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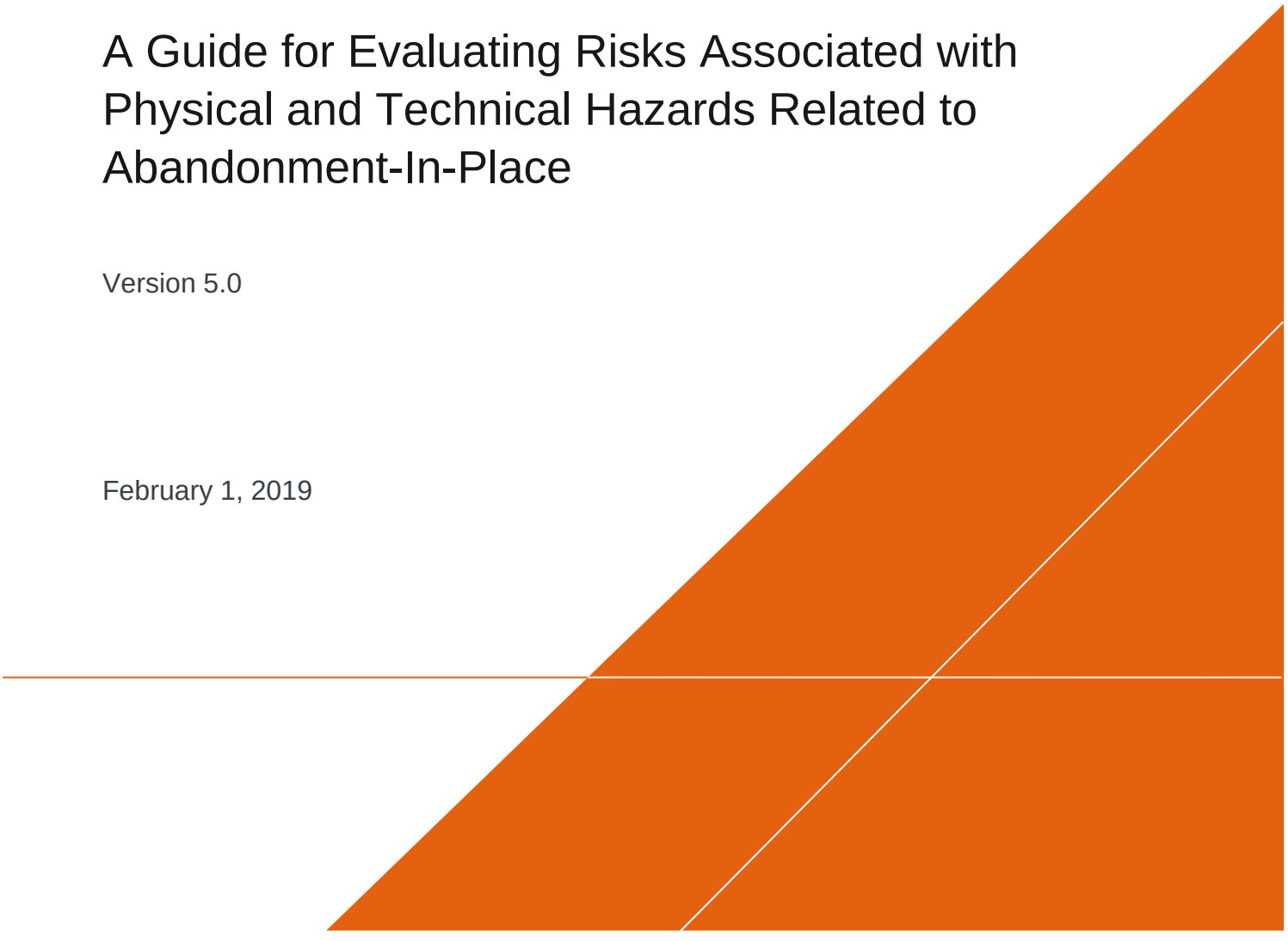
RISK-BASED DECISION-MAKING FRAMEWORK FOR PIPELINE ABANDONMENT - FINAL

A Guide for Evaluating Risks Associated with Physical and Technical Hazards Related to Abandonment-In-Place

Version 5.0

February 1, 2019



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A Guide for Evaluating Risks Associated with Physical and Technical Hazards Related to Abandonment-In-Place

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Our Ref.:

102047-000

Date:

November 2, 2018

VERSION CONTROL

Issue	Revision No	Date Issued	Description	Reviewed by
1	Draft	March 3	Risk Based Decision Making Framework for Pipeline Abandonment - Draft	SL, JB
2	Final	April 12	Risk Based Decision Making Framework for Pipeline Abandonment Final- based on client comments	SL
3	Final	August 24	Risk Based Decision Making Framework for Pipeline Abandonment Final- based on client comments	SL, JB, HF
4	Draft	November 2	Risk Based Decision Making Framework for Pipeline Abandonment – Draft with Usability Review Comments Addressed	AE, SL, JB
5	Final	February 1	Risk Based Decision Making Framework for Pipeline Abandonment – Final with Usability Review Comments Addressed	PARSC

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1. Introduction

As pipelines near the end of their operational lifecycle, decisions regarding how they will be abandoned are made. Operators make these decisions based on various considerations, of which include, but not limited to: contractual obligations, current and proposed land uses, cost, risks to human health and safety, ecology and environment, and valued/economic resources. Consultation with land owners and land managers must also play a central role in the decision-making process. Ultimately, decisions made by operators must be approved by the National Energy Board (NEB) (for interprovincial and international pipeline systems) or by provincial regulatory agencies (for intra-provincial pipeline systems).

A key decision that operators must make is where to remove abandoned pipeline from the ground and where to leave pipeline in the ground and abandon it in-place. In some cases, contractual obligations or proposed future land use will dictate the requirement for pipeline removal. However, in many cases this decision will be made based on weighing the relative risks associated with removal versus abandonment in-place, along with the feasibility and desirability of risk management measures required to mitigate risks associated with each. As stated in Canadian Energy Pipeline Association (CEPA 2007): *A risk-based comprehensive site-specific assessment is needed to validate the chosen abandonment strategy for specific pipelines*. In some cases, a combination of removal and abandonment in-place will be selected.

This guidance sets out a framework (referred to herein as the "Framework") whereby operators can evaluate (on a site-specific basis) risks associated with the physical and technical hazards related to abandoning pipelines in-place and determine the need for risk management measures to mitigate these risks. Operators can then compare risks and the feasibility and desirability of appropriate risk management measures for abandonment in-place to those associated with pipeline removal to support the selection of either of these options. It should be noted that use of the Framework by persons or organizations beyond pipeline operators could be inhibited unless detailed background information is provided to understand the setting and hazards at any particular segment of a pipeline.

In addition, this guidance does not provide a framework whereby operators can evaluate risks associated with pipeline removal, although as discussed above these must be evaluated and compared to those associated with abandonment in-place prior to final selection of either option. As stated in Pipeline Abandonment Steering Committee (PASC 1996): *Once the principal technique has been chosen, the owner/operator should assess on a site-specific basis whether an alternate approach should be followed for selected segments of line.*

Consultation with land owners, land managers, and other stakeholders has also been addressed by this guidance, without specifying details. The primary objective of the Framework is to provide a consistent, transparent, and scientific basis by which decisions pertaining to the selection of abandonment options (and associated risk management measures to address physical and technical hazards) can be made and communicated.

2. Abandonment Plans

Pipeline abandonment plans are developed to document and communicate how pipelines will be abandoned, including how issues related to public safety, environmental protection, and land use will be dealt with over the long-term (including abandonment monitoring towards end state, see Arcadis 2018). During stakeholder engagement, the framework outlined in this document can be used to engage

stakeholders when the abandonment plan is being consulted on and when input is received from stakeholders that modifies the hazard assessment.

With respect to interprovincial and international pipeline systems within the jurisdiction of the NEB, an operator must seek leave to abandon the operation of a pipeline (or abandon a pipeline), by filing an *Application to Abandon Pipeline*, as per Section 74 of the NEB Act (refer to the NEB Filing Manual (Canada 2015)). An abandonment plan, developed in consultation with land owners, land managers, and other stakeholders, forms part of this application. A summary of information to be included in such an abandonment plan is provided as *Abandonment Plan Table of Contents Example*, Appendix 1 of the NEB document entitled *Regulating Pipeline Abandonment* (Canada 2016), and is included herein as Appendix A. The Framework provided herein addresses (in whole or part) Sections 1 through 5 of this example table of contents, as they relate to the physical and technical issues associated with abandonment in-place.

[Note that (outside of the development of abandonment plans) the Framework herein does not provide guidance for completion of risk assessments specifically for Environmental and Socio-Economic Assessments required as part of an *Application to Abandon Pipeline*, as per Section 74 of the NEB Act].

With respect to requirements for abandonment plans for interprovincial pipeline systems, regulations and guidance documents specific to the relevant province(s) should be referred to.

3. Framework Development

This Framework for evaluating (on a site-specific basis) risks associated with the physical and technical hazards related to abandoning pipelines in-place was developed based on the principals of risk assessment as described in *Guidelines for risk assessment of pipeline systems* (Annex B of CAN/CSA-Z662-15 National Standard of Canada, Oil and gas pipeline systems (CSA, 2016)). The term “risk” is often used when “hazard” is the real topic in a public forum, so it is important to recognize that risk is the probability that a person will experience an adverse impact if exposed to a hazard.

The physical and technical hazards associated with pipeline abandonment in-place and our current understanding of the nature of the hazards are documented in the following publicly available documents:

- *Regulating pipeline abandonment* (Canada, 2016);
- *Pipeline abandonment scoping study* (Det Norske Veritas, 2010);
- *Pipeline abandonment assumptions, technical and environmental considerations for development of pipeline abandonment strategies* (CEPA, 2007); and,
- *Pipeline abandonment – a discussion paper on technical and environmental issues* (PASC, 1996).

In the above referenced documents, the physical and technical hazards associated with pipeline abandonment in-place are grouped, organized, and discussed in various ways. For the purpose of the Framework for risk assessment provided herein, the applicable hazards are organized as follows, but note that these are subject to change as other information becomes available or as technology evolves:

- Hazard No. 1: soil or groundwater chemical impacts to the environment from former operation of pipeline (i.e., contaminated sites);
- Hazard No. 2: environmental impacts from pipeline materials abandoned in-place, post operation:
  - Hazard No. 2a: residual product, lubricants, and treatment chemicals;
  - Hazard No. 2b: leaching from construction materials and coatings;
  - Hazard No. 2c: presence and exposure and disruption of asbestos;

- Hazard No. 3: drainage of surface water or shallow groundwater through pipeline;
- Hazard No. 4: ground subsidence beyond tolerable range;
- Hazard No. 5: exposure of abandoned pipeline due to soil erosion and geohazards (see Matrix Solutions Inc. 2018 for additional information); and,
- Hazard No. 6: exposure of abandoned pipeline at water crossings due to hydrotechnical hazards (see Matrix Solutions Inc. 2018 for additional information).

This organization of physical and technical hazards was based on how risks can be evaluated given the linkages, overlapping nature, and cause and effect relationships between them. For instance, pipe corrosion and ground subsidence are often cited as individual physical hazards, however as corrosion may result in pipe collapse which in turn may cause ground subsidence, the two are interlinked and have a cause and effect relationship. Therefore, for the purpose of the Framework, ground subsidence is identified as a hazard, with the effects of pipe corrosion considered in the frequency (or likelihood) analysis component of the risk assessment for this hazard.

4. Framework Limitations

This guidance document and Framework for evaluating risks associated with the physical and technical hazards related to abandoning pipelines in-place was developed based on abandonment methods, publicly available literature and studies (as well as those provided by the Pipeline Abandonment Research Steering Committee (PARSC)), and regulatory frameworks as of the time of development. Therefore, users should review and verify whether more recent methods, literature, studies, or regulatory requirements should be considered and incorporated into risk assessments and associated recommendations. PARSC could consider updating this guidance document and Framework if and when industry standards and methods, the science, and regulatory frameworks for pipeline abandonment in-place evolve.

This Framework for evaluating risks associated with the physical and technical hazards related to abandoning pipelines in-place is only a guide, including the worksheets which will require a degree of scientific and engineering evaluations on a site by site basis taking into account tolerable ranges and other uncertainties. Risk assessment and recommendations for risk management measures (or other such recommendations for reducing risks to human health and safety, ecology and environment, and valued/economic resources) are to be carried out and made by parties qualified to do so. Results of risk assessments (and associated recommendations) carried out and made in accordance with this Framework do not stand on their own, but rather must be validated and endorsed by parties qualified to do so. Arcadis Canada Inc. cannot be held liable for any use of, reliance on, or decision made based on the information provided (or referenced) in this guidance document and Framework. Nothing in this guidance document or Framework is intended to constitute or provide a legal opinion.

5. Framework Overview

5.1. Who should use the Framework?

The Framework was developed for use by operators of pipelines. However, it may also serve as a tool for land owners and other stakeholders interested in better understanding potential hazards associated with pipeline abandonment in-place, and how risks associated with these hazards may be evaluated and

addressed. It is also important to keep in mind that use of the Framework by persons or organizations beyond pipeline operators could be inhibited unless background information is provided to understand the setting and hazards at any particular segment of a pipeline.

5.2. Why was the Framework Developed?

The Framework was developed to provide a consistent, transparent, and scientific basis by which operators can evaluate (on a site-specific basis) risks associated with the physical and technical hazards related to pipeline abandonment in-place and determine the need for risk management measures to mitigate these risks. Operators can then compare risks and the feasibility and desirability of required risk management measures for abandonment in-place to those associated with pipeline removal to support the selection of either of these options (as discussed in Section 1).

The Framework was also developed as a tool by which issues associated with pipeline abandonment in-place may be communicated between operators, land owners and other stakeholders, and regulators.

5.3. Where can the Framework be used?

The Framework addresses the physical and technical hazards associated with pipeline abandonment in-place, regardless of regulatory jurisdiction. However, the Framework does not address specific administrative requirements of particular jurisdictions, with the exception of specific sections of abandonment plans required for interprovincial and international pipeline systems that are within the jurisdiction of the NEB, as discussed in Section 2.

5.4. When should the Framework be used?

The Framework should be used as pipelines near the end of their operational life, and operators begin to think about decisions regarding if and how they can be abandoned.

5.5. Why should the Framework be used?

The Framework provides a standard scientific approach for evaluating risks associated with the physical and technical hazards related to pipeline abandonment in-place, which are numerous and multidisciplinary. Application of such an approach is beneficial to operators as well as to land owners and other stakeholders, as it supports:

- a common understanding of goals, objectives, and data requirements for evaluation and mitigation of risks;
- effective communication of complex, multidisciplinary issues between operators, land owners and other stakeholders, and regulators;
- consistency between projects;
- scientifically defensible decision making to support effective mitigation of risks; and
- as appropriate, a foundation to assess potential costs and benefits associated with selected actions.

6. Guide to Using the Framework

The Framework for evaluating (on a site-specific basis) risks associated with the physical and technical hazards related to abandoning pipelines in place is comprised of five (5) steps, as follows:

- Step 1: Pipeline and right of way site characterization and attributes;
- Step 2: Identification of pipeline segments along which abandonment in-place may be an option;
- Step 3: Risk assessment for physical and technical hazards associated with abandonment in-place (linked to Matrix Solutions Inc. 2018 exposure assessment);
- Step 4: Evaluation of risk and significance for pipeline segments where risk management might be required to address physical and technical hazards associated with abandonment in-place; and
- Step 5: Identification of risk management measures that could be implemented to address physical and technical hazards associated with pipeline abandonment in-place (linked to Arcadis Canada Inc 2018, since long-term monitoring is frequently chosen as a means to mitigate residual risk).

Upon completion of Step 5, operators can compare risks and the feasibility and desirability of required risk management measures for abandonment in-place to those associated with pipeline removal to support the selection of either of these options.

Guidance for completing each of the five (5) steps is provided in Sections 6.1 through 6.5 below. However, users may make modifications as necessary based on what makes sense for a particular pipeline, how the approach presented herein fits into approaches that may currently be used by operators and based on additional/updated technical knowledge/information regarding how a particular hazard should be evaluated.

6.1. Step 1: Pipeline and right of way site characterization and attributes

Step 1 of the Framework involves compiling information pertaining to characteristics of the pipeline to be abandoned and associated right of way, and linearly referencing and presenting this information on maps. The risk estimations and register should be relatively easy to visualize, so operators should consider including an illustration of some, if not all of the risk-based decision data and pipeline route characteristics (e.g., land use). One solution could be the creation of templates on a software platform such as ArcGIS that could be used by all operators with reports that could be viewed interactively by stakeholders on the web. Step 1 provides a foundation for completion of subsequent steps of the Framework.

A summary of information to be included in the pipeline and right of way characterization is provided as Table 1, and was compiled based on:

- the land use categories provided by the Canadian Energy Pipeline Association (CEPA 2007),
- information to be included in abandonment plans in accordance with Sections 1 through 4 of the *Abandonment Plan Table of Contents Example* (Canada 2015) discussed in this document in Section 2 and provided herein as Appendix A, and
- information required to complete the consequence analysis component of the risk assessment (Step 3 of the Framework).

It does not include site-specific data/information/studies required for completion of the frequency analysis component of the risk assessment (Step 3 of the Framework), however this information may be included in the linearly referenced data set and associated maps.

TABLE 1. PIPELINE AND RIGHT OF WAY CHARACTERIZATION

Category	Sub-category	Sub-category
Land use	Agricultural	Cultivated
		Cultivated with special features (1)
		Non-cultivated (native prairie, rangeland, pasture)
	Non-agricultural	Developed (industrial, commercial, residential, institutional)
		Undeveloped, no prospective future development
		Prospective future development (industrial, commercial, residential, institutional)
	Sensitive areas	Potable groundwater environment
		Lands valued by Indigenous people (e.g., for hunting, gathering)
		Habitat/breeding/foraging areas for species at risk
		Parks, conservation areas, other areas of ecological, environmental, or natural significance
	Water crossings	Surface water used as a source of potable water
		Surface water used for irrigation or livestock watering
		Waterways that support commercial fisheries
		Waterways valued by Indigenous people (e.g., for fishing)
		Waterways used for recreational activities
		Significant wetlands
		Habitat/spawning/breeding/feeding grounds for species at risk
		Other than those listed above
	Other crossings	Roads and railways
		Underground utilities
		Above ground utilities, in particular powerline crossings
Pipeline characteristics	Pipe composition	Construction materials, liners, coatings, etc.
	Pipe diameter and thickness	Construction manufacturer specifications
	Product(s) transported	Source term profile
	Pipe elevation/depth	Elevation survey, depth below grade
	Operational areas/facilities	Compressor stations, meter stations, valve sites, storage facilities, etc.

Category	Sub-category	Sub-category
Land Owners	Easement agreements	Locations where they apply along the right of way

Notes:

(1) "Cultivated with special features" refers to areas where agricultural land use involves disturbances/use of deep soil that may be intersect or interfere with abandoned pipeline (e.g., deep tilling operations, tree farming, turf farms, fruit trees)

In Table 1, information is grouped into three (3) categories: 1) land use; 2) pipeline characteristics; and 3) land owners. Regarding the land use category, for specific definitions of the terms used in Table 1, the user will need to consider the regulatory jurisdiction(s) in which the pipeline is located, as definitions may vary between provinces and regulatory regimes. For example, in the province of Ontario a "water body" is defined as *a permanent stream, river, or similar watercourse or a pond or a lake, but does not include a pond constructed on the property for the purpose of controlling surface water drainage*. However, surface water may be defined differently in other provinces or by other regulatory authorities.

Regarding the land owners' category, land owners and associated easement agreements in place along the pipeline right of way should be identified and included in the linearly referenced data set and associated maps.

Specific techniques with respect to linearly referencing and presenting information are not provided herein. In the selection of such methods, users will need to consider what database/data management systems are available to them, how linearly referenced data will be transformed into features that can be displayed and analyzed on maps (in a process referred to as dynamic segmentation), and how this information can be presented to land owners and other stakeholders in order to facilitate consultation with these groups. Users will also need to consider how or if information will be presented for the pipeline as a whole or for individual segments of the pipeline, and if the latter, the criteria or process by which the pipeline should be segmented.

6.2. Step 2: Identification of where abandonment in-place is an option

Step 2 of the Framework involves using the information compiled and presented in Step 1 to identify pipelines and/or segments of pipelines along which abandonment in-place is an option that may be considered and evaluated by subsequent steps of the Framework. There are specific instances that may rule out the option of abandonment in-place, as follows:

1. Where abandonment in-place is disallowed by easement agreements, or other contractual obligations.
2. Where specific and defined future development plans (e.g., industrial, commercial, residential, institutional) require pipeline removal.
3. Where agricultural land use involves disturbance/use of deep soil and may therefore intersect or interfere with abandoned pipeline. Such land use is referred to as "cultivated with special features" and may include (but is not limited to): deep tilling operations, tree farms, turf farms, and fruit trees.
4. Where abandonment in-place is not a viable option for reasons other than 1 through 3 above.

Pipelines and/or segments of pipelines along which specific instances 1 through 4 above apply, and therefore where abandoned pipeline must be removed, should be identified and referenced. These may be added to the linearly referenced data set, and associated map(s) generated as part of Step 1.

For all other pipelines and/or segments of pipelines, abandonment in-place is an option to be carried forward for evaluation by subsequent steps of the Framework. These may also be added to the linearly referenced data set, and associated maps generated as part of Step 1.

6.3. Step 3: Risk assessment for physical and technical hazards associated with abandonment in-place

Step 3 of the Framework involves completing site-specific risk assessments for each of the physical and technical hazards associated with pipeline abandonment in-place (for pipelines and/or segments of pipeline along which abandonment in-place is an option based on the results of Step 2). For each hazard, a site-specific risk assessment is completed by following and completing a risk assessment worksheet developed for evaluation of risks to human health and safety, ecology and environment, and land use and valued/economic resources associated with that particular hazard. The physical and technical hazards associated with pipeline abandonment in-place (as organized and evaluated by the Framework as discussed in Section 3) and associated worksheets are summarized in Table 2.

TABLE 2. PHYSICAL AND TECHNICAL HAZARDS AND ASSOCIATED RISK ASSESSMENT WORKSHEETS

Hazard No.	Hazard Name	Risk Assessment Worksheet No.
Hazard No. 1	Soil and Groundwater Chemical Impacts from former operation of pipeline (contaminated sites)	PH1
Hazard No. 2	Environmental Impacts from pipeline materials abandoned in-place	--
Hazard No. 2a	Residual product, lubricants, and treatment chemicals	PH2a
Hazard No. 2b	Leaching from construction materials and coatings	PH2b
Hazard No. 2c	Presence and exposure and disruption of asbestos *Asbestosis is a chronic lung disease caused by inhaling asbestos fibres. Prolonged exposure to these fibres can cause lung tissue scarring and shortness of breath. Improper moving and/or disturbance of asbestos containing materials may mobilize these fibres, leading to the concern.*	PH2c
Hazard No. 3	Drainage of surface water or shallow groundwater through pipeline	PH3
Hazard No. 4	Ground subsidence	PH4
Hazard No. 5	Exposure of abandoned pipeline due to soil erosion and geohazards	PH5
Hazard No. 6	Exposure of abandoned pipeline at water crossings due to hydrotechnical hazards *Depending on the pipe's horizontal and vertical location, the pipeline may cause an obstruction for watercraft potentially causing damage and/or personal injury*	PH6

In relation to Hazard No. 5 and No. 6, a study was conducted on behalf of the PTAC (Matrix Solutions Inc. 2018) to analyse abandoned pipeline exposure data, which identified and considered several scenarios including pipe exposures, buoyancy control measures, sensitive areas, and frost heave.

These conclusions should be used to inform risk management decisions regarding whether pipelines should be abandoned or removed, and if abandoned (scope of this document), how to mitigate risk of exposure (i.e., buoyancy control measures) and monitoring frequency (i.e., based on pipe exposure rate).

The risk assessment worksheets referenced in Table 2 are included as Appendix B herein. These worksheets were developed based on the process of risk analysis as illustrated by Figure 1. By this process, a frequency analysis is completed to determine the frequency or likelihood of a particular hazard occurring, and a consequence analysis is completed to estimate the severity of adverse effects should the hazard occur. The results of the frequency and consequence analyses are combined to produce an estimation of risk, in a process referred to as risk estimation. In Step 4 of the Framework, as discussed in Section 6.4, the results of the risk estimation are used to complete the risk evaluation whereby the significance of the risk estimate is evaluated to determine the need for implementation of risk management measures to mitigate or manage risks associated with the particular hazard.

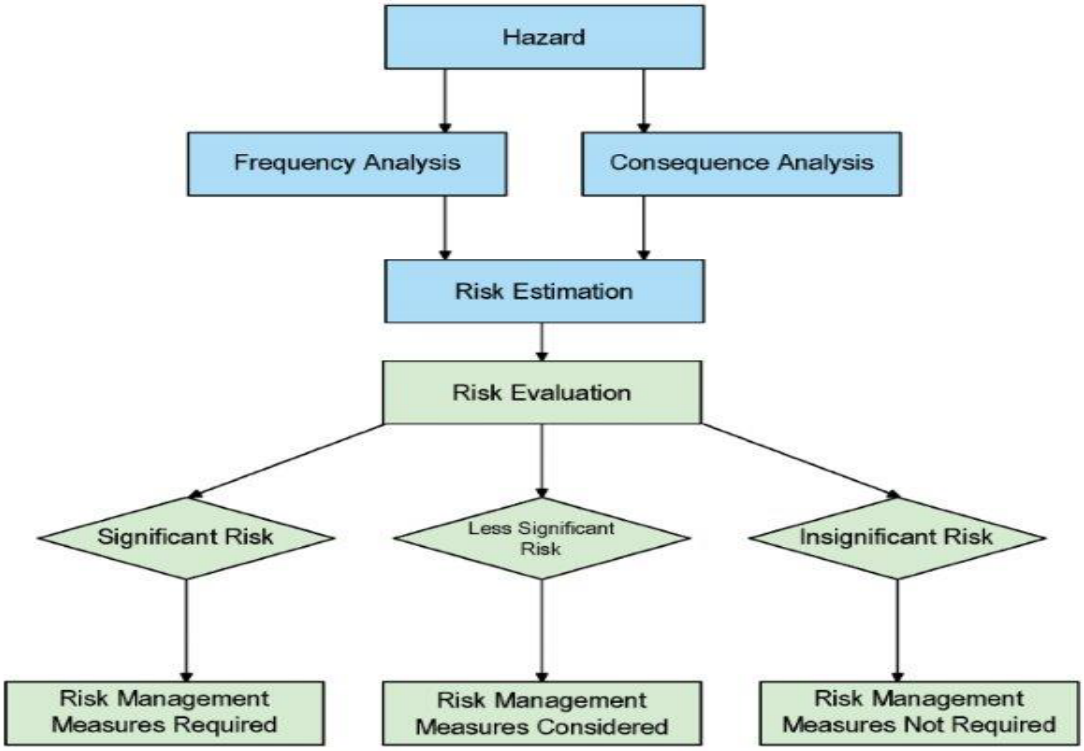


FIGURE 1 RISK ANALYSIS FLOWCHART

6.3.1. Risk Assessment Worksheets

The risk assessment worksheets for each hazard are comprised of several components, as described in Sections 6.3.1.1 through 6.3.1.6 below. Users should carefully review the information presented in each component of the worksheets, as well as the notes provided at the bottom of the worksheets.

6.3.1.1. Release mechanism

The *Release mechanism* component of the worksheets simply defines the hazard being evaluated, including the process(es) by which it may occur, as it is evaluated by the worksheets.

For example, in worksheet PH1 which evaluates *Hazard No. 1: Soil and Groundwater Chemical Impacts from former operation of pipeline*, the hazard is defined as *historical release of contaminants into the environment during former operation of the pipeline, resulting in concentrations in environmental media above applicable environmental criteria*. In this example, it is important to note that contamination is defined as concentrations above applicable environmental criteria. Therefore, the release of contaminants resulting in concentrations in environmental media below the applicable criteria or environmental remediation resulting in concentrations below the applicable criteria would not be considered a hazard to be evaluated by the worksheet. Land owner concerns should also be addressed and factored in to final risk management decisions.

No action by the user is required in this component of the worksheets.

6.3.1.2. Risk management measures required in accordance with CSA Z662

The *Risk management measures required in accordance with the CSA Z662* component of the worksheets lists the risk management measures prescribed by the CSA Z662 to mitigate or manage risks associated with the hazard being evaluated. These prescribed risk management measures are required to be implemented regardless of the results of the risk assessment for that particular hazard, but do not necessarily adequately address these risks.

In this component of the worksheets, the user may indicate whether each of the risk management measures prescribed by the CSA Z662 have been met.

6.3.1.3. Site-specific data/information/studies required to complete risk estimation

The *Site-specific data/information/studies required to complete risk estimation* component of the worksheets lists the site-specific data, information, and/or studies required to complete the risk estimate for the hazard being evaluated.

In this component of the worksheets, the user may indicate whether particular data and information has been gathered and/or particular studies have been completed.

6.3.1.4. Step I – Complete frequency analysis

Step I – Complete frequency analysis component of the worksheets provides the methodology for carrying out the hazard frequency analysis. It lists various scenarios related to the hazard being evaluated that may be present along the pipeline (or segments of the pipeline), and for each provides a rating representative of the frequency or likelihood of the hazard occurring (i.e., low, moderate, high). Definitions for each of the frequency ratings, as considered by the Framework, are provided in Table 3.

TABLE 3. HAZARD FREQUENCY RATINGS

Frequency Rating	Definition
Low	Unlikely to occur
Moderate	May occur
High	Likely to occur

Each scenario in Step I is provided a unique identification number, for example F1a is the identification number for the first scenario for Hazard No. 1, and F3b is the identification number for the second scenario for Hazard No. 3.

The user should review and analyse the appropriate site-specific data/information/studies (as discussed in Section 6.3.1.3) to determine which of the scenarios provided occur along the pipeline and where along the pipeline they occur. For each scenario that occurs along the pipeline, the user should indicate the appropriate frequency rating in the *Insert Rating* column, and the locations along the pipeline where the scenario occurs in the *Locations (along the ROW)* column. For each of the scenarios that do not occur along the pipeline, the user should indicate *not applicable* in each of these columns. Therefore, the frequency or likelihood of the hazard occurring along the various segments of the pipeline is determined.

6.3.1.5. Step II – Complete consequence analysis

Step II – Complete consequence analysis component of the worksheets provides the methodology for carrying out the hazard consequence analysis. It lists various scenarios related to the hazard being evaluated that may be present or occur along the pipeline (or segments of the pipeline), and for each provides a rating representative of the severity of the consequences should the hazard occur (i.e., low, moderate, high). Definitions for each of the consequence ratings, as considered by the Framework, are provided in Table 4.

TABLE 4. HAZARD CONSEQUENCE RATINGS

Consequence Rating	Definition
Human Health and Safety	
Low	Negligible effect
Moderate	Non-life threatening health effects or minor injury to individuals
High	Life-threatening health effects or serious injury
	Health effects to sensitive receptor groups or communities
Ecology and Environment	
Low	Negligible effects
Moderate	Toxic effects to communities/populations of non-species at risk
	Degradation of habitat/breeding/foraging areas for non-species at risk
	Degradation of area not considered to be of particular ecological, environmental, or natural significance

Consequence Rating	Definition
High	Violation of Fisheries Act or other acts or regulations
	Toxic effects to individual species at risk
	Degradation of habitat/breeding/foraging area for species at risk
	Degradation of significant wetland, park, conservation area, or other area of ecological, environmental, or natural significance
Land Use and Valued/Economic Resources	
Low	No perceived impact of land use or valued/economic resources
Moderate	Impact on lands (and associated uses) other than those considered as valued/economic resources
	Temporary and recoverable impact on lands (and associated uses) considered as valued/economic resources
	Minor/localized damage to property
High	Long-term or non-recoverable impact on lands (and associated uses) considered as valued/economic resources
	Major/large-scale damage to property

The consequence analysis is completed individually for human health and safety, ecology and environment, and land use and valued/economic resources, therefore the various scenarios are grouped together and organized accordingly under these headings. Each scenario has a unique identification number, for example C1a is the identification number for the first scenario for Hazard No. 1, and C3b is the identification number for the second scenario for Hazard No. 3.

The user should review and analyse the appropriate site-specific data/information/studies (as discussed in Section 6.3.1.3) to determine which of the scenarios provided may be present or occur along the pipeline and where along the pipeline they occur. For each scenario that occurs along the pipeline, the user should indicate the appropriate consequence rating in the *Insert Rating* column, and the locations along the pipeline where the scenario occurs in the *Locations (along the ROW)* column. For each of the scenarios that do not occur along the pipeline, the user should indicate *not applicable* in each of these columns. Therefore, the severity of the consequence(s) of the hazard occurring along the various segments of the pipeline is determined.

6.3.1.6. Step III – Complete risk estimation

Step III – Complete risk estimation component of the worksheets provides a space where the results of the frequency and consequence analyses can be combined to produce an estimation of risk, or risk estimate. Risk estimates generated by the Framework are expressed qualitatively as risk estimate categories, as summarized in Table 5.

TABLE 5. HAZARD RISK ESTIMATE CATEGORIES

Risk Estimate Categories
High Likelihood and High Consequence
High Likelihood and Moderate Consequence OR Moderate Likelihood and High Consequence
High Likelihood and Low Consequence
Moderate Likelihood and Moderate Consequence
Low Likelihood OR Low Consequence
Low Likelihood and Low Consequence
Low Likelihood and High Consequence

Note: Term "OR" in the above table indicates that only one hazard risk identified needs to be met.

The user should review the results of the frequency and consequence analyses to determine which of the risk estimate categories occur along the pipeline and where along the pipeline they occur. For each risk estimate category that occurs along the pipeline, the user should indicate the frequency scenario identification number(s) and consequence scenario identification number(s) combinations that result in this category, in the *Frequency No.* and *Consequence No.* columns (respectively), and the locations along the pipeline where these combinations occur in the *Locations* columns. For the risk estimate categories that do not occur along the pipeline, the user should indicate *not applicable* in each of these columns. Therefore, the risk estimate categories occurring along the various segments of the pipeline are determined.

6.4. Step 4: Risk evaluation

Step 4 of the Framework involves carrying out the risk evaluation for each of the physical and technical hazards associated with pipeline abandonment in-place, for which risk assessments were completed in Step 3, and producing a risk register which summarizes the hazards for which risk management measures are required or should be considered. Risk register worksheets for each hazard are included as Appendix C herein.

The significance of the risk estimate categories used in Step 3 (and presented in Table 5) are defined based on whether or not risk management measures are required to mitigate or manage the hazards to which they apply, as illustrated by Figure 2.

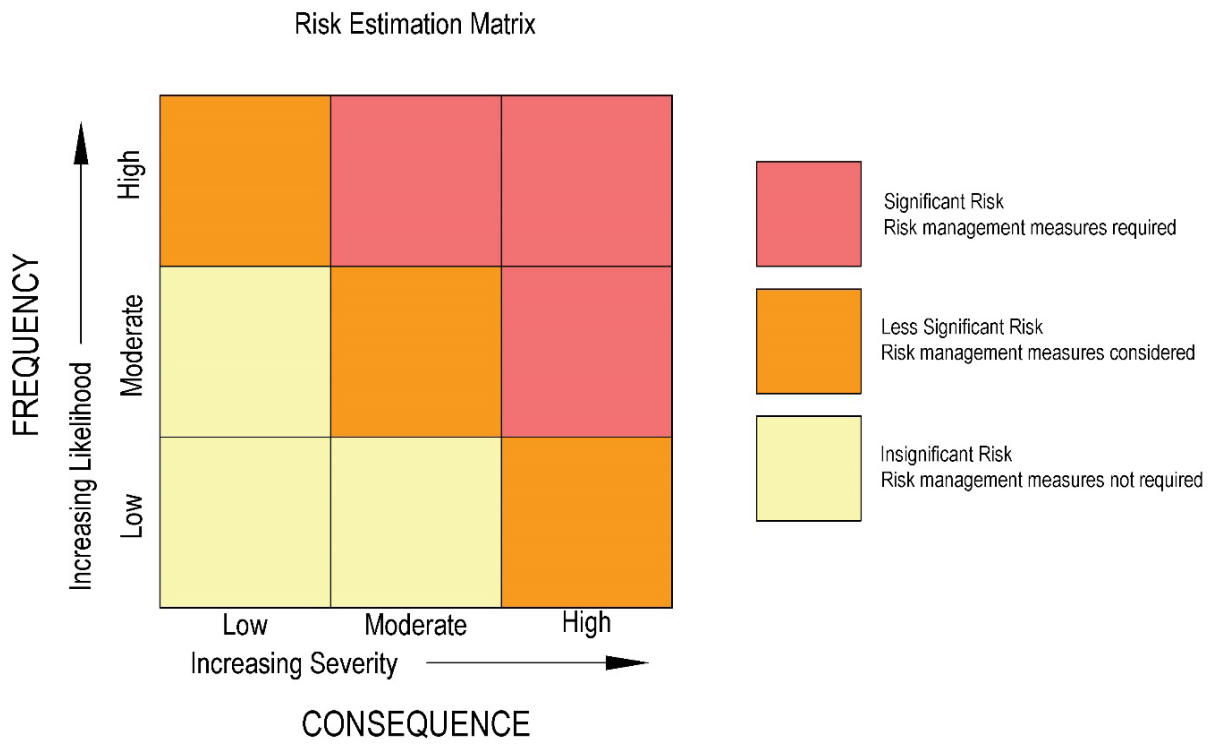


FIGURE 2 RISK EVALUATION

For each hazard, the significance of each risk estimate category that occurs along the pipeline, based on the results of Step 3, is evaluated to determine whether and where along the pipeline risk management measures are required. For each of the risk estimate categories used in Step 3 (and presented in Table 5) the significance and associated requirement for risk management measures, as considered by the Framework, is presented in Table 6.

TABLE 6. SIGNIFICANCE OF RISK ESTIMATE CATEGORIES

Risk Estimate Categories	Risk Estimate Significance	Action
High Likelihood and High Severity	Significant risk	Risk management measures required
High Likelihood and Moderate Severity OR Moderate Likelihood and High Severity	Significant risk	Risk management measures required
Moderate Likelihood and Moderate Severity	Less significant risk	Risk management measures considered
High Likelihood and Low Severity	Less significant risk	Risk management measures considered
Low Likelihood and High Severity	Less significant risk	Risk management measures considered
Low Likelihood OR Low Severity	Insignificant risk	Risk management measures not required
Low Likelihood and Low Severity	Insignificant risk	Risk management measures not required

For each hazard, the user should review the information entered into *Step III – Complete risk estimation* component of the risk assessment worksheet completed in Step 3 and based on the significance of the risk estimate categories as indicated in Table 6, determine where significant and less significant risks occur along the pipeline, and therefore where risk management measures are required or should be considered to mitigate or manage the hazard. For risk estimates determined to be significant or less significant, the user should enter the associated consequence identification number, description of consequence, and location where it occurs along the pipeline into the appropriate risk register worksheet.

The user should also consider a means to visually display the risk results (e.g., ArcGIS) to improve communication of risk over the areas concerned.

6.5. Step 5: Identification of risk management measures

Step 5 of the Framework involves identifying risk management measures that could be implemented to mitigate or manage the hazards for which they are required, based on the results of Step 4. Options for risk management measures will be dependent on the hazard for which they are required, as well as the consequences/effects that may be realized should the hazard occur. Risk management measures may be selected, in consultation with stakeholders, to reduce or eliminate the frequency or likelihood of the hazard occurring, and/or to reduce the severity of the consequences/effects should the hazard occur. With respect to the latter, risk management measures should be agreed upon and address each/all of the potential consequences, as listed in the risk register for the particular hazard.

For instance, with respect to *Hazard No. 4: Ground subsidence beyond tolerable range*, to reduce the frequency or likelihood of occurrence, pipes could be filled with a concrete slurry to prevent collapse (resulting in ground subsidence), and to reduce the severity of environmental effects of possible events from ground subsidence, a spill response plan could be developed for implementation if necessary. Risk management may also involve development and implementation of monitoring plans, to monitor indicators of potential occurrence or measurable effects.

For each hazard requiring risk management measures, an options evaluation should be completed (by a qualified party) to identify the various options for risk management, and compare them based on a relevant set of criteria, including: effectiveness, ease of implementation, cost, etc. The feasibility and desirability of each of the options could also be compared to that of pipeline removal to support selection of the best approach for pipeline abandonment.

Potential residual effects post-mitigation can be risk managed through the design and implementation of long-term monitoring programs (see Arcadis Canada Inc. 2018), which include an adaptive management process to reduce monitoring requirements and pipeline operator liability over time.

7. Case Study-Guide for Evaluating Pipeline Abandonment Risks

7.1. Introduction

To provide additional guidance on using the Framework, two case studies have been developed which outlines the process of the key steps in completing the Worksheets and the identifying the Risk Ratings based on the Frequency and Consequence Rating along with potential Mitigation outcomes. The case studies were designed to aid in the identification of the Risk Ratings where potential human and

environmental health risks are identified and some form of risk reduction (e.g. remediation) may be necessary. The case studies also aid in the formulation of technical inputs for the selection of suitable risk management alternatives.

A wide variety of provincial and federal 'frameworks' and guidance documents have now been developed or proposed across Canada for the management of environmental issues. The primary consistent factor among these frameworks is an emphasis on risk – a need to assess the risks posed by site factors, the need to manage those risks once identified, and the need to prioritize sites such that those with the greatest risks are addressed first. Professional judgment with respect to due diligence will always take precedence to ensure that any project is administered in such a way as to protect human and ecological receptors, health and safety, policy and financial drivers, site-specific conditions and regional setting.

The first case study includes a petroleum hydrocarbon spill in an agricultural setting near a surface water body. The emphasis of this case study is on contaminant migration. The groundwater and surface water are used for potable water and the surface water is used for recreational purposes. The pipeline has been cleaned following standard protocols and studies have been completed to determine the potential site risks. The second case study includes a water crossing and the pipeline segment next to a sensitive surface water environment. The emphasis of this case study is on impacts to the physical sensitive environments. The groundwater and surface water are used for potable water and the surface water is used for recreational purposes. The pipeline has been cleaned following standard protocols and studies have been completed to determine the potential site risks. Figures for the case studies have been provided as visual aids.

7.2. Key Steps

Appendix A in the Framework provides an overview of the Framework Steps, associated Tables and Worksheets and links to the appropriate sections of the Abandonment Plan Table of Contents (Canada 2015). The key steps are as follows:

1. The first step is to complete the pipeline and ROW characterization. The scorer should review all pertinent documents that have been prepared for the project. As some technical documents may not be available during the application of the tool, professional judgement should be used to populate the various technical inputs.
1. For each segment of the pipeline to be abandoned in place, the scorer will complete the Risk Estimation Worksheets (PH1 to PH6) starting with the Frequency Rating (Step 1) and Consequence Rating (Step 2) for each of Worksheets. At the end of each Worksheet is a Risk Estimation Summary (Step 3).
2. For each of the Worksheets, the Risk Rating can be obtained from Table 4, Appendix A, Risk Estimation R1 to R7.
3. Identify locations along the pipeline segment where Risk Management Measures are likely required (i.e. R1 to R3, where risks have been identified)
4. Select the most appropriate risk management measure that will be implemented to address the Risks.
5. The Mitigative Measures implemented will depend on a number of site specific factors and

adjusted on a case by case basis. For general guidance mitigative measures may include:

- Cleaning of pipeline
- Filling or plugging pipeline segments
- Removal of redundant surface equipment
- Contaminant removal or management
- Site monitoring
- Risk management or risk assessments
- Engineering or passive controls, monitoring of soil subsidence, corrosion effects, pipeline subsidence, soil erosion.
- Plugging, controlling water conduits
- Controlling pipeline buoyancy
- Monitoring potential chemical impacts and leaching.

7.3. CASE STUDY 1: Pipeline A Segment 11000 m to 13500 m

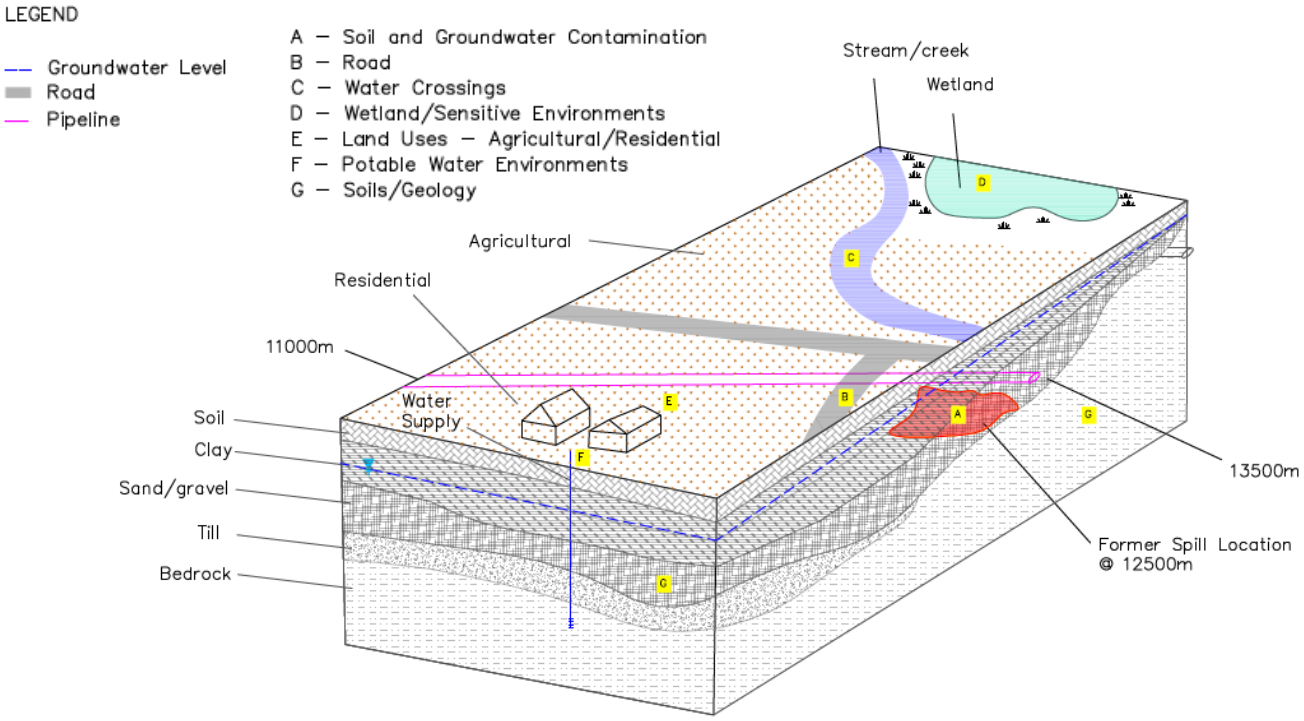


FIGURE 3 CASE STUDY 1: PIPELINE A SEGMENT 11000 M TO 13500 M ATTRIBUTES.

7.3.1. Segment Attributes

See Figure 3 for overview of Pipeline A Segment 11000 m to 13500 m attributes.

a. Residual petroleum hydrocarbon (PHC) spill at segment 12500 m associated with discharges during routine maintenance. PHC impacts have been delineated based on potable water

environment, agricultural land use. PHC concentrations are currently above the applicable cleanup criteria;

b. Surface water and groundwater are used for potable water;
c. Local waterway is used for recreational purposes;
d. Cultivated agricultural land use with special features- fruit trees with sufficient root penetration into contaminated groundwater and / or soil;
e. Pipeline has been cleaned using specific methodologies associated with target residual contaminants. The pipeline diameter is greater than 323.9 mm;
f. Testing has been completed and the pipeline construction materials are inert and not expected to leach;
g. Asbestos is not present in the external pipe coatings;
h. The pipeline is within 30 m's of surface water but does not cross the surface water body; and
i. Pipeline exposure has not occurred in the past; but is in an area susceptible to erosion.

7.3.2. Risk Estimation Scoring

Case study 1 worksheets for PH1 to PH6 are attached for reference (Appendix D). Risk estimation scoring is summarized in Table 7.

TABLE 7 RISK ESTIMATION SCORING FOR PIPELINE A SEGMENT 11000 M TO 13500 M (SEE **FIGURE 3**).

Hazard From Hazard Worksheet	Frequency Rating	Consequence Rating	Risk Rating Table 4 Appendix D	Possible Mitigation Measures
PH1- Contaminated Site @ 11500m	**High**-F1d	**High**-C1a, b; C1s, C1t	R1	Remove all contaminated soil to applicable guidelines
PH2a- Residual Contaminants- Entire segment	**Moderate** – F2 ab	**High** – C2a a, b; C2a s, t	R2	Clean pipe to applicable guidelines and monitor
PH2b- Coating Contaminant Leaching-entire segment	**Low**- F2b a	**High**- C2b a,b, C2b s, t	R7	Low risk, monitor
PH2c Asbestos	**Low**- F2c a	**Low**- C2c a	R5	No Action required
PH3 Water Conduit- entire segment	**High** -F3d	**Moderate**-**High** C3h; l, n	R1	Control water conduit, plugs or pipe blocks
PH4- Subsidence- at 12500 m	**High**- F4d	**High**- C4b, k, l	R1	Fill with inert materials
PH5- Pipe Exposure on Land 12000 to 12800 m	**Moderate-** F5b	**Moderate** -C5b	R4	Complete study and monitor as required
PH 6-Pipe Exposure at Water Crossing	NA	NA	No crossing	Not applicable

7.4.CASE STUDY 2: Pipeline B Segment 15000 m to 18000 m

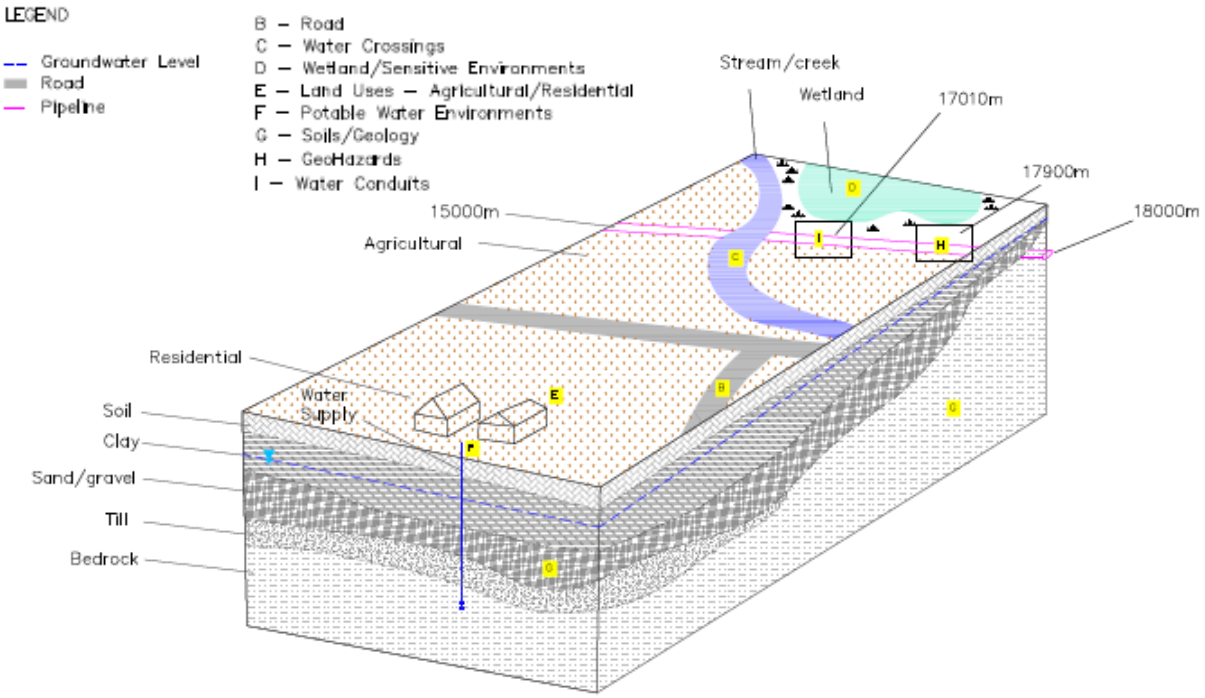


FIGURE 4 CASE STUDY 2 PIPELINE B SEGMENT 15000 M TO 18000 M ATTRIBUTES.

7.4.1. Segment Attributes

See Figure 4 for overview of Pipeline B Segment 15000 m to 18000 m attributes.

a. Pipeline runs adjacent to sensitive wetland;
b. Species at Risk within sensitive wetland;
c. Pipeline crosses a surface water body;
d. Surface water and groundwater are used for potable water;
e. Local waterway is used for recreational purposes;
f. Cultivated agricultural land use with special features- fruit trees with sufficient root penetration into contaminated groundwater and / or soil;
g. Pipeline has been cleaned using specific methodologies associated with target residual contaminants. The pipeline diameter is greater than 323.9 mm;
h. Testing has been completed and the pipeline construction materials are inert and not expected to leach;
i. Asbestos is not present in the external pipe coatings; and
j. Pipeline exposure has not occurred in the past; but is in an area susceptible to erosion.

7.4.2. Risk Estimation Scoring

Case study 2 worksheets for PH1 to PH6 are attached for reference (Appendix E). Risk estimation scoring is summarized in Table 8.

TABLE 8 RISK ESTIMATION SCORING FOR PIPELINE B SEGMENT 15000 M TO 18000 M (SEE **FIGURE 4**).

Hazard From Hazard Worksheet	Frequency Rating	Consequence Rating	Risk Rating Table 4 Appendix E	Possible Mitigation Measures
PH1- No Contaminated Sites				No Action
PH2a- Residual Contaminants- Entire segment	**Moderate** – F2a c	**High** – C2a a, b; e, i; l o, p; s, t, x, bb	R2	Clean pipe to applicable guidelines and monitor
PH2b- Coating Contaminant Leaching-entire segment	**Low**- F2b a	**High**- C2b a, b, e, i; l, o, p, s, t, v, x, bb	R7	Low risk, monitor
PH2c Asbestos	**Low**- F2c a	**Low**- C2c a	R5	No Action required
PH3 Water Conduit- @17010 m	**High** -F3d	**High** C3a, d, e, g, l, n, p, s, w	R1	Control water conduit, plugs or pipe blocks
PH4- Subsidence- at 17900 m	**High**- F4d	**High**- C4 b, c, f, k, l, o	R1	Fill with inert materials
PH5- Pipe Exposure on Land 11500 to 11800 m	**Moderate**- F5b	**Moderate** -C5b	R4	Complete study and monitor as required
PH 6-Pipe Exposure at Water Crossing	**Moderate**- F6b	**High**- C6a	R2	Complete study and monitor as required

8. References

Arcadis Canada Inc. (for Petroleum Technology Alliance of Canada), December 2018. Recommended long term monitoring program for all aspects of an abandoned pipeline.

Canada (National Energy Board), 2016. *Regulating pipeline abandonment*. Cat. No. NE23-161/2016E-PDF, ISBN 978-0-660-05660-9.

Canadian Energy Pipeline Association (CEPA), 2007. *Pipeline abandonment assumptions, technical and environmental considerations for development of pipeline abandonment strategies*.

Canada (National Energy Board), 2015. *Filing manual*. Cat. No. NE23-44/2004E, ISBN 0-662-36977-7, ISSN 1718-4711.

Det Norske Veritas (National Energy Board), November 2010. *Pipeline abandonment scoping study*. Report No.: EP028844. Reg No. ENACA855.

Matrix Solutions Inc (for Petroleum Technology Alliance of Canada). Analysis of pipeline exposure data and scoping review of exposure scenarios. June 2018.

Pipeline Abandonment Steering Committee (PASC) (comprised of representatives from the Canadian Association of Petroleum Producers, the Canadian Energy Pipeline Association, the Alberta Energy and Utilities Board, and the National Energy Board), November 1996. *Pipeline abandonment – a discussion paper on technical and environmental issues*.

Standards Council of Canada (CSA Group), July 2016. *Oil and gas pipeline systems*. CAN/CSA-Z662-15 National Standard of Canada.

APPENDIX A

Abandonment Plan Table of Contents Example

Table 1 - Steps of Risk-Based Decision Making Framework for Pipeline Abandonment

Framework Steps	Framework Tables and Worksheets	Associated sections of Abandonment Plan Table of Contents (Canada, June 2016)
Step 1: Complete pipeline and ROW characterization	Table 2 - Information to be included in pipeline and right of way characterization	1. Background a. General description of the pipeline and facilities including history and product it carries b. Proposed abandonment process including timelines(2) 2. Location map (ROW, pipe, stations, valves, storage, etc.) 3. Detailed description of facilities to be abandoned (detailed maps to be included in an appendix) a. Pipeline composition, diameter, thickness, coatings, etc. b. Adjacent pipeline facilities (corridor) c. Facility components on company-owned land d. Land use along route (e.g., agricultural, urban, parkland) e. Natural features (e.g., water bodies, wetlands, native prairie, rare vegetation, species at risk) f. Land owners and land administration agencies 4. History of ruptures, leaks and other construction occurrences(1) a. Location of incidents and any former contamination sites b. Status of contamination remediation
Step 2: Make preliminary selection of pipeline segments/lengths to be abandoned in place based on land use (current and future), pipeline diameter, and easement agreements (if applicable)	Table 3 - Criteria for preliminary selection of pipeline to be abandoned in place	5. Abandonment procedure a. Facilities to be left in place i. Locations and justification ii. Mitigation measures 1. Cleaning (procedure and standards) 2. Filling or plugging 3. Removal of unnecessary surface equipment 4. Identification of location of facilities 5. Estimation of risk and risk reduction plans a. Contamination removal or management b. Soil subsidence c. Corrosion effects d. Pipe collapse e. Soil erosion effects f. Water conduit g. Water crossings h. Transportation and utility crossings
Step 3: For pipeline segments/lengths (preliminarily) selected to be abandoned in place, complete risk estimates for each of the potential hazards associated with abandoning pipeline in place	Risk estimation worksheet PH1 Potential Hazard No. 1: Contamination from former operation of pipeline	
	Risk estimation worksheets PH2a to PH2c Potential Hazard No. 2: Contamination from residual components of hydrocarbon product, lubricants, and treatment chemicals within pipeline	
	Risk estimation worksheet PH2a Potential Hazard No. 2a: Contamination from residual components of hydrocarbon product, lubricants, and treatment chemicals within pipeline	
	Risk estimation worksheet PH2b Potential Hazard No. 2b: Contamination from leaching of contaminants from pipeline construction materials and external coatings	
	Risk estimation worksheet PH2c Potential Hazard No. 2c: Presence and exposure and disruption of asbestos in pipeline external coatings	
	Risk estimation worksheet PH3 Potential Hazard No. 3: Drainage of surface water or shallow groundwater through pipeline	
	Risk estimation worksheet PH4 Potential Hazard No. 4: Ground subsidence beyond tolerable range (for land use)	
	Risk estimation worksheet PH5 Potential Hazard No. 5: Exposure of abandoned pipeline on land due to soil erosion and geohazards inducing frost heave	
	Risk estimation worksheet PH6 Potential Hazard No. 6: Exposure of abandoned pipeline at water crossings due to hydrotechnical hazards	
Step 4: For each of the potential hazards (PH1, PH2a-c, PH3 to PH6), based on the results of the risk estimation, identify locations along the ROW where risk management measures are likely required (i.e., where R1, R2, or R3 risks have been identified).	Risk estimation worksheets (PH1, PH2a-c, PH3 to PH6)	
Step 5: Select risk management measures that will be implemented to address R1, R2, and R3 risks identified for each of the potential hazards. If implementation of risk management measures is not feasible, re-evaluate decision to abandon pipeline in place.		

Notes:
ROW - right of way
(1) Also required for completion of *PH1 Risk Estimation Worksheet* , for estimation of risks associated with contamination from former operation of pipeline
(2) Not directly associated with Framework Steps, but included in Abandonment Plan table of contents.

References:
Her Majesty the Queen in Right of Canada 2015 as represented by the National Energy Board (NEB), 2015. Regulating pipeline abandonment. PDF: Cat. No. NE23-161/2016E-PDF, ISBN 978-0-660-05660-9. June 2016.

Table 2 - Information to be Included in Pipeline and Right of Way Characterization (Step 1 of Framework)

Information to be included in pipeline ROW characterization		
1. Land use within/proximal to ROW (current and expected future)	Agricultural	Cultivated
		Cultivated with special features
		Non-cultivated (native prairie, rangeland, pasture)
	Non-agricultural	Developed (industrial, commercial, residential, institutional)
		Undeveloped
	Sensitive areas	Potable groundwater environment
		Lands valued by Indigenous people (for hunting, gathering, other)
		Habitat/breeding/foraging areas for species at risk
		Parks, conservation areas, and other areas of ecological, environmental, or natural significance
	Water crossings	Surface water used as a source of potable water
		Surface water used for irrigation or livestock watering
		Waterways that support commercial fisheries
		Waterways valued by Indigenous people (for fishing, other)
		Waterways used for recreational activities
		Significant wetlands
		Habitat/spawning/breeding/feeding grounds for species at risk
2. Pipeline	Composition	(construction materials and coatings)
	Product it carries/carried	
	Locations of (historical) operational areas	(e.g., compressor stations, metre stations, and valve sites)
	Facility components	
	Locations of historical breaches/spills	
3. Land owners and land administration agencies (and easement agreements)		

Notes:

ROW - right of way

Information best presented on map(s), with supporting text.

Table 3 - Criteria for Preliminary Selection of Pipeline to be Abandoned in Place (Step 2 of Framework)

Land Use (current and future)		Pipe Diameter		
		2" to 12" 60.3 to 323.9 mm	14" to 24" 355.6 to 610 mm	>26" >660 mm
Agricultural	Cultivated	AIP	AIP	AIP
	Cultivated with special features	R	R	R
	Cultivated with special features	AIP	AIP	AIP
	Non-cultivated	AIP	AIP	AIP
Non-agricultural	Existing developed lands	AIP	AIP	AIP
	Prospective future development - commercial/industrial/residential	R	R	R
	No future development	AIP	AIP	AIP
Other	Environmentally sensitive areas	AIP	AIP	AIP
	Road and railway crossings	AIP	AIP	AIP
	Water crossings	AIP	AIP	AIP
	Other crossings (utilities and other pipelines)	AIP	AIP	AIP
Easement agreements do not allow for AIP.		R	R	R

Notes:

AIP - abandon pipeline in place

R - remove pipeline

References:

Canadian Energy Pipeline Association, Pipeline abandonment assumptions, technical and environmental considerations for development of pipeline abandonment strategies. Prepared for the Terminal Negative Salvage Task Force of the Canadian Energy Pipeline Association. September 2006 - April 2007. (Table 1 - Pipeline abandonment matrix)

Table 4 - Hazard Frequency, Consequence, and Risk Estimation Ratings (for Steps 3 and 4 of Framework)

Term	Rating	Definition
Frequency:	Low	Unlikely to occur without risk management measures (in addition to those in accordance with CSA-Z662).
	Moderate	May occur without additional risk management measures.
	High	Likely to occur without additional risk management measures.
Consequence:	***Human health and safety:***	
	Low	Risk to human health and safety likely to be within acceptable range.
	Moderate	Exposure/negative effect(s) to individual receptors, potentially resulting in non-life threatening health effects or minor injury.
	High	Acute exposure/catastrophic event potentially resulting in death or serious injury.
		Exposure/negative effect(s) to individual receptors, potentially resulting in life-threatening health effects or serious injury.
		Exposure/negative effect(s) to sensitive receptor groups or communities.
	Ecology and environment:	
	Low	Risk to ecological receptors and environment likely to be within acceptable range.
	Moderate	Exposure/negative effect(s) to communities/populations of non-species at risk.
		Exposure/potential degradation of habitat/breeding/foraging area for non-species at risk.
		Exposure/potential degradation of area not considered to be of particular ecological, environmental, or natural significance.
	High	Violation of the Fisheries Act or other acts or regulations.
		Exposure/negative effect(s) to individual species at risk.
		Exposure/potential degradation of habitat/breeding/foraging area for species at risk.
		Exposure/potential degradation of significant wetland, or area reserved as a park, conservation area, or other area of ecological, environmental, or natural significance.
	Land use and valued/economic resources:	
	Low	No perceived impact on land use or valued/economic resources.
	Moderate	Impact on lands (and associated uses) other than those considered as valued/economic resources.
		Temporary and recoverable impact on lands (and associated uses) considered as valued/economic resources.
		Minor/localized damage to property.
	High	Long-term or non-recoverable impact on lands (and associated uses) considered as valued/economic resources.
		Major/large-scale damage to property.
Risk estimation:	R1	R1 - High likelihood and High consequences (significant risk, risk management measures required)
	R2	R2 - High likelihood and Moderate consequences OR Moderate likelihood and High consequences (significant risk, risk management measures required)
	R3	R3 - High likelihood and Low consequences (insignificant risk, risk management measures not required)
	R4	R4 - Moderate likelihood and Moderate consequences (less significant risk, risk management measures considered)
	R5	R5 - Low likelihood OR Low consequences (insignificant risk, risk management measures not required)
	R6	R6 - Low likelihood AND Low consequences (risk management measures not required)
	R7	R7- Low likelihood and High consequences (less signifcant risk, risk managements considered

APPENDIX B

Risk Assessment Worksheets

PH1 Risk Assessment Worksheet

Hazard No. 1: Soil or groundwater chemical impacts to the environment from former operation of pipeline (i.e., contaminated sites):

Release mechanism:

Historical release of contaminants into the environment during former operation of the pipeline, resulting in concentrations in environmental media (i.e., soil, groundwater, surface water, and/or sediment) above applicable environmental criteria. Common sources of historical contamination include pipeline breaches/spills, and operational areas such as compressor stations, metre stations,

Risk management measures required in accordance with CSA Z662*:	***Met***	***Not met***
10.17 Abandonment of pipeline related facilities Pipeline related facilities such as compressors and pump stations shall have all rotating and fixed equipment removed, unless they are still part of an operating or deactivated site. Associated piping, utilities, supports, and foundations shall also be removed.		
Testing for site soil contamination and appropriate remediation might be required.		
Consideration should be given to the removal of underground vaults and closed-top pits. For those that are to remain:		
a) walls and floors shall be tested for contamination. Contaminated areas shall be remediated or removed.		
b) walls shall be removed to an appropriate level below the ground surface		
c) the insides of the vault shall be filled with clean soil.		
Soils in around and underneath storage tanks shall be inspected for contamination and appropriately remediated.		
Site-specific data/information/ studies required to complete risk estimation:	***Completed***	***Not completed***
1) Phase I Environmental Site Assessment (ESA) (representative of current conditions) to identify potential sources of contamination along the pipeline ROW, prepared by a qualified professional.		
2) Phase II/III ESA (representative of current conditions) to assess/characterize soil and groundwater contamination associated with potential sources of contamination identified by the Phase I ESA, prepared by a qualified professional		
IF CONTAMINANT CONCENTRATIONS ARE ABOVE APPLICABLE ENVIRONMENTAL CRITERIA:		
3) Human health and ecological risk assessment (representative of current conditions) completed in accordance with Health Canada and Environment Canada Risk Assessment Frameworks, prepared by a qualified professional AND/OR		
4) Remediation reports that provide current concentrations of contaminants in soil and/groundwater on Site, prepared by a qualified professional		

Step I - Complete frequency analysis:

F1: Likelihood[2] that concentrations of contaminants in environmental media (i.e., soil, groundwater, surface water, and/or sediment) are above applicable environmental criteria.		***Insert rating***	***Locations (along ROW) associated with rating***
Scenarios along pipeline:			
F1a: Phase I/II/III ESAs have been completed along the pipeline ROW to identify potential sources of contamination, and assess potential impacts. Concentrations of contaminants of concern are below applicable environmental criteria.	Rate low		
F1b: Phase I/II/III ESAs have been completed along the pipeline ROW to identify potential sources of contamination, and assess potential impacts. Concentrations of contaminants of concern above applicable environmental criteria have been remediated. Associated reports are kept on file.	Rate low		
F1c: Phase I/II/III ESAs have been completed along the pipeline ROW to identify potential sources of contamination, and assess potential impacts. Concentrations of contaminants of concern are above applicable environmental criteria, however based on completion of a human health and ecological risk assessment, risks to receptors are within the acceptable range. Associated reports are kept on file.	Rate low		
F1d: Phase I/II/III ESAs have been completed along the pipeline ROW to identify potential sources of contamination, and assess potential impacts. Concentrations of contaminants of concern are above applicable environmental criteria.	Rate high		

Step II - Complete consequence analysis:

C1: Consequence(s)[2] of concentrations of contaminants in environmental media (soil, groundwater, surface water, sediment) above applicable environmental criteria:			
C1: Human health and safety:		***Insert rating*** [3, 4, 5]	***Locations (along ROW) associated with rating***
Land:	Rate high		
C1a: Contamination[1] within a potable groundwater environment.			
C1b: Contamination[1] of agricultural lands.			
C1c: Contamination of residential, institutional, or park lands.			
C1d: Contamination[1] of lands valued by Indigenous people (for hunting, gathering, other).			
Water crossings:			
C1e: Contamination[1] of surface water used as a source of potable water (e.g., reservoirs, lakes, rivers).			
C1f: Contamination[1] of surface water used for irrigation or livestock watering.			
C1g: Contamination[1] of waterways that support commercial fisheries.			
C1h: Contamination[1] of waterways valued by Indigenous people (for fishing, other).			
C1i: Contamination[1] of waterways used for recreational activities.			
Land:	Rate moderate		
C1j: Soil and/or groundwater contamination[1] in an environment other than those described above with a "high" consequence rating.			
Water crossings:			
C1k: Surface water and/or sediment contamination[1] in and environment other than those described for waterways above with a "high" consequence rating.			
C1: Ecology and environment:		***Insert rating*** [3, 4, 5]	***Locations (along ROW) associated with rating***
Land:	Rate high		
C1l: Contamination[1] of areas that are habitat/breeding/foraging areas for species at risk.			
C1m: Contamination[1] of areas reserved as parks, conservation areas, or other areas of ecological, environmental, or natural significance.			
Water crossings:			
C1n: Contamination[1] of waterways that may constitute a violation of the Fisheries Act.			
C1o: Contamination[1] of significant wetlands.			
C1p: Contamination[1] of waterways that are habitat/spawning/breeding/feeding grounds for species at risk.			
Land:	Rate moderate		
C1q: Soil and/or groundwater contamination[1] in an environment other than those described above with a "high" consequence rating.			
Water crossings:			
C1r: Surface water or sediment contamination[1] in an environment other than those described for waterways above with a "high" consequence rating.			
C1: Land use and valued/economic resources:		***Insert rating*** [3, 4, 5]	***Locations (along ROW) associated with rating***
Land:	Rate high		
C1s: Contamination[1] within a potable groundwater environment.			
C1t: Contamination[1] of agricultural lands.			
C1u: Contamination[1] of lands valued by Indigenous people (for hunting, gathering, other).			
C1v: Contamination[1] of areas reserved as parks, conservation areas, or other areas of ecological, environmental, or natural significance.			
C1w: Contamination[1] of forested lands.			
Water crossings:			
C1x: Contamination[1] of surface water used as a source of potable water (e.g., reservoirs, lakes, rivers).			
C1y: Contamination[1] of surface water used for irrigation or livestock watering.			
C1z: Contamination[1] of waterways that support commercial fisheries.			
C1aa: Contamination[1] of waterways valued by Indigenous people (for fishing, other).			
C1bb: Contamination[1] of waterways used for recreational activities.			
Land:	Rate moderate		
C1cc: Soil and/or groundwater contamination[1] in an environment other than those described above with a "high" consequence rating.			
Water crossings:			
C1dd: Surface water or sediment contamination[1] in and environment other than those described for waterways above with a "high" consequence rating.			

Step III - Complete risk estimation:

E1: Estimation of risk[2] associated with concentrations of contaminants in environmental media (soil, groundwater, surface water, sediment) above applicable environmental criteria:	**On Land**			**At Water crossings**		
E1: Human health and safety:	**Frequency No.**	**Consequence No.**	**Locations**	**Frequency No.**	**Consequence No.**	**Locations**
High likelihood and High severity						
High likelihood and Moderate severity OR Moderate likelihood and High severity						
High likelihood and Low severity	NA	NA	NA	NA	NA	NA
Low likelihood and high severity						
Low likelihood OR Low severity						
Low likelihood and Low severity	NA	NA	NA	NA	NA	NA
E1: Ecology and environment:						
High likelihood and High severity						
High likelihood and Moderate severity OR Moderate likelihood and High severity						
High likelihood and Low severity	NA	NA	NA	NA	NA	NA
Low likelihood and high severity						
Low likelihood OR Low severity						
Low likelihood and Low severity	NA	NA	NA	NA	NA	NA
E1: Land use and valued/economic resources:						
High likelihood and High severity						
High likelihood and Moderate severity OR Moderate likelihood and High severity						
High likelihood and Low severity	NA	NA	NA	NA	NA	NA
Low likelihood and high severity						
Low likelihood OR Low severity						
Low likelihood and Low severity	NA	NA	NA	NA	NA	NA

Notes:
ROW - pipeline right of way
NORM - naturally occurring radioactive materials
* Do not necessarily adequately address risks associated with the hazard.
(1) contamination - concentrations above applicable environmental criteria, or concentrations above property-specific criteria derived by a human and ecological risk assessment
(2) Refer to Tables 3, 4, and 5 of text for definitions of frequency, consequence, and risk estimation ratings.
(3) Rate based on if/where the environment/land use is present along pipeline ROW. Both current and future land use should be considered.
(4) If environment/land use is present insert applicable rating (i.e., high, moderate, or low). Otherwise, insert "not present along ROW or not applicable".
(5) There is no environment/land use on which a "low" consequence rating is applicable. Contamination[1] of any media is considered to have at least a moderate consequence rating.

PH2a Risk Assessment Worksheet

Hazard No. 2: Environmental impacts from pipeline materials abandoned in-place, post operation

Hazard No. 2a: Residual product, lubricants, and treatment chemicals

Release mechanism:

Contaminants are present within the pipeline at concentrations that could result in an adverse effect AND the pipeline structure is breached (from puncture or corrosion) to allow water in and transport of contaminants out of the pipeline into the surrounding environment[2] and/or preferential transport of contaminants within the pipeline.

Risk management measures required in accordance with CSA Z662*: 10.16 Abandonment of pipelines and pipe-type storage vessels A buried pipeline that is abandoned in place shall be:	***Met***	***Not met***
a) emptied of service fluids;		
b) purged or appropriately cleaned or both in a manner that leaves no mobile materials remaining in the pipeline.		
c) physically separated from any in-service piping;		
d) capped, plugged, or otherwise effectively sealed; and,		
e) cut off at pipeline depth.		
Site-specific data/information/ studies required to complete risk estimation:	***Completed***	***Not completed***
1. Identification of residual contaminants present within the pipeline prior to pigging/cleaning, including determination of whether PCBs or NORMs were ever present within the pipeline.		
2. Pipeline-specific purging/pigging/cleaning methodology, including targets and objectives, associated verification procedures, and results, prepared by a qualified professional.		

Step I - Complete frequency analysis:

F2a: Likelihood[3] that contaminants are present within the pipeline (at concentrations that could result in an adverse effect) and be transported out of the pipeline into the surrounding environment[2] and/or preferentially transported within the pipeline[4]:		***Insert rating***	***Locations (along ROW) associated with rating***
Scenarios along pipeline:			
F2a a: Pigging/cleaning targets were developed in consideration of the hydrocarbon product, lubricants, and treatment chemicals specific to the pipeline to be abandoned, required risk management measures (as per Section 10.16 of CSA Z662), current and intended land use, and applicable guidelines and standards (if any) AND have been met (based on results of verification procedures). No solids or waxy buildup is visible. Neither PCBs nor NORMs were ever present within the pipeline[5] .	Rate low		
F2a b: Pigging/cleaning targets were developed in consideration of the hydrocarbon product, lubricants, and treatment chemicals specific to the pipeline to be abandoned, legislated risk management measures (as per Section 10.16 of CSA Z662), current and intended land use, and applicable guidelines and standards (if any) AND have been met (based on results of verification procedures). No solids or waxy buildup is visible. PCBs and/or NORMs were once present within the pipeline[5].	Rate moderate		
F2a c: Pigging/cleaning of pipeline was completed but targets may not have been developed in consideration of the hydrocarbon product, lubricants, and treatment chemicals specific to the pipeline to be abandoned, legislated risk management measures (as per Section 10.16 of CSA Z662), current and intended land use, and applicable guidelines and standards (if any) AND/OR targets may not have been met. Neither PCBs nor NORMs were ever present within the pipeline[5].	Rate moderate		
F2a d: Pigging/cleaning of pipeline was completed but targets may not have been developed in consideration of the hydrocarbon product, lubricants, and treatment chemicals specific to the pipeline to be abandoned, legislated risk management measures (as per Section 10.16 of CSA Z662), current and intended land use, and applicable guidelines and standards (if any) AND/OR targets may not have been met. PCBs and/or NORMs were once present within the pipeline[5] .	Rate high		

Step II - Complete consequence analysis:

C2a: Consequence(s)[3] of contaminants present within the pipeline (at concentrations that could result in an adverse effect) transported out of the pipeline into the surrounding environment[2] and/or preferentially transported within the pipeline:			
C2a: Human health and safety:		***Insert rating*** [6, 7, 8]	***Locations (along ROW) associated with rating***
Land:	Rate high		
C2a a: Contamination[1] within a potable groundwater environment.			
C2a b: Contamination[1] of agricultural lands.			
C2a c: Contamination of residential, institutional, or park lands.			
C2a d: Contamination[1] of lands valued by Indigenous people (for hunting, gathering, other).			
Water crossings:			
C2a e: Contamination[1] of surface water used as a source of potable water (e.g., reservoirs, lakes, rivers).			
C2a f: Contamination[1] of surface water used for irrigation or livestock watering.			
C2a g: Contamination[1] of waterways that support commercial fisheries.			
C2a h: Contamination[1] of waterways valued by Indigenous people (for fishing, other).			
C2a i: Contamination[1] of waterways used for recreational activities.			
Land:	Rate moderate		
C2a j: Soil and/or groundwater contamination[1] in an environment other than those described above with a "high" consequence rating.			
Water crossings:			
C2a k: Surface water and/or sediment contamination[1] in and environment other than those described for waterways above with a "high" consequence rating.			
C2a: Ecology and environment:		***Insert rating*** [6, 7, 8]	***Locations (along ROW) associated with rating***
Land:	Rate high		
C2a l: Contamination[1] of areas that are habitat/breeding/foraging areas for species at risk.			
C2a m: Contamination[1] of areas reserved as parks, conservation areas, or other areas of ecological, environmental, or natural significance.			
Water crossings:			
C2a n: Contamination[1] of waterways that may constitute a violation of the Fisheries Act.			
C2a o: Contamination[1] of significant wetlands.			
C2a p: Contamination[1] of waterways that are habitat/spawning/breeding/feeding grounds for species at risk.			
Land:	Rate moderate		
C2a q: Soil and/or groundwater contamination[1] in an environment other than those described above with a "high" consequence rating.			
Water crossings:			
C2a r: Surface water or sediment contamination[1] in an environment other than those described for waterways above with a "high" consequence rating.			
C2a: Land use and valued/economic resources:		***Insert rating*** [6, 7, 8]	***Locations (along ROW) associated with rating***
Land:	Rate high		
C2a s: Contamination[1] within a potable groundwater environment.			
C2a t: Contamination[1] of agricultural lands.			
C2a u: Contamination[1] of lands valued by Indigenous people (for hunting, gathering, other).			
C2a v: Contamination[1] of areas reserved as parks, conservation areas, or other areas of ecological, environmental, or natural significance.			
C2a w: Contamination[1] of forested lands.			
Water crossings:			
C2a x: Contamination[1] of surface water used as a source of potable water (e.g., reservoirs, lakes, rivers).			
C2a y: Contamination[1] of surface water used for irrigation or livestock watering.			
C2a z: Contamination[1] of waterways that support commercial fisheries.			
C2a aa: Contamination[1] of waterways valued by Indigenous people (for fishing, other).			
C2a bb: Contamination[1] of waterways used for recreational activities.			
Land:	Rate moderate		
C2a cc: Soil and/or groundwater contamination[1] in an environment other than those described above with a "high" consequence rating.			
Water crossings:			
C2a dd: Surface water or sediment contamination[1] in and environment other than those described for waterways above with a "high" consequence rating.			

Step III - Complete risk estimation:	**On Land**			**At Water Crossings**		
E2: Estimation of risk[3] associated with contaminants present within the pipeline (at concentrations that could result in an adverse effect) transported out of the pipeline into the surrounding environment[2] and/or preferentially transported within the pipeline:						
E2: Human health and safety:	**Frequency No.**	**Consequence No.**	**Locations**	**Frequency No.**	**Consequence No.**	**Locations**
High likelihood and High severity						
High likelihood and Moderate severity OR Moderate likelihood and High severity						
High likelihood and Low severity	NA	NA	NA	NA	NA	NA
Low likelihood and high severity						
Low likelihood OR Low severity						
Low likelihood and Low severity	NA	NA	NA	NA	NA	NA
E2: Ecology and environment:						
High likelihood and High severity						
High likelihood and Moderate severity OR Moderate likelihood and High severity						
High likelihood and Low severity	NA	NA	NA	NA	NA	NA
Low likelihood and high severity						
Low likelihood OR Low severity						
Low likelihood and Low severity	NA	NA	NA	NA	NA	NA
E2: Land use and valued/economic resources:						
High likelihood and High severity						
High likelihood and Moderate severity OR Moderate likelihood and High severity						
High likelihood and Low severity	NA	NA	NA	NA	NA	NA
Low likelihood and high severity						
Low likelihood OR Low severity						
Low likelihood and Low severity	NA	NA	NA	NA	NA	NA

Notes:
ROW - pipeline right of way
PCB - polychlorinated biphenyl
NORM - naturally occurring radioactive materials
* Do not necessarily adequately address risks associated with the hazard.
(1) contamination - concentrations above applicable environmental criteria, or concentrations above property-specific criteria derived by a human and ecological risk assessment
(2) Soil, groundwater, surface water, and/or sediment.
(3) Refer to Tables 3, 4, and 5 of text for definitions of frequency, consequence, and risk estimation ratings.
(4) The frequency analysis does not consider the likelihood for the pipeline to be breached, as it is assumed that breach of the pipeline will eventually occur.
(5) Even with effective pigging, PCBs and NORMs have been identified as remaining in a limited number of gas transmission lines. These contaminants have a relatively high toxicity, and PCBs may bioaccumulate in the food chain.
(6) Rate based on if/where the environment/land use is present along pipeline ROW. Both current and future land use should be considered.
(7) If environment/land use is present insert applicable rating (i.e., high, moderate, or low). Otherwise, insert "not present along ROW".
(8) There is no environment/land use on which a "low" consequence rating is applicable. Contamination[1] of any media is considered to have at least a moderate consequence rating.

PH2b Risk Assessment Worksheet

Hazard No. 2: Environmental impacts from pipeline materials abandoned in-place, post operation

Hazard No. 2b: Leaching from construction materials and coatings

Release mechanism:

Contaminants leach from pipeline construction materials and/or external coatings at concentrations that could result in an adverse effect into the surrounding environment[2]. The pipeline structure may be breached (from puncture or corrosion) to allow water and transport of contaminants into the pipeline and preferential transport of contaminants within it.

Risk management measures required in accordance with CSA Z662 [4] *:	***Met***	***Not met***
10.16 Abandonment of pipelines and pipe-type storage vessels		
A buried pipeline that is abandoned in place shall be:		
d) capped, plugged, or otherwise effectively sealed; and,		
e) cut off at pipeline depth.		

Site-specific data/information/ studies required to complete risk estimation:	***Completed***	***Not completed***
1. Characterization of pipeline construction materials and external coatings.		
2. Characterization of contaminants and associated concentrations expected to leach from pipeline construction materials and/or external coatings over time, compared to applicable environmental criteria, completed by a qualified professional.		

Step I - Complete frequency analysis:

F2b: Likelihood[3] that contaminants will leach from pipeline construction materials and/or external coatings at concentrations that could result in an adverse effect:		***Insert rating***	***Locations (along ROW) associated with rating***
Scenarios along pipeline:			
F2b a: Pipeline construction materials and external coatings are inert and not expected to leach contaminants, neither in the short nor long term.	Rate low		
F2b b: Pipeline construction materials are expected to leach contaminants, either in the short or long term, at concentrations below applicable environmental criteria in consideration of land use.	Rate moderate		
F2b c: Pipeline construction materials are expected to leach contaminants, either in the short or long term, at concentrations above applicable environmental criteria in consideration of land use.	Rate high		

Step II - Complete consequence analysis:

C2b: Consequence(s)[3] of contaminants leaching from pipeline construction materials and/or external coatings at concentrations that could result in an adverse effect:

C2b: Human health and safety:		***Insert rating*** [5, 6, 7]	***Locations (along ROW) associated with rating***
Land:	Rate high		
C2b a: Contamination[1] within a potable groundwater environment.			
C2b b: Contamination[1] of agricultural lands.			
C2b c: Contamination of residential, institutional, or park lands.			
C2b d: Contamination[1] of lands valued by Indigenous people (for hunting, gathering, other).			
Water crossings:			
C2b e: Contamination[1] of surface water used as a source of potable water (e.g., reservoirs, lakes, rivers).			
C2b f: Contamination[1] of surface water used for irrigation or livestock watering.			
C2b g: Contamination[1] of waterways that support commercial fisheries.			
C2b h: Contamination[1] of waterways valued by Indigenous people (for fishing, other).			
C2b i: Contamination[1] of waterways used for recreational activities.			
Land:	Rate moderate		
C2b j: Soil and/or groundwater contamination[1] in an environment other than those described above with a "high" consequence rating.			
Water crossings:			
C2b k: Surface water and/or sediment contamination[1] in and environment other than those described for waterways above with a "high" consequence rating.			

C2b: Ecology and environment:		***Insert rating*** [5, 6, 7]	***Locations (along ROW) associated with rating***
Land:	Rate high		
C2b l: Contamination[1] of areas that are habitat/breeding/foraging areas for species at risk.			
C2b m: Contamination[1] of areas reserved as parks, conservation areas, or other areas of ecological, environmental, or natural significance.			
Water crossings:			
C2b n: Contamination[1] of waterways that may constitute a violation of the Fisheries Act.			
C2b o: Contamination[1] of significant wetlands.			
C2b p: Contamination[1] of waterways that are habitat/spawning/breeding/feeding grounds for species at risk.			
Land:	Rate moderate		
C2b q: Soil and/or groundwater contamination[1] in an environment other than those described above with a "high" consequence rating.			
Water crossings:			
C2b r: Surface water or sediment contamination[1] in an environment other than those described for waterways above with a "high" consequence rating.			

C2b: Land use and valued/economic resources:		***Insert rating*** [5, 6, 7]	***Locations (along ROW) associated with rating***
Land:	Rate high		
C2b s: Contamination[1] within a potable groundwater environment.			
C2b t: Contamination[1] of agricultural lands.			
C2b u: Contamination[1] of lands valued by Indigenous people (for hunting, gathering, other).			
C2b v: Contamination[1] of areas reserved as parks, conservation areas, or other areas of ecological, environmental, or natural significance.			
C2b w: Contamination[1] of forested lands.			
Water crossings:			
C2b x: Contamination[1] of surface water used as a source of potable water (e.g., reservoirs, lakes, rivers).			
C2b y: Contamination[1] of surface water used for irrigation or livestock watering.			
C2b z: Contamination[1] of waterways that support commercial fisheries.			
C2b aa: Contamination[1] of waterways valued by Indigenous people (for fishing, other).			
C2b bb: Contamination[1] of waterways used for recreational activities.			
Land:	Rate moderate		
C2b cc: Soil and/or groundwater contamination[1] in an environment other than those described above with a "high" consequence rating.			
Water crossings:			
C2b dd: Surface water or sediment contamination[1] in and environment other than those described for waterways above with a "high" consequence rating.			

Step III - Complete risk estimation:

E2b: Estimation of risk[3] associated with contaminants leaching from pipeline construction materials and/or external coatings at concentrations that could result in an adverse effect:	**On Land**			**At Water crossings**		
E2b: Human health and safety:	**Frequency No.**	**Consequence No.**	**Locations**	**Frequency No.**	**Consequence No.**	**Locations**
High likelihood and High severity						
High likelihood and Moderate severity OR Moderate likelihood and High severity						
High likelihood and Low severity	NA	NA	NA	NA	NA	NA
Low likelihood and high severity						
Low likelihood OR Low severity						
Low likelihood and Low severity	NA	NA	NA	NA	NA	NA
E2b: Ecology and environment:						
High likelihood and High severity						
High likelihood and Moderate severity OR Moderate likelihood and High severity						
High likelihood and Low severity	NA	NA	NA	NA	NA	NA
Low likelihood and high severity						
Low likelihood OR Low severity						
Low likelihood and Low severity	NA	NA	NA	NA	NA	NA
E2b: Land use and valued/economic resources:						
High likelihood and High severity						
High likelihood and Moderate severity OR Moderate likelihood and High severity						
High likelihood and Low severity	NA	NA	NA	NA	NA	NA
Low likelihood and high severity						
Low likelihood OR Low severity						
Low likelihood and Low severity	NA	NA	NA	NA	NA	NA

Notes:
ROW - pipeline right of way
PCB - polychlorinated biphenyl
NORM - naturally occurring radioactive materials
* Do not necessarily adequately address risks associated with the hazard.
(1) contamination - concentrations above applicable environmental criteria, or concentrations above property-specific criteria derived by a human and ecological risk assessment
(2) Soil, groundwater, surface water, and/or sediment.
(3) Refer to Tables 3, 4, and 5 of text for definitions of frequency, consequence, and risk estimation ratings.
(4) These risk management measures may address preferential transport of contaminants within the pipeline, but do not address leaching of contaminants into the surrounding environment.
(5) Rate based on if/where the environment/land use is present along pipeline ROW. Both current and future land use should be considered.
(6) If environment/land use is present insert applicable rating (i.e., high, moderate, or low). Otherwise, insert "not present along ROW".
(7) There is no environment/land use on which a "low" consequence rating is applicable. Contamination[1] of any media is considered to have at least a moderate consequence rating.

PH2c Risk Assessment Worksheet *Hazard No. 2: Environmental impacts from pipeline materials abandoned in-place, post operation* *Hazard No. 2c: Presence and exposure and disruption of asbestos*			
Release mechanism:			
Asbestos is present in pipeline external coatings AND is exposed and disturbed (as a result of construction/maintenance/excavation activities, soil erosion, frost heave, or other geotechnical hazards) allowing for potential contact with human receptors [(1)] involved with pipeline excavation/repair activities [(2)].			
Risk management measures required in accordance with CSA Z662*:			
None			
Site-specific data/information/ studies required to complete risk estimation:		***Completed***	***Not completed***
1. Characterization of pipeline external coatings, and identification of those containing asbestos, by a qualified professional.			
Step I - Complete frequency analysis[(7)]:			
F2c: Likelihood[(3)] that asbestos is present in pipeline external coatings and will be exposed and disturbed allowing for potential contact with human receptors[(1)] involved with pipeline excavation/repair activities[(2)].		***Insert rating***	***Locations (along pipeline) associated with rating***
Scenarios along pipeline:			
F2c a: Asbestos is not present in pipeline external coatings.	Rate low		
F2c b: Asbestos is present in pipeline external coatings.	Rate high		
Step II - Complete consequence analysis[(7)]:			
C2c: Consequence(s) of asbestos in pipeline external coatings being exposed and disturbed allowing for potential contact with human receptors[(1)] involved with pipeline excavation/repair activities[(2)].			
C2c: Human health and safety:		***Insert rating*** [(5,6)]	***Locations (along pipeline) associated with rating***
C2c a: Incidents of asbestosis[(4)].	Rate high		
C2c: Ecology and environment:		***Insert rating***	***Locations (along pipeline) associated with rating***
Not applicable	NA	NA	NA
C2c: Land use and valued/economic resources:		***Insert rating***	***Locations (along pipeline) associated with rating***
Not applicable	NA	NA	NA
Step III - Complete risk estimation:			
E2c: Estimation of risk[(7)] associated with asbestos in pipeline external coatings being exposed and disturbed allowing for potential contact with human receptors(1) involved with pipeline excavation/repair activities(2):		**On Land**	
E2c: Human health and safety:	**Frequency No.**	**Consequence No.**	**Locations**
High likelihood and High severity			
High likelihood and Moderate severity OR Moderate likelihood and High severity	NA	NA	NA
High likelihood and Low severity	NA	NA	NA
Low likelihood and high severity	NA	NA	NA
Low likelihood OR Low severity			
Low likelihood and Low severity	NA	NA	NA
E2c: Ecology and environment:			
Not applicable	NA	NA	NA
E2c: Land use and valued/economic resources:			
Not applicable	NA	NA	NA

Notes:
ROW - right of way
* Do not necessarily adequately address risks associated with the hazard.
(1) Exposure of ecological receptors is considered to be minimal, as asbestos in pipeline external coatings is not expected to be mobile in the environment or available for uptake by ecological receptors. Ecological receptors are not expected to directly contact exposed pipeline in a manner that would result in significant exposure, and pipeline external coatings do not provide and are not intermixed with food items or exposure media for
(2) It is assumed that exposed sections of pipeline (containing asbestos) would be re-covered or removed and disposed of (in accordance with applicable guidelines and regulations) by adult maintenance workers in a timely manner so to prevent exposure to other human receptors (e.g., children, visitors, trespassers, farmers, or other workers).
(3) The frequency analysis does not consider the likelihood for asbestos to be exposed and disturbed at various locations along the pipeline, as it is assumed that excavation/maintenance activities that may result in exposure and disturbance could occur anywhere along it.
(4) A chronic (long-term) lung disease caused by breathing in asbestos fibers
(5) Rate based on if/where asbestos is present along pipeline. If asbestos is present insert applicable rating (i.e., high). Otherwise, insert "asbestos not present along pipeline".
(6) There are no consequences considered to have either a "low" or "moderate" rating.
(7) Refer to Tables 3, 4, and 5 of text for definitions of frequency, consequence, and risk estimation ratings.

PH3 Risk Assessment Worksheet

Hazard No. 3: Drainage of surface water or shallow groundwater through pipeline

***Release mechanism*:**

Surface water or shallow groundwater is proximal (and hydraulically connected) to pipeline AND the pipeline structure is breached (from puncture or corrosion) to allow water into (and out of) and flow through the pipeline, resulting in drainage of surface water or groundwater, preferential flow and discharge elsewhere.

Risk management measures required in accordance with CSA Z662*:

None

Site-specific data/information/ studies required to complete risk estimation:	*Completed*	*Not completed*
1) Identification of surface water bodies along pipeline ROW.		
2) Identification of locations where pipeline (and/or fill materials surrounding pipeline) may be in contact with groundwater.		
3) Where pipeline is within 100 metres of surface water body (including: lakes, rivers, creeks, marshes, wetlands, muskegs, sloughs, reservoirs), site specific drainage study to determine if pipeline (and/or fill materials surrounding pipeline) are hydraulically connected		

Step I - Complete frequency analysis:

F3: Likelihood[1] of drainage of surface water or shallow groundwater through the pipeline[2]:		***Insert rating***	***Locations (along ROW) associated with rating***
Scenarios along pipeline:			
F3a: Pipeline located more than 100 metres from nearest surface water body (including: lakes, rivers, creeks, marshes, wetlands, muskegs, sloughs, reservoirs), OR based on site-specific drainage study is not hydraulically connected to the nearest surface water body.	Rate low		
F3b: Pipeline located where it is not likely to be in contact with groundwater.	Rate low		
F3c: Pipeline located between 30 and 100 metres from nearest surface water body.	Rate moderate		
F3d: Pipeline located within 30 metres of a surface water body (including: lakes, rivers, creeks, marshes, wetlands, muskegs, sloughs, reservoirs).	Rate high		
F3e: Pipeline located within a flood plain or area prone to flooding.	Rate high		
F3f: Pipeline located where it may be in contact with groundwater.	Rate high		

Step II - Complete consequence analysis:

C3: Consequence(s)[1] of drainage of surface water or shallow groundwater through the pipeline:			
C3: Human health and safety:		***Insert rating*** [3, 4]	***Locations (along ROW) associated with rating***
Not applicable.		NA	NA
C3: Ecology and environment:		***Insert rating*** [3, 4]	***Locations (along ROW) associated with rating***
Land:	Rate high		
C3a: Flooding of habitat/breeding/foraging areas for species at risk (including individuals).			
C3b: Flooding of areas reserved as parks, conservation areas, or other areas of ecological, environmental, or natural significance.			
Water crossings:			
C3c: Drainage of surface water that may constitute a violation of the Fisheries Act.			
C3d: Drainage of significant wetlands.			
C3e: Drainage of surface water that is habitat/spawning/breeding/feeding grounds for species at risk.			
C3f: Discharge to surface water and/or siltation that may constitute a violation of the Fisheries Act.			
C3g: Discharge to, and siltation of, surface water that is habitat/spawning/breeding/feeding grounds for species at risk.			
Land:	Rate moderate		
C3h: Flooding of habitat/breeding/foraging areas for populations/communities of non-species at risk.			
Water crossings:			
C3i: Drainage of surface water other than that described for water crossings above with a "high" consequence rating.			
C3j: Discharge to, and siltation of, surface water other than that described for water crossings above with a "high" consequence rating.			
Land:	Rate low		
C3k: Flooding of an area that does not provide habitat/breeding/foraging areas for communities/populations of non-species at risk or for individual species at risk.			
Water crossings:			
Not applicable[5].		NA	NA
C3: Land use and valued/economic resources:		***Insert rating*** [3, 4]	***Locations (along ROW) associated with rating***
Land:	Rate high		
C3l: Drainage of groundwater used as a source of potable water.			
C3m: Drainage of groundwater used for irrigation or livestock watering.			
C3n: Flooding of agricultural lands.			
C3o: Flooding of lands valued by Indigenous people (for hunting, gathering, other).			
C3p: Flooding of areas reserved as parks, conservation areas, or other areas of ecological, environmental, or natural significance.			
C3q: Flooding of forested lands.			
C3r: Flooding of urban/municipal/residential/commercial/industrial areas.			
Water crossings:			
C3s: Drainage of surface water used as a source of potable water (e.g., reservoirs, lakes, rivers).			
C3t: Drainage of surface water used for irrigation.			
C3u: Drainage of surface water that supports commercial fisheries.			
C3v: Drainage of surface water valued by Indigenous people (for fishing, other).			
C3w: Drainage of surface water used for recreational activities.			
C3x: Discharge to, and siltation of, surface water that supports commercial fisheries.			
C3y: Discharge to, and siltation of, surface water valued by Indigenous people (for fishing, other).			
C3z: Discharge to, and siltation of, surface water used for recreational activities.			
Land:	Rate moderate		
C3aa: Flooding of lands located on low-lying land other than those described above with a "high" consequence rating.			
Water crossings:			
Not applicable		NA	NA
Land:	Rate low		
Not applicable[6]		NA	NA
Water crossings:			
C3bb: Drainage of surface water other than that described for water crossings above with a "high" consequence rating.			

Step III - Complete risk estimation:						
E3: Estimation of risk[1] associated with drainage of surface water or shallow groundwater through the pipeline:		**On Land**			**At Water crossings**	
E3: Human health and safety:	**Frequency No.**	**Consequence No.**	**Locations**	**Frequency No.**	**Consequence No.**	**Locations**
Not applicable	NA	NA	NA	NA	NA	NA
E3: Ecology and environment:						
High likelihood and High severity						
High likelihood and Moderate severity OR Moderate likelihood and High severity						
High likelihood and Low severity				NA	NA	NA
Low likelihood and high severity						
Low likelihood OR Low severity						
Low likelihood and Low severity				NA	NA	NA
E3: Land use and valued/economic resources:						
High likelihood and High severity						
High likelihood and Moderate severity OR Moderate likelihood and High severity						
High likelihood and Low severity	NA	NA	NA			
Low likelihood and high severity				NA	NA	NA
Low likelihood OR Low severity						
Low likelihood and Low severity	NA	NA	NA			

Notes:
ROW - pipeline right of way
* Do not necessarily adequately address risks associated with the hazard.
(1) Refer to Tables 3, 4, and 5 of text for definitions of frequency, consequence, and risk estimation ratings.
(2) The frequency analysis does not consider the likelihood for the pipeline to be breached, as it is assumed that breach of the pipeline will eventually occur.
(3) Rate based on if/where the environment/land use is present along pipeline ROW.
(4) If environment/land use is present insert applicable rating (i.e., high, moderate, or low). Otherwise, insert "not present along ROW".
(5) Drainage of any surface water body is considered to have at least a moderate consequence rating.
(6) Flooding of any lands is considered to have at least a moderate consequence rating.

PH4 Risk Assessment Worksheet

Hazard No. 4: Ground subsidence beyond tolerable range (for land use)

Release mechanism:

Pitting and structural deterioration of pipeline (and reduced load carrying capacity of the pipe) due to corrosion [(1)], resulting in the creation of voids in the subsurface and eventual collapse of ground into voids. The tolerable range of subsidence is dependent on land use. For most land uses [(2)], pipeline diameter is the main factor in determining whether subsidence will be within the tolerable range.

Risk management measures required in accordance with CSA Z662*:

None

Site-specific data/information/ studies required to complete risk estimation:	***Completed***	***Not completed***
1. Pipeline diameter.		
2. Identification of rail, road, and underground utility crossings, or agricultural or other lands on which heavy vehicular loadings are expected[(2)] along the ROW.		
3. For pipelines with a diameter greater than 323.9 millimeters[(7)] (other than at crossings and where heavy vehicular loadings are expected as described in 2 above[(2)]), site-specific analysis to evaluate the degree of subsidence expected, and whether it is within the tolerable range		

Step I - Complete frequency analysis:			
F4: Likelihood[(6)] of ground subsidence beyond the tolerable range (for land use):		***Insert rating***	***Locations (along ROW) associated with rating***
Scenarios along pipeline:			
F4a: Pipeline has a diameter of 323.9 millimetres or less, at locations other than: road, rail, or underground utility crossings, or agricultural or other lands on which heavy vehicular loadings are expected[(2)].	Rate low		
F4b: Pipeline has a diameter of greater than 323.9 millimetres, and results of a site-specific analysis indicate that the expected degree of subsidence is within the tolerable range in consideration of land use. [At locations other than road, rail, and underground utility crossings, or agricultural or other lands on which heavy vehicular loadings are expected.[(2)]]	Rate low		
F4c: Pipeline has a diameter of greater than 323.9 millimetres, and results of a site-specific analysis indicate that the expected degree of subsidence above the tolerable range in consideration of land use. [At locations other than road, rail, and underground utility crossings, or agricultural or other lands on which heavy vehicular loadings are expected.(2)]	Rate moderate		
F4d: Pipeline of any diameter, located at: road crossings, rail crossings, underground utility crossings, or agricultural or other lands on which heavy vehicular loadings are expected[(2)].	Rate high		

Step II - Complete consequence analysis:			
C4: Consequence[(6)] of ground subsidence beyond the tolerable range (for land use):			
C4: Human health and safety:		***Insert rating*** [4, 5]	***Locations (along ROW) associated with rating***
On land:	Rate high		
C4a: Train derailments at rail crossings, vehicle accidents at road crossings, or accidents resulting from damage to underground service utilities at utility crossings.			
C4b: Heavy vehicle accidents on agricultural lands or other lands on which heavy vehicular loadings are expected.			
At water crossings:			
Not applicable.			
C4: Ecology and environment:		***Insert rating*** [4, 5]	***Locations (along ROW) associated with rating***
On land:	Rate high		
C4c: Derailments at rail crossings, vehicle accidents at road crossings, or accidents resulting from damage to underground service utilities at utility crossings located in areas that are habitat/breeding/foraging areas for species at risk.			
C4d: Derailments at rail crossings, vehicle accidents at road crossings, or accidents resulting from damage to underground service utilities at utility crossings located in areas reserved as parks, conservation areas, or other areas of ecological, environmental, or natural significance.			
At water crossings:			
C4e: Discharge to surface water and/or siltation that may constitute a violation of the Fisheries Act.			
C4f: Discharge to, and siltation of, surface water that is habitat/spawning/breeding/feeding grounds for species at risk.			
On land:	Rate moderate		
C4g: Derailments at rail crossings, vehicle accidents at road crossings, or accidents resulting from damage to underground service utilities at utility crossings located in areas that are habitat/breeding/foraging areas for populations/communities of non-species at risk.			
At water crossings:			
C4h: Discharge to, and siltation of, surface water other than that described for water crossings above with a "high" consequence rating.			
On land:	Rate low		
C4i: Derailments at rail crossings, vehicle accidents at road crossings, or accidents resulting from damage to underground service utilities at utility crossings located in areas that do not provide habitat/breeding/foraging areas for communities/populations of non-species at risk or for individual species at risk.			
At water crossings:			
Not applicable.			
C4: Land use and valued/economic resources:		***Insert rating*** [4, 5]	***Locations (along ROW) associated with rating***
On land:	Rate high		
C4j: Train derailments at rail crossings, vehicle accidents at road crossings, or accidents resulting from damage to underground service utilities at utility crossings.			
C4k: Heavy vehicle accidents on agricultural lands or other lands on which heavy vehicular loadings are expected.			
C4l: Erosion/loss of topsoil on agricultural lands.			
At water crossings:			
C4m: Discharge to, and siltation of, surface water that supports commercial fisheries.			
C4n: Discharge to, and siltation of, surface water valued by Indigenous people (for fishing, other).			
C4o: Discharge to, and siltation of, surface water used for recreational activities.			

Step III - Complete risk estimation:	**On Land**			**At Water crossings**		
E4: Estimation of risk[(6)] associated with ground subsidence outside of the tolerable range (for land use):						
E4: Human health and safety:	**Frequency No.**	**Consequence No.**	**Locations**	**Frequency No.**	**Consequence No.**	**Locations**
High likelihood and High severity				NA	NA	NA
High likelihood and Moderate severity OR Moderate likelihood and High severity				NA	NA	NA
High likelihood and Low severity	NA	NA	NA	NA	NA	NA
Low likelihood and high severity	NA	NA	NA	NA	NA	NA
Low likelihood OR Low severity				NA	NA	NA
Low likelihood and Low severity	NA	NA	NA	NA	NA	NA
E4: Ecology and environment:						
High likelihood and High severity						
High likelihood and Moderate severity OR Moderate likelihood and High severity						
High likelihood and Low severity						
Low likelihood and high severity						
Low likelihood OR Low severity						
Low likelihood and Low severity				NA	NA	NA
E4: Land use and valued/economic resources:						
High likelihood and High severity						
High likelihood and Moderate severity OR Moderate likelihood and High severity						
High likelihood and Low severity	NA	NA	NA	NA	NA	NA
Low likelihood and high severity	NA	NA	NA	NA	NA	NA
Low likelihood OR Low severity						
Low likelihood and Low severity	NA	NA	NA	NA	NA	NA

Notes:
ROW - right of way
* Do not necessarily adequately address risks associated with the hazard.
(1) Pipeline degradation processes other than corrosion for pipelines constructed of materials other than metal not considered.
(2) Tolerable range is zero at: road crossings, rail crossings, underground utility crossings, and agricultural or other lands on which heavy vehicular loadings are expected.
(3) Enhanced corrosion of pipelines abandoned without cathodic protection may occur at powerline crossings.
(4) Rate based on if/where the environment/land use is present along pipeline ROW.
(5) If environment/land use is present insert applicable rating (i.e., high, moderate, or low). Otherwise, insert "not present along ROW".
(6) Refer to Tables 3, 4, and 5 of text for definitions of frequency, consequence, and risk estimation ratings.
(7) Ground subsidence associated with the collapse of pipelines up to 323.9 mm in diameter at typical burial depths is expected to be negligible (CEPA, 2006 - 2007).

PH 5 Risk Assessment Worksheet

Hazard No. 5: Exposure of abandoned pipeline on land due to soil erosion and geohazards

Release mechanism:

Pipeline is exposed at surface due to soil erosion or geohazards that force it above ground (i.e., frost heave, seismic activity).

Risk management measures required in accordance with CSA Z662*:

None

Site-specific data/information/ studies required to complete risk estimation:	***Completed***	***Not completed***
1. Identification of the following areas along the pipeline ROW: areas susceptible to soil erosion (e.g., agricultural fields or other non-vegetated areas, shallow soil cover, steep slopes, topographic highs exposed to wind), seismically-active areas, and areas where there is permafrost		

Step I - Complete frequency analysis:			
F5: Likelihood[4] of exposure of abandoned pipeline on land due to geotechnical/geohazards:		***Insert rating***	***Locations (along ROW) associated with rating***
Scenarios along pipeline:			
F5a: Pipeline exposure did not occur/was not a hazard that required monitoring, maintenance, or risk management during operation of the pipeline AND pipeline is not located in an area susceptible to soil erosion (e.g., agricultural fields or other non-vegetated areas, shallow soil cover, steep slopes, topographic highs exposed to wind) or a seismically-active area, AND pipeline is located below frost line.	Rate low		
F5b: Pipeline exposure did not occur/was not a hazard that required monitoring, maintenance, or risk management during operation of the pipeline, however the pipeline is located in an area susceptible to soil erosion (e.g., agricultural fields or other non-vegetated areas, shallow soil cover, steep slopes, topographic highs exposed to wind).	Rate moderate		
F5c: Pipeline exposure did not occur/was not a hazard that required monitoring, maintenance, or risk management during operation of the pipeline, however the pipeline is located in a seismically active area.	Rate moderate		
F5d: Pipeline exposure did not occur/was not a hazard that required monitoring, maintenance, or risk management during operation of the pipeline, however the pipeline is located above the frost line or where there is permafrost.	Rate high		
F5e: Pipeline exposure did occur/was a hazard that required monitoring, maintenance, and/or risk management during operation of the pipeline.	Rate high		

Step II - Complete consequence analysis:			
C5: Consequence[4] of exposure of abandoned pipeline on land due to geotechnical/geohazards[3]:			
C5: Human health and safety:		***Insert rating*** [1, 2]	***Locations (along ROW) associated with rating***
Not applicable.	NA	NA	NA
C5: Ecology and environment:		***Insert rating*** [1, 2]	***Locations (along ROW) associated with rating***
Not applicable.	NA	NA	NA
C5: Land use and valued/economic resources:		***Insert rating*** [1, 2]	***Locations (along ROW) associated with rating***
On land:	Rate moderate		
C5a: Temporary loss of productivity on agricultural lands.			
C5b: Damage to agricultural or other heavy equipment.			
At water crossings:			
Not applicable.		NA	NA
On land:	Rate low		
C5c: Aesthetic impacts at any location along the ROW.			
At water crossings:			
Not applicable.		NA	NA

Step III - Complete risk estimation:	**On Land**			**At Water Crossings**		
E5: Estimation of risk[4] associated with exposure of abandoned pipeline on land due to geotechnical/geohazards:						
E5: Human health and safety:	**Frequency No.**	**Consequence No.**	**Locations**	**Frequency No.**	**Consequence No.**	**Locations**
High likelihood and High severity	NA	NA	NA	NA	NA	NA
High likelihood and Moderate severity OR Moderate likelihood and High severity	NA	NA	NA	NA	NA	NA
High likelihood and Low severity	NA	NA	NA	NA	NA	NA
Low likelihood and high severity	NA	NA	NA	NA	NA	NA
Low likelihood OR Low severity	NA	NA	NA	NA	NA	NA
Low likelihood and Low severity	NA	NA	NA	NA	NA	NA
E5: Ecology and environment:						
High likelihood and High severity	NA	NA	NA	NA	NA	NA
High likelihood and Moderate severity OR Moderate likelihood and High severity	NA	NA	NA	NA	NA	NA
High likelihood and Low severity	NA	NA	NA	NA	NA	NA
Low likelihood and high severity	NA	NA	NA	NA	NA	NA
Low likelihood OR Low severity	NA	NA	NA	NA	NA	NA
Low likelihood and Low severity	NA	NA	NA	NA	NA	NA
E5: Land use and valued/economic resources:						
High likelihood and High severity	NA	NA	NA	NA	NA	NA
High likelihood and Moderate severity OR Moderate likelihood and High severity				NA	NA	NA
High likelihood and Low severity				NA	NA	NA
Low likelihood and high severity	NA	NA	NA	NA	NA	NA
Low likelihood OR Low severity				NA	NA	NA
Low likelihood and Low severity				NA	NA	NA

Notes:
ROW - right of way
* Do not necessarily adequately address risks associated with the hazard.
(1) Rate based on if/where the environment/land use is present along pipeline ROW.
(2) If environment/land use is present insert applicable rating (i.e., high, moderate, or low). Otherwise, insert "not present along ROW".
(3) The consequence analysis does not consider release of contaminants due to pipeline exposure (and increased risk of puncture) as this hazard has been addressed as Potential Hazard 2a and 2b.
(4) Refer to Tables 3, 4, and 5 of text for definitions of frequency, consequence, and risk estimation ratings.

PH6 Risk Assessment Worksheet

Hazard No. 6: Exposure of abandoned pipeline at water crossings due to hydrotechnical hazards

Release mechanism:

Pipeline is exposed at surface due to: 1) buoyancy of the empty pipeline; 2) sediment erosion and lowering of the channel bed resulting in reduced depth of sediment cover; or, 3) stream bank erosion (where pipelines are parallel to streams or rivers). The relative buoyancy of a pipeline is increased once it is emptied (for abandonment). However, the

Risk management measures required in accordance with CSA Z662*:

None

Site-specific data/information/ studies required to complete risk estimation:	***Completed***	***Not completed***
1. Identification of water crossings, and for each, assessment of the potential/rate at which the pipeline will become exposed in the channel bed due to buoyancy and sediment erosion. This should consider the rates of sediment		
2. Identification of locations where the pipeline is parallel and proximal to a stream or river, and assessment of the potential/timeline for the pipeline to become exposed along the stream bank due to stream bank erosion.		

Step I - Complete frequency analysis:			
F6: Likelihood[4] of exposure of abandoned pipeline at water crossings due to hydrotechnical hazards:		***Insert rating***	***Locations (along ROW) associated with rating***
Scenarios along pipeline:			
F6a: Pipeline is not expected to become exposed, either within the channel bed due to buoyancy and sediment erosion, or along the stream bank to stream bank erosion.	Rate low		
F6b: Pipeline is expected to become exposed, however significant/exceptional buoyancy of the pipeline, sediment erosion, or risk of stream bank erosion that could result in frequent exposure was not identified.	Rate moderate		
F6c: Significant/exceptional buoyancy of the pipeline, sediment erosion, and/or risk of stream bank erosion that could result in frequent exposure was identified.	Rate high		

Step II - Complete consequence analysis:			
C5: Consequence[4] of exposure of abandoned pipeline at water crossings due to hydrotechnical hazards[3]:			
C5: Human health and safety:		***Insert rating*** [1, 2]	***Locations (along ROW) associated with rating***
Not applicable.	NA	NA	NA
C5: Ecology and environment:		***Insert rating*** [1, 2]	***Locations (along ROW) associated with rating***
On land:	NA		
Not applicable.		NA	NA
At water crossings:	Rate high		
C6a: Exposure and contamination in surface water that is habitat/spawning/breeding/feeding grounds for species at risk			
C6b: Exposure and contamination in surface water other than that which is habitat/spawning/breeding/feeding grounds for species at risk.	Rate moderate		
C5: Land use and valued/economic resources:		***Insert rating*** [1, 2]	***Locations (along ROW) associated with rating***
On land:	NA		
Not applicable.		NA	NA
At water crossings:	Rate low		
C6c: Aesthetic impacts at any water crossing.			

Step III - Complete risk estimation:						
E5: Estimation of risk[4] associated with exposure of abandoned pipeline at water crossings due to hydrotechnical hazards:		**On Land**			**At Water Crossings**		
E5: Human health and safety:	**Frequency No.**	**Consequence No.**	**Locations**	**Frequency No.**	**Consequence No.**	**Locations**
High likelihood and High severity	NA	NA	NA	NA	NA	NA
High likelihood and Moderate severity OR Moderate likelihood and High severity	NA	NA	NA	NA	NA	NA
High likelihood and Low severity	NA	NA	NA	NA	NA	NA
Low likelihood and high severity	NA	NA	NA	NA	NA	NA
Low likelihood OR Low severity	NA	NA	NA	NA	NA	NA
Low likelihood and Low severity	NA	NA	NA	NA	NA	NA
E5: Ecology and environment:						
High likelihood and High severity	NA	NA	NA			
High likelihood and Moderate severity OR Moderate likelihood and High severity	NA	NA	NA			
High likelihood and Low severity	NA	NA	NA	NA	NA	NA
Low likelihood and high severity	NA	NA	NA			
Low likelihood OR Low severity	NA	NA	NA	NA	NA	NA
Low likelihood and Low severity	NA	NA	NA	NA	NA	NA
E5: Land use and valued/economic resources:						
High likelihood and High severity	NA	NA	NA	NA	NA	NA
High likelihood and Moderate severity OR Moderate likelihood and High severity	NA	NA	NA	NA	NA	NA
High likelihood and Low severity	NA	NA	NA			
Low likelihood and high severity	NA	NA	NA	NA	NA	NA
Low likelihood OR Low severity	NA	NA	NA			
Low likelihood and Low severity	NA	NA	NA			

Notes:
ROW - right of way
* Do not necessarily adequately address risks associated with the hazard.
(1) Rate based on if/where the environment/land use is present along pipeline ROW.
(2) If environment/land use is present insert applicable rating (i.e., high, moderate, or low). Otherwise, insert "not present along ROW".
(3) The consequence analysis does not consider release of contaminants due to pipeline exposure (and increased risk of puncture) as this hazard has been addressed as Potential Hazard 2a and 2b.
(4) Refer to Tables 3, 4, and 5 of text for definitions of frequency, consequence, and risk estimation ratings.

APPENDIX C

Risk Register Worksheets

PH1 Risk register

Hazard No. 1: soil or groundwater chemical impacts to the environment from former operation of pipeline (i.e., contaminated sites)

Risk significance (enter significant or less significant)*	Consequence No.	Locations (along ROW) associated with rating	Potential risk management measures

Notes:
* Insignificant risks are not to be included in the risk register.

PH2a Risk register

Hazard No. 2a: residual product, lubricants, and treatment chemicals

Risk significance (enter significant or less significant)*	Consequence No.	Locations (along ROW) associated with rating	Potential risk management measures

Notes:
* Insignificant risks are not to be included in the risk register.

PH2b Risk register

Hazard No. 2b: leaching from construction materials and coatings

Risk significance (enter significant or less significant)*	Consequence No.	Locations (along ROW) associated with rating	Potential risk management measures

Notes:
* Insignificant risks are not to be included in the risk register.

PH2c Risk register

Hazard No. 2c: spresence and exposure and disruption of asbestos

Risk significance (enter significant or less significant)*	Consequence No.	Locations (along ROW) associated with rating	Potential risk management measures

Notes:
* Insignificant risks are not to be included in the risk register.

PH3 Risk register

Hazard No. 3: Drainage of surface water or shallow groundwater through pipeline

Risk significance (enter significant or less significant)*	Consequence No.	Locations (along ROW) associated with rating	Potential risk management measures

Notes:
* Insignificant risks are not to be included in the risk register.

PH4 Risk register

Hazard No. 4: Ground subsidence beyond tolerable range

Risk significance (enter significant or less significant)*	Consequence No.	Locations (along ROW) associated with rating	Potential risk management measures

Notes:
* Insignificant risks are not to be included in the risk register.

PH5 Risk register

Hazard No. 5: Exposure of abandoned pipeline due to soil erosion and geohazards

Risk significance (enter significant or less significant)*	Consequence No.	Locations (along ROW) associated with rating	Potential risk management measures

Notes:
* Insignificant risks are not to be included in the risk register.

PH6 Risk register

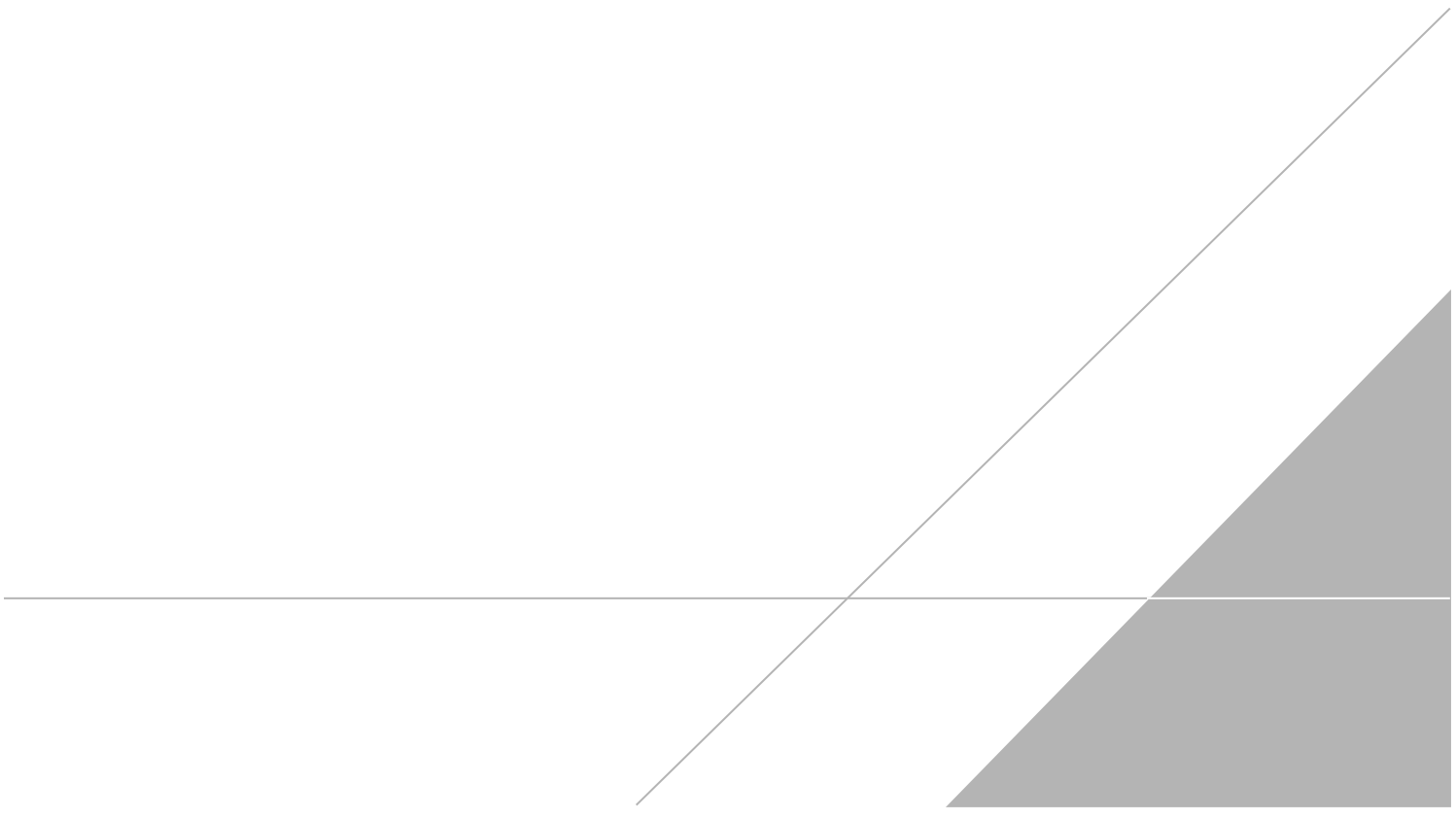
Hazard No. 6: Exposure of abandoned pipeline at water crossings due to hydrotechnical hazards

Risk significance (enter significant or less significant)*	Consequence No.	Locations (along ROW) associated with rating	Potential risk management measures

Notes:
* Insignificant risks are not to be included in the risk register.

APPENDIX D

Case Study 1 Risk Assessment Worksheets



PH1 Risk Assessment Worksheet

Hazard No. 1: Soil or groundwater chemical impacts to the environment from former operation of pipeline (i.e., contaminated sites):

Release mechanism:

Historical release of contaminants into the environment during former operation of the pipeline, resulting in concentrations in environmental media (i.e., soil, groundwater, surface water, and/or sediment) above applicable environmental criteria. Common sources of historical contamination include pipeline breaches/spills, and operational areas such as compressor stations, metre

Risk management measures required in accordance with CSA Z662*: 10.17 Abandonment of pipeline related facilities Pipeline related facilities such as compressors and pump stations shall have all rotating and fixed equipment removed, unless they are still part of an operating or deactivated site. Associated piping, utilities, supports, and foundations shall also be removed.	***Met***	***Not met***
Testing for site soil contamination and appropriate remediation might be required.		
Consideration should be given to the removal of underground vaults and closed-top pits. For those that are to remain:		
a) walls and floors shall be tested for contamination. Contaminated areas shall be remediated or removed.	Testing completed	
b) walls shall be removed to an appropriate level below the ground surface		
c) the insides of the vault shall be filled with clean soil.		
Soils in around and underneath storage tanks shall be inspected for contamination and appropriately remediated.		

Site-specific data/information/ studies required to complete risk estimation:	***Completed***	***Not completed***
1) Phase I Environmental Site Assessment (ESA) (representative of current conditions) to identify potential sources of contamination along the pipeline ROW, prepared by a qualified professional.	***X***	
2) Phase II/III ESA (representative of current conditions) to assess/characterize soil and groundwater contamination associated with potential sources of contamination identified by the Phase I ESA, prepared by a qualified professional	***X***	
IF CONTAMINANT CONCENTRATIONS ARE ABOVE APPLICABLE ENVIRONMENTAL CRITERIA:		
3) Human health and ecological risk assessment (representative of current conditions) completed in accordance with Health Canada and Environment Canada Risk Assessment Frameworks, prepared by a qualified professional AND/OR		
4) Remediation reports that provide current concentrations of contaminants in soil and/groundwater on Site, prepared by a qualified professional	***X***	

Step I - Complete frequency analysis:

F1: Likelihood[2] that concentrations of contaminants in environmental media (i.e., soil, groundwater, surface water, and/or sediment) are above applicable environmental criteria. **Scenarios along pipeline:**		***Insert rating***	***Locations (along ROW) associated with rating***
F1a: Phase I/II/III ESAs have been completed along the pipeline ROW to identify potential sources of contamination, and assess potential impacts. Concentrations of contaminants of concern are below applicable environmental criteria.	Rate low		
F1b: Phase I/II/III ESAs have been completed along the pipeline ROW to identify potential sources of contamination, and assess potential impacts. Concentrations of contaminants of concern above applicable environmental criteria have been remediated. Associated reports are kept on file.	Rate low		
F1c: Phase I/II/III ESAs have been completed along the pipeline ROW to identify potential sources of contamination, and assess potential impacts. Concentrations of contaminants of concern are above applicable environmental criteria, however based on completion of a human health and ecological risk assessment, risks to receptors are within the acceptable range. Associated reports are kept on file.	Rate low		
F1d: Phase I/II/III ESAs have been completed along the pipeline ROW to identify potential sources of contamination, and assess potential impacts. Concentrations of contaminants of concern are above applicable environmental criteria.	Rate high	F1d High	

Step II - Complete consequence analysis:

C1: Consequence(s)[2] of concentrations of contaminants in environmental media (soil, groundwater, surface water, sediment) above applicable environmental criteria: **C1: Human health and safety:**		***Insert rating*** [3, 4, 5]	***Locations (along ROW) associated with rating***
Land:	Rate high		
C1a: Contamination[1] within a potable groundwater environment.		High C1a	
C1b: Contamination[1] of agricultural lands.		High C1b	
C1c: Contamination of residential, institutional, or park lands.			
C1d: Contamination[1] of lands valued by Indigenous people (for hunting, gathering, other).			
Water crossings:			
C1e: Contamination[1] of surface water used as a source of potable water (e.g., reservoirs, lakes, rivers).			
C1f: Contamination[1] of surface water used for irrigation or livestock watering.			
C1g: Contamination[1] of waterways that support commercial fisheries.			
C1h: Contamination[1] of waterways valued by Indigenous people (for fishing, other).			
C1i: Contamination[1] of waterways used for recreational activities.			
Land:	Rate moderate		
C1j: Soil and/or groundwater contamination[1] in an environment other than those described above with a "high" consequence rating.			
Water crossings:			
C1k: Surface water and/or sediment contamination[1] in and environment other than those described for waterways above with a "high" consequence rating.			
C1: Ecology and environment:		***Insert rating*** [3, 4, 5]	***Locations (along ROW) associated with rating***
Land:	Rate high		
C1l: Contamination[1] of areas that are habitat/breeding/foraging areas for species at risk.			
C1m: Contamination[1] of areas reserved as parks, conservation areas, or other areas of ecological, environmental, or natural significance.			
Water crossings:			
C1n: Contamination[1] of waterways that may constitute a violation of the Fisheries Act.			
C1o: Contamination[1] of significant wetlands.			
C1p: Contamination[1] of waterways that are habitat/spawning/breeding/feeding grounds for species at risk.			
Land:	Rate moderate		
C1q: Soil and/or groundwater contamination[1] in an environment other than those described above with a "high" consequence rating.			
Water crossings:			
C1r: Surface water or sediment contamination[1] in an environment other than those described for waterways above with a "high" consequence rating.			
C1: Land use and valued/economic resources:		***Insert rating*** [3, 4, 5]	***Locations (along ROW) associated with rating***
Land:	Rate high		
C1s: Contamination[1] within a potable groundwater environment.		C1s High	
C1t: Contamination[1] of agricultural lands.		C1t High	
C1u: Contamination[1] of lands valued by Indigenous people (for hunting, gathering, other).			
C1v: Contamination[1] of areas reserved as parks, conservation areas, or other areas of ecological, environmental, or natural significance.			
C1w: Contamination[1] of forested lands.			
Water crossings:			
C1x: Contamination[1] of surface water used as a source of potable water (e.g., reservoirs, lakes, rivers).			
C1y: Contamination[1] of surface water used for irrigation or livestock watering.			
C1z: Contamination[1] of waterways that support commercial fisheries.			
C1aa: Contamination[1] of waterways valued by Indigenous people (for fishing, other).			
C1bb: Contamination[1] of waterways used for recreational activities.			
Land:	Rate moderate		
C1cc: Soil and/or groundwater contamination[1] in an environment other than those described above with a "high" consequence rating.			
Water crossings:			
C1dd: Surface water or sediment contamination[1] in and environment other than those described for waterways above with a "high" consequence rating.			

Step III - Complete risk estimation:

E1: Estimation of risk[2] associated with concentrations of contaminants in environmental media (soil, groundwater, surface water, sediment) above applicable environmental criteria:		**On Land**		**At Water crossings**		
E1: Human health and safety:	**Frequency No.**	**Consequence No.**	**Locations**	**Frequency No.**	**Consequence No.**	**Locations**
High likelihood and High severity		High F1d	High C1a, C1b			
High likelihood and Moderate severity OR Moderate likelihood and High severity						
High likelihood and Low severity	NA	NA	NA	NA	NA	NA
Low likelihood and high severity						
Low likelihood OR Low severity						
Low likelihood AND Low severity	NA	NA	NA	NA	NA	NA
E1: Ecology and environment:						
High likelihood and High severity						
High likelihood and Moderate severity OR Moderate likelihood and High severity						
High likelihood and Low severity	NA	NA	NA	NA	NA	NA
Low likelihood and high severity						
Low likelihood OR Low severity						
Low likelihood AND Low severity	NA	NA	NA	NA	NA	NA
E1: Land use and valued/economic resources:						
High likelihood and High severity		High F1d	High C1s, Clt			
High likelihood and Moderate severity OR Moderate likelihood and High severity						
High likelihood and Low severity	NA	NA	NA	NA	NA	NA
Low likelihood and high severity						
Low likelihood OR Low severity						
Low likelihood AND Low severity	NA	NA	NA	NA	NA	NA

Notes:

ROW - pipeline right of way

NORM - naturally occurring radioactive materials

* Do not necessarily adequately address risks associated with the hazard.

(1) contamination - concentrations above applicable environmental criteria, or concentrations above property-specific criteria derived by a human and ecological risk assessment

(2) Refer to Tables 3, 4, and 5 of text for definitions of frequency, consequence, and risk estimation ratings.

(3) Rate based on if/where the environment/land use is present along pipeline ROW. Both current and future land use should be considered.

(4) If environment/land use is present insert applicable rating (i.e., high, moderate, or low). Otherwise, insert "not present along ROW or not applicable".

(5) There is no environment/land use on which a "low" consequence rating is applicable. Contamination[1] of any media is considered to have at least a moderate consequence rating.

PH2a Risk Assessment Worksheet

Hazard No. 2: Environmental impacts from pipeline materials abandoned in-place, post operation

Hazard No. 2a: Residual product, lubricants, and treatment chemicals

Release mechanism:

Contaminants are present within the pipeline at concentrations that could result in an adverse effect AND the pipeline structure is breached (from puncture or corrosion) to allow water in and transport of contaminants out of the pipeline into the surrounding environment[2] and/or preferential transport of contaminants within the pipeline.

Risk management measures required in accordance with CSA Z662*:	***Met***	***Not met***
10.16 Abandonment of pipelines and pipe-type storage vessels		
A buried pipeline that is abandoned in place shall be:		
a) emptied of service fluids;	X	
b) purged or appropriately cleaned or both in a manner that leaves no mobile materials remaining in the pipeline.	X	
c) physically separated from any in-service piping;	X	
d) capped, plugged, or otherwise effectively sealed; and,	X	
e) cut off at pipeline depth.	X	
Site-specific data/information/ studies required to complete risk estimation:	***Completed***	***Not completed***
1. Identification of residual contaminants present within the pipeline prior to pigging/cleaning, including determination of whether PCBs or NORMs were ever present within the pipeline.	***X Residual PHCs identified***	
2. Pipeline-specific purging/pigging/cleaning methodology, including targets and objectives, associated verification procedures, and results, prepared by a qualified professional.	***X Residual impacts removed following standard procedures***	

Step I - Complete frequency analysis:

F2a: Likelihood[3] that contaminants are present within the pipeline (at concentrations that could result in an adverse effect) and be transported out of the pipeline into the surrounding environment[2] and/or preferentially transported within the pipeline[4]:		***Insert rating***	***Locations (along ROW) associated with rating***
Scenarios along pipeline:			
F2a a: Pigging/cleaning targets were developed in consideration of the hydrocarbon product, lubricants, and treatment chemicals specific to the pipeline to be abandoned, required risk management measures (as per Section 10.16 of CSA Z662), current and intended land use, and applicable guidelines and standards (if any) AND have been met (based on results of verification procedures). No solids or waxy buildup is visible. Neither PCBs nor NORMs were ever present within the pipeline[5].	Rate low		
F2a b: Pigging/cleaning targets were developed in consideration of the hydrocarbon product, lubricants, and treatment chemicals specific to the pipeline to be abandoned, legislated risk management measures (as per Section 10.16 of CSA Z662), current and intended land use, and applicable guidelines and standards (if any) AND have been met (based on results of verification procedures). No solids or waxy buildup is visible. PCBs and/or NORMs were once present within the pipeline[5].	Rate moderate	F2a b Moderate	
F2a c: Pigging/cleaning of pipeline was completed but targets may not have been developed in consideration of the hydrocarbon product, lubricants, and treatment chemicals specific to the pipeline to be abandoned, legislated risk management measures (as per Section 10.16 of CSA Z662), current and intended land use, and applicable guidelines and standards (if any) AND/OR targets may not have been met. Neither PCBs nor NORMs were ever present within the pipeline[5].	Rate moderate		
F2a d: Pigging/cleaning of pipeline was completed but targets may not have been developed in consideration of the hydrocarbon product, lubricants, and treatment chemicals specific to the pipeline to be abandoned, legislated risk management measures (as per Section 10.16 of CSA Z662), current and intended land use, and applicable guidelines and standards (if any) AND/OR targets may not have been met. PCBs and/or NORMs were once present within the pipeline[5].	Rate high		

Step II - Complete consequence analysis:

C2a: Consequence(s)[3] of contaminants present within the pipeline (at concentrations that could result in an adverse effect) transported out of the pipeline into the surrounding environment[2] and/or preferentially transported within the pipeline:			
C2a: Human health and safety:		***Insert rating*** [6, 7, 8]	***Locations (along ROW) associated with rating***
Land:	Rate high		
C2a a: Contamination[1] within a potable groundwater environment.		High C2a a	
C2a b: Contamination[1] of agricultural lands.		High C2a b	
C2a c: Contamination of residential, institutional, or park lands.			
C2a d: Contamination[1] of lands valued by Indigenous people (for hunting, gathering, other).			
Water crossings:			
C2a e: Contamination[1] of surface water used as a source of potable water (e.g., reservoirs, lakes, rivers).			
C2a f: Contamination[1] of surface water used for irrigation or livestock watering.			
C2a g: Contamination[1] of waterways that support commercial fisheries.			
C2a h: Contamination[1] of waterways valued by Indigenous people (for fishing, other).			
C2a i: Contamination[1] of waterways used for recreational activities.			
Land:	Rate moderate		
C2a j: Soil and/or groundwater contamination[1] in an environment other than those described above with a "high" consequence rating.			
Water crossings:			
C2a k: Surface water and/or sediment contamination[1] in and environment other than those described for waterways above with a "high" consequence rating.			
C2a: Ecology and environment:		***Insert rating*** [6, 7, 8]	***Locations (along ROW) associated with rating***
Land:	Rate high		
C2a l: Contamination[1] of areas that are habitat/breeding/foraging areas for species at risk.			
C2a m: Contamination[1] of areas reserved as parks, conservation areas, or other areas of ecological, environmental, or natural significance.			
Water crossings:			
C2a n: Contamination[1] of waterways that may constitute a violation of the Fisheries Act.			
C2a o: Contamination[1] of significant wetlands.			
C2a p: Contamination[1] of waterways that are habitat/spawning/breeding/feeding grounds for species at risk.			
Land:	Rate moderate		
C2a q: Soil and/or groundwater contamination[1] in an environment other than those described above with a "high" consequence rating.			
Water crossings:			
C2a r: Surface water or sediment contamination[1] in an environment other than those described for waterways above with a "high" consequence rating.			
C2a: Land use and valued/economic resources:		***Insert rating*** [6, 7, 8]	***Locations (along ROW) associated with rating***
Land:	Rate high		
C2a s: Contamination[1] within a potable groundwater environment.		High C2a s	
C2a t: Contamination[1] of agricultural lands.		High C2a t	
C2a u: Contamination[1] of lands valued by Indigenous people (for hunting, gathering, other).			
C2a v: Contamination[1] of areas reserved as parks, conservation areas, or other areas of ecological, environmental, or natural significance.			
C2a w: Contamination[1] of forested lands.			
Water crossings:			
C2a x: Contamination[1] of surface water used as a source of potable water (e.g., reservoirs, lakes, rivers).			
C2a y: Contamination[1] of surface water used for irrigation or livestock watering.			
C2a z: Contamination[1] of waterways that support commercial fisheries.			
C2a aa: Contamination[1] of waterways valued by Indigenous people (for fishing, other).			
C2a bb: Contamination[1] of waterways used for recreational activities.			
Land:	Rate moderate		
C2a cc: Soil and/or groundwater contamination[1] in an environment other than those described above with a "high" consequence rating.			
Water crossings:			
C2a dd: Surface water or sediment contamination[1] in and environment other than those described for waterways above with a "high" consequence rating.			

Step III - Complete risk estimation:

E2: Estimation of risk[3] associated with contaminants present within the pipeline (at concentrations that could result in an adverse effect) transported out of the pipeline into the surrounding environment[2] and/or preferentially transported within the pipeline:	**On Land**			**At Water Crossings**		
E2: Human health and safety:	**Frequency No.**	**Consequence No.**	**Locations**	**Frequency No.**	**Consequence No.**	**Locations**
High likelihood and High severity						
High likelihood and Moderate severity OR Moderate likelihood and High severity	F2a b Moderate	C2a a, C2a b High				
High likelihood and Low severity	NA	NA	NA	NA	NA	NA
Low likelihood and high severity						
Low likelihood OR Low severity						
Low likelihood AND Low severity	NA	NA	NA	NA	NA	NA
E2: Ecology and environment:						
High likelihood and High severity						
High likelihood and Moderate severity OR Moderate likelihood and High severity						
High likelihood and Low severity	NA	NA	NA	NA	NA	NA
Low likelihood and high severity						
Low likelihood OR Low severity						
Low likelihood AND Low severity	NA	NA	NA	NA	NA	NA
E2: Land use and valued/economic resources:						
High likelihood and High severity						
High likelihood and Moderate severity OR Moderate likelihood and High severity	F2a b Moderate	C2a s, t High				
High likelihood and Low severity	NA	NA	NA	NA	NA	NA
Low likelihood and high severity						
Low likelihood OR Low severity						
Low likelihood AND Low severity	NA	NA	NA	NA	NA	NA

Notes:
ROW - pipeline right of way
PCB - polychlorinated biphenyl
NORM - naturally occurring radioactive materials
* Do not necessarily adequately address risks associated with the hazard.
(1) contamination - concentrations above applicable environmental criteria, or concentrations above property-specific criteria derived by a human and ecological risk assessment
(2) Soil, groundwater, surface water, and/or sediment.
(3) Refer to Tables 3, 4, and 5 of text for definitions of frequency, consequence, and risk estimation ratings.
(4) The frequency analysis does not consider the likelihood for the pipeline to be breached, as it is assumed that breach of the pipeline will eventually occur.
(5) Even with effective pigging, PCBs and NORMs have been identified as remaining in a limited number of gas transmission lines. These contaminants have a relatively high toxicity, and PCBs may bioaccumulate in the food chain.
(6) Rate based on if/where the environment/land use is present along pipeline ROW. Both current and future land use should be considered.
(7) If environment/land use is present insert applicable rating (i.e., high, moderate, or low). Otherwise, insert "not present along ROW".
(8) There is no environment/land use on which a "low" consequence rating is applicable. Contamination[1] of any media is considered to have at least a moderate consequence rating.

PH2b Risk Assessment Worksheet

Hazard No. 2: Environmental impacts from pipeline materials abandoned in-place, post operation

Hazard No. 2b: Leaching from construction materials and coatings

Release mechanism:

Contaminants leach from pipeline construction materials and/or external coatings at concentrations that could result in an adverse effect into the surrounding environment (2). The pipeline structure may be breached (from puncture or corrosion) to allow water and transport of contaminants into the pipeline and preferential transport of contaminants within it.

Risk management measures required in accordance with CSA Z662 (4) *:	***Met***	***Not met***
10.16 Abandonment of pipelines and pipe-type storage vessels		
A buried pipeline that is abandoned in place shall be:		
d) capped, plugged, or otherwise effectively sealed; and,		
e) cut off at pipeline depth.		
Site-specific data/information/ studies required to complete risk estimation:	***Completed***	***Not completed***
1. Characterization of pipeline construction materials and external coatings.	*X*	
2. Characterization of contaminants and associated concentrations expected to leach from pipeline construction materials and/or external coatings over time, compared to applicable environmental criteria, completed by a qualified professional.		

Step I - Complete frequency analysis:

F2b: Likelihood(3) that contaminants will leach from pipeline construction materials and/or external coatings at concentrations that could result in an adverse effect:		***Insert rating***	***Locations (along ROW) associated with rating***
Scenarios along pipeline:			
F2b a: Pipeline construction materials and external coatings are inert and not expected to leach contaminants, neither in the short nor long term.	Rate low	F2b a Low	
F2b b: Pipeline construction materials are expected to leach contaminants, either in the short or long term, at concentrations below applicable environmental criteria in consideration of land use.	Rate moderate		
F2b c: Pipeline construction materials are expected to leach contaminants, either in the short or long term, at concentrations above applicable environmental criteria in consideration of land use.	Rate high		

Step II - Complete consequence analysis:

C2b: Consequence(s)(3) of contaminants leaching from pipeline construction materials and/or external coatings at concentrations that could result in an adverse effect:			
C2b: Human health and safety:		***Insert rating*** (5, 6, 7)	***Locations (along ROW) associated with rating***
Land:			
C2b a: Contamination(1) within a potable groundwater environment.		C2b a High	
C2b b: Contamination(1) of agricultural lands.		C2b b High	
C2b c: Contamination of residential, institutional, or park lands.			
C2b d: Contamination(1) of lands valued by Indigenous people (for hunting, gathering, other).			
Water crossings:	C1		
C2b e: Contamination(1) of surface water used as a source of potable water (e.g., reservoirs, lakes, rivers).			
C2b f: Contamination(1) of surface water used for irrigation or livestock watering.			
C2b g: Contamination(1) of waterways that support commercial fisheries.			
C2b h: Contamination(1) of waterways valued by Indigenous people (for fishing, other).			
C2b i: Contamination(1) of waterways used for recreational activities.			
Land:			
C2b j: Soil and/or groundwater contamination(1) in an environment other than those described above with a "high" consequence rating.	Rate moderate		
Water crossings:			
C2b k: Surface water and/or sediment contamination(1) in an environment other than those described for waterways above with a "high" consequence rating.			
C2b: Ecology and environment:		***Insert rating*** (5, 6, 7)	***Locations (along ROW) associated with rating***
Land:			
C2b l: Contamination(1) of areas that are habitat/breeding/foraging areas for species at risk.			
C2b m: Contamination(1) of areas reserved as parks, conservation areas, or other areas of ecological, environmental, or natural significance.	Rate high		
Water crossings:			
C2b n: Contamination(1) of waterways that may constitute a violation of the Fisheries Act.			
C2b o: Contamination(1) of significant wetlands.			
C2b p: Contamination(1) of waterways that are habitat/spawning/breeding/feeding grounds for species at risk.			
Land:			
C2b q: Soil and/or groundwater contamination(1) in an environment other than those described above with a "high" consequence rating.	Rate moderate		
Water crossings:			
C2b r: Surface water or sediment contamination(1) in an environment other than those described for waterways above with a "high" consequence rating.			
C2b: Land use and valued/economic resources:		***Insert rating*** (5, 6, 7)	***Locations (along ROW) associated with rating***
Land:			
C2b s: Contamination(1) within a potable groundwater environment.		C2b s High	
C2b t: Contamination(1) of agricultural lands.		C2b t High	
C2b u: Contamination(1) of lands valued by Indigenous people (for hunting, gathering, other).			
C2b v: Contamination(1) of areas reserved as parks, conservation areas, or other areas of ecological, environmental, or natural significance.			
C2b w: Contamination(1) of forested lands.	Rate high		
Water crossings:			
C2b x: Contamination(1) of surface water used as a source of potable water (e.g., reservoirs, lakes, rivers).			
C2b y: Contamination(1) of surface water used for irrigation or livestock watering.			
C2b z: Contamination(1) of waterways that support commercial fisheries.			
C2b aa: Contamination(1) of waterways valued by Indigenous people (for fishing, other).			
C2b bb: Contamination(1) of waterways used for recreational activities.			
Land:			
C2b cc: Soil and/or groundwater contamination(1) in an environment other than those described above with a "high" consequence rating.	Rate moderate		
Water crossings:			
C2b dd: Surface water or sediment contamination(1) in and environment other than those described for waterways above with a "high" consequence rating.			

Step III - Complete risk estimation:

E2b: Estimation of risk(3) associated with contaminants leaching from pipeline construction materials and/or external coatings at concentrations that could result in an adverse effect:	**On Land**			**At Water crossings**		
E2b: Human health and safety:	**Frequency No.**	**Consequence No.**	**Locations**	**Frequency No.**	**Consequence No.**	**Locations**
High likelihood and High severity						
High likelihood and Moderate severity OR Moderate likelihood and High severity						
High likelihood and Low severity	NA	NA	NA	NA	NA	NA
Low likelihood and high severity	F2b a Low	C2b a; C2b b High				
Low likelihood OR Low severity						
Low likelihood AND Low severity	NA	NA	NA	NA	NA	NA
E2b: Ecology and environment:						
High likelihood and High severity						
High likelihood and Moderate severity OR Moderate likelihood and High severity						
High likelihood and Low severity	NA	NA	NA	NA	NA	NA
Low likelihood and high severity						
Low likelihood OR Low severity						
Low likelihood AND Low severity	NA	NA	NA	NA	NA	NA
E2b: Land use and valued/economic resources:						
High likelihood and High severity						
High likelihood and Moderate severity OR Moderate likelihood and High severity						
High likelihood and Low severity	NA	NA	NA	NA	NA	NA
Low likelihood and high severity	F2b a Low	C2b s, t High				
Low likelihood OR Low severity						
Low likelihood AND Low severity	NA	NA	NA	NA	NA	NA

Notes:

ROW - pipeline right of way

PCB - polychlorinated biphenyl

NORM - naturally occurring radioactive materials

* Do not necessarily adequately address risks associated with the hazard.

(1) contamination - concentrations above applicable environmental criteria, or concentrations above property-specific criteria derived by a human and ecological risk assessment

(2) Soil, groundwater, surface water, and/or sediment.

(3) Refer to Tables 3, 4, and 5 of text for definitions of frequency, consequence, and risk estimation ratings.

(4) These risk management measures may address preferential transport of contaminants within the pipeline, but do not address leaching of contaminants into the surrounding environment.

(5) Rate based on if/where the environment/land use is present along pipeline ROW. Both current and future land use should be considered.

(6) If environment/land use is present insert applicable rating (i.e., high, moderate, or low). Otherwise, insert "not present along ROW".

(7) There is no environment/land use on which a "low" consequence rating is applicable. Contamination(1) of any media is considered to have at least a moderate consequence rating.

PH2c Risk Assessment Worksheet

Hazard No. 2: Environmental impacts from pipeline materials abandoned in-place, post operation

Hazard No. 2c: Presence and exposure and disruption of asbestos

Release mechanism:

Asbestos is present in pipeline external coatings AND is exposed and disturbed (as a result of construction/maintenance/excavation activities, soil erosion, frost heave, or other geotechnical hazards) allowing for potential contact with human receptors [1] involved with pipeline excavation/repair activities [2].

Risk management measures required in accordance with CSA Z662*:

None

Site-specific data/information/ studies required to complete risk estimation:	***Completed***	***Not completed***
1. Characterization of pipeline external coatings, and identification of those containing asbestos, by a qualified professional.		

Step I - Complete frequency analysis[7]:

F2c: Likelihood[3] that asbestos is present in pipeline external coatings and will be exposed and disturbed allowing for potential contact with human receptors[1] involved with pipeline excavation/repair activities[2].		***Insert rating***	***Locations (along pipeline) associated with rating***
Scenarios along pipeline:			
F2c a: Asbestos is not present in pipeline external coatings.	Rate low	F2c a Low	
F2c b: Asbestos is present in pipeline external coatings.	Rate high		

Step II - Complete consequence analysis[7]:

C2c: Consequence(s) of asbestos in pipeline external coatings being exposed and disturbed allowing for potential contact with human receptors[1] involved with pipeline excavation/repair activities[2].

C2c: Human health and safety:		***Insert rating*** [5,6]	***Locations (along pipeline) associated with rating***
C2c a: Incidents of asbestosis[4].	Rate high	Low	
C2c: Ecology and environment:		***Insert rating***	***Locations (along pipeline) associated with rating***
Not applicable	NA	NA	NA
C2c: Land use and valued/economic resources:		***Insert rating***	***Locations (along pipeline) associated with rating***
Not applicable	NA	NA	NA

Step III - Complete risk estimation:

E2c: Estimation of risk[7] associated with asbestos in pipeline external coatings being exposed and disturbed allowing for potential contact with human receptors(1) involved with pipeline excavation/repair activities(2):	**On Land**		
E2c: Human health and safety:	**Frequency No.**	**Consequence No.**	**Locations**
High likelihood and High severity			
High likelihood and Moderate severity OR Moderate likelihood and High severity	NA	NA	NA
High likelihood and Low severity	NA	NA	NA
Low likelihood and high severity	NA	NA	NA
Low likelihood OR Low severity	F2c a Low	C2c a Low	
Low likelihood AND Low severity	NA	NA	NA
E2c: Ecology and environment:			
Not applicable	NA	NA	NA
E2c: Land use and valued/economic resources:			
Not applicable	NA	NA	NA

Notes:

ROW - right of way

* Do not necessarily adequately address risks associated with the hazard.

(1) Exposure of ecological receptors is considered to be minimal, as asbestos in pipeline external coatings is not expected to be mobile in the environment or available for uptake by ecological receptors. Ecological receptors are not expected to directly contact exposed pipeline in a manner that would result in significant exposure, and pipeline external coatings do not provide and are not intermixed with food items or exposure media for

(2) It is assumed that exposed sections of pipeline (containing asbestos) would be re-covered or removed and disposed of (in accordance with applicable guidelines and regulations) by adult maintenance workers in a timely manner so to prevent exposure to other human receptors (e.g., children, visitors, trespassers, farmers, or other workers).

(3) The frequency analysis does not consider the likelihood for asbestos to be exposed and disturbed at various locations along the pipeline, as it is assumed that excavation/maintenance activities that may result in exposure and disturbance could occur anywhere along it.

(4) A chronic (long-term) lung disease caused by breathing in asbestos fibers

(5) Rate based on if/where asbestos is present along pipeline. If asbestos is present insert applicable rating (i.e., high). Otherwise, insert "asbestos not present along pipeline".

(6) There are no consequences considered to have either a "low" or "moderate" rating.

(7) Refer to Tables 3, 4, and 5 of text for definitions of frequency, consequence, and risk estimation ratings.

PH3 Risk Assessment Worksheet

Hazard No. 3: Drainage of surface water or shallow groundwater through pipeline

Release mechanism:

Surface water or shallow groundwater is proximal (and hydraulically connected) to pipeline AND the pipeline structure is breached (from puncture or corrosion) to allow water into (and out of) and flow through the pipeline, resulting in drainage of surface water or groundwater, preferential flow and discharge elsewhere.

Risk management measures required in accordance with CSA Z662*:

None

Site-specific data/information/ studies required to complete risk estimation:	***Completed***	***Not completed***
1) Identification of surface water bodies along pipeline ROW.	***X***	
2) Identification of locations where pipeline (and/or fill materials surrounding pipeline) may be in contact with groundwater.	***X***	
3) Where pipeline is within 100 metres of surface water body (including: lakes, rivers, creeks, marshes, wetlands, muskegs, sloughs, reservoirs), site specific drainage study to determine if pipeline (and/or fill materials surrounding pipeline) are hydraulically connected	X	

Step I - Complete frequency analysis:

F3: Likelihood[1] of drainage of surface water or shallow groundwater through the pipeline[2]:		***Insert rating***	***Locations (along ROW) associated with rating***
Scenarios along pipeline:			
F3a: Pipeline located more than 100 metres from nearest surface water body (including: lakes, rivers, creeks, marshes, wetlands, muskegs, sloughs, reservoirs), OR based on site-specific drainage study is not hydraulically connected to the nearest surface water body.	Rate low		
F3b: Pipeline located where it is not likely to be in contact with groundwater.	Rate low		
F3c: Pipeline located between 30 and 100 metres from nearest surface water body.	Rate moderate		
F3d: Pipeline located within 30 metres of a surface water body (including: lakes, rivers, creeks, marshes, wetlands, muskegs, sloughs, reservoirs).	Rate high	F3d High	
F3e: Pipeline located within a flood plain or area prone to flooding.	Rate high		
F3f: Pipeline located where it may be in contact with groundwater.	Rate high		

Step II - Complete consequence analysis:

C3: Consequence(s)[1] of drainage of surface water or shallow groundwater through the pipeline:			
C3: Human health and safety:		***Insert rating*** [3, 4]	***Locations (along ROW) associated with rating***
Not applicable.		NA	NA
C3: Ecology and environment:		***Insert rating*** [3, 4]	***Locations (along ROW) associated with rating***
Land:	Rate high		
C3a: Flooding of habitat/breeding/foraging areas for species at risk (including individuals).			
C3b: Flooding of areas reserved as parks, conservation areas, or other areas of ecological, environmental, or natural significance.			
Water crossings:			
C3c: Drainage of surface water that may constitute a violation of the Fisheries Act.			
C3d: Drainage of significant wetlands.			
C3e: Drainage of surface water that is habitat/spawning/breeding/feeding grounds for species at risk.			
C3f: Discharge to surface water and/or siltation that may constitute a violation of the Fisheries Act.			
C3g: Discharge to, and siltation of, surface water that is habitat/spawning/breeding/feeding grounds for species at risk.			
Land:	Rate moderate		
C3h: Flooding of habitat/breeding/foraging areas for populations/communities of non-species at risk.		C3h Moderate	
Water crossings:			
C3i: Drainage of surface water other than that described for water crossings above with a "high" consequence rating.			
C3j: Discharge to, and siltation of, surface water other than that described for water crossings above with a "high" consequence rating.			
Land:	Rate low		
C3k: Flooding of an area that does not provide habitat/breeding/foraging areas for communities/populations of non-species at risk or for individual species at risk.			
Water crossings:			
Not applicable[5]		NA	NA
C3: Land use and valued/economic resources:		***Insert rating*** [3, 4]	***Locations (along ROW) associated with rating***
Land:	Rate high		
C3l: Drainage of groundwater used as a source of potable water.		C3l High	
C3m: Drainage of groundwater used for irrigation or livestock watering.			
C3n: Flooding of agricultural lands.		C3n High	
C3o: Flooding of lands valued by Indigenous people (for hunting, gathering, other).			
C3p: Flooding of areas reserved as parks, conservation areas, or other areas of ecological, environmental, or natural significance.			
C3q: Flooding of forested lands.			
C3r: Flooding of urban/municipal/residential/commercial/industrial areas.			
Water crossings:			
C3s: Drainage of surface water used as a source of potable water (e.g., reservoirs, lakes, rivers).			
C3t: Drainage of surface water used for irrigation.			
C3u: Drainage of surface water that supports commercial fisheries.			
C3v: Drainage of surface water valued by Indigenous people (for fishing, other).			
C3w: Drainage of surface water used for recreational activities.			
C3x: Discharge to, and siltation of, surface water that supports commercial fisheries.			
C3y: Discharge to, and siltation of, surface water valued by Indigenous people (for fishing, other).			
C3z: Discharge to, and siltation of, surface water used for recreational activities.			
Land:	Rate moderate		
C3aa: Flooding of lands located on low-lying land other than those described above with a "high" consequence rating.			
Water crossings:			
Not applicable		NA	NA
Land:	Rate low		
Not applicable[6]		NA	NA
Water crossings:			
C3bb: Drainage of surface water other than that described for water crossings above with a "high" consequence rating.			

Step III - Complete risk estimation:

E3: Estimation of risk[2] associated with drainage of surface water or shallow groundwater through the pipeline:	**On Land**			**At Water crossings**		
E3: Human health and safety:	**Frequency No.**	**Consequence No.**	**Locations**	**Frequency No.**	**Consequence No.**	**Locations**
Not applicable	NA	NA	NA	NA	NA	NA
E3: Ecology and environment:						
High likelihood and High severity						
High likelihood and Moderate severity OR Moderate likelihood and High severity	F3d High	C3h Moderate				
High likelihood and Low severity				NA	NA	NA
Low likelihood and high severity						
Low likelihood OR Low severity						
Low likelihood AND Low severity				NA	NA	NA
E3: Land use and valued/economic resources:						
High likelihood and High severity	F3d High	C3l,n High				
High likelihood and Moderate severity OR Moderate likelihood and High severity						
High likelihood and Low severity	NA	NA	NA			
Low likelihood and high severity				NA	NA	NA
Low likelihood OR Low severity						
Low likelihood AND Low severity	NA	NA	NA			

Notes:

ROW - pipeline right of way

* Do not necessarily adequately address risks associated with the hazard.

(1) Refer to Tables 3, 4, and 5 of text for definitions of frequency, consequence, and risk estimation ratings.

(2) The frequency analysis does not consider the likelihood for the pipeline to be breached, as it is assumed that breach of the pipeline will eventually occur.

(3) Rate based on if/where the environment/land use is present along pipeline ROW.

(4) If environment/land use is present insert applicable rating (i.e., high, moderate, or low). Otherwise, insert "not present along ROW".

(5) Drainage of any surface water body is considered to have at least a moderate consequence rating.

(6) Flooding of any lands is considered to have at least a moderate consequence rating.

PH4 Risk Assessment Worksheet

Hazard No. 4: Ground subsidence beyond tolerable range (for land use)

Release mechanism:

Pitting and structural deterioration of pipeline (and reduced load carrying capacity of the pipe) due to corrosion[1] , resulting in the creation of voids in the subsurface and eventual collapse of ground into voids. The tolerable range of subsidence is dependent on land use. For most land uses[2] , pipeline diameter is the main factor in determining whether subsidence will be within the tolerable range. Subsidence

Risk management measures required in accordance with CSA Z662*:

None

Site-specific data/information/ studies required to complete risk estimation:	***Completed***	***Not completed***
1. Pipeline diameter.	X	
2. Identification of rail, road, and underground utility crossings, or agricultural or other lands on which heavy vehicular loadings are expected[2] along the ROW.	X	
3. For pipelines with a diameter greater than 323.9 millimeters[7] (other than at crossings and where heavy vehicular loadings are expected as described in 2 above[2]), site-specific analysis to evaluate the degree of subsidence expected, and whether it is within the tolerable range in	X	

Step I - Complete frequency analysis:

F4: Likelihood[6] of ground subsidence beyond the tolerable range (for land use):		***Insert rating***	***Locations (along ROW) associated with rating***
Scenarios along pipeline:			
F4a: Pipeline has a diameter of 323.9 millimetres or less, at locations other than: road, rail, or underground utility crossings, or agricultural or other lands on which heavy vehicular loadings are expected[2].	Rate low		
F4b: Pipeline has a diameter of greater than 323.9 millimetres, and results of a site-specific analysis indicate that the expected degree of subsidence is within the tolerable range in consideration of land use. [At locations other than road, rail, and underground utility crossings, or agricultural or other lands on which heavy vehicular loadings are expected.[2]]	Rate low		
F4c: Pipeline has a diameter of greater than 323.9 millimetres, and results of a site-specific analysis indicate that the expected degree of subsidence above the tolerable range in consideration of land use. [At locations other than road, rail, and underground utility crossings, or agricultural or other lands on which heavy vehicular loadings are expected.(2)]	Rate moderate		
F4d: Pipeline of any diameter, located at: road crossings, rail crossings, underground utility crossings, or agricultural or other lands on which heavy vehicular loadings are expected[2].	Rate high	F4d High	

Step II - Complete consequence analysis:

C4: Consequence[6] of ground subsidence beyond the tolerable range (for land use):			
C4: Human health and safety:		***Insert rating*** [4, 5]	***Locations (along ROW) associated with rating***
On land:	Rate high		
C4a: Train derailments at rail crossings, vehicle accidents at road crossings, or accidents resulting from damage to underground service utilities at utility crossings.			
C4b: Heavy vehicle accidents on agricultural lands or other lands on which heavy vehicular loadings are expected.		C4b High	
At water crossings:			
Not applicable.			
C4: Ecology and environment:		***Insert rating*** [4, 5]	***Locations (along ROW) associated with rating***
On land:	Rate high		
C4c: Derailments at rail crossings, vehicle accidents at road crossings, or accidents resulting from damage to underground service utilities at utility crossings located in areas that are habitat/breeding/foraging areas for species at risk.			
C4d: Derailments at rail crossings, vehicle accidents at road crossings, or accidents resulting from damage to underground service utilities at utility crossings located in areas reserved as parks, conservation areas, or other areas of ecological, environmental, or natural significance.			
At water crossings:			
C4e: Discharge to surface water and/or siltation that may constitute a violation of the Fisheries Act.			
C4f: Discharge to, and siltation of, surface water that is habitat/spawning/breeding/feeding grounds for species at risk.			
On land:	Rate moderate		
C4g: Derailments at rail crossings, vehicle accidents at road crossings, or accidents resulting from damage to underground service utilities at utility crossings located in areas that are habitat/breeding/foraging areas for populations/communities of non-species at risk.			
At water crossings:			
C4h: Discharge to, and siltation of, surface water other than that described for water crossings above with a "high" consequence rating.			
On land:	Rate low		
C4i: Derailments at rail crossings, vehicle accidents at road crossings, or accidents resulting from damage to underground service utilities at utility crossings located in areas that do not provide habitat/breeding/foraging areas for communities/populations of non-species at risk or for individual species at risk.			
At water crossings:			
Not applicable.			
C4: Land use and valued/economic resources:		***Insert rating*** [4, 5]	***Locations (along ROW) associated with rating***
On land:	Rate high		
C4j: Train derailments at rail crossings, vehicle accidents at road crossings, or accidents resulting from damage to underground service utilities at utility crossings.			
C4k: Heavy vehicle accidents on agricultural lands or other lands on which heavy vehicular loadings are expected.		C4k High	
C4l: Erosion/loss of topsoil on agricultural lands.		C4l High	
At water crossings:			
C4m: Discharge to, and siltation of, surface water that supports commercial fisheries.			
C4n: Discharge to, and siltation of, surface water valued by Indigenous people (for fishing, other).			
C4o: Discharge to, and siltation of, surface water used for recreational activities.			

Step III - Complete risk estimation:

E4: Estimation of risk[6] associated with ground subsidence outside of the tolerable range (for land use):	**On Land**			**At Water crossings**		
E4: Human health and safety:	**Frequency No.**	**Consequence No.**	**Locations**	**Frequency No.**	**Consequence No.**	**Locations**
High likelihood and High severity	F4d High	C4 b High		NA	NA	NA
High likelihood and Moderate severity OR Moderate likelihood and High severity				NA	NA	NA
High likelihood and Low severity	NA	NA	NA	NA	NA	NA
Low likelihood and high severity	NA	NA	NA	NA	NA	NA
Low likelihood OR Low severity				NA	NA	NA
Low likelihood AND Low severity	NA	NA	NA	NA	NA	NA
E4: Ecology and environment:						
High likelihood and High severity						
High likelihood and Moderate severity OR Moderate likelihood and High severity						
High likelihood and Low severity						
Low likelihood and high severity						
Low likelihood OR Low severity						
Low likelihood AND Low severity				NA	NA	NA
E4: Land use and valued/economic resources:						
High likelihood and High severity	F4d High	C4k, l High				
High likelihood and Moderate severity OR Moderate likelihood and High severity						
High likelihood and Low severity	NA	NA	NA	NA	NA	NA
Low likelihood and high severity	NA	NA	NA	NA	NA	NA
Low likelihood OR Low severity						
Low likelihood AND Low severity	NA	NA	NA	NA	NA	NA

Notes:

ROW - right of way

* Do not necessarily adequately address risks associated with the hazard.

(1) Pipeline degradation processes other than corrosion for pipelines constructed of materials other than metal not considered.

(2) Tolerable range is zero at: road crossings, rail crossings, underground utility crossings, and agricultural or other lands on which heavy vehicular loadings are expected.

(3) Enhanced corrosion of pipelines abandoned without cathodic protection may occur at powerline crossings.

(4) Rate based on if/where the environment/land use is present along pipeline ROW.

(5) If environment/land use is present insert applicable rating (i.e., high, moderate, or low). Otherwise, insert "not present along ROW".

(6) Refer to Tables 3, 4, and 5 of text for definitions of frequency, consequence, and risk estimation ratings.

(7) Ground subsidence associated with the collapse of pipelines up to 323.9 mm in diameter at typical burial depths is expected to be negligible (CEPA, 2006 - 2007).

PH 5 Risk Assessment Worksheet

Hazard No. 5: Exposure of abandoned pipeline on land due to soil erosion and geohazards

Release mechanism:

Pipeline is exposed at surface due to soil erosion or geohazards that force it above ground (i.e., frost heave, seismic activity).

Risk management measures required in accordance with CSA Z662*:

None

Site-specific data/information/ studies required to complete risk estimation:	***Completed***	***Not completed***
1. Identification of the following areas along the pipeline ROW: areas susceptible to soil erosion (e.g., agricultural fields or other non-vegetated areas, shallow soil cover, steep slopes, topographic highs exposed to wind), seismically-active areas, and areas where there is permafrost or where	X	

Step I - Complete frequency analysis:			
F5: Likelihood[4] of exposure of abandoned pipeline on land due to geotechnical/geohazards:		***Insert rating***	***Locations (along ROW) associated with rating***
Scenarios along pipeline:			
F5a: Pipeline exposure did not occur/was not a hazard that required monitoring, maintenance, or risk management during operation of the pipeline AND pipeline is not located in an area susceptible to soil erosion (e.g., agricultural fields or other non-vegetated areas, shallow soil cover, steep slopes, topographic highs exposed to wind) or a seismically-active area, AND pipeline is located below frost line.	Rate low		
F5b: Pipeline exposure did not occur/was not a hazard that required monitoring, maintenance, or risk management during operation of the pipeline, however the pipeline is located in an area susceptible to soil erosion (e.g., agricultural fields or other non-vegetated areas, shallow soil cover, steep slopes, topographic highs exposed to wind).	Rate moderate	F5b Moderate	
F5c: Pipeline exposure did not occur/was not a hazard that required monitoring, maintenance, or risk management during operation of the pipeline, however the pipeline is located in a seismically active area.	Rate moderate		
F5d: Pipeline exposure did not occur/was not a hazard that required monitoring, maintenance, or risk management during operation of the pipeline, however the pipeline is located above the frost line or where there is permafrost.	Rate high		
F5e: Pipeline exposure did occur/was a hazard that required monitoring, maintenance, and/or risk management during operation of the pipeline.	Rate high		
Step II - Complete consequence analysis:			
C5: Consequence[4] of exposure of abandoned pipeline on land due to geotechnical/geohazards[3]:			
C5: Human health and safety:		***Insert rating*** [1, 2]	***Locations (along ROW) associated with rating***
Not applicable.	NA	NA	NA
C5: Ecology and environment:		***Insert rating*** [1, 2]	***Locations (along ROW) associated with rating***
Not applicable.	NA	NA	NA
C5: Land use and valued/economic resources:		***Insert rating*** [1, 2]	***Locations (along ROW) associated with rating***
On land:	Rate moderate		
C5a: Temporary loss of productivity on agricultural lands.			
C5b: Damage to agricultural or other heavy equipment.		C5b Moderate	
At water crossings:			
Not applicable.		NA	NA
On land:	Rate low		
C5c: Aesthetic impacts at any location along the ROW.			
At water crossings:			
Not applicable.		NA	NA

Step III - Complete risk estimation:						
E5: Estimation of risk[4] associated with exposure of abandoned pipeline on land due to geotechnical/geohazards:	**On Land**			**At Water Crossings**		
E5: Human health and safety:	**Frequency No.**	**Consequence No.**	**Locations**	**Frequency No.**	**Consequence No.**	**Locations**
High likelihood and High severity	NA	NA	NA	NA	NA	NA
High likelihood and Moderate severity OR Moderate likelihood and High severity	NA	NA	NA	NA	NA	NA
High likelihood and Low severity	NA	NA	NA	NA	NA	NA
Low likelihood and high severity	NA	NA	NA	NA	NA	NA
Low likelihood OR Low severity	NA	NA	NA	NA	NA	NA
Low likelihood AND Low severity	NA	NA	NA	NA	NA	NA
E5: Ecology and environment:						
High likelihood and High severity	NA	NA	NA	NA	NA	NA
High likelihood and Moderate severity OR Moderate likelihood and High severity	NA	NA	NA	NA	NA	NA
High likelihood and Low severity	NA	NA	NA	NA	NA	NA
Low likelihood and high severity	NA	NA	NA	NA	NA	NA
Low likelihood OR Low severity	NA	NA	NA	NA	NA	NA
Low likelihood AND Low severity	NA	NA	NA	NA	NA	NA
E5: Land use and valued/economic resources:						
High likelihood and High severity	NA	NA	NA	NA	NA	NA
High likelihood and Moderate severity OR Moderate likelihood and High severity	F5b Moderate	C5b moderate		NA	NA	NA
High likelihood and Low severity				NA	NA	NA
Low likelihood and high severity	NA	NA	NA	NA	NA	NA
Low likelihood OR Low severity				NA	NA	NA
Low likelihood AND Low severity				NA	NA	NA

Notes:

ROW - right of way

* Do not necessarily adequately address risks associated with the hazard.

(1) Rate based on if/where the environment/land use is present along pipeline ROW.

(2) If environment/land use is present insert applicable rating (i.e., high, moderate, or low). Otherwise, insert "not present along ROW".

(3) The consequence analysis does not consider release of contaminants due to pipeline exposure (and increased risk of puncture) as this hazard has been addressed as Potential Hazard 2a and 2b.

(4) Refer to Tables 3, 4, and 5 of text for definitions of frequency, consequence, and risk estimation ratings.

PH6 Risk Assessment Worksheet

Hazard No. 6: Exposure of abandoned pipeline at water crossings due to hydrotechnical hazards

Release mechanism:

Pipeline is exposed at surface due to: 1) buoyancy of the empty pipeline; 2) sediment erosion and lowering of the channel bed resulting in reduced depth of sediment cover; or, 3) stream bank erosion (where pipelines are parallel to streams or rivers). The relative buoyancy of a pipeline is increased once it is emptied (for abandonment). However, the rate/frequency of

Risk management measures required in accordance with CSA Z662*:

None

Site-specific data/information/ studies required to complete risk estimation:	***Completed***	***Not completed***
1. Identification of water crossings, and for each, assessment of the potential/rate at which the pipeline will become exposed in the channel bed due to buoyancy and sediment erosion. This should consider the rates of sediment	X	
2. Identification of locations where the pipeline is parallel and proximal to a stream or river, and assessment of the potential/timeline for the pipeline to become exposed along the stream bank due to stream bank erosion.	X	

Step I - Complete frequency analysis:

F6: Likelihood[4] of exposure of abandoned pipeline at water crossings due to hydrotechnical hazards:		***Insert rating***	***Locations (along ROW) associated with rating***
Scenarios along pipeline:			
F6a: Pipeline is not expected to become exposed, either within the channel bed due to buoyancy and sediment erosion, or along the stream bank to stream bank erosion.	Rate low	F6a Low	
F6b: Pipeline is expected to become exposed, however significant/exceptional buoyancy of the pipeline, sediment erosion, or risk of stream bank erosion that could result in frequent exposure was not identified.	Rate moderate		
F6c: Significant/exceptional buoyancy of the pipeline, sediment erosion, and/or risk of stream bank erosion that could result in frequent exposure was identified.	Rate high		

Step II - Complete consequence analysis:

C5: Consequence[4] of exposure of abandoned pipeline at water crossings due to hydrotechnical hazards[3]:

C5: Human health and safety:		***Insert rating*** [1, 2]	***Locations (along ROW) associated with rating***
Not applicable.	NA	NA	NA
C5: Ecology and environment:		***Insert rating*** [1, 2]	***Locations (along ROW) associated with rating***
On land:	NA		
Not applicable.		NA	NA
At water crossings:	Rate high		
C6a: Exposure and contamination in surface water that is habitat/spawning/breeding/feeding grounds for species at risk			
C6b: Exposure and contamination in surface water other than that which is habitat/spawning/breeding/feeding grounds for species at risk.	Rate moderate		
C5: Land use and valued/economic resources:		***Insert rating*** [1, 2]	***Locations (along ROW) associated with rating***
On land:	NA		
Not applicable.		NA	NA
At water crossings:	Rate low		
C6c: Aesthetic impacts at any water crossing.			

Step III - Complete risk estimation:

E5: Estimation of risk[4] associated with exposure of abandoned pipeline at water crossings due to hydrotechnical hazards:		**On Land**		**At Water Crossings**		
E5: Human health and safety:	**Frequency No.**	**Consequence No.**	**Locations**	**Frequency No.**	**Consequence No.**	**Locations**
High likelihood and High severity	NA	NA	NA	NA	NA	NA
High likelihood and Moderate severity OR Moderate likelihood and High severity	NA	NA	NA	NA	NA	NA
High likelihood and Low severity	NA	NA	NA	NA	NA	NA
Low likelihood and high severity	NA	NA	NA	NA	NA	NA
Low likelihood OR Low severity	NA	NA	NA	NA	NA	NA
Low likelihood AND Low severity	NA	NA	NA	NA	NA	NA
E5: Ecology and environment:						
High likelihood and High severity	NA	NA	NA			
High likelihood and Moderate severity OR Moderate likelihood and High severity	NA	NA	NA			
High likelihood and Low severity	NA	NA	NA	NA	NA	NA
Low likelihood and high severity	NA	NA	NA			
Low likelihood OR Low severity	NA	NA	NA	NA	NA	NA
Low likelihood AND Low severity	NA	NA	NA	NA	NA	NA
E5: Land use and valued/economic resources:						
High likelihood and High severity	NA	NA	NA	NA	NA	NA
High likelihood and Moderate severity OR Moderate likelihood and High severity	NA	NA	NA	NA	NA	NA
High likelihood and Low severity	NA	NA	NA			
Low likelihood and high severity	NA	NA	NA	NA	NA	NA
Low likelihood OR Low severity	NA	NA	NA		NA	
Low likelihood AND Low severity	NA	NA	NA			

Notes:

ROW - right of way

* Do not necessarily adequately address risks associated with the hazard.

(1) Rate based on if/where the environment/land use is present along pipeline ROW.

(2) If environment/land use is present insert applicable rating (i.e., high, moderate, or low). Otherwise, insert "not present along ROW".

(3) The consequence analysis does not consider release of contaminants due to pipeline exposure (and increased risk of puncture) as this hazard has been addressed as Potential Hazard 2a and 2b.

(4) Refer to Tables 3, 4, and 5 of text for definitions of frequency, consequence, and risk estimation ratings.

APPENDIX E

Case Study 2 Risk Assessment Worksheets

PH1 Risk Assessment Worksheet

Hazard No. 1: Soil or groundwater chemical impacts to the environment from former operation of pipeline (i.e., contaminated sites):

Release mechanism:

Historical release of contaminants into the environment during former operation of the pipeline, resulting in concentrations in environmental media (i.e., soil, groundwater, surface water, and/or sediment) above applicable environmental criteria. Common sources of historical contamination include pipeline breaches/spills, and operational areas such as compressor stations, metre

Risk management measures required in accordance with CSA Z662*:	***Met***	***Not met***
10.17 Abandonment of pipeline related facilities Pipeline related facilities such as compressors and pump stations shall have all rotating and fixed equipment removed, unless they are still part of an operating or deactivated site. Associated piping, utilities, supports, and foundations shall also be removed.		
Testing for site soil contamination and appropriate remediation might be required.		
Consideration should be given to the removal of underground vaults and closed-top pits. For those that are to remain:		
a) walls and floors shall be tested for contamination. Contaminated areas shall be remediated or removed.		
b) walls shall be removed to an appropriate level below the ground surface		
c) the insides of the vault shall be filled with clean soil.		
Soils in around and underneath storage tanks shall be inspected for contamination and appropriately remediated.		
Site-specific data/information/ studies required to complete risk estimation:	***Completed***	***Not completed***
1) Phase I Environmental Site Assessment (ESA) (representative of current conditions) to identify potential sources of contamination along the pipeline ROW, prepared by a qualified professional.	***X- No spills identified***	
2) Phase II/III ESA (representative of current conditions) to assess/characterize soil and groundwater contamination associated with potential sources of contamination identified by the Phase I ESA, prepared by a qualified professional		
IF CONTAMINANT CONCENTRATIONS ARE ABOVE APPLICABLE ENVIRONMENTAL CRITERIA:		
3) Human health and ecological risk assessment (representative of current conditions) completed in accordance with Health Canada and Environment Canada Risk Assessment Frameworks, prepared by a qualified professional AND/OR		
4) Remediation reports that provide current concentrations of contaminants in soil and/groundwater on Site, prepared by a qualified professional		

Step I - Complete frequency analysis:

F1: Likelihood[2] that concentrations of contaminants in environmental media (i.e., soil, groundwater, surface water, and/or sediment) are above applicable environmental criteria.		***Insert rating***	***Locations (along ROW) associated with rating***
Scenarios along pipeline:			
F1a: Phase I/II/III ESAs have been completed along the pipeline ROW to identify potential sources of contamination, and assess potential impacts. Concentrations of contaminants of concern are below applicable environmental criteria.	Rate low		
F1b: Phase I/II/III ESAs have been completed along the pipeline ROW to identify potential sources of contamination, and assess potential impacts. Concentrations of contaminants of concern above applicable environmental criteria have been remediated. Associated reports are kept on file.	Rate low		
F1c: Phase I/II/III ESAs have been completed along the pipeline ROW to identify potential sources of contamination, and assess potential impacts. Concentrations of contaminants of concern are above applicable environmental criteria, however based on completion of a human health and ecological risk assessment, risks to receptors are within the acceptable range. Associated reports are kept on file.	Rate low		
F1d: Phase I/II/III ESAs have been completed along the pipeline ROW to identify potential sources of contamination, and assess potential impacts. Concentrations of contaminants of concern are above applicable environmental criteria.	Rate high		

Step II - Complete consequence analysis:

C1: Consequence(s)[2] of concentrations of contaminants in environmental media (soil, groundwater, surface water, sediment) above applicable environmental criteria:			
C1: Human health and safety:		***Insert rating*** [3, 4, 5]	***Locations (along ROW) associated with rating***
Land:	Rate high		
C1a: Contamination[1] within a potable groundwater environment.			
C1b: Contamination[1] of agricultural lands.			
C1c: Contamination of residential, institutional, or park lands.			
C1d: Contamination[1] of lands valued by Indigenous people (for hunting, gathering, other).			
Water crossings:			
C1e: Contamination[1] of surface water used as a source of potable water (e.g., reservoirs, lakes, rivers).			
C1f: Contamination[1] of surface water used for irrigation or livestock watering.			
C1g: Contamination[1] of waterways that support commercial fisheries.			
C1h: Contamination[1] of waterways valued by Indigenous people (for fishing, other).			
C1i: Contamination[1] of waterways used for recreational activities.			
Land:	Rate moderate		
C1j: Soil and/or groundwater contamination[1] in an environment other than those described above with a "high" consequence rating.			
Water crossings:			
C1k: Surface water and/or sediment contamination[1] in and environment other than those described for waterways above with a "high" consequence rating.			
C1: Ecology and environment:		***Insert rating*** [3, 4, 5]	***Locations (along ROW) associated with rating***
Land:	Rate high		
C1l: Contamination[1] of areas that are habitat/breeding/foraging areas for species at risk.			
C1m: Contamination[1] of areas reserved as parks, conservation areas, or other areas of ecological, environmental, or natural significance.			
Water crossings:			
C1n: Contamination[1] of waterways that may constitute a violation of the Fisheries Act.			
C1o: Contamination[1] of significant wetlands.			
C1p: Contamination[1] of waterways that are habitat/spawning/breeding/feeding grounds for species at risk.			
Land:	Rate moderate		
C1q: Soil and/or groundwater contamination[1] in an environment other than those described above with a "high" consequence rating.			
Water crossings:			
C1r: Surface water or sediment contamination[1] in an environment other than those described for waterways above with a "high" consequence rating.			
C1: Land use and valued/economic resources:		***Insert rating*** [3, 4, 5]	***Locations (along ROW) associated with rating***
Land:	Rate high		
C1s: Contamination[1] within a potable groundwater environment.			
C1t: Contamination[1] of agricultural lands.			
C1u: Contamination[1] of lands valued by Indigenous people (for hunting, gathering, other).			
C1v: Contamination[1] of areas reserved as parks, conservation areas, or other areas of ecological, environmental, or natural significance.			
C1w: Contamination[1] of forested lands.			
Water crossings:			
C1x: Contamination[1] of surface water used as a source of potable water (e.g., reservoirs, lakes, rivers).			
C1y: Contamination[1] of surface water used for irrigation or livestock watering.			
C1z: Contamination[1] of waterways that support commercial fisheries.			
C1aa: Contamination[1] of waterways valued by Indigenous people (for fishing, other).			
C1bb: Contamination[1] of waterways used for recreational activities.			
Land:	Rate moderate		
C1cc: Soil and/or groundwater contamination[1] in an environment other than those described above with a "high" consequence rating.			
Water crossings:			
C1dd: Surface water or sediment contamination[1] in and environment other than those described for waterways above with a "high" consequence rating.			

Step III - Complete risk estimation:

E1: Estimation of risk[2] associated with concentrations of contaminants in environmental media (soil, groundwater, surface water, sediment) above applicable environmental criteria:		**On Land**		**At Water crossings**		
E1: Human health and safety:	**Frequency No.**	**Consequence No.**	**Locations**	**Frequency No.**	**Consequence No.**	**Locations**
High likelihood and High severity						
High likelihood and Moderate severity OR Moderate likelihood and High severity						
High likelihood and Low severity	NA	NA	NA	NA	NA	NA
Low likelihood and high severity						
Low likelihood OR Low severity						
Low likelihood AND Low severity	NA	NA	NA	NA	NA	NA
E1: Ecology and environment:						
High likelihood and High severity						
High likelihood and Moderate severity OR Moderate likelihood and High severity						
High likelihood and Low severity	NA	NA	NA	NA	NA	NA
Low likelihood and high severity						
Low likelihood OR Low severity						
Low likelihood AND Low severity	NA	NA	NA	NA	NA	NA
E1: Land use and valued/economic resources:						
High likelihood and High severity						
High likelihood and Moderate severity OR Moderate likelihood and High severity						
High likelihood and Low severity	NA	NA	NA	NA	NA	NA
Low likelihood and high severity						
Low likelihood OR Low severity						
Low likelihood AND Low severity	NA	NA	NA	NA	NA	NA

Notes:

ROW - pipeline right of way

NORM - naturally occurring radioactive materials

* Do not necessarily adequately address risks associated with the hazard.

(1) contamination - concentrations above applicable environmental criteria, or concentrations above property-specific criteria derived by a human and ecological risk assessment

(2) Refer to Tables 3, 4, and 5 of text for definitions of frequency, consequence, and risk estimation ratings.

(3) Rate based on if/where the environment/land use is present along pipeline ROW. Both current and future land use should be considered.

(4) If environment/land use is present insert applicable rating (i.e., high, moderate, or low). Otherwise, insert "not present along ROW or not applicable".

(5) There is no environment/land use on which a "low" consequence rating is applicable. Contamination[1] of any media is considered to have at least a moderate consequence rating.

PH2a Risk Assessment Worksheet

Hazard No. 2: Environmental impacts from pipeline materials abandoned in-place, post operation

Hazard No. 2a: Residual product, lubricants, and treatment chemicals

Release mechanism:

Contaminants are present within the pipeline at concentrations that could result in an adverse effect AND the pipeline structure is breached (from puncture or corrosion) to allow water in and transport of contaminants out of the pipeline into the surrounding environment[2] and/or preferential transport of contaminants within the pipeline.

Risk management measures required in accordance with CSA Z662*:	***Met***	***Not met***
10.16 Abandonment of pipelines and pipe-type storage vessels		
A buried pipeline that is abandoned in place shall be:		
a) emptied of service fluids;	X	
b) purged or appropriately cleaned or both in a manner that leaves no mobile materials remaining in the pipeline.	X	
c) physically separated from any in-service piping;	X	
d) capped, plugged, or otherwise effectively sealed; and,	X	
e) cut off at pipeline depth.	X	
Site-specific data/information/ studies required to complete risk estimation:	***Completed***	***Not completed***
1. Identification of residual contaminants present within the pipeline prior to pigging/cleaning, including determination of whether PCBs or NORMs were ever present within the pipeline.	***X Residual PHCs identified***	
2. Pipeline-specific purging/pigging/cleaning methodology, including targets and objectives, associated verification procedures, and results, prepared by a qualified professional.	***X Residual impacts removed following standard procedures***	

Step I - Complete frequency analysis:

F2a: Likelihood[3] that contaminants are present within the pipeline (at concentrations that could result in an adverse effect) and be transported out of the pipeline into the surrounding environment[2] and/or preferentially transported within the pipeline[4]:		***Insert rating***	***Locations (along ROW) associated with rating***
Scenarios along pipeline:			
F2a a: Pigging/cleaning targets were developed in consideration of the hydrocarbon product, lubricants, and treatment chemicals specific to the pipeline to be abandoned, required risk management measures (as per Section 10.16 of CSA Z662), current and intended land use, and applicable guidelines and standards (if any) AND have been met (based on results of verification procedures). No solids or waxy buildup is visible. Neither PCBs nor NORMs were ever present within the pipeline[5].	Rate low		
F2a b: Pigging/cleaning targets were developed in consideration of the hydrocarbon product, lubricants, and treatment chemicals specific to the pipeline to be abandoned, legislated risk management measures (as per Section 10.16 of CSA Z662), current and intended land use, and applicable guidelines and standards (if any) AND have been met (based on results of verification procedures). No solids or waxy buildup is visible. PCBs and/or NORMs were once present within the pipeline[5].	Rate moderate		Entire pipe segment
F2a c: Pigging/cleaning of pipeline was completed but targets may not have been developed in consideration of the hydrocarbon product, lubricants, and treatment chemicals specific to the pipeline to be abandoned, legislated risk management measures (as per Section 10.16 of CSA Z662), current and intended land use, and applicable guidelines and standards (if any) AND/OR targets may not have been met. Neither PCBs nor NORMs were ever present within the pipeline[5].	Rate moderate	F2a c	
F2a d: Pigging/cleaning of pipeline was completed but targets may not have been developed in consideration of the hydrocarbon product, lubricants, and treatment chemicals specific to the pipeline to be abandoned, legislated risk management measures (as per Section 10.16 of CSA Z662), current and intended land use, and applicable guidelines and standards (if any) AND/OR targets may not have been met. PCBs and/or NORMs were once present within the pipeline[5].	Rate high		

Step II - Complete consequence analysis:

C2a: Consequence(s)[3] of contaminants present within the pipeline (at concentrations that could result in an adverse effect) transported out of the pipeline into the surrounding environment[2] and/or preferentially transported within the pipeline:			
C2a: Human health and safety:		***Insert rating*** [6, 7, 8]	***Locations (along ROW) associated with rating***
Land:	Rate high		
C2a a: Contamination[1] within a potable groundwater environment.		High C2a a	
C2a b: Contamination[1] of agricultural lands.		High C2a b	
C2a c: Contamination of residential, institutional, or park lands.			
C2a d: Contamination[1] of lands valued by Indigenous people (for hunting, gathering, other).			
Water crossings:			
C2a e: Contamination[1] of surface water used as a source of potable water (e.g., reservoirs, lakes, rivers).		High C2a e	
C2a f: Contamination[1] of surface water used for irrigation or livestock watering.			
C2a g: Contamination[1] of waterways that support commercial fisheries.			
C2a h: Contamination[1] of waterways valued by Indigenous people (for fishing, other).			
C2a i: Contamination[1] of waterways used for recreational activities.		High C2a i	
Land:	Rate moderate		
C2a j: Soil and/or groundwater contamination[1] in an environment other than those described above with a "high" consequence rating.			
Water crossings:			
C2a k: Surface water and/or sediment contamination[1] in and environment other than those described for waterways above with a "high" consequence rating.			
C2a: Ecology and environment:		***Insert rating*** [6, 7, 8]	***Locations (along ROW) associated with rating***
Land:	Rate high		
C2a l: Contamination[1] of areas that are habitat/breeding/foraging areas for species at risk.		C2a l	
C2a m: Contamination[1] of areas reserved as parks, conservation areas, or other areas of ecological, environmental, or natural significance.			
Water crossings:			
C2a n: Contamination[1] of waterways that may constitute a violation of the Fisheries Act.			
C2a o: Contamination[1] of significant wetlands.		C2a o	
C2a p: Contamination[1] of waterways that are habitat/spawning/breeding/feeding grounds for species at risk.		C2a p	
Land:	Rate moderate		
C2a q: Soil and/or groundwater contamination[1] in an environment other than those described above with a "high" consequence rating.			
Water crossings:			
C2a r: Surface water or sediment contamination[1] in an environment other than those described for waterways above with a "high" consequence rating.			
C2a: Land use and valued/economic resources:		***Insert rating*** [6, 7, 8]	***Locations (along ROW) associated with rating***
Land:	Rate high		
C2a s: Contamination[1] within a potable groundwater environment.		High C2a s	
C2a t: Contamination[1] of agricultural lands.		High C2a t	
C2a u: Contamination[1] of lands valued by Indigenous people (for hunting, gathering, other).			
C2a v: Contamination[1] of areas reserved as parks, conservation areas, or other areas of ecological, environmental, or natural significance.			
C2a w: Contamination[1] of forested lands.			
Water crossings:			
C2a x: Contamination[1] of surface water used as a source of potable water (e.g., reservoirs, lakes, rivers).		High C2a x	
C2a y: Contamination[1] of surface water used for irrigation or livestock watering.			
C2a z: Contamination[1] of waterways that support commercial fisheries.			
C2a aa: Contamination[1] of waterways valued by Indigenous people (for fishing, other).			
C2a bb: Contamination[1] of waterways used for recreational activities.		High C2a bb	
Land:	Rate moderate		
C2a cc: Soil and/or groundwater contamination[1] in an environment other than those described above with a "high" consequence rating.			
Water crossings:			
C2a dd: Surface water or sediment contamination[1] in and environment other than those described for waterways above with a "high" consequence rating.			

Step III - Complete risk estimation:

E2: Estimation of risk[3] associated with contaminants present within the pipeline (at concentrations that could result in an adverse effect) transported out of the pipeline into the surrounding environment[2] and/or preferentially transported within the pipeline:	**On Land**			**At Water Crossings**		
E2: Human health and safety:	**Frequency No.**	**Consequence No.**	**Locations**	**Frequency No.**	**Consequence No.**	**Locations**
High likelihood and High severity						
High likelihood and Moderate severity OR Moderate likelihood and High severity	F2a c Moderate	C2 aa, C2 ab High		F2 ab Moderate	C2 ae, C2 ai High	
High likelihood and Low severity	NA	NA	NA	NA	NA	NA
Low likelihood and high severity						
Low likelihood OR Low severity						
Low likelihood AND Low severity	NA	NA	NA	NA	NA	NA
E2: Ecology and environment:						
High likelihood and High severity						
High likelihood and Moderate severity OR Moderate likelihood and High severity	F2a c Moderate	C2a l High		F2 ab Moderate	C2 ao High, C2a p	
High likelihood and Low severity	NA	NA	NA	NA	NA	NA
Low likelihood and high severity						
Low likelihood OR Low severity						
Low likelihood AND Low severity	NA	NA	NA	NA	NA	NA
E2: Land use and valued/economic resources:						
High likelihood and High severity						
High likelihood and Moderate severity OR Moderate likelihood and High severity	F2 ab Moderate	C2 as, C2 at High		F2 ab Moderate	C2 ax, 2c abb High	
High likelihood and Low severity	NA	NA	NA	NA	NA	NA
Low likelihood and high severity						
Low likelihood OR Low severity						
Low likelihood AND Low severity	NA	NA	NA	NA	NA	NA

Notes:

ROW - pipeline right of way

PCB - polychlorinated biphenyl

NORM - naturally occurring radioactive materials

* Do not necessarily adequately address risks associated with the hazard.

(1) contamination - concentrations above applicable environmental criteria, or concentrations above property-specific criteria derived by a human and ecological risk assessment

(2) Soil, groundwater, surface water, and/or sediment.

(3) Refer to Tables 3, 4, and 5 of text for definitions of frequency, consequence, and risk estimation ratings.

(4) The frequency analysis does not consider the likelihood for the pipeline to be breached, as it is assumed that breach of the pipeline will eventually occur.

(5) Even with effective pigging, PCBs and NORMs have been identified as remaining in a limited number of gas transmission lines. These contaminants have a relatively high toxicity, and PCBs may bioaccumulate in the food chain.

(6) Rate based on if/where the environment/land use is present along pipeline ROW. Both current and future land use should be considered.

(7) If environment/land use is present insert applicable rating (i.e., high, moderate, or low). Otherwise, insert "not present along ROW".

(8) There is no environment/land use on which a "low" consequence rating is applicable. Contamination[1] of any media is considered to have at least a moderate consequence rating.

PH2b Risk Assessment Worksheet

Hazard No. 2: Environmental impacts from pipeline materials abandoned in-place, post operation

Hazard No. 2b: Leaching from construction materials and coatings

Release mechanism:

Contaminants leach from pipeline construction materials and/or external coatings at concentrations that could result in an adverse effect into the surrounding environment [2]. The pipeline structure may be breached (from puncture or corrosion) to allow water and transport of contaminants into the pipeline and preferential transport of contaminants within it.

Risk management measures required in accordance with CSA Z662 [4] *:		***Met***	***Not met***
10.16 Abandonment of pipelines and pipe-type storage vessels			
A buried pipeline that is abandoned in place shall be:			
d) capped, plugged, or otherwise effectively sealed; and,			
e) cut off at pipeline depth.			
Site-specific data/information/ studies required to complete risk estimation:		***Completed***	***Not completed***
1. Characterization of pipeline construction materials and external coatings.		*X*	
2. Characterization of contaminants and associated concentrations expected to leach from pipeline construction materials and/or external coatings over time, compared to applicable environmental criteria, completed by a qualified professional.			
Step I - Complete frequency analysis:			
F2b: Likelihood[3] that contaminants will leach from pipeline construction materials and/or external coatings at concentrations that could result in an adverse effect:		***Insert rating***	***Locations (along ROW) associated with rating***
Scenarios along pipeline:			
F2b a: Pipeline construction materials and external coatings are inert and not expected to leach contaminants, neither in the short nor long term.	Rate low	F2b a Low	
F2b b: Pipeline construction materials are expected to leach contaminants, either in the short or long term, at concentrations below applicable environmental criteria in consideration of land use.	Rate moderate		
F2b c: Pipeline construction materials are expected to leach contaminants, either in the short or long term, at concentrations above applicable environmental criteria in consideration of land use.	Rate high		
Step II - Complete consequence analysis:			
C2b: Consequence(s)[3] of contaminants leaching from pipeline construction materials and/or external coatings at concentrations that could result in an adverse effect:			
C2b: Human health and safety:		***Insert rating*** [5, 6, 7]	***Locations (along ROW) associated with rating***
Land:			
C2b a: Contamination[1] within a potable groundwater environment.		C2b a High	
C2b b: Contamination[1] of agricultural lands.		C2b b High	
C2b c: Contamination of residential, institutional, or park lands.			
C2b d: Contamination[1] of lands valued by Indigenous people (for hunting, gathering, other).			
Water crossings:	Rate high		
C2b e: Contamination[1] of surface water used as a source of potable water (e.g., reservoirs, lakes, rivers).		C2b e High	
C2b f: Contamination[1] of surface water used for irrigation or livestock watering.			
C2b g: Contamination[1] of waterways that support commercial fisheries.			
C2b h: Contamination[1] of waterways valued by Indigenous people (for fishing, other).			
C2b i: Contamination[1] of waterways used for recreational activities.		C2b i High	
Land:			
C2b j: Soil and/or groundwater contamination[1] in an environment other than those described above with a "high" consequence rating.	Rate moderate		
Water crossings:			
C2b k: Surface water and/or sediment contamination[1] in and environment other than those described for waterways above with a "high" consequence rating.			
C2b: Ecology and environment:		***Insert rating*** [5, 6, 7]	***Locations (along ROW) associated with rating***
Land:			
C2b l: Contamination[1] of areas that are habitat/breeding/foraging areas for species at risk.		C2b l High	
C2b m: Contamination[1] of areas reserved as parks, conservation areas, or other areas of ecological, environmental, or natural significance.			
Water crossings:	Rate high		
C2b n: Contamination[1] of waterways that may constitute a violation of the Fisheries Act.			
C2b o: Contamination[1] of significant wetlands.		C2b o High	
C2b p: Contamination[1] of waterways that are habitat/spawning/breeding/feeding grounds for species at risk.		C2b p High	
Land:			
C2b q: Soil and/or groundwater contamination[1] in an environment other than those described above with a "high" consequence rating.	Rate moderate		
Water crossings:			
C2b r: Surface water or sediment contamination[1] in an environment other than those described for waterways above with a "high" consequence rating.			
C2b: Land use and valued/economic resources:		***Insert rating*** [5, 6, 7]	***Locations (along ROW) associated with rating***
Land:			
C2b s: Contamination[1] within a potable groundwater environment.		C2b s High	
C2b t: Contamination[1] of agricultural lands.		C2b t High	
C2b u: Contamination[1] of lands valued by Indigenous people (for hunting, gathering, other).			
C2b v: Contamination[1] of areas reserved as parks, conservation areas, or other areas of ecological, environmental, or natural significance.		C2b v High	
C2b w: Contamination[1] of forested lands.	Rate high		
Water crossings:			
C2b x: Contamination[1] of surface water used as a source of potable water (e.g., reservoirs, lakes, rivers).		C2b x High	
C2b y: Contamination[1] of surface water used for irrigation or livestock watering.			
C2b z: Contamination[1] of waterways that support commercial fisheries.			
C2b aa: Contamination[1] of waterways valued by Indigenous people (for fishing, other).			
C2b bb: Contamination[1] of waterways used for recreational activities.		C2b bb High	
Land:			
C2b cc: Soil and/or groundwater contamination[1] in an environment other than those described above with a "high" consequence rating.	Rate moderate		
Water crossings:			
C2b dd: Surface water or sediment contamination[1] in and environment other than those described for waterways above with a "high" consequence rating.			

Step III - Complete risk estimation:	**On Land**			**At Water crossings**		
E2b: Estimation of risk[3] associated with contaminants leaching from pipeline construction materials and/or external coatings at concentrations that could result in an adverse effect:						
E2b: Human health and safety:	**Frequency No.**	**Consequence No.**	**Locations**	**Frequency No.**	**Consequence No.**	**Locations**
High likelihood and High severity						
High likelihood and Moderate severity OR Moderate likelihood and High severity						
High likelihood and Low severity	NA	NA	NA	NA	NA	NA
Low likelihood and high severity	F2b a Low	C2b a; 2Cb b High		F2b a Low	C2b e; C2b i High	
Low likelihood OR Low severity						
Low likelihood AND Low severity	NA	NA	NA	NA	NA	NA
E2b: Ecology and environment:						
High likelihood and High severity						
High likelihood and Moderate severity OR Moderate likelihood and High severity						
High likelihood and Low severity	NA	NA	NA	NA	NA	NA
Low likelihood and high severity	F2b a Low	C2b l High		F2b a Low	C2b o, p High	
Low likelihood OR Low severity						
Low likelihood AND Low severity	NA	NA	NA	NA	NA	NA
E2b: Land use and valued/economic resources:						
High likelihood and High severity						
High likelihood and Moderate severity OR Moderate likelihood and High severity						
High likelihood and Low severity	NA	NA	NA	NA	NA	NA
Low likelihood and high severity	F2b a Low	C2b s, t, v High		F2b a Low	C2b x; bb High	
Low likelihood OR Low severity						
Low likelihood AND Low severity	NA	NA	NA	NA	NA	NA

Notes:
ROW - pipeline right of way
PCB - polychlorinated biphenyl
NORM - naturally occurring radioactive materials
* Do not necessarily adequately address risks associated with the hazard.
(1) contamination - concentrations above applicable environmental criteria, or concentrations above property-specific criteria derived by a human and ecological risk assessment
(2) Soil, groundwater, surface water, and/or sediment.
(3) Refer to Tables 3, 4, and 5 of text for definitions of frequency, consequence, and risk estimation ratings.
(4) These risk management measures may address preferential transport of contaminants within the pipeline, but do not address leaching of contaminants into the surrounding environment.
(5) Rate based on if/where the environment/land use is present along pipeline ROW. Both current and future land use should be considered.
(6) If environment/land use is present insert applicable rating (i.e., high, moderate, or low). Otherwise, insert "not present along ROW".
(7) There is no environment/land use on which a "low" consequence rating is applicable. Contamination[1] of any media is considered to have at least a moderate consequence rating.

PH2c Risk Assessment Worksheet

Hazard No. 2: Environmental impacts from pipeline materials abandoned in-place, post operation

Hazard No. 2c: Presence and exposure and disruption of asbestos

Release mechanism:

Asbestos is present in pipeline external coatings AND is exposed and disturbed (as a result of construction/maintenance/excavation activities, soil erosion, frost heave, or other geotechnical hazards) allowing for potential contact with human receptors [1] involved with pipeline excavation/repair activities [2].

Risk management measures required in accordance with CSA Z662*:

None

Site-specific data/information/ studies required to complete risk estimation:		***Completed***	***Not completed***
1. Characterization of pipeline external coatings, and identification of those containing asbestos, by a qualified professional.			
Step I - Complete frequency analysis[7]:			
F2c: Likelihood[3] that asbestos is present in pipeline external coatings and will be exposed and disturbed allowing for potential contact with human receptors[1] involved with pipeline excavation/repair activities[2].		***Insert rating***	***Locations (along pipeline) associated with rating***
Scenarios along pipeline:			
F2c a: Asbestos is not present in pipeline external coatings.	Rate low	F2c a Low	
F2c b: Asbestos is present in pipeline external coatings.	Rate high		
Step II - Complete consequence analysis[7]:			
C2c: Consequence(s) of asbestos in pipeline external coatings being exposed and disturbed allowing for potential contact with human receptors[1] involved with pipeline excavation/repair activities[2].			
C2c: Human health and safety:		***Insert rating*** [5,6]	***Locations (along pipeline) associated with rating***
C2c a: Incidents of asbestosis[4].	Rate high	Low	
C2c: Ecology and environment:		***Insert rating***	***Locations (along pipeline) associated with rating***
Not applicable	NA	NA	NA
C2c: Land use and valued/economic resources:		***Insert rating***	***Locations (along pipeline) associated with rating***
Not applicable	NA	NA	NA
Step III - Complete risk estimation:			
E2c: Estimation of risk[7] associated with asbestos in pipeline external coatings being exposed and disturbed allowing for potential contact with human receptors(1) involved with pipeline excavation/repair activities(2):	**On Land**		
E2c: Human health and safety:	**Frequency No.**	**Consequence No.**	**Locations**
High likelihood and High severity			
High likelihood and Moderate severity OR Moderate likelihood and High severity	NA	NA	NA
High likelihood and Low severity	NA	NA	NA
Low likelihood and high severity	NA	NA	NA
Low likelihood OR Low severity	F2c a Low	C2 c a Low	
Low likelihood AND Low severity	NA	NA	NA
E2c: Ecology and environment:			
Not applicable	NA	NA	NA
E2c: Land use and valued/economic resources:			
Not applicable	NA	NA	NA

Notes:

ROW - right of way

* Do not necessarily adequately address risks associated with the hazard.

(1) Exposure of ecological receptors is considered to be minimal, as asbestos in pipeline external coatings is not expected to be mobile in the environment or available for uptake by ecological receptors. Ecological receptors are not expected to directly contact exposed pipeline in a manner that would result in significant exposure, and pipeline external coatings do not provide and are not intermixed with food items or exposure media for

(2) It is assumed that exposed sections of pipeline (containing asbestos) would be re-covered or removed and disposed of (in accordance with applicable guidelines and regulations) by adult maintenance workers in a timely manner so to prevent exposure to other human receptors (e.g., children, visitors, trespassers, farmers, or other workers).

(3) The frequency analysis does not consider the likelihood for asbestos to be exposed and disturbed at various locations along the pipeline, as it is assumed that excavation/maintenance activities that may result in exposure and disturbance could occur anywhere along it.

(4) A chronic (long-term) lung disease caused by breathing in asbestos fibers

(5) Rate based on if/where asbestos is present along pipeline. If asbestos is present insert applicable rating (i.e., high). Otherwise, insert "asbestos not present along pipeline".

(6) There are no consequences considered to have either a "low" or "moderate" rating.

(7) Refer to Tables 3, 4, and 5 of text for definitions of frequency, consequence, and risk estimation ratings.

PH3 Risk Assessment Worksheet

Hazard No. 3: Drainage of surface water or shallow groundwater through pipeline

Release mechanism:

Surface water or shallow groundwater is proximal (and hydraulically connected) to pipeline AND the pipeline structure is breached (from puncture or corrosion) to allow water into (and out of) and flow through the pipeline, resulting in drainage of surface water or groundwater, preferential flow and discharge elsewhere.

Risk management measures required in accordance with CSA Z662*:

None

Site-specific data/information/ studies required to complete risk estimation:	***Completed***	***Not completed***
1) Identification of surface water bodies along pipeline ROW.	***X***	
2) Identification of locations where pipeline (and/or fill materials surrounding pipeline) may be in contact with groundwater.	***X***	
3) Where pipeline is within 100 metres of surface water body (including: lakes, rivers, creeks, marshes, wetlands, muskegs, sloughs, reservoirs), site specific drainage study to determine if pipeline (and/or fill materials surrounding pipeline) are hydraulically connected	X	

Step I - Complete frequency analysis:

F3: Likelihood[1] of drainage of surface water or shallow groundwater through the pipeline[2]:		***Insert rating***	***Locations (along ROW) associated with rating***
Scenarios along pipeline:			
F3a: Pipeline located more than 100 metres from nearest surface water body (including: lakes, rivers, creeks, marshes, wetlands, muskegs, sloughs, reservoirs), OR based on site-specific drainage study is not hydraulically connected to the nearest surface water body.	Rate low		
F3b: Pipeline located where it is not likely to be in contact with groundwater.	Rate low		
F3c: Pipeline located between 30 and 100 metres from nearest surface water body.	Rate moderate		
F3d: Pipeline located within 30 metres of a surface water body (including: lakes, rivers, creeks, marshes, wetlands, muskegs, sloughs, reservoirs).	Rate high	F3d High	
F3e: Pipeline located within a flood plain or area prone to flooding.	Rate high		
F3f: Pipeline located where it may be in contact with groundwater.	Rate high		

Step II - Complete consequence analysis:

C3: Consequence(s)[1] of drainage of surface water or shallow groundwater through the pipeline:			
C3: Human health and safety:		***Insert rating*** [3, 4]	***Locations (along ROW) associated with rating***
Not applicable.		NA	NA
C3: Ecology and environment:		***Insert rating*** [3, 4]	***Locations (along ROW) associated with rating***
Land:	Rate high		
C3a: Flooding of habitat/breeding/foraging areas for species at risk (including individuals).		C3a High	
C3b: Flooding of areas reserved as parks, conservation areas, or other areas of ecological, environmental, or natural significance.			
Water crossings:			
C3c: Drainage of surface water that may constitute a violation of the Fisheries Act.			
C3d: Drainage of significant wetlands.		C3d High	
C3e: Drainage of surface water that is habitat/spawning/breeding/feeding grounds for species at risk.		C3e High	
C3f: Discharge to surface water and/or siltation that may constitute a violation of the Fisheries Act.			
C3g: Discharge to, and siltation of, surface water that is habitat/spawning/breeding/feeding grounds for species at risk.		C3g High	
Land:	Rate moderate		
C3h: Flooding of habitat/breeding/foraging areas for populations/communities of non-species at risk.			
Water crossings:			
C3i: Drainage of surface water other than that described for water crossings above with a "high" consequence rating.			
C3j: Discharge to, and siltation of, surface water other than that described for water crossings above with a "high" consequence rating.			
Land:	Rate low		
C3k: Flooding of an area that does not provide habitat/breeding/foraging areas for communities/populations of non-species at risk or for individual species at risk.			
Water crossings:			
Not applicable[5]		NA	NA
C3: Land use and valued/economic resources:		***Insert rating*** [3, 4]	***Locations (along ROW) associated with rating***
Land:	Rate high		
C3l: Drainage of groundwater used as a source of potable water.		C3l Hgh	
C3m: Drainage of groundwater used for irrigation or livestock watering.			
C3n: Flooding of agricultural lands.		C3n High	
C3o: Flooding of lands valued by Indigenous people (for hunting, gathering, other).			
C3p: Flooding of areas reserved as parks, conservation areas, or other areas of ecological, environmental, or natural significance.		C3p High	
C3q: Flooding of forested lands.			
C3r: Flooding of urban/municipal/residential/commercial/industrial areas.			
Water crossings:			
C3s: Drainage of surface water used as a source of potable water (e.g., reservoirs, lakes, rivers).		C3s High	
C3t: Drainage of surface water used for irrigation.			
C3u: Drainage of surface water that supports commercial fisheries.			
C3v: Drainage of surface water valued by Indigenous people (for fishing, other).			
C3w: Drainage of surface water used for recreational activities.		C3 w High	
C3x: Discharge to, and siltation of, surface water that supports commercial fisheries.			
C3y: Discharge to, and siltation of, surface water valued by Indigenous people (for fishing, other).			
C3z: Discharge to, and siltation of, surface water used for recreational activities.			
Land:	Rate moderate		
C3aa: Flooding of lands located on low-lying land other than those described above with a "high" consequence rating.			
Water crossings:			
Not applicable		NA	NA
Land:	Rate low		
Not applicable[6]		NA	NA
Water crossings:			
C3bb: Drainage of surface water other than that described for water crossings above with a "high" consequence rating.			

Step III - Complete risk estimation:

E3: Estimation of risk[2] associated with drainage of surface water or shallow groundwater through the pipeline:	**On Land**			**At Water crossings**		
E3: Human health and safety:	**Frequency No.**	**Consequence No.**	**Locations**	**Frequency No.**	**Consequence No.**	**Locations**
Not applicable	NA	NA	NA	NA	NA	NA
E3: Ecology and environment:						
High likelihood and High severity						
High likelihood and Moderate severity OR Moderate likelihood and High severity	F3d High	C3a high		F3d High	C3 d, e g High	
High likelihood and Low severity				NA	NA	NA
Low likelihood and high severity						
Low likelihood OR Low severity						
Low likelihood AND Low severity				NA	NA	NA
E3: Land use and valued/economic resources:						
High likelihood and High severity	F3d High	C3l,n high		F3d High	C3 p, s, w High	
High likelihood and Moderate severity OR Moderate likelihood and High severity						
High likelihood and Low severity	NA	NA	NA			
Low likelihood and high severity				NA	NA	NA
Low likelihood OR Low severity						
Low likelihood AND Low severity	NA	NA	NA			

Notes:

ROW - pipeline right of way

* Do not necessarily adequately address risks associated with the hazard.

(1) Refer to Tables 3, 4, and 5 of text for definitions of frequency, consequence, and risk estimation ratings.

(2) The frequency analysis does not consider the likelihood for the pipeline to be breached, as it is assumed that breach of the pipeline will eventually occur.

(3) Rate based on if/where the environment/land use is present along pipeline ROW.

(4) If environment/land use is present insert applicable rating (i.e., high, moderate, or low). Otherwise, insert "not present along ROW".

(5) Drainage of any surface water body is considered to have at least a moderate consequence rating.

(6) Flooding of any lands is considered to have at least a moderate consequence rating.

PH4 Risk Assessment Worksheet

Hazard No. 4: Ground subsidence beyond tolerable range (for land use)

Release mechanism:

Pitting and structural deterioration of pipeline (and reduced load carrying capacity of the pipe) due to corrosion[1] , resulting in the creation of voids in the subsurface and eventual collapse of ground into voids. The tolerable range of subsidence is dependent on land use. For most land uses[2] , pipeline diameter is the main factor in determining whether subsidence will be within the tolerable range. Subsidence

Risk management measures required in accordance with CSA Z662*:

None

Site-specific data/information/ studies required to complete risk estimation:	***Completed***	***Not completed***
1. Pipeline diameter.	X	
2. Identification of rail, road, and underground utility crossings, or agricultural or other lands on which heavy vehicular loadings are expected[2] along the ROW.	X	
3. For pipelines with a diameter greater than 323.9 millimeters[7] (other than at crossings and where heavy vehicular loadings are expected as described in 2 above[2]), site-specific analysis to evaluate the degree of subsidence expected, and whether it is within the tolerable range in	X	

Step I - Complete frequency analysis:

F4: Likelihood[6] of ground subsidence beyond the tolerable range (for land use):		***Insert rating***	***Locations (along ROW) associated with rating***
Scenarios along pipeline:			
F4a: Pipeline has a diameter of 323.9 millimetres or less, at locations other than: road, rail, or underground utility crossings, or agricultural or other lands on which heavy vehicular loadings are expected[2].	Rate low		
F4b: Pipeline has a diameter of greater than 323.9 millimetres, and results of a site-specific analysis indicate that the expected degree of subsidence is within the tolerable range in consideration of land use. [At locations other than road, rail, and underground utility crossings, or agricultural or other lands on which heavy vehicular loadings are expected.[2]]	Rate low		
F4c: Pipeline has a diameter of greater than 323.9 millimetres, and results of a site-specific analysis indicate that the expected degree of subsidence above the tolerable range in consideration of land use. [At locations other than road, rail, and underground utility crossings, or agricultural or other lands on which heavy vehicular loadings are expected.(2)]	Rate moderate		
F4d: Pipeline of any diameter, located at: road crossings, rail crossings, underground utility crossings, or agricultural or other lands on which heavy vehicular loadings are expected[2].	Rate high	F4d High	

Step II - Complete consequence analysis:

C4: Consequence[6] of ground subsidence beyond the tolerable range (for land use):			
C4: Human health and safety:		***Insert rating*** [4, 5]	***Locations (along ROW) associated with rating***
On land:	Rate high		
C4a: Train derailments at rail crossings, vehicle accidents at road crossings, or accidents resulting from damage to underground service utilities at utility crossings.			
C4b: Heavy vehicle accidents on agricultural lands or other lands on which heavy vehicular loadings are expected.		C4b High	
At water crossings:			
Not applicable.			
C4: Ecology and environment:		***Insert rating*** [4, 5]	***Locations (along ROW) associated with rating***
On land:	Rate high		
C4c: Derailments at rail crossings, vehicle accidents at road crossings, or accidents resulting from damage to underground service utilities at utility crossings located in areas that are habitat/breeding/foraging areas for species at risk.		C4 c High	
C4d: Derailments at rail crossings, vehicle accidents at road crossings, or accidents resulting from damage to underground service utilities at utility crossings located in areas reserved as parks, conservation areas, or other areas of ecological, environmental, or natural significance.			
At water crossings:			
C4e: Discharge to surface water and/or siltation that may constitute a violation of the Fisheries Act.			
C4f: Discharge to, and siltation of, surface water that is habitat/spawning/breeding/feeding grounds for species at risk.		C4 f High	
On land:	Rate moderate		
C4g: Derailments at rail crossings, vehicle accidents at road crossings, or accidents resulting from damage to underground service utilities at utility crossings located in areas that are habitat/breeding/foraging areas for populations/communities of non-species at risk.			
At water crossings:			
C4h: Discharge to, and siltation of, surface water other than that described for water crossings above with a "high" consequence rating.			
On land:	Rate low		
C4i: Derailments at rail crossings, vehicle accidents at road crossings, or accidents resulting from damage to underground service utilities at utility crossings located in areas that do not provide habitat/breeding/foraging areas for communities/populations of non-species at risk or for individual species at risk.			
At water crossings:			
Not applicable.			
C4: Land use and valued/economic resources:		***Insert rating*** [4, 5]	***Locations (along ROW) associated with rating***
On land:	Rate high		
C4j: Train derailments at rail crossings, vehicle accidents at road crossings, or accidents resulting from damage to underground service utilities at utility crossings.		C4j High	
C4k: Heavy vehicle accidents on agricultural lands or other lands on which heavy vehicular loadings are expected.		C4k High	
C4l: Erosion/loss of topsoil on agricultural lands.		C4l High	
At water crossings:			
C4m: Discharge to, and siltation of, surface water that supports commercial fisheries.			
C4n: Discharge to, and siltation of, surface water valued by Indigenous people (for fishing, other).			
C4o: Discharge to, and siltation of, surface water used for recreational activities.		C4o High	

Step III - Complete risk estimation:

E4: Estimation of risk[6] associated with ground subsidence outside of the tolerable range (for land use):	**On Land**			**At Water crossings**		
E4: Human health and safety:	**Frequency No.**	**Consequence No.**	**Locations**	**Frequency No.**	**Consequence No.**	**Locations**
High likelihood and High severity	F4d High	C4 b High		NA	NA	NA
High likelihood and Moderate severity OR Moderate likelihood and High severity				NA	NA	NA
High likelihood and Low severity	NA	NA	NA	NA	NA	NA
Low likelihood and high severity	NA	NA	NA	NA	NA	NA
Low likelihood OR Low severity				NA	NA	NA
Low likelihood AND Low severity	NA	NA	NA	NA	NA	NA
E4: Ecology and environment:						
High likelihood and High severity	F4d High	C4 c High		F4d High	C4f High	
High likelihood and Moderate severity OR Moderate likelihood and High severity						
High likelihood and Low severity						
Low likelihood and high severity						
Low likelihood OR Low severity						
Low likelihood AND Low severity				NA	NA	NA
E4: Land use and valued/economic resources:						
High likelihood and High severity	F4d High	C4j k, l High		F4d High	C4o High	
High likelihood and Moderate severity OR Moderate likelihood and High severity						
High likelihood and Low severity	NA	NA	NA	NA	NA	NA
Low likelihood and high severity	NA	NA	NA	NA	NA	NA
Low likelihood OR Low severity						
Low likelihood AND Low severity	NA	NA	NA	NA	NA	NA

Notes:

ROW - right of way

* Do not necessarily adequately address risks associated with the hazard.

(1) Pipeline degradation processes other than corrosion for pipelines constructed of materials other than metal not considered.

(2) Tolerable range is zero at: road crossings, rail crossings, underground utility crossings, and agricultural or other lands on which heavy vehicular loadings are expected.

(3) Enhanced corrosion of pipelines abandoned without cathodic protection may occur at powerline crossings.

(4) Rate based on if/where the environment/land use is present along pipeline ROW.

(5) If environment/land use is present insert applicable rating (i.e., high, moderate, or low). Otherwise, insert "not present along ROW".

(6) Refer to Tables 3, 4, and 5 of text for definitions of frequency, consequence, and risk estimation ratings.

(7) Ground subsidence associated with the collapse of pipelines up to 323.9 mm in diameter at typical burial depths is expected to be negligible (CEPA, 2006 - 2007).

PH 5 Risk Assessment Worksheet

Hazard No. 5: Exposure of abandoned pipeline on land due to soil erosion and geohazards

Release mechanism:

Pipeline is exposed at surface due to soil erosion or geohazards that force it above ground (i.e., frost heave, seismic activity).

Risk management measures required in accordance with CSA Z662*:

None

Site-specific data/information/ studies required to complete risk estimation:	***Completed***	***Not completed***
1. Identification of the following areas along the pipeline ROW: areas susceptible to soil erosion (e.g., agricultural fields or other non-vegetated areas, shallow soil cover, steep slopes, topographic highs exposed to wind), seismically-active areas, and areas where there is permafrost or where	X	

Step I - Complete frequency analysis:			
F5: Likelihood[4] of exposure of abandoned pipeline on land due to geotechnical/geohazards:		***Insert rating***	***Locations (along ROW) associated with rating***
Scenarios along pipeline:			
F5a: Pipeline exposure did not occur/was not a hazard that required monitoring, maintenance, or risk management during operation of the pipeline AND pipeline is not located in an area susceptible to soil erosion (e.g., agricultural fields or other non-vegetated areas, shallow soil cover, steep slopes, topographic highs exposed to wind) or a seismically-active area, AND pipeline is located below frost line.	Rate low		
F5b: Pipeline exposure did not occur/was not a hazard that required monitoring, maintenance, or risk management during operation of the pipeline, however the pipeline is located in an area susceptible to soil erosion (e.g., agricultural fields or other non-vegetated areas, shallow soil cover, steep slopes, topographic highs exposed to wind).	Rate moderate	F5b Moderate	
F5c: Pipeline exposure did not occur/was not a hazard that required monitoring, maintenance, or risk management during operation of the pipeline, however the pipeline is located in a seismically active area.	Rate moderate		
F5d: Pipeline exposure did not occur/was not a hazard that required monitoring, maintenance, or risk management during operation of the pipeline, however the pipeline is located above the frost line or where there is permafrost.	Rate high		
F5e: Pipeline exposure did occur/was a hazard that required monitoring, maintenance, and/or risk management during operation of the pipeline.	Rate high		
Step II - Complete consequence analysis:			
C5: Consequence[4] of exposure of abandoned pipeline on land due to geotechnical/geohazards[3]:			
C5: Human health and safety:		***Insert rating*** [1, 2]	***Locations (along ROW) associated with rating***
Not applicable.	NA	NA	NA
C5: Ecology and environment:		***Insert rating*** [1, 2]	***Locations (along ROW) associated with rating***
Not applicable.	NA	NA	NA
C5: Land use and valued/economic resources:		***Insert rating*** [1, 2]	***Locations (along ROW) associated with rating***
On land:	Rate moderate		
C5a: Temporary loss of productivity on agricultural lands.			
C5b: Damage to agricultural or other heavy equipment.		C5b moderate	
At water crossings:			
Not applicable.		NA	NA
On land:	Rate low		
C5c: Aesthetic impacts at any location along the ROW.			
At water crossings:			
Not applicable.		NA	NA

Step III - Complete risk estimation:							
E5: Estimation of risk[4] associated with exposure of abandoned pipeline on land due to geotechnical/geohazards:		**On Land**			**At Water Crossings**		
E5: Human health and safety:	**Frequency No.**	**Consequence No.**	**Locations**		**Frequency No.**	**Consequence No.**	**Locations**
High likelihood and High severity	NA	NA	NA		NA	NA	NA
High likelihood and Moderate severity OR Moderate likelihood and High severity	NA	NA	NA		NA	NA	NA
High likelihood and Low severity	NA	NA	NA		NA	NA	NA
Low likelihood and high severity	NA	NA	NA		NA	NA	NA
Low likelihood OR Low severity	NA	NA	NA		NA	NA	NA
Low likelihood AND Low severity	NA	NA	NA		NA	NA	NA
E5: Ecology and environment:							
High likelihood and High severity	NA	NA	NA		NA	NA	NA
High likelihood and Moderate severity OR Moderate likelihood and High severity	NA	NA	NA		NA	NA	NA
High likelihood and Low severity	NA	NA	NA		NA	NA	NA
Low likelihood and high severity	NA	NA	NA		NA	NA	NA
Low likelihood OR Low severity	NA	NA	NA		NA	NA	NA
Low likelihood AND Low severity	NA	NA	NA		NA	NA	NA
E5: Land use and valued/economic resources:							
High likelihood and High severity	NA	NA	NA		NA	NA	NA
High likelihood and Moderate severity OR Moderate likelihood and High severity	F5b Moderate	C5b moderate			NA	NA	NA
High likelihood and Low severity					NA	NA	NA
Low likelihood and high severity	NA	NA	NA		NA	NA	NA
Low likelihood OR Low severity					NA	NA	NA
Low likelihood AND Low severity					NA	NA	NA

Notes:

ROW - right of way

* Do not necessarily adequately address risks associated with the hazard.

(1) Rate based on if/where the environment/land use is present along pipeline ROW.

(2) If environment/land use is present insert applicable rating (i.e., high, moderate, or low). Otherwise, insert "not present along ROW".

(3) The consequence analysis does not consider release of contaminants due to pipeline exposure (and increased risk of puncture) as this hazard has been addressed as Potential Hazard 2a and 2b.

(4) Refer to Tables 3, 4, and 5 of text for definitions of frequency, consequence, and risk estimation ratings.

PH6 Risk Assessment Worksheet

Hazard No. 6: Exposure of abandoned pipeline at water crossings due to hydrotechnical hazards

Release mechanism:

Pipeline is exposed at surface due to: 1) buoyancy of the empty pipeline; 2) sediment erosion and lowering of the channel bed resulting in reduced depth of sediment cover; or, 3) stream bank erosion (where pipelines are parallel to streams or rivers). The relative buoyancy of a pipeline is increased once it is emptied (for abandonment). However, the rate/frequency of

Risk management measures required in accordance with CSA Z662*:

None

Site-specific data/information/ studies required to complete risk estimation:	***Completed***	***Not completed***
1. Identification of water crossings, and for each, assessment of the potential/rate at which the pipeline will become exposed in the channel bed due to buoyancy and sediment erosion. This should consider the rates of sediment	X	
2. Identification of locations where the pipeline is parallel and proximal to a stream or river, and assessment of the potential/timeline for the pipeline to become exposed along the stream bank due to stream bank erosion.	X	

Step I - Complete frequency analysis:			
F6: Likelihood[4] of exposure of abandoned pipeline at water crossings due to hydrotechnical hazards:		***Insert rating***	***Locations (along ROW) associated with rating***
Scenarios along pipeline:			
F6a: Pipeline is not expected to become exposed, either within the channel bed due to buoyancy and sediment erosion, or along the stream bank to stream bank erosion.	Rate low		
F6b: Pipeline is expected to become exposed, however significant/exceptional buoyancy of the pipeline, sediment erosion, or risk of stream bank erosion that could result in frequent exposure was not identified.	Rate moderate	F6b	
F6c: Significant/exceptional buoyancy of the pipeline, sediment erosion, and/or risk of stream bank erosion that could result in frequent exposure was identified.	Rate high		

Step II - Complete consequence analysis:			
C5: Consequence[4] of exposure of abandoned pipeline at water crossings due to hydrotechnical hazards[3]:			
C5: Human health and safety:		***Insert rating*** [1, 2]	***Locations (along ROW) associated with rating***
Not applicable.	NA	NA	NA
C5: Ecology and environment:		***Insert rating*** [1, 2]	***Locations (along ROW) associated with rating***
On land:	NA		
Not applicable.		NA	NA
At water crossings:	Rate high		
C6a: Exposure and contamination in surface water that is habitat/spawning/breeding/feeding grounds for species at risk		C6a high	
C6b: Exposure and contamination in surface water other than that which is habitat/spawning/breeding/feeding grounds for species at risk.	Rate moderate		
C5: Land use and valued/economic resources:		***Insert rating*** [1, 2]	***Locations (along ROW) associated with rating***
On land:	NA		
Not applicable.		NA	NA
At water crossings:	Rate low		
C6c: Aesthetic impacts at any water crossing.			

Step III - Complete risk estimation:	**On Land**			**At Water Crossings**		
E5: Estimation of risk[4] associated with exposure of abandoned pipeline at water crossings due to hydrotechnical hazards:						
E5: Human health and safety:	**Frequency No.**	**Consequence No.**	**Locations**	**Frequency No.**	**Consequence No.**	**Locations**
High likelihood and High severity	NA	NA	NA	NA	NA	NA
High likelihood and Moderate severity OR Moderate likelihood and High severity	NA	NA	NA	NA	NA	NA
High likelihood and Low severity	NA	NA	NA	NA	NA	NA
Low likelihood and high severity	NA	NA	NA	NA	NA	NA
Low likelihood OR Low severity	NA	NA	NA	NA	NA	NA
Low likelihood AND Low severity	NA	NA	NA	NA	NA	NA
E5: Ecology and environment:						
High likelihood and High severity	NA	NA	NA			
High likelihood and Moderate severity OR Moderate likelihood and High severity	NA	NA	NA	F6b Moderate	C6a High	
High likelihood and Low severity	NA	NA	NA	NA	NA	NA
Low likelihood and high severity	NA	NA	NA			
Low likelihood OR Low severity	NA	NA	NA	NA	NA	NA
Low likelihood AND Low severity	NA	NA	NA	NA	NA	NA
E5: Land use and valued/economic resources:						
High likelihood and High severity	NA	NA	NA	NA	NA	NA
High likelihood and Moderate severity OR Moderate likelihood and High severity	NA	NA	NA	NA	NA	NA
High likelihood and Low severity	NA	NA	NA			
Low likelihood and high severity	NA	NA	NA	NA	NA	NA
Low likelihood OR Low severity	NA	NA	NA	F6a Low	NA	
Low likelihood AND Low severity	NA	NA	NA			

Notes:

ROW - right of way

* Do not necessarily adequately address risks associated with the hazard.

(1) Rate based on if/where the environment/land use is present along pipeline ROW.

(2) If environment/land use is present insert applicable rating (i.e., high, moderate, or low). Otherwise, insert "not present along ROW".

(3) The consequence analysis does not consider release of contaminants due to pipeline exposure (and increased risk of puncture) as this hazard has been addressed as Potential Hazard 2a and 2b.

(4) Refer to Tables 3, 4, and 5 of text for definitions of frequency, consequence, and risk estimation ratings.

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