Petroleum Technology Alliance Canada

RECOMMENDED LONG TERM MONITORING PROGRAM FOR ALL ASPECTS OF AN ABANDONED PIPELINE

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Acronyms and Abbreviations

AEC	Areas of Environmental Concern
CEPA	Canadian Energy Pipeline Association
COC	Contaminants of Concern
ELC	Equivalent Land Capability
LMCI	Land Matters Consultation Initiative
LTM	Long Term Monitoring
NEB	National Energy Board
PARSC	Pipeline Abandonment Research Steering Committee
PTAC	Petroleum Technology Alliance Canada
SSTL	Site Specific Target Levels

NOTE: This plan is consistent with the Long-Term Monitoring requirements set forth in the Risk-Based Decision Making Framework for Pipeline Abandonment [1] and the outline provided in the FCSAP Long Term Monitoring Planning Guidance, Appendix A: Long Term Monitoring Plan Template for Federal Contaminated Site Remediation / Risk Management Projects [2].

1 INTRODUCTION

These guidelines were prepared on behalf of the Petroleum Technology Alliance Canada (PTAC) and the Pipeline Abandonment Research Steering Committee (PARSC) to assist the Canadian oil and gas industry operators, regulators and land owners to plan for pipeline abandonment through the development of a long-term monitoring (LTM) program **[3]**. A separate framework has been established to evaluate the risks of pipeline abandonment-in-place and removal, to select the most appropriate option for each segment, and to reduce risks during abandonment [1]. LTM is required for residual risks that remain after the site assessments and mitigation of environmental effects have been completed and the conditions of the National Energy Board (NEB) Abandonment Order have been met **[5]**.

The NEB has provided an abandonment process planning flowchart. The abandonment program is developed in consultation with stakeholders according to the prevailing regulatory requirements. The pipeline is abandoned upon regulatory release when the LTM program comes into effect. The abandonment process involves making a risk-based determination for each pipeline segment about abandonment in place or removal. The decisions must account for LTM to mitigate residual risk (addressed in this document), reclamation, remedial action contingencies, potential exposure scenarios, relevant pipeline system information, and potential land use (future and present) **[5]**. The Risk-Based Decision-Making Framework for Pipeline Abandonment [1] provides guidance to facilitate risk-based decisions pertaining to the overall abandonment process.

These guidelines do not apply to decommissioning, which keeps open the possibility of pipeline reactivation.

1.1 Purpose of this Guide

These guidelines are to provide a recommended program for LTM that is risk-based and practical **[3]**, ensures economical protection of human health and the environment, manages residual risks, and provides a forum for stakeholder input **[5]**. The LTM manages the residual risks identified in the abandonment decision-making process. Monitoring performance objectives provide the criteria for effective remedial action.

1.2 Scope of this Guide

These guidelines are to act as a first step and as a common starting point for specific work by assisting in the development, review and acceptance of a detailed LTM program for typical and special aspects of an abandonment project. The recommended program is informed by existing guidelines, standards, and previous abandonment projects in the province of Alberta. An effective abandonment LTM program provides a plan for the conditions to be monitored, methods, and frequencies based on pipeline characteristics, land use, site conditions and particular technical issues [1].

1.3 Intended Users

These guidelines are intended for Canadian oil and gas industry operators and regulators [1].

2 BACKGROUND

The NEB are responsible for the development of auditing, inspection and enforcement tools for abandonment plan and monitoring performance measures **[6]**, as imposed under NEB Condition 16 - Abandonment Monitoring Plan [13]. A comprehensive review was undertaken by the NEB as part of the Land Matters Consultation Initiative (LMCI) which involved four discussion papers on the different topic areas, 45 meetings and workshops in 25 communities across Canada, and written submissions from 13 parties to consider how abandoned-in-place facilities should be monitored and tracked **[7]**. The final LMCI report in 2009 recommended that knowledge gaps on the physical issues of pipeline abandonment be addressed **[6]**. The NEB also surveyed the pipeline industry with a questionnaire in 1995 about abandonment experience that included information about monitoring after abandonment **[5]**.

The Canadian Energy Pipeline Association (CEPA), NEB, Alberta Energy and Utilities Board (AEUB) and the Canadian Association of Petroleum Producers (CAPP) have also collaborated on technical and environmental issues associated with pipeline abandonment. For example, the NEB published a review document in 1996 titled “Pipeline Abandonment – A Discussion Paper on Technical and Environmental Issues” **[5]**. In 2007, CEPA published a report titled “Pipeline Abandonment Assumptions” which discussed technical and environmental considerations for development of pipeline abandonment strategies **[8]**.

2.1 Abandonment Project Stages

The NEB oversees three general stages in a pipeline abandonment project [13]:

1. **Physical Abandonment Activities (Condition 9)**

   In-field activities associated with abandonment that may impact the environment, including clearing, mowing, grading, scrapping, soil removal and reclamation activities.

2. **Reclamation Monitoring (Condition 11)**

   Monitoring and reporting to identify areas that may require additional reclamation to restore land to a state comparable with the surrounding environment.

   As per NEB Condition 11, the Reclamation and Reclamation Monitoring Plan is to include a description of the reclamation measures to be applied, identification of criteria and thresholds to be used to determine that the Right of Way has reached equivalent land capability (with rationale), a description and schedule for the monitoring activities, and a description of and justification as to how the results of its stakeholder consultations have been incorporated.

   This stage can be included as part of the long-term monitoring plan for abandoned pipelines, where method selected is abandonment in place (i.e., since this monitoring stage can be applied to abandonment by removal projects as well).

3. **Abandoned Pipeline Monitoring (Condition 16)**

   Monitoring and reporting to ensure compliance with NEB regulations and to respond to any concerns raised by the public.

> As per NEB Condition 16, the Abandoned Pipeline Monitoring Plan is to includes identification of hazards (e.g., pipe exposure, ground subsidence), evaluation for associated risks, development of controls, and communication of identified hazards and control with all relevant stakeholders. The NEB also expects plan to describe the methods for, including the frequency of, monitoring, and that the plan should demonstrate how the methods will be effective in identifying any issues arising over time. Results of consultation with potentially affected stakeholders also needs to be included into the abandoned pipeline monitoring plan.

This guide is focused on the abandoned pipeline monitoring stage, but it is recognized that plan may also include elements from the reclamation monitoring stage (e.g., continued monitoring of potential contaminants of concern from reclamation through to abandonment stage).

2.2 Development of this Guide

Det Norske Veritas (DNV) was commissioned to conduct a literature review regarding the current understanding worldwide with respect to the physical and technical issues associated with onshore pipeline abandonment and use the results of the literature review to critically analyze and identify gaps in current knowledge and make recommendations as to potential future research projects that could help to fill those gaps. DNV published this Scoping Study in November 2010 [9].

The PARSC was established as a framework to guide and direct innovation and applied research, technology development, demonstration, and deployment in order to address knowledge gaps summarized in the DNV Scoping Study [9]. The purpose of this document is to provide a framework to assist with the development of suitable LTM programs for abandoned pipelines that are required to mitigate identified residual risks (see Risk Management Framework for Abandoned Pipelines [1]).

The Risk-Based Decision Making Framework for Pipeline Abandonment [1] outlines the methodology for conducting risk assessments to inform detailed pipeline abandonment decisions that consist of variables affecting pipeline integrity and toxic exposure [9]. Risks can arise from the physical removal or degradation of pipeline facilities and from receptor exposure to released substances. This guide concerns the eventual LTM that is needed to mitigate the residual risks identified in these comprehensive site-specific risk-based assessments and to validate the chosen abandonment strategy for identified segments of specific pipeline projects [3].

2.3 Reference Documents Used

The primary reference documents consulted during development of this document are:

- FCSAP Long Term Monitoring Planning Guidance, Appendix A (2012 March) [2]
- Risk-Based Decision-Making Framework for Pipeline Abandonment (2018 November) [1]
- Analysis of Pipeline Exposure Data and Scoping Review of Exposure Scenarios (2018 June) [10]
- Pipeline Abandonment - A Discussion Paper on Technical and Environmental Issues (1996 November) [5]
- Pipeline Abandonment Assumptions - Technical and Environmental considerations for development of Pipeline Abandonment strategies (2007 April) [8]
- NGTL Peace River Abandonment – Reasons for Decision (2018 March) [13]

3 PIPELINE IDENTIFICATION AND CHARACTERIZATION

3.1 Identification of Pipeline Segments for Abandonment

The Risk-Based Decision-Making Framework can guide identification of pipeline segments suitable for abandonment. Once identified, the intention of the monitoring program is to mitigate residual risks which may be challenged by pipeline abandonment. Areas sensitive to land disturbance should be identified, such as natural habitats, and those with slope, erosion or flood vulnerability. Land improvements could involve agricultural tiles, landscaping or other engineered facilities. Stakeholder engagement is key to identifying areas of potential land development. The decisions to abandon-in-place or remove a pipeline section should be based on site-specific assessments [5].

3.2 Pipeline Characterization

Documents with information that may be relevant to abandonment monitoring program should be retained: design, construction and modification, operational procedures and event history, maintenance, and those pertaining to site and abandonment decision-making assessments.

During the risk assessment process, the following information should be collected and recorded to characterize the entire project of pipeline abandoned-in-place [1]:

- Location (coordinates defining which section the characteristics apply)
- Composition (materials, liners, coatings)
- Size (diameter, thickness)
- Operational history (product transported, incidents, mitigations)
- Associated facilities

3.3 Right of Way Characterization

Pipeline details and survey coordinates defining the right-of-way (ROW) corridor should be reviewed for accuracy and completion: pipeline and associated facility dimensions, construction, materials, operational history, and current conditions including depth of cover, plug locations, sections of filled material. Land uses should be reviewed and confirmed including ROW crossings, water bodies and adjacent property.

The risk-based decision-making process involves characterization of the pipeline ROW according to land use by [1]:

- Agricultural
- Non-agricultural
- Sensitive areas
- Water crossings
- Other crossings

The pipeline may be further segmented from the original plan by pipeline or land use characterization during the risk-based decision-making process [1].

4 INFORMATION AND RECORDS MANAGEMENT

Information can be categorized as legacy: design, operational history, and site condition and assessment; and ongoing monitoring data and site conditions. The abandonment monitoring program should identify which records are retained, the storage medium, location and responsibility for retention and update.

LTM program records encompass two categories: pre-abandonment information, and data generated during the LTM program. A post-abandonment log book should be maintained with records of [2]:

- Regulatory permits and conditions (including reclamation certificates)
- Pipeline section details
- Past crossing agreements
- Post-abandonment aerial surveillances
- Slumping over or water flow through pipe
- Changes in pipeline state from the original abandonment plan
- Remedial work performed on the pipeline after abandonment
- Observations of post-abandonment contamination
- Input from stakeholders

The responsible organization must retain the reports of all monitoring and surveillance programs developed under section 39 of the Onshore Pipeline Regulations for at least two years after abandonment [11]. This should be considered as a minimum requirement. Records pertaining to LTM and surveillance programs should be retained as long as they are relevant to the residual risks for which monitoring is required as a form of mitigation.

5 REGULATORY MANAGEMENT

5.1 Statutes and Regulations

The 2012 Canadian Environmental Assessment Act under section 47 requires an environmental assessment if greater than 40 km of pipeline are planned to be removed from the ground [12].

The NEB regulates interprovincial and international pipeline systems in Canada under the NEB Act. Abandonment must be in accordance with the Onshore Pipeline Regulations. The provinces regulate intraprovincial pipelines. There may be municipal requirements for pipeline abandonment [5].

Other federal legislation such as the Navigation Protection Act or the Fisheries Act should also be consulted, as needed, with respect to pipeline abandonment [5]. Table 1 lists applicable Canadian pipeline statutes and regulations that are current at the time of writing. The LTM program should be compliant with legislation current in the applicable pipeline jurisdiction.

Table 1. Canadian pipeline statutes and regulations.

Jurisdiction	Regulator	Statute	Paragraph	Subject
Federal	NEB	National Energy Board Act	Part V paragraph 74(d)	Leave of the NEB to abandon
		Onshore Pipeline Regulations	Paragraph 50	Application for Leave to Abandon
			Paragraph 39	Surveillance and Monitoring
Yukon, Northwest Territories, Nunavut	NEB	Canada Oil and Gas Operations Act	Paragraph 4(d)	Leave of the NEB to abandon
British Columbia	Oil and Gas Commission	Oil and Gas Activities Act		
		Pipeline and Liquefied Natural Gas Facility Regulation, BC Reg 281/2010	Paragraph 11(a)	Abandon the pipeline in accordance with CSA Z662
Alberta	Alberta Energy Regulator	Pipeline Act	Paragraph 23, 24	Abandonment upon order by Regulator to protect the public or environment
		Pipeline Regulation SOR/99-294	Paragraph 82-85	Requirements for discontinue and abandonment
		Environmental Protection and Enhancement Act	Paragraph 138	Reclamation certificate

		Conservation and Reclamation Regulation, Alta Reg 115/1993		
Saskatchewan	Oil and Gas Conservation Board	The Pipelines Act	Paragraph 5(2)	Licence required to abandon
		Pipeline Regulations, 2000, RRS c P-12.1 Reg 1	Paragraph 9	Abandonment application
	Saskatchewan Power Corporation	The SaskEnergy Act		
Manitoba	Oil and Gas Conservation Board	The Oil and Gas Act	Paragraphs 171-172	Certificate of Abandonment
Ontario	Technical Standards and Safety Authority	Technical Standards and Safety Act		
		Oil and Gas Pipeline Systems, O Reg 210/01		
Quebec	Régie du bâtiment du Québec	Building Act, CQLR c B-1.1		
		Construction Code, CQLR c B-1.1, r 2		
Nova Scotia	Nova Scotia Utility and Review Board	Pipeline Act	Paragraph 20	Consent of the Board to abandon
		Pipeline Regulations (Nova Scotia), NS Reg 66/98	Part IX, paragraph 51	Notify the Board of abandonment
New Brunswick	New Brunswick Energy and Utilities Board	Gas Distribution Act		
Prince Edward Island	no applicable legislation			
Newfoundland	Mines and Energy	The Petroleum and Natural Gas Act		

It should be noted that although various provincial regulators consider pipe cleanliness, environmental regulatory process requirements for pipeline abandonment remain limited to Alberta Environment [8].

For example, Table 2 lists legislation that was consulted during the Peace River Mainline Abandonment Project that may be applicable to other pipeline abandonment projects in Alberta [12].

Table 2. Legislation consulted during the Peace River Mainline Abandonment Project

Legislation	Authority
Wildlife Act Alberta	Alberta Environment and Parks
Weed Control Act	Alberta Agriculture and Forestry

Public Lands Act	Alberta Environment and Parks
Water Act	Alberta Environment and Parks
Resources Act	Alberta Culture and Tourism
Alberta Wetland Policy Implementation	Alberta Environment and Parks
Migratory Birds Convention Act	Environment Canada
Species at Risk Act	Environment Canada
Federal Policy on Wetland Conservation	Environment Canada
Fisheries Act	National Energy Board (Department of Fisheries and Oceans memorandum of understanding)

5.2 Standards and Guidelines

The CAPP drafted guidance (2002) for Alberta regarding [8]:

- Technical and environmental issues
- Operator and regulator responsibilities in the abandonment process

DNV (2010) conducted a literature search for the NEB to identify applicable environmental standards, which are summarized as follows [9]:

1. The CCME has several specific documents that aid in appropriate management and remediation of contaminated sites associated with the oil and gas industry.
2. The Canada-Wide Standards for Petroleum Hydrocarbons in Soil (PHC CWS) and the Canadian Council of Ministers of the Environment (CCME) use a three-tiered approach as a remedial standard for contaminated soil and subsoil occurring in four land use categories. The first tier is the direct adoption of Canadian soil quality guidelines [13] while the second tier allows limited modification of Canadian soil quality guidelines by setting site-specific objectives. The third tier uses risk assessment procedures to establish remediation objectives at contaminated sites on a site-specific basis [14].
    - It has been recognized that this standard may also be used to establish criteria for pipeline cleanliness [8].
    - This is a resource for establishing threshold criteria and triggers for mitigating action.
3. Contaminant-specific guidelines [15]:
    - Canadian Soil Quality Guidelines for carcinogenic and other polycyclic aromatic hydrocarbons (PAHs) [16].
    - Canadian Soil Quality Guidelines for polychlorinated biphenyls (PCBs) [17].
    - Canadian Soil Quality Guidelines for benzene [18], toluene [19], ethylbenzene [20] and xylene [21] (BTEX).

4. The Canadian Guidelines for the Management of Naturally Occurring Radioactive Materials (NORM) [22] have been developed by the NORM Working Group, a working group of the Federal Provincial Territorial Radiation Protection Committee (FPTRPC), which sets out principles and procedures for the detection, classification, handling, and material management of NORM in Canada, and guidance for compliance with federal transportation regulations.

The CEPA recommended that companies maintain awareness of allowable threshold criteria for specific contaminants such as PCBs and NORM, for which regulations and guidelines were under development at the time of writing [3]. Sample coatings from pipelines to be abandoned should be analyzed to determine the amount of leachable material, particularly from asphalt and coal tar material that may contain PCBs [23]. PCBs and NORM can remain despite effective pigging [9] [24].

5.3 Cultural, Natural, and Historical Preservation

Section 67 of the 2012 Canadian Environmental Assessment Act mandates the requirement to determine whether a project proposed on land is likely to cause significant adverse environmental effects before making any decision that would allow the project to proceed. PTAC should consider the development of an Environmental Review Process for this purpose [12].

5.4 Public Participation

The abandonment project schedule should provide an opportunity for meaningful input into the planning process by the affected public, especially landowners and land managers. The owner/operator is responsible for notifying landowners, municipal authorities, and other affected parties (such as one-call associations) of the abandonment of the pipeline. Any pipeline abandoned in place should remain part of any provincial one-call program, so that third parties can be advised whether the lines they wish to have located are active or abandoned [5].

A review of innovations for the pipeline industry found that landowners have expressed concern that pipeline abandoned-in-place over time will [15]:

- Collapse and result in major subsidence
- Become undesirable conduits for water in a corroded state
- Frost heave posing a risk to farm machinery over time

A review found no conclusive research about the landowner’s concerns [15]. The stakeholder consultation will identify any other hazards of concern. Monitoring frequency and contingency mitigation plans should be deemed acceptable to all stakeholders.

Records and stakeholder correspondence of public meetings should be retained.

6 SUMMARY OF RISK-BASED PIPELINE ABANDONMENT DECISIONS

A comparative risk assessment can assign priorities to the segments for budget and scheduling [25] and be a tool for the abandonment decision process [9]. A risk-based corrective action classification system [26] could be adopted for pipeline abandonment to distinguish between necessary immediate actions and those that could be postponed with monitoring [9].

In 2007 CEPA provided a Pipeline Abandonment Matrix with primary options according to land use for either abandonment-in-place or removal of pipeline segments [8]. The Risk-Based Decision-Making Framework contained an adaptation of this table for pipeline and ROW characterization for abandoned pipelines [1].

6.1 Focus on Residual Risks

The FCSAP LTM framework is based on a comprehensive evaluation of site risks that are identified and ranked for abandoned pipelines using the Risk-Based Decision-Making Framework [1]. These identified risks also underpin the development of the monitoring strategy which will be used to mitigate any residual risks that are deemed unacceptable (e.g., pipeline exposure, puncture and collapse).

In addition to supporting ongoing monitoring, maintaining risk registers for projects during the post-abandonment stage will help managers communicate changes in residual risk levels and to make rational, risk-based decisions regarding site management (e.g., discontinuation of monitoring program).

6.2 Risk Drivers

Geohazards consist of geotechnical and hydrotechnical hazards. They are concentrated at rivers, slopes, water bodies, crossings and other distinct locations, controlled by local factors such as soil type, access to moisture and local temperature/insulation effects. Geohazards for abandonment must be reviewed at distinct locations [9].

The most active geohazards for typical pipelines are [9] [27]:

- Hydrotechnical (scour, channel degradation, bank erosion, stream encroachment, avulsion)
- Surface erosion (varies with rainfall, channelization, soil types, slope, vegetation)
- Subsurface erosion (varies with river energy, soil)
- Geotechnical (earth/mass movements; varies with soil types, groundwater, slope loading)

Pipeline exposure after abandonment due to geohazards and other environmental factors occur at a frequency of about one pipe exposure per 100 years per 1,000 km of pipe. Most exposure incidents are expected to occur at water crossings, and to a lesser extent in mountainous areas and with erodible soils. On the other hand, frost action is highly unlikely to impact abandoned buried pipelines. It is expected that pipelines will be removed, in lieu of abandonment, at sensitive ecological locations and for areas where pipeline exposure frequency and risk is elevated [10].

Table 3 details the causes, modes and effects of pipeline abandonment hazards that would underpin residual risks for general and special applications. Pipeline exposure data and scenarios were further evaluated in 2018 through a study commissioned by PTAC **[10]**.

Table 3. Categorization of hazards and residual risks mitigated through LTM

Cause	Mode	Effect / Residual Risk	Application
Corrosion	Conduit	Soil, water contamination	General
	Channeling	Waterway disturbance	Special
	Subsidence	Soil quality / habitat	General
	Subsidence	Infrastructure crossings	Special
Hydrotechnical	Scour	Bed erosion	Special
	Avulsion	Bank erosion	Special
Buoyancy	Restraint degradation	Exposure	Special
Geotechnical	Erosion	Exposure	General
	Seismic	Exposure	Special
	Frost Heave	Exposure	Special
Loss of control measures	Intrusion	Damage / injury	Special

6.3 Monitoring Program Elements

Elements of effective monitoring have been identified as [28]:

- Identify the hazard
- Evaluate the character of hazard and risks
- Design the monitoring and mitigation based on the hazard and risks
- Implement with criteria and contingency plans
- Review the collected data regularly

The hazards will correspond to the residual risks identified during application of the Risk-Based Decision-Making Framework process [1]. Risk is the product of hazard consequence severity and event frequency. The monitoring frequency should be set to keep the risk acceptable, and performance criteria set to represent conditions of increased severity and/or frequency that would make the risk unacceptable. Mitigation could be planned to address either the severity or frequency of a hazard.

The LTM program records should incorporate the assumptions and results of the site assessments and abandonment strategy that is the outcome of the decisions reached for each pipeline segment. They would include hazard location and characterization, residual risk details, monitoring frequency and methods and mitigation contingencies. The records should be robust and clear to enable long-term management and adoption by succeeding organizations as may be required. If the LTM program identifies the formation of unacceptable conditions, land reclamation (Section 6.4) will be required.

The LTM requirements are discussed in further detail in Section 7.

6.4 Land Reclamation

Reclamation is the restoration of land where pipeline abandonment activities have caused ground disturbance, as identified through the LTM program. Key reclamation components for environmental protection where a pipeline is abandoned-in-place are removal of roads not required for the LTM program and a revegetation strategy [5].

Reclamation criteria should be agreed upon by the owner, regulatory authority, and landowner prior to the commencement of field activity as part of the monitoring program to ensure complete remediation [2]. Revegetation should consider species that are quick to establish but beware of invasive non-native species [5].

Reclamation measures should be planned and scheduled, and subsequent reclamation monitoring planned after the first full growing season. The monitoring should assess the effectiveness of the measures, observing slopes, soil subsidence, topsoil loss, vegetation and weed growth.

Criteria to stop reclamation monitoring have been defined for previous abandonment projects, for example when:

- Ground conditions were stabilized and vegetation growth well established [29]
- A self-sustaining minimum live plant cover of 75% as confirmed by an environmental monitor [30] [31]
- Established of equivalent land capability (ELC) according to measurable parameters in consultation with the NEB and landowners [12].

ELC is defined as Conservation and Reclamation Regulation, (Alta Reg 115/1993) [32]:

> “the ability of the land to support various land uses after conservation and reclamation is similar to the ability that existed prior to an activity being conducted on the land, but that the individual land uses will not necessarily be identical”

Reclamation Assessment Criteria for Pipelines has been a resource for previous pipeline abandonment projects [12].

Measurable parameters have been established in previous abandonment projects during site assessments for comparison to representative undisturbed areas as the ELC criteria. ELC factors included agricultural production, natural revegetation, erosion vulnerability, wildlife habitat features, aquatic resources, and the concerns of landowners or resource managers. Disturbance of wetlands were assessed according to wetland function [12].

The LTM program may include a separate reclamation monitoring plan [33]. Reclamation monitoring is the second stage of the NEB’s oversight of abandonment projects where performance may be compiled by recording the numbers of locations with successful reclamation, deficient reclamation, and abandoned-in-place issues identified, in progress and resolved [12] [13]. It is used to identify areas that may require additional reclamation to restore land to a state comparable with surrounding environment [13].

7 LONG TERM MONITORING PROGRAM

The final step of the Risk-Based Decision-Making Framework established for pipeline abandonment involves identifying risk mitigation measures to reduce the frequency or severity of hazards. One of the identified components of risk management, as detailed in this section, is the development of a LTM program to mitigate residual risks [1]. The NEB also imposes the submission of an Abandoned Pipeline Monitoring Plan (Condition 16) within 120 days after commencement of physical abandonment activities [13] that outlines a systematic, explicit, comprehensive and proactive approach (i.e., scope of this LTM guidance). LTM is either the observation of the hazard directly or of the effects of the hazard [28]. The LTM program can be used to detect geologic and other environmental changes and their associated effects, as well as to facilitate decisions regarding on-going risk management for abandoned pipelines (e.g., discontinue monitoring or land reclamation).

The NEB Filing Manual [34] describes various biophysical elements that should be considered in LTM program design, including but not limited to:

- Inspection plans to ensure compliance with biophysical and socio-economic commitments, consistent with sections 48, 53, and 54 of the Onshore Pipeline Regulations (OPR). These inspection plans must be sufficiently detailed to demonstrate adequacy and effectiveness.
- Surveillance and monitoring program for the protection of the pipeline, the public and the environment as required by section 39 of the OPR. The monitoring program must be sufficiently detailed to demonstrate its adequacy and effectiveness.
- Consideration of any particular elements that are of greater concern and evaluate the need for a more in-depth monitoring program for those elements.
- CEAA designated physical activities, identify which elements and monitoring procedures would constitute follow-up under the CEAA 2012.

Section 7 describes the monitoring considerations for the categories of hazards and residual risks identified in Table 3. The engineered controls (e.g., signage) and general monitoring conditions to be considered are detailed in Section 7.1. Section 7.2 provides additional information on potential special conditions that are not typically applicable to specific abandonment projects.

7.1 General Monitoring Conditions and Engineering Controls

7.1.1 Corrosion

A NEB consultant reported [35] corrosion factors to be quality of pipeline coating; soil aeration; soil type, homogeneity and moisture; and electrical factors related to pipe materials. Corrosion effects present locally where coating holidays or disbondment lead to pits and spiral corrosion which lead ultimately to random perforations. The corrosion process is estimated generally to take years to result in non-uniform collapse along the length of a pipeline [5].

Cathodic protection may be discontinued for pipeline abandoned in place. NGTL removed cathodic protection from Peace River project pipeline [12]. Enbridge continued cathodic protection in order to reduce the rate of corrosion and set out to continue monitoring the system [36].

The National Institute of Standards and Technology (NIST) studied coated and uncoated coupons of steel exposed under freely corroding conditions in soils throughout of the United States, concluding that [37] [9]:

- Soil corrosivity increases with decreasing pH
- Soil corrosivity increases with decreasing resistivity
- Pitting rates follow a power law, with an exponent that is generally near 0.5 and varies with soil properties

Pipeline corrosion poses a residual risk of subsidence (Section 7.1.2) but can also potentially be a source of contamination to soil and/or groundwater.

7.1.1.1 Channelling

Pipeline abandoned-in-place poses a risk by forming water conduits through corrosion resulting in unnatural water and material transport. The potential to drain or interconnect water bodies is greater at water crossings, and where soil density is low when saturated and the water table rises for some time close to ground level. Unnatural flow could occur by drainage or flooding. Water and soil contamination are confounding effects. This risk can be mitigated through pipeline segmentation and monitoring [36].

A study of the water conduit effect in abandoned pipelines identified monitoring activities as mitigation against water conduit scenarios as aerial photography, visual inspections, groundwater monitoring by observation well/piezometer network, or regularly scheduled overflights. Conduit formation around small water bodies is complicated by relatively small size, potentially complex hydrological relationships. Recognition can be complicated by the ephemeral nature of many wetlands, and precipitation variation. Monitoring over multiple years may be needed to discern these effects [11].

Assessment of small water bodies prior to abandonment should consider: (1) the conditions found in the wetlands, (2) the likelihood of successful reclamation of the water body, and (3) the presence of any species at risk or higher value considerations. Wetlands may belong to a regional wetland system with complex interrelationships between small lakes, wetlands and water tables that could make monitoring expensive and time consuming and the results uncertain [11].

7.1.1.2 Contamination

The spread of contamination is an effect identified in Table 3 resulting from corrosion and collapse of the pipeline. Contamination could be mobilized by percolation through the conduits created by structural degradation of the pipeline over time. Contamination may be known from operational history or result from abandonment activity.

Potential contaminants of concern included PAHs, volatile organic compounds, total extractable hydrocarbons, total petroleum hydrocarbons, and heavy metals [12]. Similar assessments on other projects may result in requirements for LTM post-abandonment.

The nature of contamination expected from the operational history of the pipeline should be a factor together with the pipeline design to inform decision on monitoring parameters. In Alberta, pipeline licensees are responsible to purge, clean, isolate and cap pipeline abandoned-in-place [4]. These measures will minimize the potential for spread of contamination.

Potential sources of contamination may include, but are not limited to [5] [24]:

- Substances produced in the hydrocarbon stream
- Substances deposited in the pipeline wall
- Treatment chemicals
- Pipeline body and associated chemicals
- Pipeline coatings

The pipe cleaning procedure and cleanup of contamination to regulatory requirements are key environmental protection measures. The amount of residual left inside a pipeline should be within permissible limits where they exist, and ideally, such that there would be no impact to the environment if the integrity of the abandoned pipeline was compromised. Pipeline hydrostatic test water guidelines could be used as a starting point for establishing allowable levels of contaminants in crude oil and natural gas pipelines [5]. It should also be noted that composite pipelines typically have polyethylene components that can absorb a significant amount of gas or fluid during operation since the internal strength layer often has spaces where gases can accumulate. Once pressure is reduced to zero with pipeline abandonment, these absorbed gases or fluids could evolve over time, potentially leading to unexpected contamination of surrounding soils [41].

The LTM program details and timing of sampling and analysis should be consistent with likelihood and significance of identified residual risks (i.e., higher monitoring frequency for risks with higher likelihood), and there should also be contingency plans developed with corrective actions to address the potential discovery of new contamination [47]. Season and site accessibility are other factors that should also be taken into consideration in the design of the LTM program, given social (e.g., stakeholders concerns) and economic (e.g., cost / benefit for remote sites) factors.

7.1.2 Hydrotechnical – Subsidence or Erosion

Topsoil conservation is a key environmental protection measure. Subsidence and/or erosion creates a potential effect on land use by the degradation of soil.

7.1.2.1 Erosion

Soil erosion is primarily a concern to slope stability but may also encompass topsoil loss or siltation and loss of aquatic habitat. Vulnerability to erosion depends on location and abandonment activity. Operational slope movement monitoring and erosion remediation data should be factors in the abandonment monitoring program. Other owner/operators, regulators and landowners should be consulted during the abandonment plan development. The NEB abandonment checklist for planning and approvals includes slope movement monitoring **[5]** that may be performed by operational slope monitoring equipment with a suggested a 2-year monitoring period. Erosion monitoring and reclamation planning should also be coordinated **[5]**.

Potentially unstable slopes that are identified during ROW patrols should receive additional monitoring, assessment and remediation as required [36]. For example, Enbridge Line 3 would be assessed for geotechnical threats such as slope stability or erosion. Site-specific assessments of identified areas may also prompt more frequent or detailed monitoring [36].

7.1.2.2 Subsidence

The degree of subsidence associated with larger-diameter pipelines is highly dependent on pipeline diameter, depth of cover, and local soil conditions, but can be expected in many cases to be in a tolerable range. Sensitivity to soil subsidence is site-specific, depending on land use and the local environmental setting [5].

Subsidence can present a direct safety hazard, impact on land use and aesthetics, or through water channeling leading to erosion. The NEB has identified subsidence factors as site-specific corrosion mechanics, pipeline thickness and diameter, pipeline coating quality, burial depth, soil type, pipeline material failure mechanics and soil failure mechanics [5].

The NEB had found no documented cases of subsidence due to pipeline collapse in 1996. A soil mechanics study concluded that subsidence of pipelines less than 323.9 millimeters (mm) (1′¾″) diameter would be negligible, and of larger pipelines tolerable [39] [5].

The dominant factors in large diameter pipeline subsidence are pipeline diameter, depth of cover and local soil conditions. Heavy vehicle loads may increase vulnerability to subsidence. The NEB suggested development of tolerance criteria, a field observation program and scale modelling [5].

Most abandoned pipelines would retain their overall structural integrity for decades, if not centuries. A risk-based comprehensive site specific assessment should confirm the prognosis for subsidence within acceptable criteria in future years, considering safety, land-use and environmental factors. Pipe removal poses a greater subsidence risk. The NEB has recognized that considerable work may be needed to validate the risk of subsidence due to pipeline corrosion. This work could occur as part of the effort to define a risk-based assessment process [8].

Inspection requirements (an engineering control), such as visual inspections and Ground Penetrating Radar, should be incorporated in the abandonment monitoring plan [5]. Monitoring frequencies and procedures should be established during detailed engineering, taking account of loading and design capacity [36].

7.1.2.2.1 Infrastructure Crossings

Infrastructure components which the pipeline may cross include railways, primary and secondary highways, roads, other pipelines, power lines, and communication lines. Transportation crossings are sensitive to small subsidence that may motivate special mitigation such as filling the pipe.

For example, Enbridge Line 3 monitoring plan included warning signs and line markers to be visually inspected during regular patrols and updated as required. Signage was to be checked annually for condition and visibility [36].

7.1.3 Buoyancy or Geotechnical – Exposure

Exposure rates should be higher for an abandoned pipeline that is not maintained or subject to active visual inspections, and otherwise due to loss of buoyancy control of empty pipe [10].

The effects of pipeline exposure are [9]:

- Interference with land use
- Degradation of the pipe or coating
- Puncture or collapse

Mass movements can result in pipeline exposure, but more frequently cause strain and puncture. Exposure is more frequent at river banks or where soil migrates from around the pipeline. The rate of exposure is unlikely to be changed by abandonment [9].

Pipeline depth monitoring can be used to test, evaluate and mitigate depth-of-cover (DOC) concerns according to the operating and maintenance manual [36]. For example, electromagnetic line locating equipment can be used to accurately locate and record the depths for each pipeline over time. The DOC the decommissioned pipeline can be surveyed as part of LTM program, where results can be reviewed regularly, and further mitigation can be considered if DOC is found to be unacceptable. The DOC survey program for the decommissioned pipeline should be completed at least once every ten years. The frequency for the depth of cover survey program may be reduced for portions of the pipeline based on internal risk assessments [36].

Depth of soil cover is self-regulated within the Canadian pipeline industry assisted by the Excavation Damage Prevention (EDP) toolbox. The DOC guidelines provide a basis for monitoring criteria and triggers for mitigating action for DOC over abandoned pipelines.

The EDP toolbox specifies the minimum DOC as [36]:

- 80 centimeters (cm) in Alberta
- 120 cm in Ontario on cropland
- 60 cm in the rest of Canada

Mitigating actions may include [36], but are not limited to:

- Adding soil over the pipeline
- Lowering the pipeline
- Developing new agreements to restrict land use with the appropriate stakeholders
- Installing mechanical protection over the pipeline.

7.1.4 Loss of Control Measures

The NEB has recommended removal of apparatus associated with a pipeline abandoned-in-place to a depth of 1 meter (m). Line and aerial markers identifying the location of abandoned-in-place pipeline facilities should be left in place. Apparatus left in place should not pose a hazard to people, equipment, wildlife or livestock, and be secured, marked and recorded [5].

Periodic review and/or examination of LTM program, line and aerial markers, apparatus left in place and maintenance of document control are intended to prevent loss of control measures. It is not anticipated that loss of control will result in unacceptable effects, particularly in the near-term, but it could potentially trigger stakeholder concerns with ability of organization to effectively risk manage the site(s) as well as potential compliance and/or regulatory issues.

7.2 Special Conditions

7.2.1 Hydrotechnical – Scour and Avulsion

Vertical erosion rates are estimated at an average 20-30 mm per year when typical flow regimes and storm events are considered together. The rate of pipeline exposure due to hydrotechnical hazards should not be affected by abandonment or the filling or plugging of the pipeline [9].

Surface water erosion includes erosion of the backfill directly above the pipeline or of other areas on the ROW that were cleared or disturbed for pipeline installation. The occurrence of this mode of exposure is thought to be generally increased upon abandonment, since inspection will be reduced or eliminated [9].

7.2.2 Buoyancy or Geotechnical – Frost Heave

The risk of frost heave is greater in northern areas due to soil, groundwater and temperature conditions [**40**] [9], but a recent assessment found potential impacts to be negligible [**10**].

The need for consideration in LTM programs will vary with location. For example, the Enbridge Line 3 shares a congested ROW with up to 6 other operating pipelines which are generally spaced 3 m center to center. These pipelines operate at temperatures up to 38°C, and the heat transfer from the operating lines contribute to a local thawed zone surrounding the pipelines. Enbridge's depth of cover surveys identified locations of soil upheaval, loss of soil coverage, or thaw subsidence areas where the pipeline has reduced cover regardless of the cause. Areas with insufficient depth of cover are assessed and mitigated according to an operating and maintenance manual [36].

It should also be noted that in frost sensitive northern areas the discontinuation of pipelines may interrupt surface water-ground water interactions, leading to ponding, erosion and channeling along the ROW, whether the pipeline is left in-place or removed [**41**] [9].

7.3 Monitoring Plans

LTM requirements are a significant factor to consider since it carries on long after the decisions regarding pipeline abandonment have been made. As such, the monitoring program should be linked to the Risk Management Plan [1] development to ensure that the full scope of these requirements will be evident. The Risk Management Plan should also consider a full life cycle approach, including a cost-benefit analysis, stakeholder communication, and available funding departments to facilitate informed decisions on which action(s) (e.g. removal or abandonment) could provide the most cost-effective long-term solution. Monitoring plans are a means to mitigate residual risk identified in the risk management plan that indicate potential events or effects beyond abandonment [1].

The United States ITRC indicates that monitoring requirement development be structured to encompass the following components **[42]**.

- Assure protection of potentially exposed populations (e.g., subsidence, groundwater contamination)
- Monitor changes in site conditions (e.g., vegetation, changes to landform)
- Assess the efficiency and effectiveness (performance) of the remedial option for meeting remedial action objectives (i.e., to ensure abandonment decision is meeting risk management objectives)
- Support decisions regarding the need to optimize the remedial design (e.g., if removal needs to be considered based on results from LTM program)
- Support site closeout (i.e., ownership of land, but no formal LTM program needed).

An important component here to consider is the notable progression to project closeout (i.e., an appropriate end-state for an abandoned section of pipeline). Closeout does not necessarily mean to be able to walk away, although that would be the ideal situation. Closeout will typically include an iterative risk-based review, which is then followed with appropriate monitoring program changes and continuation until the subsequent review period. Typically, a stabilized closed site requires limited inspection over time, but will have situation-based triggers for follow-up action.

The NEB has established that a ROW LTM program should be included in the post-abandonment plan. Abandonment project monitoring plans vary according the location and size of pipeline, land use, and terrain features along the ROW. They are developed according to identified hazards and may involve special requirements in sensitive locations. They must consider ROW maintenance [5].

The NEB checklist of abandonment activities included monitoring and maintenance activities [5]:

- Aerial patrol
- Specific site visits
- Weed monitoring / control
- Liaison with landowners, tenants, public land managers
- “first-call” response and location of underground pipe
- Crossings
- Erosion control maintenance

These activities should also be taken into consideration during the development of a LTM program in addition to the monitoring components outlined in Section 7.1 and 7.2. If the LTM program identifies unacceptable changes (e.g., land subsidence, groundwater above applicable guidelines), then corrective actions (e.g., pipeline removal, soil remediation) should be taken into consideration.

Risk to the public and the environment is reduced prior to abandonment through environmental site assessments, mitigation of unacceptable potential environmental effects (e.g., pipeline removal in areas where abandonment is deemed unacceptable) and by satisfying the conditions of the NEB Abandonment Order. The Abandonment Plan should identify maintenance and the procedures, frequency and performance measures of LTM [11].

In short, the LTM requirements are expected to vary from site to site, changing in breadth and depth (i.e., reduced frequency and requirements) as the site matures and the residual risk lessens.

7.3.1 Monitoring Stage Term and Frequency

Monitoring frequency is not static throughout the life cycle of project post-abandonment. The level of monitoring effort will decrease as the site matures and stabilizes. A mature stabilized site presents less risk and, as such, requires a reduced level of monitoring. As a result, the LTM Plan must present monitoring frequencies which reflect the current state of the site and the risk level.

The frequency of monitoring will be determined and conducted in a risk-based manner [1] using the approach outlined below. Note that the approach should be tied back in to the performance goals identified in the Risk Management Plan [1].

- **Initial Monitoring:** Initial Monitoring is undertaken immediately following completion of remedial construction activities. The frequency requirements will be assessed based on the technical requirements and to measure the progress of the remediation measures. The LTM Plan developed to address the residual risks identified in the Risk Management Plan will have considered the balance of monitoring costs on remote sites in the selection of the remedial option. As a result of the cost-benefit analysis at the Risk Management stage, the Initial Monitoring should provide the most efficient and cost-effective solution while maintaining robustness to assure protection of human health and the environment.

  Studies have shown that the initial stage typically does not extend beyond five years. Frequency of monitoring within each yearly cycle will be dependent on parameters and the site particulars. Technological advances in remote monitoring should be considered as solutions to onsite presence, thereby reducing the logistical and financial burdens. The initial monitoring period will be continued beyond five years if the site conditions are found to not be relatively stable over time (i.e., steady-state conditions).

- **Iterative Review and Monitor Intervals:** The Iterative Review and Monitor Intervals typically represent a reduced level of effort from the initial monitoring period (5 years or more), as the site has matured for a period of time and is considered to be at or near steady-state conditions.

  During each review, the LTM Plan, monitoring data from past interval, and the associated risks are reviewed to confirm whether the site objectives have been satisfied and/or that the area surrounding abandoned pipelines continues to reflect stable or improving conditions. If residual risks and site conditions have improved, monitoring requirements and frequencies should be adjusted accordingly.

  The subsequent monitoring effort and time interval prior to the next iterative review and monitor cycle should be consistent with the magnitude and nature of the risks, with a frequency no less than 3 to 5 years. It is important that during each of the iterative review and monitor cycles that newer monitoring technologies and evolving stakeholder concerns are taken into consideration.

  The iterative review and monitor interval period will extend from the completion of the initial monitoring (typically five years) and continue for a period that varies from 10, 15 to 25+ years.

- **Site Closure and Beyond**: Monitoring is expected to continue in one form or another until site closure (i.e., end state) is achieved (i.e., no observable changes in monitoring over time, public and regulatory stakeholders satisfied). Beyond site closure, further investigation, monitoring and/or mitigation will only be required if landowner observes changes in the terrain.

It should be noted that his monitoring may be affected by geological, wildlife, weather or other contributing factors which need to be taken into consideration.

7.3.2 Corrective Actions

The LTM program should identify applicable follow-up and / or corrective actions for each of the monitoring activities that outlines what follow-up steps to take if an unacceptable change has been observed (e.g., subsidence) or measured (e.g., groundwater contamination above applicable guidelines).

Examples of potential unacceptable changes identified in LTM program and the associated follow-up and / or correction actions are as follows:

1. **Substantial ground subsidence observed during LTM program aerial patrol or site visits**

   Follow-up action: Ground Penetrating Radar to confirm pipeline integrity
   Corrective action (potential – after risk evaluation): Pipeline removal

2. **Loss of weed monitoring / control**

   Follow-up action: Mowing or brush-cutting.
   Corrective action: Review effectiveness of vegetation management in LTM program and recommend efficiency improvements to mitigate likelihood of reoccurrence.

3. **Liaison with landowners, tenants, public land managers**

   Follow-up action: Communication to identify and capture stakeholder concerns.
   Corrective action: Evaluate potential opportunities to enhance LTM program to address stakeholder concerns.

4. **“first-call” response and location of underground pipe**

   Follow-up action: Confirm response times and location of underground pipe.
   Corrective action: Review effectiveness of response plans, including ability to quickly identify location and information associated with abandoned underground pipes.

5. **Crossings**

   Follow-up action: Ground Penetrating Radar to confirm pipeline integrity at road and railway crossings. If pipeline is not visible at surface for water crossings, dive to confirm integrity.
   Corrective action (potential – after risk evaluation): Pipeline removal

6. **Erosion control maintenance**

   Follow-up action: Soil placement, grading and re-vegetation
   Corrective action: Evaluate pipeline role in reinforcing and stabilizing a slope and potential risks associated with likelihood for re-occurrence (e.g., exposure in cultivated land).

8 ABANDONMENT MONITORING CASE STUDIES

The purpose of this section is to provide a quick overview and reference to other abandonment long-term monitoring programs to draw attention to the reality that monitoring needs will vary from site to site and over time as these sites mature, or in some cases, until decommissioning has been completed. The NEB differentiate between reclamation monitoring (i.e., second stage of NEB oversight, after most physical abandonment activities are complete) and abandonment monitoring (i.e., third stage of NEB oversight, once pipeline is abandoned) [13]. Monitoring activities during reclamation will be more extensive than post-abandonment since purpose is to identify areas in need of additional reclamation to restore the land

8.1 Arrow Bowen Gas Project – Arrow Energy

Arrow Energy have planned to continue the operational environmental monitoring program for the Arrow Bowen Gas Project in Australia until all decommissioning and rehabilitation works are completed, in addition to further assessments and monitoring driven by decommissioning work and pollutants [44].

Monitoring locations were identified during the concept select phase and from ecological site assessments. Annual reviews are to be conducted during operations and post-closure phases. The key monitoring aspects are [44]:

- Soil erosion
- Revegetation
- Weed infestation
- Drain & waterway integrity, sediment control structures

8.2 Line 3 – Enbridge

Enbridge monitored and maintained the Line 3 pipeline ROW by patrol according to ongoing operations and maintenance programs [36], which included:

- Inspecting the pipeline ROW via pipeline patrols;
- Assessing areas of potential geotechnical threats;
- Maintaining pipeline signage;
- Performing DOC surveys;
- Monitoring and applying the cathodic protection system;
- Continuing maintenance of the ROW; and
- Performing enhanced monitoring using ground penetrating radar or equivalent 7 technology at primary highways and active railways.

Active monitoring that was then extended to the decommissioned pipeline consisted of [36]:

- Completing pipeline inspections during patrols,
- Assessing areas of potential geotechnical threats,
- Maintaining pipeline signage,
- Performing DOC surveys, and
- Monitoring the CP system.

Line 3 monitoring patrols were to be conducted by walking, driving, flying or other appropriate means, periodically, and recorded. Additional investigations when warranted were to document the location and condition of exposed pipe, and to assess the effects of unsupported spans, atmospheric corrosion, and third-party damage. Remediation would be gauged to risk, including, but are not limited to [36]:

- On-going monitoring;
- Improving community awareness; or
- Providing additional depth of cover, buoyancy control, pipeline protection, cladding, matting, or drainage control.

8.3 One Lateral Pipeline – Bonavista Energy Corp

Monitoring of One Lateral pipelines abandoned in-place included [29]:

- First call services,
- Maintenance of internal databases such as geographic information system,
- Maintenance of appropriate signage,
- Maintenance and administration of third-party crossings
- Visual inspections along the ROW at or from excavation points i.e., side valves, and paved roads for re-vegetation and subsidence.

The visual inspections would look for (but not be limited to) the following [29]:

- Vegetation regrowth in seeded areas
- Erosion and bank stability at water crossings (especially important in spring)
- The general conditions of the ROW
- Land levelling and grading activities
- Soil subsidence, sink holes
- Weed proliferation

8.4 John Lakes Pipeline – AltaGas

The NEB required AltaGas to file for the John Lakes Pipeline abandonment a Post-Abandonment Monitoring Plan that was to include [45]:

- A description of the environmental components or issues to be monitored;
- Monitoring methods for each environmental component or issue;
- Further corrective actions planned and a schedule for further monitoring and reporting;
- A description of and justification as to how AltaGas has incorporated the results of its consultation, including any recommendations from OLCN, into the plan; and
- Confirmation that a copy of the Post-Abandonment Monitoring Plan has been provided to OLCN.

8.5 2017 Meter Stations and Laterals Abandonment – NOVA Gas Transmission Ltd

The NEB required NOVA Gas Transmission Ltd (NGTL) to file a Post-Abandonment Monitoring Plan for the 2017 Meter Stations and Laterals Abandonment [46] that included:

- A description of the environmental components or issues to be monitored;
- Monitoring methods for each environmental component or issue; and,
- Further corrective actions planned and a schedule for further monitoring and reporting.

9 AUTHORITY AND ACCOUNTABILITY

In Alberta, Pipeline Regulation SOR/99-294 requires the pipeline owner to have perpetual liability for abandoned pipelines [4]. The NEB also requires the owner / operator of a pipeline to be responsible for a ROW monitoring plan to ensure that the pipeline left in place remains free of problems.

A 1997 NEB paper examined the legal issues associated with retirement regarding ongoing responsibility for the retired pipeline ROW concluding that [9]:

“in the absence of an express provision to impose conditions which would continue after the abandonment order comes into effect, [the NEB concluded] that it has no authority to attach conditions subsequent to an abandonment order”

The NEB has therefore adopted an approach that requires regulated pipelines to satisfy stakeholder conditions before a retirement can take effect [9], where the key stakeholders of pipeline abandonment include the owner / operator, landowner, public, and regulator [5].

10 FUNDING AND RESOURCE REQUIREMENTS

The costs of abandonment must include monitoring and potential future remediation. Regulatory changes may lead to unanticipated abandonment costs to ensure "no responsibility by the owner/operator" after a prescribed monitoring period [5].

A major issue still to be addressed is the question of who would assume responsibility if the owner/operator becomes insolvent. The pipeline industry has established a fund in Alberta to cover the cost of reclamation and abandonment of orphaned oil and gas wells and certain associated pipeline facilities [5]. The NEB therefore requires companies to set money aside, and have a suitable mechanism to access that money, for its remaining obligations to monitor and to address unforeseen events such as subsidence and exposure of pipe [11].

For example, in the Peace River application [12]:

> "Once ELC is achieved, no further post-abandonment activities are planned. If, however, additional monitoring takes place or future reclamation activities are required, the costs associated with this work are expected to be funded either through the abandonment trust except for the costs associated with monitoring of abandoned facilities co-located with operational facilities, which are expected to be funded through normal operations and maintenance expense treatment.

11 REFERENCES

[1] Arcadis (for Petroleum Technology Alliance of Canada), 2017 August 14. *Risk-Based Decision-Making Framework for Pipeline Abandonment*.

[2] Franz Environmental Inc (for Environment Canada), 2012 March. *FCSAP Long Term Monitoring Planning Guidance*.

[3] Petroleum Technology Alliance of Canada, 2017 May 30. *Request for Proposals - PARSC 014 – Recommended Long Term Monitoring Program for All Aspects of an Abandoned Pipeline*.

[4] Alberta Innovates - Technology Futures (for Petroleum Technology Alliance of Canada), 2015 September. *Cleaning of Pipelines for Abandonment*.

[5] National Energy Board, 1996 November. *Pipeline Abandonment - A Discussion Paper on Technical and Environmental Issues*.

[6] National Energy Board, 2009 May. *Land Matters Consultation Initiative Streams 1, 2 and 4*

[7] National Energy Board, 2009 May. *Supplementary Information for the LMCI Final Report - List of Issues Raised Through LMCI and NEB Comments*.

[8] Canadian Energy Pipeline Association, 2006 September - 2007 April. *Pipeline Abandonment Assumptions - Technical and Environmental considerations for development of Pipeline Abandonment strategies*.

[9] Det Norske Veritas (for National Energy Board), 2010 November. *Pipeline Abandonment Scoping Study*. Report No. EP028844

[10] Matrix Solutions, Inc. (for Petroleum Technology Alliance of Canada), 2018 June. Analysis of Pipeline Exposure Data and Scoping Review of Exposure Scenarios.

[11] National Energy Board, 2016 June. *Regulating Pipeline Abandonment*.

[12] Stantec, 2016 August. *Peace River Mainline Abandonment Project – Environmental and Socio-Economic Assessment – Section 74 Application*.

[13] NEB. 2018. Reasons for Decision. NOVA Gas Transmission Ltd Peace River Mainline Abandonment Project. National Energy Board. MH-002-2017.

[14] CCME. (2007). Canadian soil quality guidelines for the protection of environmental and human health: summary tables. http://www.esdat.net/Environmental%20Standards/Canada/SOIL/rev_soil_summary_tbl_7.0_e.pdf

[15] CCME (2008). Canada-wide standards for petroleum hydrocarbons (PHC) in soil. https://www.ccme.ca/files/Resources/csm/phc_cws/phc_standard_1.0_e.pdf

[16] Portfire Associates (for Petroleum Technology Alliance of Canada), 2014 March 14. *Innovation Roadmap for Transmission Pipeline Transportation of Petroleum*.

[17] CCME (2010). Carcinogenic and other polycyclic aromatic hydrocarbons (PAHS). https://www.ccme.ca/files/Resources/supporting_scientific_documents/pah_soqg_scd_1445.pdf

[18] CCME (1999). Canadian Soil Quality Guidelines for the protection of environmental and human health - polychlorinated biphenyls (total). http://ceqg-rcqe.ccme.ca/download/en/274

[19] CCME (2004a) Canadian soil quality guidelines for the protection of environmental and human health – benzene. http://ceqg-rcqe.ccme.ca/download/en/259

[20] CCME (2004b) Canadian soil quality guidelines for the protection of environmental and human health – toluene. http://ceqg-rcqe.ccme.ca/download/en/283

[21] CCME (2004c) Canadian soil quality guidelines for the protection of environmental and human health – ethylbenzene. http://ceqg-rcqe.ccme.ca/download/en/267

[22] CCME (2004d) Canadian soil quality guidelines for the protection of environmental and human health – xylenes. http://ceqg-rcqe.ccme.ca/download/en/287

[23] Health Canada (2011) Canadian Guidelines for the Management of Naturally Occurring Radioactive Materials (NORM). http://www.norm.ca/wp-content/uploads/2015/03/Canadian-Guidelines-for-the-Management-of-NORM-2011.pdf

[24] NOVA Environment & Corrosion (for Petroleum Technology Alliance of Canada), 2017 July 3. *Fate and Decomposition of Pipe Coating Materials in Abandoned Pipelines*.

[25] Thorne WE et al, 1996 June. *Identification and Assessment of Trace Contaminants Associated With Oil and Gas Pipeline Abandoned in Place*. In 1996 1st International Pipeline Conference (pp. 1263-1270). American Society of Mechanical Engineers.

[26] Wright PC, Hogdon AM (1989). Decision procedures for pipeline rehab. *Oil and Gas Journal*, 87(32):40-52.

[27] Ravishankar K, Connor J (2008). *Use Of Risk-Based Business Approach For Characterization Of Environmental Remediation Liabilities In Upstream Oil And Gas Production Facilities*. In SPE International Conference on Health, Safety, and Environment in Oil and Gas Exploration and Production. Society of Petroleum Engineers.

[28] Leir, M. (2009). Geohazard integrity management program for onshore pipelines. In *9th International Symposium on Environmental Concerns in Rights-of-Way Management, Portland, Oregon*.

[29] Braun J, et al., 1998 November 9. *Geologic hazards evaluation boosts risk-management program for Western U.S. pipeline*. Oil & Gas Journal.

[30] Bonavista Energy Corporation, 2016 March 10. *Application to abandon one lateral pipeline*.

[31] Many Islands Pipe Lines, 2017 December 15. *Abandonment of Renaissance Bronson North Pipeline Application*.

[32] Many Islands Pipe Lines, 2017 December 13. *Pipeline Engineering Abandonment Plan for Bronson North MIPL(C)L Abandonment*.

[33] Conservation and Reclamation Regulation, Alberta Regulation 115/1993, Environmental Protection and Enhancement Act, http://canlii.ca/t/535zf retrieved on 2019-01-30

[34] NEB, 2017 January 23. Response to Information Request.

[35] NEB, 2017 July 13. *Filing Manual*. https://www.neb.gc.ca/bts/ctrg/gnnb/flngmnl/index-eng.html.

[36] Webster, R.D., Pipeline Corrosion Evaluation, Topical Report, Corrpro Canada, Inc., 1995.

[37] Enbridge Pipelines Inc (for National Energy Board), 2014 November 5. *Line 3 Replacement Program - Engineering Decommissioning Report*.

[38] Romanoff M (1957). Underground corrosion. Washington (DC: US Government Printing Office.

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

[40] Saunders, R., Preliminary Geotechnical Assessment of Pipeline Subsidence Phenomena, Topical Report, Geo-Engineering Ltd., 1995.

[41] Mackay, J. R., & Burrous, C. (1979). Uplift of objects by an up-freezing ice surface. Canadian Geotechnical Journal, 16(3), 609-613.

[42] Van Everdingen RO (1979). Potential interactions between pipelines and terrain in a northern environment. Environment Canada, Inland Waters Directorate, Technical Bulletin Series, (ll4).

[43] NEB, 2017 June 21. *Remediation Process Guide*. https://www.neb-one.gc.ca/sftnvrnmnt/nvrnmnt/rmdtnprcssgd/index-eng.html

[44] ITRC, March 2006. Exit Strategy – Seeing the Forest Beyond the Trees. Second in a Series of Remediation Process Optimization Advanced Topics. US Interstate Technology & Regulatory Council.

[45] Arrow Energy, 2013 February 14. *Environmental Impact Statement – 29 Decommissioning & Rehabilitation*.

[46] North Shore Environmental Consultants (for AltaGas Holdings Inc), 2017 October. *John Lake Pipelines Aboriginal Participation and Monitoring Plan*.

[47] NOVA Gas Transmission Ltd, 2018 January 3. *Application for the 2017 Meter Stations and Laterals Abandonment Program*.

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