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Journal:	<i>Environmental Reviews</i>
Manuscript ID	er-2017-0003.R3
Manuscript Type:	Review
Date Submitted by the Author:	20-May-2017
Complete List of Authors:	Belvederesi, Chiara; MSES Inc., Thompson, Megan; MSES Inc. Komers, Petr; MSES Inc.
Keyword:	Environmental consequences, oil and gas pipelines, Canada, accident database, United States

**Canada’s federal database is inadequate for the assessment of environmental
consequences of oil and gas pipeline failures**

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Word count: 7368

Belvederesi, C., Thompson, M.S., and Komers, P.E. 2017. Canada's federal database is inadequate for the assessment of environmental consequences of oil and gas pipeline failures. Environ. Rev. Submitted for publication.

Abstract: In Canada, the National Energy Board (NEB) regulates inter-provincial oil and gas pipelines, and maintains historical records that contain data on oil and gas pipeline accidents; these data include information about operators, accidents' cause and the resulting consequences. New inter-provincial pipelines are being built in Canada to transport fuels, but no comprehensive statistical analysis of the risk to environmental receptors exists. This study assesses the quality and quantity of NEB pipeline failure data available in Canada with a focus on environmental consequences, and investigates differences between Canada and a more thoroughly studied jurisdiction, the United States, in tracking accident data. The discrepancies in agencies' jurisdiction and regulated mileage are analyzed, along with reporting criteria and initial recording year. The level of detail provided by the two agencies is compared, identifying deficiencies in data collection. The Pipeline and Hazardous Material Safety Administration (PHMSA) regulates 76 percent (%) of pipelines in the US while the NEB only monitors 9% of pipelines in Canada. PHMSA provides four databases that include accidents from the 1980s for most pipelines, and from 2011 for liquefied natural gas facilities; the NEB database includes accident data starting from 2008, which derive primarily from transmission pipelines. Information about environmental consequences is quite detailed in the US database, which reports 21 descriptive fields, while in Canada, only two NEB database fields describe environmental outcomes. Moreover, dissimilarities in accident reporting criteria prevent the combination of data from the two agencies. Consequently, the NEB database does not allow for

statistically robust and system wide analysis of the environmental consequences of pipeline failures in Canada. Furthermore, to calculate failure rates (annual number of accidents per km of pipeline) for regulated pipelines, annual total mileage estimates are required. Mileage per year is provided by PHMSA for gas gathering, transmission, and distribution pipelines starting from 1984, and for hazardous liquid pipelines from 2004; the NEB provides annual mileage from 2010, a shorter period of record. The Canadian federal agencies are encouraged to improve accuracy and consistency in recording past accidents and in collecting pipeline data, with the goal of preventing and minimizing future pipeline failures.

Keywords: Environmental consequences, oil and gas pipelines, Canada, accident database, United States

1 Introduction

1.1 Overview

Pipelines are the safest method of transporting oil and gas (Green and Jackson 2015). However, pipeline failures do occur and they can lead to serious environmental harm. In Canada, the growing need to build new inter-provincial pipelines highlights the importance of investigating pipeline failures (Canadian Association of Petroleum Producers 2016; Cheadle 2016). Using case studies, Lee et al. (2015) analyzed selected oil spills with the goal of providing recommendations to improve the current practice of risk assessment in Canada. This study aims to determine whether it is possible to obtain numerical probabilities of the occurrence of oil and gas pipeline accidents in Canada and relate those probabilities to measures of the resulting environmental consequences. Risk analysis is intended to predict and aid in effectively preventing the occurrence of adverse events. Adequate data is fundamental to assess the causes, consequences, frequency and probability of accidents. Information from past oil and gas pipeline accidents can be used to conduct risk analyses; however, the historical data must be collected using consistent methods and criteria, and records must be complete to reduce uncertainties and to obtain statistically rigorous results. For example, a study conducting a risk assessment of marine spills using both quantitative and qualitative data obtained from more than one department or agency found that analyses often suffer from limitations due to the inconsistency of spill data collection methods between agencies (WSP et al. 2014).

In Canada, major pipeline failures have significantly affected the environment. For example, in April 2011, Plains Midstream Canada ULC reported a pipeline failure that released 4500 m³ of crude oil into a water body close to the Traditional Territory of the Woodland Cree First Nation near Peace River, Alberta. Wildlife and vegetation were also affected (Energy Resources

69 Conservation Board 2013). In June 2012, the same company detected abnormal operating
70 conditions on a pipeline that led to a release of 462.75 m³ of crude oil into the Red Deer River,
71 AB. The accident and related response and remediation efforts caused impacts to wildlife, water,
72 soils, and vegetation (Alberta Energy Regulator, 2014a). Although the volume spilled was less
73 than in the former accident, the product released into the Red Deer River was not limited to the
74 spill location but spread along the river, affecting landowners and businesses downstream for
75 about 40 km from the release point to the Dickson Dam reservoir. On July 15, 2015, Nexen
76 Energy notified the Alberta Energy Regulator (AER) of a pipeline release. The company
77 reported an initial estimated emulsion volume of 5000 m³ in a 40 m x 400 m area. The release
78 did not flow into a waterbody and there were no reported impacts to the public or to wildlife;
79 nevertheless, the AER directed the operator to implement a wildlife protection plan in the area
80 (Alberta Energy Regulator, 2015b). These examples show that, depending on the type and
81 amount of product spilled, the location of the pipeline in relation to environmental receptors, and
82 the timing and nature of the response, the environmental consequences of pipeline failures can
83 vary greatly.

84 Statistical analysis of the causes and consequences of past accidents can help the industry to
85 reduce the number of future occurrences and minimize resulting impacts. It is important to track
86 pipeline accidents by systematically collecting and reporting detailed information when they
87 occur, in order to enhance pipeline safety by identifying hazards associated with fuels
88 transportation. The most basic information is the annual failure rate, calculated as the number of
89 accidents per pipeline mileage for a given year. To understand the dynamic of these accidents, it
90 is also necessary to know what causes lead to the pipeline failure. Pipeline design characteristics,
91 such as wall thickness, pipe diameter, pipe material, installation year, maximum allowable

operating pressure, population density at the accident location, and the company that operates the line may also be related to the failure. Equally important is the understanding of the nature of consequences, including environmental impacts. Details on the level of environmental impact, specifically on air, soils, water bodies, wildlife and vegetation, are essential to carry out a statistical analysis on environmental consequences. Conducting an analysis of historical data, whether quantitative or qualitative, to characterize the environmental impacts of pipeline accidents should be based on a consistent approach. On one hand, a qualitative analysis includes details not provided by quantitative approaches, such as local responses and effects on a community at the location of the accident, but it may introduce subjectivity and inconsistencies that derive from the experience and personal preferences of the person or company conducting the analysis. On the other hand, a quantitative approach reduces the subjectivity of an analysis and improves the applicability of its findings to other cases. This study focuses on quantitative data because quantitative analyses can lead to less subjective statistical studies that use consistently structured data, providing for the calculation of risks and probabilities and supporting engineering designs (Wang et al. 2015, Han and Weng 2011, Shariar et al. 2012).

Federal agencies collect and publish data about oil and gas pipeline failures in Canada and the US. The National Energy Board (NEB) and the Transportation Safety Board of Canada (TSB) gather information about pipeline accidents in Canada. Generally more comprehensive, however, are the US Department of Transportation's (DOT) Pipeline and Hazardous Material Safety Administration (PHMSA) databases, in which annual data on oil and gas pipeline accidents for regulated pipelines in the US are published. Each agency has different reporting criteria, uses different database formats and reporting parameters, and includes accidents from different time ranges. In addition to federal agencies, provincial agencies in Canada also collect oil and gas

pipeline failure data for pipelines that operate under provincial jurisdiction. A quantitative assessment of the environmental consequences of pipeline failures for use in Canada must begin with selection of the most suitable dataset for this purpose.

1.2 Review of Regulatory Oversight and Reporting in Canada and The United States

In Canada, the pipeline planning and development process involves federal and provincial agencies that regulate the pipeline network system. Provincial agencies regulate the intra-provincial pipeline network, including water pipelines, while federal agencies regulate the inter-provincial network, which are exclusively oil and gas pipelines. For this reason, the provincial agencies' combined jurisdiction is more extensive than the federal agencies'. Most oil and gas pipelines are in western Canada (the provinces of British Columbia, Alberta and Saskatchewan), where the largest oil reserves are. The Alberta Energy Regulator (AER) regulates more than 422,000 km of pipelines in Alberta, including water pipelines. All pipeline accidents that occur in the AER jurisdiction, including those in which a pipeline is hit but does not leak, must be reported to the AER. Accidents are qualitatively rated as high, medium and low consequence based on impacts on the public, wildlife and the environment as follows:

- High consequence: accidents that could have significant impact on the public, wildlife, or the environment, or that involve the release of a substance that affects a large area or waterbody.
- Medium consequence: accidents that could have a moderate impact on the public, wildlife, or the environment, and no impact on a flowing water body.
- Low consequence: accidents that involve little to no substance released and have little to no impact on the public, wildlife, and the environment (but no impact on a water body).

Information about 2015 and 2016 pipeline accidents is publicly available on the AER website (Alberta Energy Regulator 2017c).

The Saskatchewan Petroleum and Natural Gas Spill Report Directory refers to Directive PNG014 for pipeline accident reporting requirements. Criteria that define whether an accident must be reported to the Saskatchewan agency are provided by the agency (Government of Saskatchewan 2016). The PNG Digitized Spill Report Directory provides historical accident documents up to November 4, 2015. Accidents that occurred since November 4, 2015 are collected in a digital database. It contains general information about each accident, although details on environmental impacts are not mentioned.

The British Columbia Oil and Gas Commission regulates over 40,000 km of pipelines in British Columbia (BC). Data about pipeline accidents are accessible on an interactive web-based map that shows where accidents have occurred from 2009 to present. The interactive map helps to locate accidents and to obtain general information on the type of product released, pipeline operator and occurrence date, although details on environmental impacts are absent. According to the BC agency, “accident” means “a present or imminent event or circumstance, resulting from an oil and gas activity that is the subject of a plan, that is outside the scope of normal operations, and may or may not be an emergency” (BC Oil and Gas commission 2017). After being reported, accidents are classified into four categories reflecting the level of risk: Minor, Level 1, Level 2 or Level 3 (Public Safety Report, 2012):

- Minor: accidents that do not meet the criteria for Levels 1-3. Accident has impact on permit holder only, and no potential impacts to people, property or the environment.
- Level 1: accident has moderate to major impact on permit holder only; no potential impacts to people, property or environment.

- Level 2: accident may pose a risk to the public and/or environment.
- Level 3: accident has serious impacts to the public and/or environment and results in immediate danger.

Provincial agencies in Canada regulate pipeline accidents within their territories according to differing reporting criteria and regulate a different range of products, in addition to oil and gas. The inconsistency in the definition of accidents and consequences among provincial agencies means that it is not possible to readily combine data from different provinces to create a composite database of oil and gas pipeline failures in Canada. Combining provincial datasets is further complicated by the lack of transparent and comparable rationales used to rank relative risks associated with failure consequences.

The NEB is an independent federal agency established in 1959 by the Government of Canada that regulates over 73,000 kilometers (km) of mainly transmission pipelines throughout their life cycle, from pipeline design and construction to abandonment. Pipelines that cross inter-provincial or international borders are under NEB jurisdiction, while intra-provincial pipelines (i.e. within one province) are regulated by each individual province. The NEB requires pipeline companies to meet safety standards through a management system in order to prevent, manage and mitigate risks associated with oil and gas transportation. The NEB also investigates historical pipeline failures to monitor companies' integrity management programs, emergency response and design safety principles (Natural Resources Canada 2016) and has been collecting failure information in a digital database from 2008. Compared to provincial agencies, the NEB provides oil and gas pipeline accident data in a standardized digital format for a longer period. The TSB is an independent federal agency created in 1990 by the Canadian Transportation Incident Investigation and Safety Board Act that investigates accidents in different modes of

transportation, including marine, pipeline, rail and air, to advance transportation safety (Transportation Safety Board of Canada 2016). Both the NEB and TSB maintain databases of pipeline failures for the pipelines under their jurisdictions. Pipeline operators are required to submit information about these accidents when they occur.

In the US, data on oil and gas pipeline accidents are collected by the PHMSA, which is a part of the DOT. Pipeline operators are required to submit annual reports by the Code of Federal Regulations (49 CFR, Parts 191, 195) to PHMSA. These reports contain information about pipeline operators, pipe design, accidents' causes and resulting consequences that are helpful for safety researchers, government agencies, industry professionals and PHMSA personnel who conduct inspection, planning and risk assessment activities (Pipeline Hazardous Material Safety Administration 2016a). Four databases on pipeline accidents are available for gas gathering and transmission, gas distribution, hazardous liquids and liquefied natural gas facilities.

PHMSA and NEB databases have been used by researchers to carry out statistical analyses of pipeline accidents. Failure statistics for onshore pipelines transporting oil, refined products and natural gas have been compared between the US, Canada and Europe (Cuhna 2012). Similarly, the PHMSA and NEB data were analyzed with other data sets available from Europe, Canada, USA, and South America, to calculate the annual frequency of failures caused by geohazards for hydrocarbon gathering and transmission pipelines (Porter et al. 2016). The PHMSA data were used to calculate annual mileage and accident rates for onshore gas transmission pipelines in the US (Lam 2015; Lam and Zhou 2016). Data from the PHMSA database were also analyzed to investigate causes and consequences of unplanned releases of hazardous products (Restrepo et al. 2009) and to investigate historical onshore hazardous liquid pipeline accidents caused by natural hazards (Girgin and Krausmann 2016). Few studies have focused on the consequences of past

oil and gas pipeline failures, including environmental impacts (but see Cuhna 2014; Parvizsedghy and Zayed 2014).

Overall, authors in the past preferred the PHMSA database over other international databases for use in quantitative assessment of oil and gas pipeline failures. This is generally because of the ease of obtaining information from PHMSA, the completeness and longer record length of the data, and consistency in the structure of reporting accidents, which facilitates effective and informative data analysis. In order to assess pipeline failures and environmental consequences in Canada, it would be best to analyze accident data from Canada. However, no such analysis has been performed using NEB or TSB data, and no comparison of the quality and usefulness of the national and international databases for the purpose of analyzing pipeline failure rates and their environmental consequences is available. For this reason, an assessment of the suitability of Canadian databases and a comparison with the more often-used PHMSA database is the focus of this review.

2 Approach

Basic information about pipeline failures including annual pipeline mileage, causes and consequences of failure, design characteristics and the operator of the pipeline involved in the accident were evaluated in this review. The availability of this information was then cross-referenced with the availability of database fields dealing with environmental impacts of pipeline failures, to determine whether each database could be used for a risk assessment of environmental consequences.

In Canada, both the NEB and TSB collect and publish historical databases on pipeline failures, containing descriptive fields about the company that operates the pipeline, and accident causes

and outcomes; however, the database provided by NEB describes each accident in more detail than the TSB. In particular, the NEB database indicates whether an environmental consequence occurred, along with a description of conditions that resulted in adverse effects on the environment, while the TSB only states whether the accidents lead to environmental consequences or not. For this reason, the TSB database is less suitable for use in the desired statistical analysis, and this review focuses on the data quality of the NEB database.

The NEB provides information on environmental consequences due to spills mostly from transmission pipelines in a digital format, starting in 2008 (National Energy Board 2016a). Table 1 shows descriptive environment-related fields contained in the dataset. Field descriptions are not provided in the NEB database. Information about accidents that occurred before 2008 is collected in a print format available for reference at the NEB library in Calgary. It contains a list of accidents listed according to pipeline operators, with reported information on failure events at the time of the accident; however, few details are provided about accident consequences and it is difficult to use this historical dataset for a statistical analysis and risk assessment of pipeline failure consequences in Canada. In fact, before 2008, pipeline operators reported information at the time of the accident in the absence of consistent reporting criteria that outline common principles in reporting information. Digitization of this pre-2008 record and consistent integration with more recent data is necessary to enable the use of these data in statistical analyses.

In the US, four PHMSA databases are available online (Pipeline and Hazardous Material Safety Administration 2016b) that provide accident information on gas transmission, gathering, distribution, hazardous liquid pipelines and liquefied natural gas facilities. Table 2 shows

descriptive environment-related fields as reported in one of these databases, the hazardous liquid pipeline dataset.

This review also compares differences between agencies’ jurisdiction and reporting criteria; this information is available online from both the NEB and PHMSA (National Energy Board 2016b; National Energy Board 2016c; US Government Publishing Office 2016). Comparing the agencies’ jurisdiction and accident reporting criteria helps to understand the accuracy and applicability of the data collected and whether or not the agencies are collecting data using similar principles. This would be particularly useful if the NEB database alone proves to contain an insufficient number of cases for the analysis of environmental impacts, because a statistical analysis could still be carried out by combining the NEB and PHMSA datasets to obtain a higher number of failure cases.

3 Findings

3.1 Spill cases reported by the NEB and PHMSA

Examining specific cases reported by the NEB and PHMSA in their databases can help in the understanding of the quality and quantity of information gathered and made available by the two agencies. From the NEB digital database, two example cases have been chosen that report adverse environmental effects but that suffer from commonly occurring incomplete data reporting. First, an accident reported by TransCanada Pipelines Limited in 2014 occurred in Ontario, near Maple and is classified as “Adverse Environmental Effect” under the Accident type category. The release type is not reported, as well as the released substance subtype and the substance carried; in this case, there is no information about what type of product was released to the environment. The immediate failure cause is classified as natural force damage and the

275 accident states positive residual effects on the environment. Conditions that resulted in adverse
276 effects on the environment show the release of toxic substance. No further information is
277 provided about the environmental impact. In the second example, a case reported by NOVA Gas
278 Transmission Ltd. in 2015 occurred in Alberta near Fort McKay and, as in the first case, is
279 classified as “Adverse Environmental Effect” under the Accident type category. The release type
280 is “not applicable”, the released substance type is not reported, while the substance carried is
281 reported as natural gas. The immediate failure cause is classified as external interference,
282 operating conditions, and the accident states negative residual effects on the environment
283 although conditions that resulted in adverse effects on the environment are classified as “Frac out
284 into water body”. Neither of these two cases included a reported release volume.

285 From the PHMSA digital database for hazardous liquid pipelines, two typical cases have been
286 chosen that reported environmental impacts. First, an accident reported by Loop Inc. occurred in
287 2010 in Louisiana and was caused by equipment failure, leading to the release of 202 barrels of
288 crude oil. The accident caused environmental damage to wildlife (birds), and water (surface
289 contamination). A wildlife remediation protocol was applied as part of the broader
290 environmental remediation, and the 202 barrels of product released were recovered. The
291 commodity did not reach a high consequence area (defined as sensitive areas for the environment
292 or highly populated areas). In the second PHMSA example, an accident reported by Bridger
293 Pipelines LLC. occurred in 2015 in Montana in close proximity to a water body, on an uncased
294 section of a hazardous liquid pipeline. The pipeline leaked 758 barrels of crude oil into the
295 Yellowstone River, which caused water contamination (surface water, drinking water and public
296 water contamination). No impacts are recorded to soil and wildlife and no environmental
297 remediation is reported. Only 65 barrels of product were recovered.

The NEB database does not report details on conditions that resulted in adverse effects on the environment and it is not possible to determine the type or extent of environmental impacts caused by a pipeline spill from the information provided in the NEB database. In contrast, the PHMSA database reports greater detail on the conditions that resulted in the environmental impacts. It is still not possible to quantify the extent of the damage to the environment based on the PHMSA data because the Yes/No/Null statements do not allow for a quantitative assessment. Information reported by PHMSA allows for quantifying the frequency but not the severity with which wildlife, soil, vegetation and water bodies have been affected by oil and gas spills.

3.2 Jurisdiction and mileage

In Canada, the NEB divides oil and gas companies under its jurisdiction into two groups:

- Group 1 companies are those with more extensive systems. They are subject to a greater degree of regulatory oversight than Group 2 companies;
- Group 2 companies tend to be smaller, have fewer shippers and are subject to a lighter degree of regulatory oversight. They are regulated on a complaints basis (National Energy Board 2016d).

However, the definition of “more extensive system” and “greater” or “lighter degree of regulatory oversight” is not clear from information provided on the NEB website.

In total, 97 oil and gas companies are regulated by NEB; 13 belong to Group 1 and 84 belong to Group 2; they operate about 73,000 km of mainly oil and gas transmission lines in Canada and partially in the US. Oil and gas transmission, gathering and distribution pipelines cover approximately 840,000 km (Natural Resource Canada 2016). Therefore, in terms of pipeline

length, the NEB regulates 9% of the oil and gas pipeline system in Canada. Water pipelines are not included in the NEB jurisdiction.

In the US, PHMSA regulates both intra and inter-state pipelines. Its jurisdiction covers 3000 gas transmission, gathering and distribution operators and 200 hazardous liquids operators for a total mileage of 2.8 million km out of a total of about 3.7 million km of pipelines across the US (Pipeline and Hazardous Material Safety Administration 2013). Therefore, PHMSA regulates 76% of the oil and gas pipeline system in the US.

Both the NEB and PHMSA collect annual data on oil and gas pipeline mileage and accidents. The NEB provides annual mileage starting in 2010 upon request, by privately contacting NEB personnel (National Energy Board 2016e). Annual mileage prior to 2010 is not available in digital format and is not readily available from NEB personnel. In contrast, PHMSA publishes annual mileage online from 1984 to the most recent complete calendar year (Pipeline and Hazardous Material Safety Administration 2016c). Table 3 shows differences in agencies' jurisdiction and mileage information.

3.3 Database reporting criteria

Both agencies in the US and Canada provide databases containing information about historical oil and gas pipeline accidents. The NEB uses the Onshore Pipeline Regulations (OPR) and the Processing Plant Regulations (PPR) for oil and gas pipeline accident reporting criteria (National Energy Board 2016b; National Energy Board 2016c; National Energy Board 2016f).

Section 52 of the OPR and section 46 of the PPR state that a company “shall immediately notify the NEB of any accident relating to the construction, operation or abandonment of its pipeline and shall submit a preliminary and detailed accident report to the Board as soon as is practicable;

also, after notification of an accident, an inspection officer may partially or completely relieve a company from the requirement to submit a preliminary and detailed accident report”.

Information gathered by PHMSA is available from the 1980s; three databases are available online for each pipeline type: gas distribution, gas gathering and transmission, and hazardous liquid pipelines that include crude oil pipelines. Because PHMSA has periodically changed its reporting criteria over time, the databases are divided into three sections as shown in Table 4. Each section follows different reporting criteria.

In the US, Title 49 of the Code of Federal Regulations (CFR) (US Government Publishing Office 2016), sections §191.3 and §195.50, require operators to file a descriptive document within 30 days after an accident occurs. The definition of accident is described for gas transmission, gathering and distribution pipelines in section §191.3, while section §195.50 describes cases in which the operator is required to report accidents for hazardous liquid pipelines.

There are significant differences in reporting criteria for accidents between the NEB and PHMSA that are highlighted in Table 5. An accident must always be reported if it causes at least death or injury for both NEB and PHMSA liquid and gas pipeline systems. Property damage costs as a reporting criterion is only applied by PHMSA, while NEB does not require any minimum amount. This means that the NEB database would include a larger number of cases, specifically those that cost less than the PHMSA criteria of \$50,000, all else being equal. For the NEB, the minimum release volume for a reportable accident is 1.5 m³ for low vapor pressure products, which are liquid fuels. A much smaller minimum release of 0.019 m³ is PHMSA’s reporting criterion for liquid products. This means that the PHMSA database should include a larger number of these cases compared to the NEB, specifically occurrences with less than 1.5 m³ of product released, all else being equal. Ignitions and explosions are consequences that

require reporting for both gas and liquid products to the NEB, but are reporting criteria only for liquid and not gas pipelines for PHMSA. Many occurrences included in the NEB database would not be included in the PHMSA dataset and vice versa, due to these different reporting criteria. It is not possible to manually integrate the datasets by applying the most conservative (exclusive) reporting criteria because some criteria, such as cost, are not applied in both databases. For this reason, the two databases cannot be combined to obtain more cases and improve the power of any potential statistical analyses, because doing so would lead to unrepresentative and inaccurate conclusions.

3.4 Database accident information

This section focuses on descriptive fields provided in each database that report details on accidents and the environmental consequences of pipeline failures. The NEB reports accidents that have occurred since 2008 in a single digital database for transmission, gathering and distribution pipelines that carry low and high vapor pressure products. Because NEB jurisdiction includes only inter-provincial pipelines, the database mainly contains transmission pipeline information. In contrast, PHMSA provides four databases for gas transmission and gathering, gas distribution, hazardous liquid pipelines and liquefied natural gas facilities. Accidents that have occurred since the 1980s are included in the databases, with the exception of the liquefied natural gas facilities database, where accidents that occurred since 2011 are included.

A list of definitions for the descriptive fields is provided with the PHMSA database, which helps in the understanding of what information each descriptive field reports. The NEB database, by contrast, does not provide definitions or explanations of descriptive fields; a glossary of terms is available online, although not all of the fields are included (National Energy Board 2016f).

Both the NEB and PHMSA databases collect information about the pipeline operator, date and time of the accident, pipeline design characteristics, causes that led to failure and related outcomes. The main difference between the two databases is in the level of detail provided. PHMSA uses a total of 614 descriptive fields to explain each failure, while the NEB uses 102. The difference between the databases is further evident when considering descriptive fields related to environmental impacts; as mentioned in Section 2, PHMSA describes wildlife, vegetation, water and soil contamination in 21 descriptive fields, indicating whether or not environmental remediation occurred. Conversely, the NEB database simply indicates whether the pipeline failure affected the environment, and provides few details about how the environment was affected. In particular, between 2008 and 2016, the NEB reports 80 cases with impacts on the environment, but only 10 cases include descriptions about those environmental impacts; during the same time window PHMSA reported 2507 hazardous liquid pipeline spills where the environment was affected and details about the type of environmental impact are provided for all 2507 cases. Table 6 summarizes differences between the NEB and PHMSA databases in collecting accident information.

4 Conclusions and Recommendations

Statistical analyses of historical pipeline failures and the resulting environmental consequences help to identify risks and assess possible impacts in the event of future accidents. Gathering information in publicly accessible databases facilitates such analyses; however, in Canada, inconsistency in reporting criteria among provincial agencies, the difficulty in obtaining mileage information and the incompleteness in data records of environmental impacts allow for only limited quantitative analyses that are based on specific case studies. To evaluate the potential for

412 a comprehensive system-wide analysis, this study focuses on federal agencies that report
413 information on pipeline accidents in Canada. Information contained in the database provided by
414 the NEB was compared with information provided in the PHMSA database in the US, including
415 jurisdiction, mileage data, accident reporting criteria and the level of detail reported in each
416 dataset. Results show that the two agencies differ significantly in their jurisdiction; while
417 PHMSA regulates both inter and intra-state pipelines, covering 76% of all pipelines in the US,
418 NEB regulates only the 9% of oil and gas pipelines in Canada that are inter-provincial pipelines.
419 Assessing such a small fraction of the total pipeline system in Canada is not representative of the
420 overall risks that pipeline failures pose in terms of environmental impacts across Canada. In
421 addition, annual mileage data is only available from the NEB starting from 2010; for this reason,
422 quantitative studies on failure rates (number of accidents per unit length per year) before 2010
423 cannot be conducted in Canada using the publicly available NEB information. Publicly available
424 databases on oil and gas pipeline accidents are maintained by both the NEB and PHMSA;
425 however, PHMSA provides failure data starting from the 1980s while the NEB database provides
426 data for pipeline accidents from 2008; this means that far fewer cases over a much shorter
427 timespan are available for a quantitative assessment of pipeline accident consequences in
428 Canada. In the NEB database, only 12.5% of all cases that resulted in environmental impacts
429 have accompanying data that specify how the environment was affected, while PHMSA reports
430 information on wildlife, vegetation, water and soil contamination for each accident where
431 environmental impacts occurred. For the purpose of statistical analysis of pipeline failures and
432 the resulting environmental consequences, data provided by the NEB for Canada are inferior to
433 the US PHMSA data; an effective demonstration of this is the frequent use of PHMSA data in
434 the literature, although improvements would be necessary for both agencies. Both datasets would

435 be improved by reducing data gaps and errors in reporting information in the databases. In
436 addition, quantifying impacts on the environment by adding the amount of product released into
437 water bodies, soil, and air, and including the number of animals and type of vegetation affected
438 by the contaminant, would considerably increase the data quality of the two agencies. Tracking
439 and analyzing pipeline accident-related environmental consequences in Canada using data
440 provided by the NEB is difficult because important environmental details are rarely reported. As
441 a result, the NEB database is neither complete nor sufficiently comprehensive to conduct a
442 representative quantitative assessment of environmental consequences that have resulted from oil
443 and gas pipeline failures in Canada.

444 In order to improve data collection and provision, the following actions could be taken by
445 regulators in Canada:

- 446 • Provide publicly-available comprehensive database documentation for users. Provide
447 definitions with clear explanations for every field in the dataset.
- 448 • Report annual mileage data publicly and make it available on the NEB website.
- 449 • Ensure and enforce completeness in reporting information for descriptive data fields,
450 avoiding blank database cells.
- 451 • Change reporting criteria, in order to be consistent and inclusive across jurisdictions and
452 also with the PHMSA database, with the aim of including a higher number of comparable
453 accident cases for review and analysis.
- 454 • Including information about what type of receiving environment was involved (e.g. bogs,
455 fens, ponds, lakes, streams, grasslands, croplands, riparian, forest) and what type of fuel was
456 discharged (e.g. conventional crude oil, diluted bitumen, refined fuels, etc.) would greatly
457 improve the accident data collection. Moreover, details about impacts on wildlife (number of

observed mortalities and number of animals affected), soil (volume released onto soil, contaminant concentrations, type and volume of soil impacted), water (volume released into a water body and contaminant concentrations at specified time intervals) and vegetation (spatial extent of any given vegetation type affected) should be included in the database. Accident reports should also state whether environmental remediation was required and whether and how much of the released product was recovered.

- Include both inter-provincial and intra-provincial pipeline failure data in a publicly-available database. Ensure that federal and provincial data sets are compatible.

Improving data collection for oil and gas pipeline failures in Canada would help regulators, industry, researchers and the public to understand the impact that pipelines accidents have on the environment. Accidents mentioned in Section 1.1 of this report, and others similar to these, are not included in the NEB database because the pipelines were not inter-provincial. The inclusion of data from the 91% of pipelines not regulated by the NEB would significantly contribute to a more accurate analysis of pipeline failure consequences across Canada. This knowledge could in turn be used to minimize risks associated with pipeline accidents and enhance pipeline safety by informing the design, construction and environmental management plans for new and existing pipelines.

476 **Acknowledgements**

477 The authors gratefully acknowledge the availability and support of the NEB library personnel in
478 Calgary, Alberta. Nina Modeland provided research and technical support.

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Tables

Table 1: Oil and gas pipeline failure descriptive fields on environmental consequences provided by the NEB

Field
Residual effects on the environment (Yes/No)
Conditions that resulted in adverse effects on the environment (Narrative description)

Table 2: Oil and gas pipeline failures descriptive fields on environmental consequences provided by PHMSA

Field	Description
WILDLIFE_IMPACT_IND	Wildlife Impact (Yes, No, Null)
FISH_AQUATIC_IMPACT_IND	Fish/aquatic (Yes, Null)
BIRDS_IMPACT_IND	Birds (Yes, Null)
TERRESTRIAL_IMPACT_IND	Terrestrial (Yes, Null)
SOIL_CONTAMINATION	Soil Contamination (Yes, No, Null)
LONG_TERM_ASSESSMENT	Long term impact assessment performed or planned (Yes, No, Null)
REMEDIATION_IND	Anticipated remediation (Yes, No, Null)
SURFACE_WATER_REMED_IND	Surface water Remediation (Yes, Null)
GROUNDWATER_REMED_IND	Groundwater Remediation (Yes, Null)
SOIL_REMED_IND	Soil Remediation (Yes, Null)
VEGETATION_REMED_IND	Vegetation Remediation (Yes, Null)
WILDLIFE_REMED_IND	Wildlife Remediation (Yes, Null)
WATER_CONTAM_IND	Water Contamination (Yes, No)
OCEAN_SEAWATER_IND	Ocean/Seawater Contamination (Yes, Null)
SURFACE_CONTAM_IND	Surface Contamination (Yes, Null)
GROUNDWATER_CONTAM_IND	Groundwater Contamination (Yes, Null)
DRINKING_WATER_CONTAM_IND	Drinking water Contamination (Yes, Null)
PRIVATE_WELL_CONTAM_IND	Private Well Contamination (Yes, Null)
PUBLIC_WATER_CONTAM_IND	Public Water Intake Contamination (Yes, Null)
AMOUNT_RELEASED	Amount released in or reaching water (barrels)
REL_WATER_NAME	Name of body of water, if commonly known

Table 3: PHMSA and NEB differences in jurisdiction and annual mileage data

	NEB	PHMSA
Jurisdiction	9% regulated pipelines	76% regulated pipelines
	inter-provincial pipelines	intra and inter-state pipelines
Annual mileage	available upon request from 2010	available online from 1980s

Table 4: Oil and gas pipeline failures database sections provided by PHMSA

Database	Section
Gas transmission and gathering pipelines	1986-2001
	2002-2009
	2010-2017
Gas distribution pipelines	1986-2004
	2004-2009
	2010-2017
Hazardous liquid pipelines	1986-2001
	2002-2009
	2010-2017

Table 5: NEB and PHMSA accident reporting criteria

	NEB	PHMSA	
	GAS AND LIQUIDS (HVP and LVP*)	GAS	LIQUIDS
Death	required	required	required
Injury	required	required	required
Cost	not required	>\$50000 (excluding cost of gas lost)	>\$50000 (including cost of product lost)
Release	LVP>1.5m ³ no limit for HVP	gas loss ≥ 3 million ft ³ (84950.5 m ³)	≥5 gallons (0.019m ³)
Fire	required	not required	required
Explosion	required	not required	required
Other	adverse effects on environment	liquefied natural gas facility shutdown	not required

* HVP: high vapour pressure, LVP: low vapour pressure

Table 6: PHMSA and NEB databases comparison summary

NEB	PHMSA
Accidents from 2008	Accidents from the 1980s
One database includes all types of pipelines, mainly transmission.	Four databases for gas transmission and gathering, gas distribution, hazardous liquid pipelines and liquefied natural gas facilities
Definitions not always provided	Definitions provided
102 descriptive fields provide information on the accident	614 descriptive fields provide information and details on the accident
2 descriptive fields describe environmental impacts due to pipeline spills	21 descriptive fields describe environmental impacts due to liquid pipeline spills
87.5% of accidents that caused environmental impact do not include details (blank cells).	Details are always provided in case of environmental impact