

**Line 3 Replacement Project:  
Assessment of Accidental Releases:  
Technical Report**

Prepared for:  
Department of Commerce, Energy  
Environmental Review Analysis Staff

Prepared by:  
Stantec Consulting Services Inc.  
RPS/ASA  
Dynamic Risk Assessment Systems Inc.

January 13, 2017

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Preface  
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## **PREFACE**

Stantec Consulting Ltd. (Stantec), RPS Group PLC (RPS), and Dynamic Risk Assessment Systems, Inc. (Dynamic Risk) were retained to prepare a risk assessment for potential large releases of crude oil from the Line 3 Replacement Project (L3RP).

## **PURPOSE**

The purpose of this document is to provide information on the risk of an accidental large volume release of crude oil from the proposed L3RP at seven individual watercourse crossing sites. These seven sites were selected to be representative of the broad geographic and environmental diversity, including environmentally sensitive areas, that are: (1) present throughout the State of Minnesota; and (2) intersected by both the preferred and alternative L3RP routes.

Risk is defined most concisely as the 'chance of loss'. Accordingly, in the context of the risk associated with the operation of the L3RP pipeline, the term 'risk' is used as a joint expression of chance (the annual probability of incurring a rupture in the L3RP pipeline) and loss (the consequences associated with such a rupture).

As stated in the Final Scoping Decision Document for Line 3 Pipeline Replacement Project, the risk assessment was conducted to assess potential effects (i.e., consequences) associated with an accidental large volume release of crude oil using computational modeling to investigate releases at seven individual representative sites throughout north and central Minnesota. Information from the modeling of large crude oil releases at these representative sites will be used to make broad assessments of the potential consequences that are predicted across a range of geographic and environmental regions. Results can be used to make comparisons between similar environments to understand the potential effects that may occur at other locations with similar features among and across all proposed or alternative routes.

## **DIRECTION ON TECHNICAL WORK**

Stantec, RPS and Dynamic Risk (referred to collectively as the Consulting Team) were retained by Enbridge Energy, Limited Partnership (Enbridge). The Consulting Team was responsible for identifying potential approaches for assessing the risk (as both failure likelihood/probability and potential consequences) of large crude oil releases, and identifying a preferred approach based on comments from the Minnesota Department of Commerce, Energy Environmental Review and Analysis (DOC-EERA) (including state and federal agencies and their consultant) and Enbridge. Once the preferred approach was identified, the Consulting Team undertook the technical work under its own direction. Presentations on the preliminary results of the technical work were made to the DOC-EERA, state and federal agencies, and Enbridge at several points during the completion of the technical work. Every party was involved in each phase of the

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work, including formulating the questions, identifying an approach, specifying the model inputs, assessing the outputs, and discussing the conclusions.

The Consulting Team then prepared a technical report on the risk assessment, with the exception of Chapter 2: Project Description, which was prepared by Enbridge. Comments on the draft report were received from the DOC-EERA and Enbridge. In response to these comments, revisions to the draft report 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 submission to the DOC-EERA.

**FUNDING**

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

**AUTHORSHIP**

The risk assessment of large releases of crude oil was prepared by the Consulting Team. The Technical Lead for each section of the report was as follows:

<b>Chapter</b>	<b>Technical Lead(s) Responsible for the Chapter</b>
1.0 INTRODUCTION	Jeff Green, Stantec
2.0 PROJECT DESCRIPTION	Enbridge Application
3.0 FRAMING THE SITE SELECTION AND MODELING ANALYSIS	Jeff Green, Stantec and Matt Horn, RPS
4.0 FAILURE PROBABILITY ANALYSES	Jim Mihell, Dynamic Risk
5.0 MODELING OF OIL RELEASES	Matt Horn, RPS
6.0 TRAJECTORY AND FATE RESULTS FOR MODELING LOCATIONS	Matt Horn, RPS
7.0 ASSESSMENT OF ENVIRONMENTAL EFFECTS OF OIL RELEASES	Malcolm Stephenson, Stantec
8.0 REVIEW OF ENVIRONMENTAL RECOVERY FOLLOWING RELEASES OF OIL	Heidi Tillquist, Stantec
9.0 SUMMARY AND CONCLUSIONS	Consulting Team
10.0 REFERENCES	Consulting Team

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**DECLARATION**

As the Technical Leads for the Risk Assessment of Large Releases of Oil for the Line 3 Replacement Project, 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 analyses and all conclusions reflect our work and opinions. Modifications in response to verbal or written comments from the DOC-EERA, state and federal agencies or Enbridge have not modified the technical aspects and results of our work or our conclusions.

Jeff Green, Stantec



Jim Mihell, Dynamic Risk



Matt Horn, RPS



Malcolm Stephenson, Stantec



Heidi Tillquist, Stantec



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**ATTACHMENT A**

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## Abbreviations

AOI	Area of Interest
API	American Petroleum Institute
ATSDR	United States Department of Health Agency for Toxic Substances and Disease Registry
AST	Aboveground Storage Tank
AUT	Automated Ultrasonic Testing
BFGRID	Boundary Conforming Gridding Model
BFHYDRO	Boundary Conforming Hydrodynamic Model
bgs	below ground surface
BLM	Bureau of Land Management
BS&W	basic sediment and water
BTEX	Benzene, toluene, ethylbenzene, and xylene
CAA	Clean Air Act
CCME	Canadian Council of Ministers of the Environment
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	United States Code of Federal Regulations
CLB	Cold Lake Blend
CLSB	Cold Lake Summer Blend
CLWB	Cold Lake Winter Blend
cm	centimeter
CO	Carbon Monoxide
Commission	Minnesota Public Utilities Commission
COPC	Chemical of Potential Concern
CP	Cathodic Protection
DARP	Damage Assessment and Restoration Plan
DEM	Digital Elevation Model
Dilbit	Diluted Bitumen
DOC	Dissolved Oxygen Content
DSAW	Double Submerged Arc Welded
DSD	Droplet Size Distribution

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Dynamic Risk	Dynamic Risk Assessment Systems, Inc.
EAC	Environmentally-Assisted Cracking
ECS	Ecological Classification System
EERA	Energy Environmental Review and Analysis
EIS	Environmental Impact Statement
Enbridge	Enbridge Energy Limited Partnership
EPRG	European Pipeline Research Group
EPT	Ephemeroptera spp., Plecoptera spp., and caddisfly Trichoptera spp.
EROM	Extended Unit Runoff Method
ERW	Electric Resistance Welded
FBE	Fusion Bond Epoxy
FSDD	Final Scoping Decision Document
ft	feet
ft/yr	feet per year
g/cm <sup>3</sup>	gram per cubic centimeter
GMAW	Gas Metal Arc Welding
HCA	High Consequence Areas
HDD	Horizontal Directional Drill
H <sub>2</sub> S	Hydrogen Sulfide
HSLA	High Strength Low Alloy
HVAC	High Voltage AC
HVDC	High Voltage DC
ILI	In-Line Inspection
km	kilometer
L3RP	Line Three Replacement Project
lvp	low vapor pressure
m	meter
m <sup>3</sup>	m <sup>3</sup>
MAH	Monoaromatic Hydrocarbons
MAOP	Maximum Allowable Operating Pressure
MI DCH	Michigan Department of Community Health
MI DEQ	Michigan Department of Environmental Quality
MN DA	Minnesota Department of Agriculture

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MN DH	Minnesota Department of Health
MN DNR	Minnesota Department of Natural Resources
MN DOC	Minnesota Department of Commerce
MOC	Measurement of Change
mph	miles per hour
mg/kg	milligram per kilogram
MN PCA	Minnesota Pollution Control Agency
MRL	Minimum Risk Level
MT DEQ	Montana Department of Environmental Quality
NAAQS	National Ambient Air Quality Standards
NAS	National Academies of Sciences, Engineering and Medicine
NED	National Elevation Database
NHD	National Hydrography Dataset
NHN	National Hydro Network
NLCD	National Land Cover Database
NO <sub>2</sub>	Nitrogen Dioxide
NO <sub>x</sub>	Oxides of Nitrogen
NOAA	National Oceanic and Atmospheric Administration
NRC	National Research Council
NRDA	Natural Resource Damage Assessment
NRDAM/CME	NRDA Models for Coastal and Marine Environments
NRDAM/GLE	NRDA Models for Great Lakes Environment
NTSB	National Transportation Safety Board
NWI	National Wetlands Inventory
O&M	Operations and Maintenance
OD	Outside Diameter
OHWL	Ordinary High Water Line
OPA	Oil Particular Aggregate
PAH	Poly-Aromatic Hydrocarbon
PCB	Polychlorinated Biphenyl
PEC	Probable Effect Concentration
PGPR	Plant Growth Promoting Rhizobacteria
PHC	Petroleum Hydrocarbon Fraction

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PHC F1-F4	Petroleum Hydrocarbon Fractions F1 to F4
PHMSA	Pipeline and Hazardous Materials Safety Administration
PM	Particulate Matter
PM2.5	Particulate Matter with an aerodynamic diameter less than 2.5 micrometers
PM10	Particulate Matter with an aerodynamic diameter less than 10 micrometers
ppb	parts per billion
ppm	parts per million
PRCI	Pipeline Research Committee International
ROW	Right-of-Way
RPS	RPS Group PLC
SCADA	Supervisory Control and Data Acquisition
SCC	Stress Corrosion Cracking
SGCN	Species in Greatest Conservation Need
SIP	State Implementation Plan
SMYS	Specified Minimum Yield Strength
SO <sub>2</sub>	Sulfur Dioxide
SPM	Suspended Particulate Matter
SQT	Sediment Quality Triad
Stantec	Stantec Consulting Services Inc.
TEC	Threshold Effect Concentration
THC	Total Hydrocarbon Concentration
TMCP	Thermomechanical Controlled Processing
TPAH	Total Petroleum Aromatic Hydrocarbon
TPH	Total Petroleum Hydrocarbon
TSS	Total Suspended Solids
µg/L	microgram per liter
UOE	U&O Expanded
USACE	United States Army Corps of Engineers
USEPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
UV	ultraviolet
VOC	Volatile Organic Compound

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Vol %	volume percent
WBD	National Watershed Boundary Dataset
WMA	Wildlife Management Area
WSF	Water Soluble Fraction
Wt %	weight percent
WQMAP	Water Quality Mapping and Analysis Program

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Glossary  
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## Glossary

**Actinomycetes:** bacteria that resemble fungi because their elongated cells form long filaments or hyphae.

**Aquatic Benthic Macroinvertebrates:** Invertebrates that spend at least some portion of their life cycle in an aquatic habitat, that live in or on the bottom substrate and that are large enough to be seen without magnification.

**Automatic Ultrasonic Testing (AUT) Phased Array Inspection:** An advanced ultrasonic testing process in which timed pulsed ultrasonic signals from an array of ultrasonic transducers are swept through a range of angles, and subsequently analyzed by a computer algorithm to identify and size defects that might reside in a weld.

**Biophysical Environment:** The biotic (living) and abiotic (non-living) surroundings.

**Biosparging:** Compressed air injected at low flow rates below the water table used to increase dissolved oxygen levels in the groundwater to enhance biodegradation.

**Bioventing:** Ambient air injected or extracted at low flow rates and used to replenish oxygen for microbial respiration in the vadose zone.

**Clean up:** collection and removal of oil from the environment.

**Direct Current Voltage Gradient (DCVG):** An above-ground electrical survey technique used for assessing the effectiveness of corrosion protection and for locating coating faults on buried steel pipelines.

**Dissolution:** Water soluble compounds in oil dissolve into surrounding water.

**Double Submerged Arc Welded (DSAW) steel line pipe:** Steel line pipe manufactured from skelp that is formed into a tubular shape, and in which the seam is welded using the double submerged arc welding process.

**Ectomycorrhizae:** mycorrhizal fungi with a sheath that forms around the root tips of a plant and hyphae that penetrate into the root structure.

**Electric Resistance Welded (ERW) steel line pipe:** Steel line pipe manufactured from skelp that is formed into a tubular shape, and in which the seam is welded using the electric resistance welding process.

**Emulsification:** Combination of two liquids with one being suspended in the other.

**Fish Kill:** A significant and sudden death of fish, shellfish and other aquatic animals. Such events are characterized by large numbers of animals dying over a short time, usually in a defined area.

**Gas Metal Arc Welding (GMAW):** A welding process that utilizes an electric arc to fuse both the base metal and a consumable wire, both of which are shielded by an inert gas to prevent undesirable reaction of atmospheric gases with the molten metal that is formed during the welding process.



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**Groundwater:** Water below the earth's surface that occurs below the water table in the soil pores and bedrock fractures.

**Hard Spot:** Associated with vintage pipe manufacturing processes, hard spots are local changes in hardness of steel pipe resulting from non-uniform quenching procedures during manufacture, or changes in chemistry of the steel. Hard spots, when stressed, are subject to failure from mechanisms such as hydrogen-stress cracking.

**Hardenability:** The characteristic of steel, related to its chemical constituents, which enables it to become hard when subjected to heat treatment, such as heating and quenching, or welding.

**High Strength Low Alloy (HSLA):** A type of steel alloy steel that provides superior mechanical properties and weldability through the use of small additions of micro-alloy elements such as niobium and / or vanadium along with thermal-mechanical controlled processing.

**Horizontal Directional Drilling (HDD):** A steerable trenchless method of installing underground pipe in an arc along a prescribed bore path by using a surface-launched drilling rig, with minimal impact on the surrounding area.

**Hydrostatic testing:** Hydrostatic testing is a process of verifying the integrity of the pipeline before it is placed into service. Hydrostatic testing involves filling the pipeline with water to a designated pressure and holding it for a specified period of time.

**In situ:** in place or on site.

**Internal Coupon:** A metal strip that can be inserted at strategic locations within a pipeline and subsequently retrieved and evaluated at periodic intervals to monitor corrosion during the operation of a pipeline.

**Monte Carlo Analysis:** A computer-based technique that employs stochastic resampling of randomly-selected variables from probability density functions representing the distribution of those variables. In reliability analysis, the selection of each unique combination of random variables is used to establish whether a limiting condition has been exceeded. By iterating this analysis numerous times, the fraction of times that the limiting condition is exceeded can be estimated with a degree of confidence that is related to the number of iterations used in the analysis.

**Lentic:** Still waters such as lakes and ponds.

**Lotic:** Flowing waters such as rivers, streams and brooks.

**Macrophytes:** Aquatic plants large enough to be visible with the naked eye.

**Mycelium:** vegetative part of a fungus consisting of the hyphae (branching filaments).

**Natural Attenuation:** A variety of physical, chemical, or biological processes that, under favorable conditions, act without human intervention to reduce the mass, toxicity, mobility, volume, or concentration of contaminants in soil or groundwater. These in situ processes include biodegradation; dispersion; dilution; sorption; volatilization; radioactive decay; and chemical or biological stabilization, transformation, or destruction of contaminants (from USEPA).

**Phytoremediation:** use of plants to clean contaminated sites.

**Photo-oxidation:** The degradation of oil by sunlight that results in the loss of alkylated polycyclic aromatic hydrocarbons.

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**Photolysis:** Process whereby molecules are broken down into smaller units by the absorption of light.

**Phytotoxic:** harmful or lethal to plants.

**Reclamation:** return of areas disturbed by cleanup activities to approximate pre-disturbance conditions through reseeded and other methods.

**Recovery:** Return of an ecosystem or Valued Ecosystem Component to some desired state following disturbance.

**Remediation:** physical chemical or biological processes applied post cleanup to reduce contaminant concentrations.

**Rehabilitation:** the transfer of oiled wildlife to specialized treatment to clean up the oil and return the specimen to health.

**Restoration:** Taking action to return natural resources to pre-spill conditions (from USFWS). Rehabilitating, replacing, or acquiring the equivalent of injured natural resources and the services they provided. Restoration includes both primary and compensatory restoration projects (from NOAA). Physical alterations of habitat and environmental structures to restore the habitat.

**Riffle Habitat:** Lotic habitat of shallow fast flowing turbulent water.

**Rhizome:** horizontal underground stem able to produce roots and shoots.

**Silt fence:** A silt fence is a sediment control device used on construction sites to protect nearby wetlands and waterbodies from stormwater runoff. A typical fence consists of a piece of synthetic fabric (sometimes referred to as geotextile fabric) stretched between a series of stakes where runoff is expected to reach wetlands or waterbodies. The fabric filters remove sediment from the water before it reaches the wetland or waterbody.

**Skelp:** Steel that is rolled into plate form so that it can subsequently be formed and welded into pipe.

**Slope breaker:** A slope breaker is an erosion control device to reduce stormwater runoff velocity and divert it from the disturbed construction area to more stable ground. A typical slope breaker consists of a ridge or channel constructed diagonally across the right-of-way on a hill.

**Sorption:** Removal of solutes from solution onto mineral surfaces.

**Specified Minimum Yield Strength (SMYS):** The specified minimum stress that a material can be subjected to before it experiences permanent deformation.

**Temperate Zone:** In the Northern Hemisphere, the area between the tropic of Cancer and the Arctic Circle.

**Thermomechanical Controlled Processing (TMCP):** A steelmaking technique that utilizes carefully-designed hot-reduction and cooling schedules, typically in conjunction with micro-alloying with elements such as niobium and / or vanadium, along with other elements in order to achieve superior mechanical properties and weldability.

**Transmissivity:** Ability of a formation to transmit oil to a recovery well.

**U & O Expansion (UOE) steel line pipe:** Steel line pipe manufactured from skelp that is formed into a tubular shape by first forming a U-shape, and subsequently forming a cylinder with a longitudinal seam, which is then sealed by welding.

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**Vadose zone:** Region of aeration above the water table, including the capillary fringe.

**Volatilization:** Vapors from volatile components of the oil disperse into the soil gas above the water table and diffuse laterally and upwards.

**Weldability:** The ease with which welding of a given material can be performed without producing defects such as cracks due to undesirably high hardenability (See also Hardenability).