River Flow Condition	Month (Season)
High Flow	April (Spring)
Average Flow	June (Summer/Fall)
Low Flow	January (Winter)

During less frequent flood events (such as the 5-year or 10-year storm), overbank conditions may allow water to reach Lake Superior more quickly, due to larger river flows, resulting faster velocities in the main channel, and shorter downstream distances to Lake Superior, as higher waters along the sinuous channel may cut out meanders from flow path (e.g., overflow channels). However, overbank conditions also result in greater dilution, reduced duration of exposure, and result in complex and time-varying flow patterns, which can result in slower velocity water in out-of-bank flow regions, which may actually reduce downstream transport of oil. Therefore, portions of a release may arrive at Lake Superior faster than within-bank conditions, while other portions may not. An overbank, flooding scenario was not modeled in this Technical Appendix, but previous analysis of this type of scenario at a different location in the Bad River (the Existing Route Line 5 crossing, Horn et al., 2022) was used to predict that oil could move faster and farther than other seasonal conditions under a 500-yr flood condition.

Each representative release scenario was run separately in SIMAP as a deterministic (i.e., single trajectory) model simulation. The trajectory, fate, and potential effects were simulated for a total of four days following the release, enabling a longer period of time for oil to reach Lake Superior. During low river flow wintertime conditions with 100% ice coverage, the oil was predicted to rise through the water column and become trapped under the ice, where it would thin to a terminal thickness (see Appendix B). The ice cover was assumed to effectively cap the oil and prevent all evaporation.

Three release volumes were modeled at the crossings of each river, including an FBR release (9,874 bbl for the Bad River crossing and 8,517 bbl for the White River crossing), a HARV discharge of 1,911 bbl, and a RARV discharge of 334 bbl (Table 2-5, Table 2-6). Each FBR and HARV discharge was modeled during high, average, and low river flow conditions. The RARV discharge was only simulated under average river flow conditions for comparison to the larger volume releases. Releases were assumed to occur over a 13-minute period, associated with the maximum allowable amount of time for incident detection and valve closure. From the perspective of oil trajectory and fate, this timing was conservatively short to maximize the pulse of oil (maximum volume in shortest period of time), as the total duration of the release would likely take tens of minutes or even hours for gravitational drain down to finish. In this more realistic scenario, should the same volume of oil be released over a longer period of time, the amount of oil present at any point in space/time would be lower, forming thinner slicks, resulting in lower concentrations, and potentially resulting in lower likelihood biological effects threshold exceedances. Additionally, more time may allow for more effective mitigation (i.e., collection and containment) efforts. The releases were assumed to occur at the sediment-water interface at the river bottom of the pipeline crossing.

Table 2-5. Bad River Crossing Scenarios modeled in SIMAP.

Scenario ID	Spill Site	Spill Event & Response	River Flow Condition	Season	Spill Duration	Total Spilled Volume (bbl)	Model Duration
1	Proposed Route Crossing of Bad River 46.336 °N, 90.649 °W	FBR Unmitigated	High	Spring	13 min	9,874	4 days
2			Average	Summer			
3			Low	Winter (Ice)			
4		HARV Unmitigated	High	Spring		1,911	
5			Average	Summer			
6			Low	Winter (Ice)			
7		RARV Unmitigated	Average	Summer		334	
8		FBR Mitigated	High	Spring	13 min	9,874	4 days
9			Average	Summer			
10			Low	Winter (Ice)			
11		HARV Mitigated	High	Spring		1,911	
12			Average	Summer			
13			Low	Winter (Ice)			
14		RARV Mitigated	Average	Summer		334	

Table 2-6. White River Crossing Scenarios modeled in SIMAP.

Scenario ID	Spill Site	Spill Event & Response	River Flow Condition	Season	Spill Duration	Total Spilled Volume (bbl)	Model Duration
1	Proposed Route Crossing of White River 46.502 °N, 90.895 °W	FBR Unmitigated	High	Spring	13 min	8,517	4 days
2			Average	Summer			
3			Low	Winter (Ice)			
4		HARV Unmitigated	High	Spring		1,911	
5			Average	Summer			
6			Low	Winter (Ice)			
7		RARV Unmitigated	Average	Summer		334	
8		FBR Mitigated	High	Spring	13 min	8,517	4 days
9			Average	Summer			
10			Low	Winter (Ice)			
11		HARV Mitigated	High	Spring		1,911	
12			Average	Summer			
13			Low	Winter (Ice)			
14		RARV Mitigated	Average	Summer		334	

The same suite of scenarios was modeled both with and without emergency response mitigation, which was implemented as a set of pre-identified downstream Modeled Control Points (MCPs) that included various containment and collection tactics (see details in Section 2.1 and Appendix B). Response actions modeled in this study included surface and shoreline containment booming, as well as surface oil skimming technologies. At each MCP, a variable number of surface skimming equipment were utilized. Booms were positioned at an angle across the channel in order to funnel oil flowing downstream into the point, where collection skimmers were placed to maximize surface oil collection. Response planning information was provided to RPS by Enbridge, which identified the placement of each CP, as well as the timing, response equipment utilized, and the assumed efficiency for each piece of equipment (Enbridge, 2022a).

The results of the deterministic SIMAP simulations provide a time history of the fate and weathering of oil over the duration of the release (mass balance), expressed as the percentage of released oil on the water surface, on the shoreline, evaporated to the atmosphere, entrained in the water column, and naturally degraded. In addition, footprints of the instantaneous maximum for individual trajectories over the course of the entire modeled duration (4 days) depict the cumulative path of floating surface oil thickness, mass of shoreline oil, and the maximum concentration of dissolved hydrocarbons (i.e., the soluble fraction) in the water column at any point in time. Figures presenting these results are included in Appendix B.

Biological effects modeling was conducted with the SIMAP exposure model, investigating the time-varying and space-varying concentration and duration of exposure, to predict the EA-100s for each scenario. Surface, shoreline, and in-water effects were assessed at two different sensitivity thresholds for ecological receptors including 5 µg/L, which represented sensitive species, and 50 µg/L, which represented average sensitivity species. Biological effects analyses were conducted to bound the potential impacts that each release may have on the ecological receptors within the environment.

2.3 Hydrocarbon Route Assessment and HCA Analysis

2.3.1 OILMAPLand Model Description

The OILMAPLand model is a two-dimensional modeling system that has been developed by RPS over the last roughly twenty years to provide a conservative approximation of the overland movement of released oil or chemicals as well as the potential extent of downstream movement in the surface water network. The OILMAPLand spill modeling system is used to simulate the overland flow of crude oil releases to predict the location, volume, and timing that oil may enter a watercourse. Oil flow over land is governed by the physical characteristics and slope of the land surface. The model predicts the downslope path and calculates an oil mass balance that includes the calculated losses from oil adhesion to land over the oiled path, the formation of small puddles, oil pooling in large depressions on the land surface, and oil evaporation to the atmosphere (Figure 2-12). This is used to determine the remaining volume of oil that has the potential to reach a waterway. Once in the water, the releases are modeled as they propagate downstream, and in winter months when the waterway is predicted to be frozen, over the land surface until the entire amount of product is released.

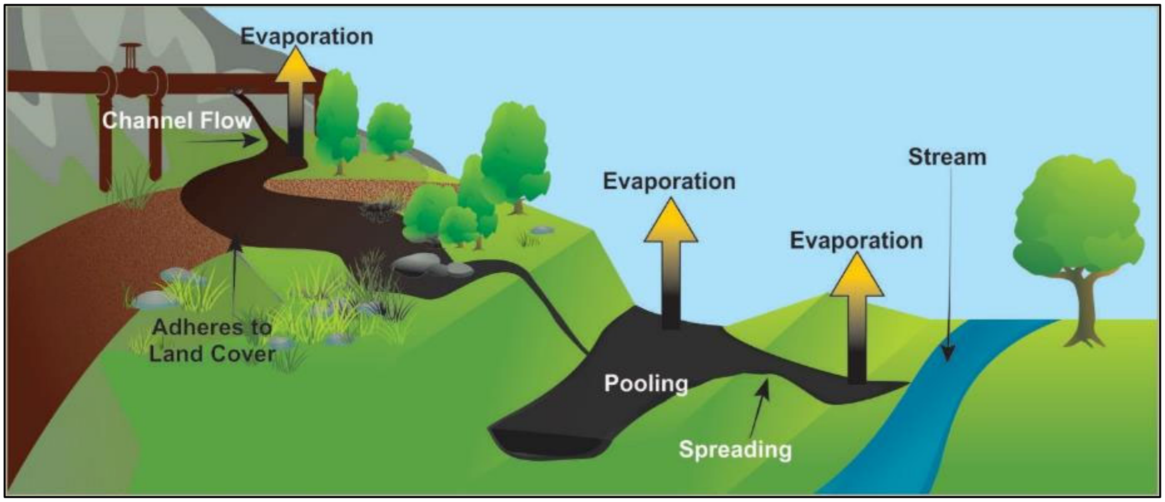

Figure 2-12. Conceptual diagram of land transport model for OILMAPLand, depicting the possible fate of oil as it moves over the land surface.

When oil reaches an ice-free waterway, the water transport portion of the OILMAPLand model simulates the downstream movement of oil on the water surface at a defined velocity (by watercourse segment or reach). As oil moves downstream, estimates of the amount of oil lost to the shore from adhesion and to the atmosphere by evaporation are made.

While OILMAPLand does provide an indication of the downstream extent of oiling and mass balance of oil, it is not able to provide detailed predictions of three-dimensional oil fate and transport. These 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, are not modeled in smaller waterways, where impacts to results would be less meaningful and would not align with the overarching goal of the OILMAPLand assessment. However, these processes were modeled in SIMAP (see Section 2.2) for the larger Bad River and White River watercourse crossings, where an effects assessment was conducted requiring this greater level of detail. Further details of the OILMAPLand modeling, theory, and approach are provided in Appendix C.

2.3.2 Modeling Approach

RPS conducted a route alternatives analysis of the Existing, Proposed, and Route Alternatives to assess the range of predicted overland and downstream movement and behavior of hypothetical hydrocarbon releases from any point along each pipeline. An interval-based approach was used in OILMAPLand to assess releases along the entirety of each pipeline route that move over the land surface and down the surface-water network. The OILMAPLand model was used to generate release point locations spaced at 100-meter intervals (328 ft) along each pipeline route, as well as at every watercourse crossing identified in the NHDPlus dataset. A total of 5,029 individual release points were simulated from the Existing, Proposed, and Route Alternatives using the OILMAPLand model, with between 552 and 1,684 hypothetical release points associated with new construction per pipeline route (Table 2-7).

Table 2-7. Total number of hypothetical release points simulated along each pipeline route and the number of those release points that are associated with watercourse crossings.

Pipeline Route	# of Release Points Along Pipeline Route (Total)*	# of Release Points Associated with New Construction
Existing Route	1,052	0
RA-01	1,330	552
Proposed Route	1,452	732
RA-02	1,426	1,009
RA-03	1,688	1,684
Total # of unique simulations	5,029	

*Note that the total number of release points along each pipeline route alternative (i.e., Pipeline Extent Considered) includes a combination of points along the existing route as well as points associated with new construction (see Figure 1-1 for reference).

Hypothetical release locations included in the assessments for each pipeline route began and ended at the same westernmost and easternmost points where RA-03 diverted from the existing line (i.e., the Pipeline Extent Considered in Figure 1-1 denoted by the asterisks). This means that portions of the existing Line 5 were used in the analysis of multiple Route Alternatives. These portions were included to allow for commensurable comparisons of each route alternative between the same upstream and downstream endpoints.

Site-specific spill volumes were assigned to each hypothetical release location based on predicted FBR release volumes provided by Enbridge (2022b) or the RARV (334 bbl for all locations). Spill durations were assigned based on a calculation involving drained volume, pipeline diameter, pipeline shutdown time, and elevation profile of the pipeline. Stream velocities were generalized for each watershed, based on watershed averages, and were modeled during representative high river flow conditions (for the FBR releases) and during representative low river flow conditions (for the RARV releases). Corresponding environmental conditions (e.g., wind speed, temperature, etc.) were based on average values for April and January, respectively. The outputs of this modeling were developed as a site of OILMAPLand-predicted trajectories from each simulated release point.

2.3.3 HCA and AOI Analysis

The OILMAPLand-predicted trajectories were overlaid upon maps of HCAs and AOIs to enable comparison between the different potentials for impact from hypothetical releases along each pipeline route. The HCAs analyzed included the five types defined by PHMSA in 49 CFR § 195.450 and 49 CFR § 195.6: commercially navigable waterways (CNW), high population areas (HPA), other populated areas (OPA), drinking water resources (DW), and ecological resource unusually sensitive areas (ESA). While AOIs are not defined regulatorily, receptors of interest to various stakeholders are frequently considered in addition to defined HCAs. For this assessment, AOIs included the Reservation, wild rice areas, State and Federal Lands, and Lake Superior (Figure 1-2). The wild rice areas included those in the vicinity of the Kakagon-Bad River Slough complex (i.e., within the Reservation), as well as elsewhere throughout the region.

Both the HCA and AOI analyses within the route comparison identified “direct” could-affect segments, where segments of the pipeline centerline directly intersected an HCA/AOI, and “indirect” could-affect segments, where releases from points along the pipeline segment would be predicted to reach an HCA/AOI following overland and/or downstream transport. Reported portions of the pipeline that directly impact an HCA/AOI were also always considered to indirectly impact the HCA/AOI.

2.3.4 High-Resolution Segment Analysis

The total length of pipeline that had the potential to impact each watercourse crossing or “potential impact segment” was calculated to serve as the basis for estimating the failure probability of each watercourse crossing in Appendix A. This length was determined in a high-resolution segment analysis using a high-resolution outflow and overland spill modeling assessment conducted with OILMAPLand. Simulations were modeled at hypothetical release locations spaced at 10-m intervals along the pipeline on either side of the White River and Bad River crossings, up to the point that the coarser and previously conducted 100-m interval (328 ft) results clearly depicted the oil being transported away from the river crossing or through a separate hydrologic route that entered the river a significant distance from the crossing itself. A total of six segment analyses were performed, including one for each of the Proposed Route, RA-01, and RA-02 crossings of both the White River and Bad River. In total of 3,579 hypothetical FBR crude oil releases were simulated. RA-03 is not in the watershed and therefore does not cross the White River or the Bad River, and thus was not included in this analysis. A higher resolution elevation dataset (the Ashland County DEM) was used to improve the accuracy of the assessment. Inputs were otherwise the same as those used in the modeling conducted for the HCA and AOI Analysis.

3 RESULTS AND FINDINGS

3.1 Probability Assessment

DNV was tasked by Enbridge with examining the POF of the L5WSRP. PHMSA data as well as DNV's proprietary probabilistic risk model were utilized to calculate the POF of the mainline pipe for the Proposed Route, as well as the alternate RA-01, RA-02, and RA-03 routes. Finally, the POFs for the Bad River and White River HDD crossings and representative open cut crossings were calculated to provide an upper bound POF for all water crossings. The probability of various release volumes from the resultant failures was also calculated.

It is estimated that the POF, considering all commodities transported, for the L5WSRPfor the Proposed Route is 3.96x10-6 failures per mile per year for all release sizes and the POF of a FBR is 6.34x10-8 per mile per year. This POF is equivalent to the extremely remote chance of a failure occurring somewhere on a given mile of pipe of 1 in 252,000 and a FBR of 1 in 15,700,000 for any given year.

The POF of any size release at the Bad River ranges from $1.25x10^{-7}$ to $4.59x10^{-7}$ depending on the route, and at the White River ranges from $2.92x10^{-7}$ to $8.34x10^{-7}$ depending on the route. The POF of any size release at any other water body crossed by the relocation using a shorter HDD is estimated to be lower than those predicted for these crossings. The POF of a release greater than 334 barrels at the Bad River Crossing ranges from $2.14x10^{-8}$ to $7.85x10^{-8}$ per year depending on route. The POF of a release greater than 334 barrels at the White River Crossing ranges from $4.99x10^{-8}$ to $1.43x10^{-7}$ per year depending on route. The overall POF for any release in a waterbody crossed by the relocation is extremely remote, in all cases less than 1 in 6,990,000 in any given year.

3.2 Hydrocarbon Trajectory, Fate, and Effects Assessment

3.2.1 SIMAP Modeling

Enbridge has identified the range of potential effects from hypothetical releases that could occur along the Proposed Route under different seasonal conditions using local geographic and environmental conditions. The trajectory and fate results from the simulations at the Bad River and White River (presented in Appendix B) may also be used to infer how downstream movement and behavior of oil might occur under similar release scenarios at locations along the other route alternatives. The exact trajectory, fate, and potential effects of any given release are dependent on the release location, product type, release volume, environmental conditions at the time of the release, and emergency response mitigation measures that may be employed.

Emergency response mitigation activities were assessed to quantify the reduction in the magnitude and extent of potential impacts during different environmental conditions (seasons), factoring in the variability in transport and fate of the released oil under different environmental conditions. Of note, during wintertime conditions, a spill is more likely to become trapped in snow cover or spread on the ice surface, thereby never reaching a watercourse in the first place. The movement of oil over a frozen land surface and through snow and ice is highly variable and this transport can take place over many hours or days. Snow and ice conditions could significantly (or completely) reduce the volume of oil ever reaching a waterway. If a spill did enter the water column under ice, collection may be able to continue for a longer period due to the low river flow conditions typical of this season and the potential for oil to become trapped beneath the ice near the release location. Emergency response efforts can be limited at any time of the year (including winter) based upon location-specific and environmental condition-specific limitations that may impact response activities. This includes, for example, weather delays in reaching and accessing CPs, weather conditions causing temporary work stoppage, or equipment issues or maintenance needs. The time to complete removal would be dependent on the exact environmental and release conditions as well as the actual emergency response efforts that were undertaken at the time of the release. To address the potential for adverse response conditions, RPS' modeling used conservatively-based recovery rates and timing to reflect scenarios where emergency response efforts and success could be reasonably lower than might occur in real-world circumstances (Section 2.1.2.8).

The scenarios considered included full-bore ruptures (FBR; 9,874 bbl in Bad River and 8,517 bbl in White River), historical accidental release volumes (HARV; 1,911 bbl), and recent average release volumes (RARV; 334 bbl). Although they are smaller than the FBR, even the HARV and RARV scenarios targeted conservatively large volume releases with a low probability of occurrence (Section 3.1). Since 2010, Enbridge has transported approximately 25% of the crude oil produced in North America in its pipelines and recorded 122 total spills, of which 90% were less than 10 bbl, with both the mode and median of these release volumes being less than 1 bbl. Smaller releases, such as 10 bbl, were not modeled and would be expected to have minimal impacts on the environment. Releases were simulated under three different seasonal and corresponding river flow conditions, including wintertime conditions with 100% ice cover. Simulations were allowed to progress unmitigated (i.e., no emergency response efforts, which is highly unlikely to occur in any real-world release) at the Bad River and White River crossings. Each unmitigated scenario was also modeled with response mitigation.

The tiered modeling approach applied in Technical Appendix B allowed for quantitative results to be calculated for a variety of metrics related to trajectory, fate, and potential effects. Results were mapped for each release scenario and comparisons were made between them. Appendix B first provides a summary of the trajectory and fate of oil for each of the scenarios and then provides a discussion of the potential biological effects.

Discussions are focused on the influences that variable environmental conditions, release volumes, and mitigation efforts have on the results for each simulated release. The findings in this report can be used to identify regions and resources that may be at risk, should there be a large volume release of oil, as well as the estimated magnitude of potential effects. In addition, these results may be used to bound the amount of time that may be available for response mitigation measures to be implemented to protect resources and limit the magnitude and extent of oil contamination.

While it is understood that the identified scenarios are in no way intended to predict a specific future event, the results presented in this document demonstrate a range of potential trajectory and fate, as well as the predicted effects that may result from large volume releases of oil based upon a set of geographic criteria, environmental variability, and biological sensitivities. In the unlikely event of a pipeline rupture or a valve loss resulting in a release of oil in the magnitude modeled here (FBR, HARV, and RARV releases of Bakken crude oil), the potential credible worst case resulting effects are described. The geographic range (i.e., extent) and magnitude of the adverse effects depends on the environmental conditions at the time of the release, the release parameters themselves, and the presence of sensitive receptors. Therefore, the predicted effects identified here are by no means the most expected outcome, as they are highly conservative estimates that tended to err on the side of predicting greater magnitudes and extents of potential effects.

The mass balance results of the twenty-four representative deterministic simulations provide a time history of the fate and weathering of oil over the duration of the release, expressed as the percentage of released oil on the water surface, on the shoreline, evaporated, entrained in the water column, degraded, and removed (i.e., successful emergency response activities which clean or remove oil from the environment.

The following conclusions were reached based on the above-described SIMAP modeling across the 24 different scenarios modeled at the Proposed Route crossings of the Bad River and White River.

1. Trajectory and Fate – In general, Bakken is a light crude oil with low density and viscosity and a high content of soluble and volatile hydrocarbons. Due to these characteristics, under ice-free conditions, 34-42% of the oil was predicted to evaporate quickly (within ~1 day). Evaporation continued in the simulations up to 40-50% where it was predicted to remain on the surface being transported downstream over an additional three days. In the unmitigated FBR releases under average river flow conditions (for both rivers), which are unlikely and extreme worst-case scenarios, the majority of oil was predicted to form surface slicks that would move downstream, stranding on shorelines and evaporating, with the potential for 35-39% of the release to remain on the surface or enter Lake Superior at the end of the 4-day simulation. This was not the case for the unmitigated high and low river flow scenarios or any of the mitigated scenarios, where less than 0.1% surface oil was predicted to reach Lake Superior due to stranding on upstream vegetation (high river flow), remaining trapped under the ice surface closer to the release location (low river flow, ice-covered conditions), and the containment and collection of oil by successful emergency response mitigation measures that would be employed. Almost all of the HARV and RARV scenarios were of sufficiently small volume that surface oil was not predicted to reach Lake Superior under any condition, mitigated or even unmitigated. Only the average river flow HARV releases were predicted to have patchy and discontinuous sheens extending north of Highway 2. Of note, surface oil slicks are the primary target of some of the most effective mitigation efforts aimed at containing and collecting released oil (e.g., booms and skimmers). Oil stranding on shoreline would be addressed by Enbridge's SCAT program (Enbridge, 2016). Some limited sediment oiling was predicted in each simulation, but the sedimented

oil was patchy and discontinuous, with predicted deposition typically around 0.01 g/m^2 and some localized and patchy areas that reached 0.5 g/m^2 deposition in more quiescent waters.

Seasonal river flow conditions were the dominant factor in downstream transport (e.g., timing) of surface oil in each river, with oil typically being transported fastest and farthest under high river flow conditions, followed by average, and then low river flow conditions. An overbank, flooding scenario was not modeled in this Technical Appendix, but previous analysis of this type of scenario at a different location in the Bad River (the Existing Route Line 5 crossing, Horn et al., 2022) was used to predict that oil could move faster and farther than other seasonal conditions under flood conditions. For the completely unmitigated scenarios, hydrocarbon contamination (whole oil and/or its dissolved constituents) was predicted to reach Lake Superior within approximately 2 days, 3 days, or 4 days following a release for both the White River and Bad River under high, average, and low river flow conditions, respectively. In other words, there would be a 2- to 4-day time lag for response activities to be undertaken to limit oil from reaching the Lake and downstream-most receptors (e.g., the Kakagon-Bad River Slough Complex). Actual response mitigation activation is anticipated to begin at the first CPs within 3.1 to 3.8 hours (Section 2.1.3).

During wintertime low river flow conditions, nearly all (>98%) of the oil in the unmitigated release scenarios was predicted to remain trapped beneath the ice, which prevented evaporation and enhanced dissolution of soluble constituents (which would otherwise preferentially evaporate under ice-free conditions) into the water column. This wintertime scenario used a set of highly conservative assumptions that were intended to bound the upper limit of oil trapped beneath the ice to maximize the potential for in-water effects. Depending on real-world conditions (e.g., partial ice coverage, fissures or leads in the ice, etc.) at the time of release, the amount of oil trapped beneath ice would likely be less than was predicted in these simulations.

Release volume, response mitigation, and the presence of ice were also large factors impacting the predicted oil trajectory, fate, and magnitude of potential effects in the Bad River and White River. Credible worst-case release volumes (i.e., FBR volumes) were generally predicted to result in larger extents with higher concentrations and thicknesses of contamination, which increased the potential for biological exposure and acute mortality. The shortest extents were predicted for the RARV scenarios, where surface and shoreline oiling were predicted to stop before Highway 2 without mitigation and before Copper Falls (Bad River) or before the White River Boreal Forest State Natural Area (White River), with mitigation. For the HARV scenarios in both rivers and the FBR scenarios in the White River, mitigation prevented whole oil (i.e., insoluble fraction) from reaching the wild rice areas, Kakagon-Bad River Slough complex, and Lake Superior. For all wintertime scenarios under 100% ice cover, no evaporation was simulated, and all of the soluble fraction was predicted to dissolve (with no reduction from volatilization), which resulted in the highest in-water concentrations and potential downstream movement into Lake Superior. In an actual response, substantial additional resources would be deployed at an additional barrier downstream of Highway 2, as well as additional tactics at the CPs (e.g., X-Tex fabric, pom-pom snares, and sorbent booms) that could minimize sheens and help capture submerged oil droplets downstream of turbulent waters.

2. Surface Effects – The most notable surface effects were predicted for fur-bearing mammals and dabbling waterfowl, which spend large amounts of time moving through surface waters as they forage, which would expose them to surface slicks. Most of these effects were predicted to occur in upstream areas, closer to the release locations, where the surface oil slicks were thickest and more continuous.

These surface effects assume the presence of fur-bearers and dabbling waterfowl at all points within the river, regardless of whether surveys have identified their presence.

The EA-100s and percentages of assumed habitats affected were predominantly influenced by the volume of oil released, with the largest release volumes (FBR) predicted to result in the largest potential for effects. Smaller releases (HARV followed by RARV), generally had the lowest predicted surface effects. No surface effects were predicted for releases under low river/ice flow conditions because oil was trapped below the surface of the ice.

Secondarily, surface effects were influenced by river flow conditions at the time of the release. Although higher river flow rates would move oil faster and tend to increase the potential coverage for surface effects, the duration of exposure at any given location was shorter and the greater holding capacity of vegetated shorelines in high river flow bank full conditions, was predicted to result in more oil stranding on upstream shorelines. Consequently, surface oil exposures further downstream were reduced for those scenarios (especially in the White River), countering some of the influence of faster downstream transport.

Finally, response mitigation had the strongest influence on the potential for surface effects for average river flow conditions, but less so for high flow conditions in the White River, due to these scenarios having lower surface effects overall due to the vegetated banks upstream of MCPs retaining more oil, even without mitigation. The application of emergency response mitigation efforts resulted in reductions in the predicted surface effects on wildlife ranging from approximately 40-90% lower in average flow scenarios and 10-50% lower in high flow scenarios. All mitigated HARV and RARV scenarios had low predictions of acute mortality, over at most 6% of the model domain, while the FBR scenarios had predicted mortalities covering up to 17% of the model domain.

3. Shoreline Effects – In all scenarios other than low river flow wintertime conditions, effects were predominantly predicted within wetland areas. This was due to the prevalence of wetland areas within the model domain and the large oil holding capacity of wetland shorelines themselves, which resulted in acute effects to vegetation. Most effects were predicted to occur in upstream vegetated areas, closer to the release locations, where the potentials for shoreline exposure were greatest due to surface oil slicks being thickest and more continuous.

   Shoreline effects were predominantly influenced by river flow conditions and the resulting shore type in contact with the water at the time of the release. Under high river flow bank full conditions, more vegetation was exposed to surface floating oil. Secondarily, shoreline effects were influenced by the volume of oil released, with the largest release volumes (FBR) predicted to result in the largest potential for effects. Larger river flow rates generally resulted in greater transport and potential for shoreline effects with larger percentages of wetland shorelines (i.e., high river flow conditions) and longer lengths affected. The maximum length of vegetated shoreline from any scenario predicted to be affected was 15 km (9.3 mi., or approximately 18% of total vegetated shoreline) for the FBR release in the White River under high river flow conditions. However, in the White River, under average flow conditions, shoreline effects were relatively high (affecting 98-100% of vegetated shoreline) because nearly all wetland habitats were in the upper portion of the river, where it was exposed to heavy black oil before slicks thinned to sheens. Finally, response mitigation had a notable influence on the potential for shoreline effects, especially for scenarios where containment and collection efforts removed oil prior to reaching downstream wetlands. No shoreline effects were predicted for releases during low river/ice flow conditions because vegetated shorelines were assumed to be covered by a layer of ice.

Response mitigation caused a near complete reduction (~100%) in predicted effects to wetland vegetation (where any initially occurred without mitigation), because a large portion of the surface slicks were contained and collected prior to reaching the predominantly wetland shorelines at downstream Bad River and White River locations as well as within the Bad River Slough. Under average high river flow conditions, predicted effects lengths were below 0.1 km (or <1%), regardless of release volume. Under high river flow conditions, mitigation significantly reduced predicted effects for the FBR release scenarios (23-83% lower than completely unmitigated scenarios), but had almost no effect on the HARV release scenarios in the White River, because acute mortality was predicted primarily at wetland locations upstream of response MCPs (covering approximately 3-8% of the model domain).

4. In-water Effects – Pelagic (swimming) and demersal (bottom-dwelling) organisms were predicted to have the largest effects, followed by planktonic (drifting) organisms (e.g., early-stage amphibians). As would be expected, sensitive species were predicted to have higher areas of potential effects, when compared to average sensitivity species.

   In-water effects were primarily influenced by spill volume and river flow rate. Potential effects to sensitive species were greatest for average river flow conditions, followed by high river flow or low river flow, depending on the oil release volume. This progression was the result of a balance between levels of contamination (i.e., concentrations of hydrocarbons in the water column), downstream transport, and the duration of exposure. Greater transport does increase extent, but it reduces duration of exposure. In addition, dilution was greater under high river flow conditions due to greater volumes of water moving through the river. In-water effects were also notably influenced by the volume of oil released, with larger release volumes predicted to result in larger potential for effects.

   Because emergency response mitigation efforts focus predominantly on removing whole oil floating on the surface, and dissolution of soluble hydrocarbons largely occurred before the first MCP, in-water effects were not appreciably impacted by response mitigation. The dissolved contaminants within the water column moved downstream, unaffected by response efforts.

5. Mitigation – The response mitigation activities modeled as part of this assessment focused on containing and collecting surface oil, which was predicted to remove between a quarter and nearly all the total volume of released oil, and had a large effect on reducing shoreline oiling and predicted surface effects. At the end of the various mitigated simulations, <0.1% of the oil was predicted to remain on the surface. In other words, mitigation was predicted to remove any oil that had otherwise been able to reach Lake Superior or remained on the surface when no response mitigation was conducted over the 4-day simulation (i.e., certain scenarios with higher release volumes and greater downstream transport).

   Notably, for the mitigated HARV and RARV scenarios, as well as the mitigated FBR scenarios in the White River, mitigation prevented surface slicks from reaching the most downstream portions of the Bad River (north of Highway 2), including the wild rice areas and Bad River Slough. However, for the FBR scenarios in the Bad River, a sufficient oil volume was released that a small amount of surface oil (<1 bbl in total) was predicted to reach the area adjacent to the Bad River Slough and Lake Superior, at levels that were never greater than patchy and discontinuous dull brown or rainbow sheens (<10 μm). In a realistic response, these thin and short-duration sheens (less than a few hours) would be addressed by an additional barrier set up downstream of Highway 2. Although not modeled here, due to the dynamic nature of real spill and environmental conditions, an additional barrier would allow for additional containment and skimming resources to be deployed, as well as additional tactics to minimize sheens and help capture submerged oil droplets downstream of turbulent waters. Even with the equipment modeled here at the planned MCPs, mitigation activities limited oil contact with wetlands and wild rice habitats located in downstream areas, thereby reducing the potential for effects. Downstream surface biological effects were substantially reduced as well. However, mitigation activities did not appreciably reduce dissolved hydrocarbons in the water column, whose transport is not affected by response activities.

3.2.2 Previous SIMAP Modeling

Several additional types of hydrocarbon spill scenarios not captured by the modeling conducted in this Oil Spill Report can be better understood through review of previous modeling that was conducted in 2021-2022 as part of ongoing litigation (Horn, 2022). Like this assessment, RPS assessed the range of downstream movement, behavior, timing, and potential effects that may result from a set of hypothetical crude oil releases from the Line 5 pipeline. These releases were modeled at the Existing Route crossing of the Bad River and the Existing Route crossing of Beartrap Creek, which is a smaller watercourse (average 20 ft width) just west of the Bad River watershed that flows directly into the Kakagon-Bad River Slough Complex. This report section describes certain results of that modeling study, as they relate to three topics: 1) how a release from Line 5 into the Bad River might occur during high river flow flood conditions, with overbank flow; 2) how a release from Line 5 might occur if it entered a smaller tributary, such as Beartrap Creek; and 3) how a release from Line 5 into the Bad River might transport and behave within Lake Superior, assuming no response mitigation activities were undertaken in either the Bad River or Lake Superior. All of the results from this previous modeling are necessarily greater (in extent, concentration, and potential effects) than what might occur from a similar release at crossings on the Proposed Route, given that the Proposed Route crossing is 55 km (34 mi) upstream of the Existing Route crossing on the Bad River and 10 km (6 mi) upstream of the Existing Route crossing on Beartrap Creek, and that Enbridge’s emergency response would occur within hours of the release occurring.

3.2.2.1 Spills during flood flow conditions

RPS previously modeled two scenarios released from the Existing Route crossing of the Bad River to understand the transport, fate, and effects of oil that could occur in the event of a spill during a flood event with overbank river flow conditions (Horn, 2022). The Bad River flood of July 2016 was used as the baseline to represent the hydrodynamics during an approximately 500-yr event. One unmitigated FBR release and one unmitigated HARV release were simulated from the center of the Bad River crossing (at the sediment-water interface) and were otherwise modeled using the same assumptions and methodology as simulated in the present study. Due to differences in pipeline configuration and topography on the Existing Route, the FBR volume was also much larger (21,974 bbl) than the FBR volume modeled herein at the Proposed Route crossing (9,874 bbl).

The results of the two flooding simulations represented the shortest possible time for oil to reach Lake Superior (approx. 25 km or 16 mi downstream of the Existing Route crossing) and the extents and concentrations of oil that could occur in those conditions. Flood stage conditions were predicted to affect the greatest total length of vegetated shoreline (40.4 km of 188.2 km, or 21% of vegetated habitat) compared to other flow conditions because flood conditions increased the total length of shorelines able to be oiled. Approximately 42-57% of the total release volume was predicted to reach Lake Superior, with the first oil arriving approximately 11 hours after the hypothetical unmitigated release. Potential in-water effects were also maximized in flood conditions, with 19-times the wetted area and extensive transport. However, as a percentage of habitat experiencing 100%

mortality, the flood stage scenario had lower results than all other FBR scenarios, due to fast moving water and greater dilution, which reduced the predicted percent mortality at any given point. In addition, flood stage mortality may have been overestimated due to a much greater total area being covered with water and the assumption that receptors were present everywhere.

Any hypothetical release under flood-conditions from the Proposed Route would have necessarily lower risk and potential to reach the Lake than the scenarios previously modeled at the Existing Route crossing, due to the Proposed Route being located an additional 55 km (34 mi) upstream of the Existing Route and a substantially lower FBR release volume. Nonetheless, in the event of a FBR release where no mitigation is conducted at any point on the Bad River, there is likely the potential for a portion of the oil that does not evaporate or strand on shorelines to quickly reach Lake Superior. However, this portion would be much smaller than previously modeled at the Existing Route, given that the Proposed Route crossing is located an additional 55 km (34 mi) upstream.

3.2.2.2 Spills in Beartrap Creek

RPS previously performed season-specific OILMAPLand modeling of hydrocarbon releases from the Existing Route crossing of Beartrap Creek to determine the potential trajectory and fate of oil under multiple environmental conditions, including high river flow, low river flow with frozen banks, low river flow with frozen water surface, and a no-flow, snow-covered scenario (Horn, 2022). Oil was tracked as it was transported downstream on the water surface, adhered to the creek banks, and evaporated into the atmosphere. The frozen surface, low river flow scenario, with the release at the creek bottom was considered the worst case for the amount of oil predicted to enter Lake Superior, as oil would remain in the water column, trapped beneath the ice.

Under high river flow conditions, oil was predicted to reach the Lake in as little as 17.3 hours. Under monthly average low river flow conditions, the oil was predicted to enter Lake Superior in 26.5 hours. If the release were to occur into the very slow river flow conditions under 100% ice cover, oil was predicted to reach the lake in 216 hours, or approximately 9 days. Due to the ice cover, which capped evaporation and reduced shoreline oiling, a larger portion of the release had the potential to reach the Lake, when compared to the ice-free scenarios.

If a release were to occur during winter months where the creek would be completely frozen, the oil may break through the ice, reaching the surface and spreading onto the snow-covered land (ice) surface. In a completely frozen watercourse, the FBR was predicted to spread on the ice surface (moving downstream along the watercourse channel) for approximately 10.5 hours, before all of the released volume was predicted to spread over the ice, be absorbed into the snowpack, and evaporate to the atmosphere. The low temperature and slow modeled wind speeds reduced the amount of evaporation that was predicted to occur (5.8% of the total volume), leaving a larger proportion of the oil on the snow-covered land surface. For comparison, under high river flow conditions, with warmer temperatures and higher wind speeds, spreading on the water surface, and a longer model duration enhanced evaporation, resulting in 24.3% of the total volume predicted to evaporate. Under the low river flow (frozen banks) conditions, the lower air temperatures resulted in slightly less evaporation, with 17.4% of the total volume predicted to evaporate. If left unmitigated for longer periods of time, the amount evaporated within each of these scenarios would increase.

Any release into Beartrap Creek from the Proposed Route would necessarily have lower risk and potential to reach the Lake than the scenarios previously modeled at the Existing Route crossing, due to the Proposed Route being located an additional 10 km (6 mi) upstream of the Existing Route. Nonetheless, in the event of an FBR release, where no mitigation was conducted at any point on Beartrap Creek, there is likely potential for a portion of the oil that does not evaporate or strand on shorelines to quickly reach Lake Superior. However, this portion would be smaller than previously modeled at the Existing Route, given that the Proposed Route crossing is located an additional 10 km (6 mi) upstream.

3.2.2.3 Spills into Lake Superior

RPS previously conducted oil spill modeling within Lake Superior, assuming that hypothetical releases from the Existing Route crossing of the Bad River were able to reach the Lake, which is located 24 km (or 15 mi) downstream of the crossing. A probabilistic assessment using overly conservative assumptions for the amount of oil reaching the Lake and its weathering state was conducted based on modeling 50 different simulated releases over a randomized start period spanning 8 months in 2021. This set of simulations was intended to adequately represent the variability in wind and current speeds and directions in the region over time, resulting in a prediction of the probable oil pathways for releases at the outlet of the Bad River into Lake Superior. This suite of scenarios provided an understanding of the probability and minimum time to specific threshold exceedances within the Lake, assuming that an unmitigated FBR release at the Existing Route crossing had occurred.

Two specific scenarios were further modeled in SIMAP to better understand the movement and behavior of oil within the environment and the predicted surface oil thickness and resulting shoreline concentrations that would result from the specific environmental conditions that were modeled. One scenario was selected from the 50 FBR simulations to represent the 50th percentile surface oiling case, which simultaneously represented the 60th percentile shoreline oiling case. Another scenario was created anew under average river flow conditions to represent a more reasonable and smaller volume release (HARV) that included the planned emergency response mitigation efforts that Enbridge would employ in the Bad River, but no mitigation efforts within Lake Superior.

The probability of surface oil exceeding the conservatively low socioeconomic threshold of 0.01 µm for the unmitigated FBR was predicted to be highest in the vicinity of the release location between the Bad River outlet and the Apostle Islands, as well as areas directly eastward. Moving further away, the probability that a surface oil slick could exceed this threshold over the entire 60-day simulation diminished as distance from the spill site increased. The probability that oil would have exceeded this highly conservative threshold at any point in time over the 60-day simulation was predicted to be >50% within approximately 75-150 km of the hypothetical release location. The oil that was predicted to reach this distance was transported in as little as 3-5 days. However, beyond this distance, the probability rapidly declined to less than 10% within 150-200 km after as little as 10-20 days.

The probability of surface oil exceeding the higher, but still conservative, threshold of 10 µm for potential ecological effects for the unmitigated FBR was largely contained within 25 km of the release location (but extended to 50 km for a small portion), generally between the Bad River outlet and the Apostle Islands. The oil would arrive at these locations within approximately 1-3 days. The probability that oil would exceed the ecological threshold was less than 1% in all other areas of Lake Superior and this stochastic assessment did not consider duration of exposure (which would be short) to estimate the potential for effects. Notably, these simulations did not present realistic conditions because it was assumed that no mitigation would occur in either the Bad River or Lake Superior, over multiple days after release.

For the more reasonable HARV scenario, with response mitigation occurring within the Bad River, only 8 bbl of oil was predicted to enter Lake Superior. In a real-world release, this volume of oil would be targeted by

Enbridge's emergency response activities which would take place in Lake Superior (but was not modeled here). This Bad River mitigated HARV scenario was predicted to result in very limited surface oil within Lake Superior that would enter as a dark brown sheen, with several barrels of oil stranding nearly immediately near the mouth of the Bad River in the adjacent wetland habitats and sandy shorelines.

Any release from the Proposed Route would have necessarily lower risk and potential to reach Lake Superior than the scenarios previously modeled at the Existing Route crossing, due to the Proposed Route being located an additional 55 km (34 mi) upstream of the Existing Route. The hypothetical FBR, unmitigated scenarios modeled in the previous assessment become even more unreasonable, given the 2- to 4-day delay that would need to occur prior to any oil being transported downstream to the Lake that did not otherwise evaporate, strand on shorelines, or be removed by response mitigation. No surface oil was predicted to reach the Lake for many of the scenarios modeled in the present assessment of the Proposed Route crossings of the Bad River and White River, including all scenarios modeled with mitigation. Therefore, the oil movement and behavior predictions made in the previous modeling within Lake Superior would not apply.

3.3 Hydrocarbon Route Assessment and HCA Analysis

Simulations were performed to assess the trajectory and fate of oil overland and through the surface water hydrologic system in order to determine the potential impact of hypothetical releases on downstream receptors, including HCAs and specific AOIs (Section 2.3.3). FBR releases under high river flow conditions and RARV releases under low river flow conditions were simulated at each location. Depictions of the predicted overland and downstream pathway of hypothetical releases that were modeled along each pipeline route were provided for each route analysis (Figure 3-1, Figure 3-2). These results include route-specific and site-specific pathways for each individual release simulated along the pipeline routes. The trajectories were then used to evaluate and compare the potential for impacts to receptors from each pipeline route alternative within the Pipeline Extent Considered. The FBR analysis presented a conservative basis for assessing the upper range of susceptible resources (HCAs and AOIs), relevant for routing decisions, while the RARV analysis presented a lower range of potential impacts, relevant to contextualize more limited transport potential for smaller volume releases under lower river flow conditions.

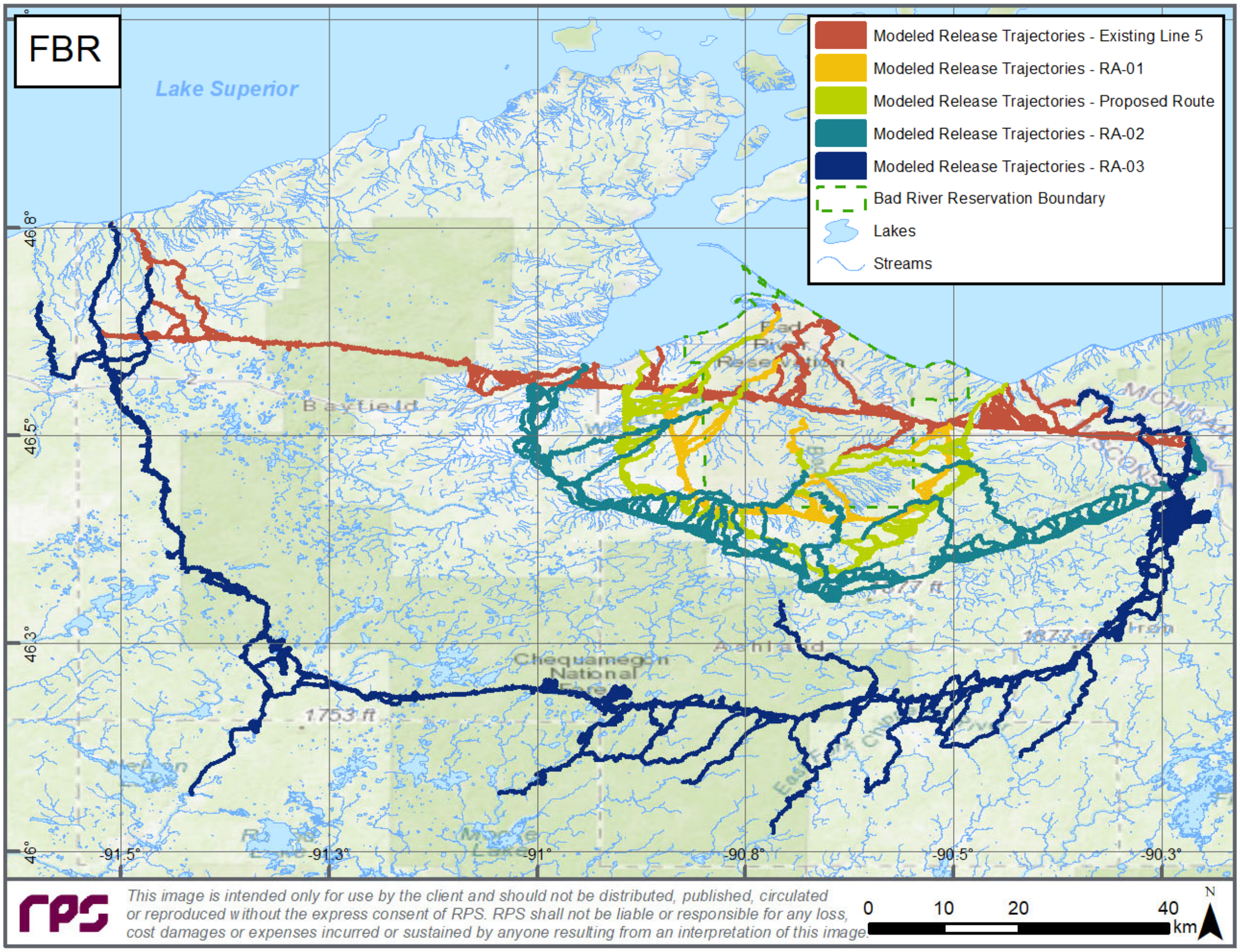

Figure 3-1. Modeled FBR release trajectories under high river flow conditions for all pipeline routes. Note that some trajectories may not be visible as they are underneath trajectories for another route.

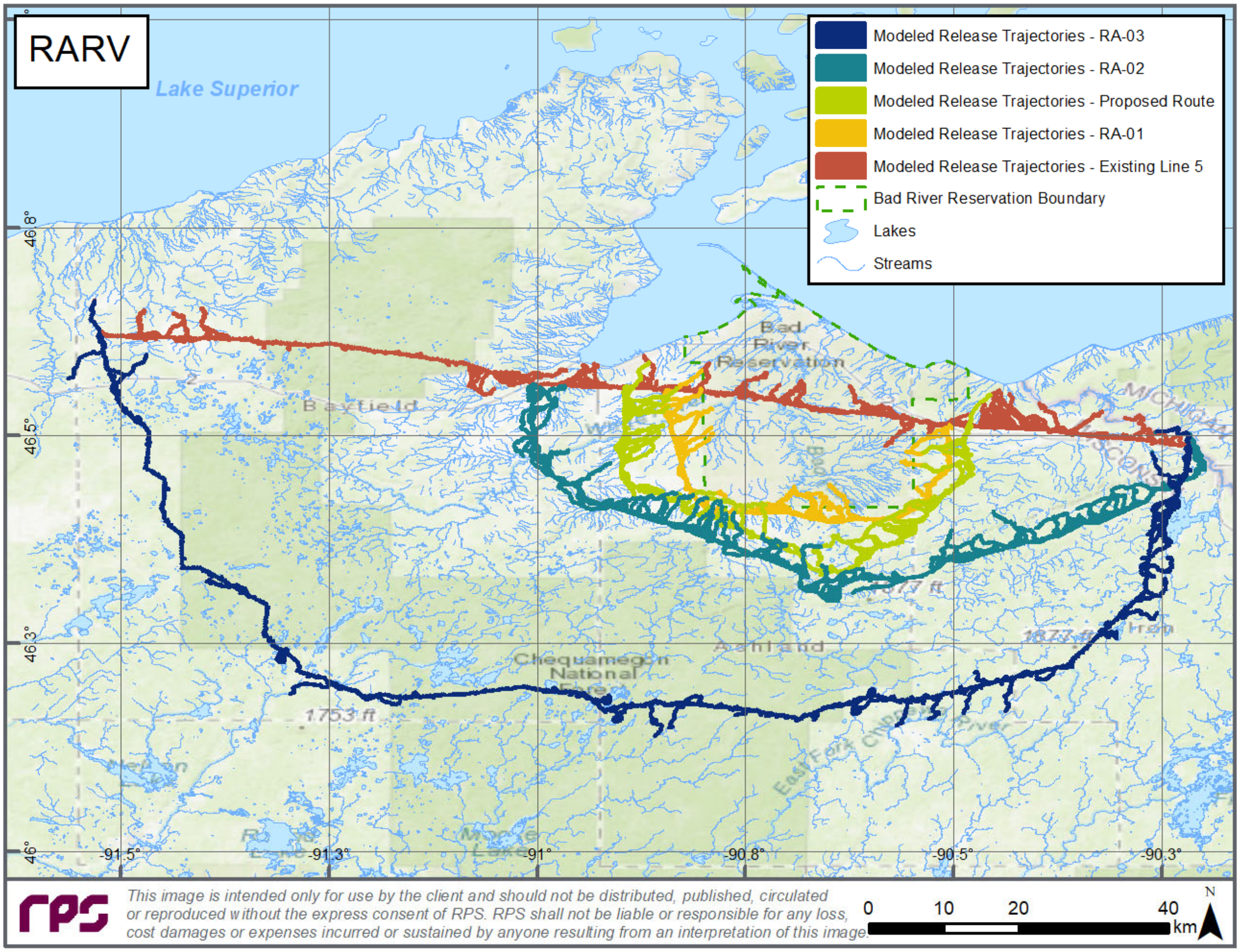

Figure 3-2. Modeled RARV release trajectories under low river flow conditions for all pipeline routes. Note that some trajectories may not be visible as they are underneath trajectories for another route.

The total length of pipeline with the predicted potential to enter Lake Superior decreased as route alternatives shifted farther inland (away from the Lake) to the south of the existing line. Therefore, the Existing Route had the greatest overall length of pipeline where simulated FBR releases were predicted to reach Lake Superior. Of note, nearly all of the Effects Lengths of route alternatives that were predicted to reach Lake Superior occurred along the existing portions of Line 5, rather than from the new construction (Figure 3-1). No simulated releases from new construction were predicted to reach Lake Superior through the Reservation over the model time period.

As the relocation moves farther from the existing pipeline, the likelihood of impacts from a potential release to the Reservation and Lake Superior decrease. This is because of the greater distance from the hypothetical release points to the Reservation and Lake Superior, which provides additional time for oil spill response activities to halt the downstream transport of the released product before it reaches those areas, or in the case of large sections of RA-03, the released product would be transported away from the Bad River entirely due to it being in another watershed.

A comparative ranking assessment was undertaken using the FBR releases to most conservatively and qualitatively rank overall segment analysis risk scores for each pipeline route alternative. Essentially, the values for each criterion assessed in Technical Appendix C (e.g., the length of pipeline with potential to impact various receptors) were compared between pipeline routes (Table 3-1). A lower score represents a less impactful pipeline route alternative, or one that was predicted to collectively have the potential to impact sensitive receptors from shorter stretches of the pipeline. However, it is important to note that this ranking does not mean that any specific hypothetical release would be more or less impactful to any single resource identified in the ranking. Rather, if one was to consider the entire pipeline route alternative (and hypothetical releases along the entire pipeline), the segment analysis ranking identifies a non-dimensional value of total resources that would have the potential to be affected, relative to the other pipeline alternatives. No weighting was used to compare different ranking criteria, meaning no single receptor was assumed to be more important than any other.

Table 3-1. Comparative ranking assessment of each pipeline route alternative based upon equal weighting of each criteria investigated. The segment analysis rank represents a non-dimensional number where the lowest possible score (rank of 1 in all categories) would represent the “best” route to minimize the areas of concern that may be susceptible to potential impacts following a release.

Route	Total Length (km)	New Construction (km)	New Construction Length of Pipeline in Wetlands (km)	AOI segment lengths (km)				Unique AOIs± (#)	Length with Potential to Reach Water (km)	HCA segment lengths (km)					Unique HCAs (#)
				Lake Superior	Wild Rice	Bad River Reservation	Federal, State, & County/ Local Lands			Overall	OPA	DW	ESA	CNW	
Existing	103.5	0	0	63.1	18.8	26.2	80.7	7	76.3	76.4	27.5	44.5	62.2	40	22
RA-01	127.2	50.5	9.45	42.5	4.5	50	102.3	10	101.8	67	14.9	25.1	42.4	30.6	13
Proposed	136.8	66	8.34	39.4	0.8	57.2	124.4	10	109.2	59.9	23.6	25.8	36.7	28.2	15
RA-02	135	93.4	12.59	21.5	5.9	35.5	126.4	12	110.1	77.6	45.4	46.9	19.2	15.2	18
RA-03	163.8	163.4	49.34	0	25.1	0	150.9	15	93.5	39.2	37.4	3.1	9.8	0	14

Route	Rank															Segment Analysis Rank
Existing	1	1	1	5	4	2	1	1	1	4	3	4	5	5	5	**43**
RA-01	2	2	3	4	2	4	2	2	3	3	1	2	4	4	1	**39**
Proposed	4	3	2	3	1	5	3	2	4	2	2	3	3	3	3	**43**
RA-02	3	4	4	2	3	3	4	4	5	5	5	5	2	2	4	**55**
RA-03	5	5	5	1	5	1	5	5	2	1	4	1	1	1	2	**44**

*Analyzed watercourse crossings include all crossings of the pipeline ROW (i.e., not access road or pipeyard crossings) across watercourses recorded in the NHDPlus dataset.

±Unique AOIs include the sum of (non-duplicate) State and Federal Lands and one count each for Lake Superior, wild rice, and the Reservation. Additional lands associated with county and local government, as well as Forest Crop Law lands, were not individually listed as AOIs, due to the wide variety and overlapping nature of these resources between each dataset (e.g., contained within Federal and State lands).

Once the individual criteria rankings were determined, an overall segment analysis rank was calculated as the sum of the individually-ranked criteria by pipeline route. Again, the lowest segment analysis score would represent a pipeline route alternative that had the lowest potential for impact based upon the identified criteria. In general, this would imply that RA-01 (39) had the lowest score, that the Existing Route (43), Proposed Route (43) had the same scores in the mid-range, and RA-03 (44) was slightly worse, while RA-02 was the least favorable (55). If any single receptor or comparison metric was weighted as more important than another, then the overall segment analysis ranks reported here would change. For example, if a goal was made to minimize the new construction length (i.e., to reduce certain/expected effects from construction generally or specifically in wetlands) or a specific receptor (e.g., wild rice, state & federal lands, and unique AOIs) was deemed more important than another, then RA-03 would likely become far less favorable. Similarly, if a goal was made to prioritize reducing effects to Lake Superior, the Reservation (regarding both receptors and timing), releases reaching water, or OPAs, then RA-01 may be considered a less favorable route. The Existing Route would be less favorable for similar reasons, as it passes directly through the Reservation and nearer these receptors. This segment analysis score is helpful in framing route comparisons, but there are many other factors to consider for route selection, including likelihood of release (addressed in Appendix A) and potential for consequences from construction (addressed in the separate Construction Assessment) and accidental events (addressed in Appendices B and C), as well as many others not considered in this assessment (e.g., economic, political).

RA-03 is quite unique in this analysis. RA-03 has the shortest overall length of could-affect segments (meaning lengths of pipeline where a potential release could impact an HCA), but the second longest length of could-affect segments for OPA HCAs. RA-03 essentially eliminates impacts to the Reservation and Lake Superior within the Pipeline Extent Considered. However, this much longer route (with an additional net length of 60 km [37 mi] compared to the Existing Route and additional 27 km [17 mi] compared to the Proposed Route) moves potential impacts to other AOIs, including significant wild rice areas outside the Reservation, 12 State and Federal Lands, and the longest length through wetlands. These Unique AOIs include state forests and fishery areas, large portions of the Chequamegon-Nicolet National Forest (an effects length of 86.5 km [53.7 mi] or 52.3% of RA-03), the Saint Croix National Scenic Riverway, and 49.34 km (30.66 miles) of wetland areas (making up 30.1% of RA-03).

The potential impacts of each pipeline alternative route vary significantly, based on which impact metric is considered more important. Taking the full analysis into account, the Proposed Route appears to be the most favorable route alternative. The Proposed Route has a very small length of pipeline where a simulated release could reach wild rice areas in the evaluated timeframe, and reduces potential impacts to Lake Superior and HCAs compared to the existing pipeline. The proximity of RA-01 to the Reservation increases the potential for effects to the Reservation, wild rice, Lake Superior, and ESAs. RA-02 received the highest overall segment analysis rank for comparative risk. RA-03 has the longest overall length of pipeline, which would maximize the potential land surface susceptible to a release and would increase the number of total receptors and new receptors that may be affected following a release. In addition, RA-03 would have the longest length of new pipe, which would maximize the guaranteed effects from construction activities through large portions of the Chequamegon-Nicolet National Forest (52.2 km [32.4 mi] of pipeline resulting in direct effects). Additionally, 49.34 km (30.66 miles) of new construction (making up 30.1% of RA-03) would take place in wetlands.

The high-resolution segment analysis provided the length of the pipeline crossing where a release could directly impact the White River or Bad River for each route alternative. The length of this segment varied significantly, based on the terrain in the area of the crossing. For the White River, this length varied between 210 m and 600 m (689-1,969 ft) for the three routes that cross that River (RA-01, RA-02, and the Proposed Route). For the Bad River, this length varied between 90 m and 330 m (295-1,083 ft).

The analysis presented in this Technical Appendix does not include an assessment of the likelihood of a release and subsequent impact to the AOIs or HCAs, and does not imply any actual impacts to these areas. Representative analyses of potential consequences from an oil spill are provided in Appendix B. In the case of a single, actual release, impacts would vary greatly, based on the location of the release, the overall release volume, and the effectiveness of response efforts. Additionally, this analysis does not evaluate impacts that might occur from hypothetical spills on the remainder of existing Line 5, outside of the Pipeline Extent Considered, as these would not change based on the route alternatives assessed here.

4 CONCLUDING STATEMENT

Quantitative, consequence analyses were performed using a variety of computational modeling approaches to assess the range of potential effects associated hypothetical accidental oil releases (i.e., unplanned and may never occur) along the Proposed Route and Route Alternatives of the L5WSRP. This Oil Spill Report and its Technical Appendices provide the results of the consequence analyses and an analysis of the likelihood of a release of magnitude during pipeline operations. An executive-level summary of modeling approaches and conclusions from each assessment has been provided at the beginning of this Oil Spill Report.

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Technical Appendix A – Probability of Failure Analysis

Appendix to Operations Assessment: Oil Spill Report