Government of Canada Gouvernement du Canada

Risk Management Scope

for

Hydrogen Sulfide (H_2S) Chemical Abstracts Service Registry Number (CAS RN): 7783-06-4

Environment and Climate Change Canada

Health Canada

February 2024

Canada

Summary of proposed risk management

This document outlines the risk management options under consideration for hydrogen sulfide. This substance was assessed as part of the Hydrogen Sulfide (H_2S), Sodium Sulfide (Na(SH) and Sodium Sulfide (Na_2S) assessment. Hydrogen sulfide is proposed to be harmful to the environment and human health.

In particular, the Government of Canada is considering risk management options that would contribute to reducing exposure of the general population and the natural environment to incidental releases to air of hydrogen sulfide from inactive oil and gas wells to levels that are protective of human health and the environment. It is recognized that provinces and several territories have requirements in place for oil and gas well management. As such, current regulatory regimes and programs will be reviewed, including federal initiatives that may contribute to reducing incidental releases of hydrogen sulfide from inactive oil and gas wells, to inform potential risk management options.

To adequately select and define the risk management options, information on the following items should be provided (on or before April 2 2024), to the contact details identified in section 8 of this document, to inform risk management decision-making:

- Jurisdictional inventories of individual oil and gas wells in Canada, with their current lifecycle stage (completed, active, inactive, suspended, abandoned, reclaimed, or orphaned), age of the well, date of completion, date of abandonment, and if they have been designated “sour”.
- Jurisdictional inventories of recent incidental releases of hydrogen sulfide from active and inactive oil and gas wells, duration of exposure of individuals or terrestrial plants and wildlife populations, recorded effects, including the concentration of hydrogen sulfide released from these wells and any subsequent follow up actions.
- Socio-economic impacts and/or benefits associated with:
    - Incidental releases of hydrogen sulfide from inactive oil and gas wells and risk management of these releases;
    - Proper suspension and abandonment of orphaned oil and gas wells; and
    - Proper abandonment of inactive oil and gas wells including costs and factors that may impact costs.
- Technical information related to:
    - Managing incidental releases of hydrogen sulfide from active and inactive oil and gas wells, such as monitoring programs or technologies, best practices, etc.

- Recent findings from a study in southern Ontario suggest that methane gas from the ground may have seeped into groundwater reservoirs with high sulfate concentrations, leading to biogenically formed hydrogen sulfide which can subsequently leak from the old abandoned oil and gas wells in the area. It is not known if these conditions also exist in other parts of Canada. Information related to the biogenic production of hydrogen sulfide is requested, including any analytical or case studies or research on this process, and the location of areas of groundwater in Canada with high concentrations of sulfate.
- An overview of risk management measures for oil and gas wells in place at the provincial and territorial government levels has been presented in section 7.1.2. It is recognized that this is a complex and rapidly evolving regulatory environment, and thus corrections and/or updates where these actions may have been incorrectly characterized or noted are requested.

The risk management options may evolve through consideration of assessments and risk management options published for other Chemicals Management Plan substances and other federal initiatives and programs as required to ensure effective, coordinated, and consistent risk management decision-making.

Note: The above summary is an abridged list of considerations to manage this substance and to seek information on identified information gaps and uncertainties. Refer to section 3 of this document for more complete details in this regard.

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1. Context

The *Canadian Environmental Protection Act* (CEPA) (Canada 1999) provides the authority for the Minister of the Environment and the Minister of Health (the ministers) to conduct assessments to determine if substances are toxic to the environment and/or harmful to human health as set out in section 64 of CEPA[1,2], and if so to manage the associated risks.

Pursuant to the Act, the ministers have conducted an assessment under the Government of Canada's Chemicals Management Plan for the substance hydrogen sulfide, Chemical Abstracts Service Registry Number (CAS RN)[3] 7783-06-4 (H_2S), and two substances that have the potential to form hydrogen sulfide in the aquatic environment, sodium sulfide (Na(SH), referred to as sodium bisulfide in this document (CAS RN 16721-80-5), and sodium sulfide (Na_2S; CAS RN 1313-82-2).

2. Issue

In 2017, Health Canada and Environment and Climate Change Canada conducted and published a draft scientific assessment of hydrogen sulfide, sodium bisulfide, and sodium sulfide in Canada (ECCC, HC 2017). New information was received after the publication that led to changes in the proposed conclusions for hydrogen sulfide. As a result, Health Canada and Environment and Climate Change Canada have updated the draft scientific assessment, and a notice summarizing the scientific considerations of the updated draft assessment for these substances was published in the *Canada Gazette*, Part I, on February 3 2024. Refer to the Updated Draft Screening Assessment for Hydrogen Sulfide, Sodium Bisulfide, and Sodium Sulfide, for further information.

[1] Section 64 [of CEPA]: *For the purposes of* [Parts 5 and 6 of CEPA]*, except where the expression "inherently toxic" appears, a substance is toxic if it is entering or may enter the environment in a quantity or concentration or under conditions that*

- *(a) have or may have an immediate or long-term harmful effect on the environment or its biological diversity;*
- *(b) constitute or may constitute a danger to the environment on which life depends; or*
- *(c) constitute or may constitute a danger in Canada to human life or health.*

[2] A determination of whether one or more of the criteria of section 64 of CEPA are met is based upon an assessment of potential risks to the environment and/or to human health associated with exposures in the general environment. For humans, this includes, but is not limited to, exposures from ambient and indoor air, drinking water, foodstuffs, products used by consumers. A conclusion under CEPA is not relevant to, nor does it preclude, an assessment against the hazard criteria specified in the *Hazardous Products Regulations*, which are part of the regulatory framework for the Workplace Hazardous Materials Information System for products intended for workplace use. Similarly, a conclusion based on the criteria contained in section 64 of CEPA does not preclude actions being taken under other sections of CEPA or other Acts.

[3] CAS RN: Chemical Abstracts Service Registry Number. The Chemical Abstracts Service information is the property of the American Chemical Society and any use or redistribution, except as required in supporting regulatory requirements and/or for reports to the Government of Canada when the information and the reports are required by law or administrative policy, is not permitted without the prior, written permission of the American Chemical Society.

2.1 Updated draft assessment conclusion

On the basis of the information available, the updated draft assessment proposes that hydrogen sulfide is toxic under sections 64(*a*) and 64(*c*) of CEPA because it may be entering the environment in a quantity or concentration or under conditions that have or may have an immediate or long-term harmful effect on the environment or its biological diversity or that constitute or may constitute a danger in Canada to human life or health (ECCC, HC 2023).

The updated draft assessment proposes that the other two substances, sodium bisulfide and sodium sulfide, do not meet any of the criteria set out in section 64 of CEPA. The updated draft assessment also proposes that hydrogen sulfide meets the persistence but not the bioaccumulation criteria, as defined in the *Persistence and Bioaccumulation Regulations* made under CEPA (Canada 2000).

Risks of harm to the environment and human health were identified from the incidental releases of hydrogen sulfide from certain inactive oil and gas wells, As such, this document will focus on this specific exposure source of concern (refer to section 5) identified in the updated draft assessment.

Of note, the proposed risk management options and the proposed conclusion outlined in the updated draft assessment are preliminary and may be subject to change.

2.2 Proposed recommendation under CEPA

On the basis of the findings of the updated draft assessment conducted pursuant to CEPA, the Ministers propose to recommend that hydrogen sulfide be added to Part 2 in Schedule 1 to CEPA[4]. Addition of a substance to Schedule 1 to CEPA enables the Government to propose certain risk management measures under CEPA to manage potential ecological and human health risks associated with the substance.

Until regulations specifying criteria for the classification of substances that pose the highest risk or that are carcinogenic, mutagenic or toxic to reproduction are available, hydrogen sulfide is proposed to be recommended for addition to Part 2 of Schedule 1. Following the availability of the aforementioned criteria, the substance may be moved to Part 1 of Schedule 1, if applicable.

CEPA sets out a 2-track approach for managing risks.

[4] After an assessment of a given substance under Part 5 of CEPA, other than section 83, the Ministers shall propose one of the following measures: take no further action with respect to the substance, add the substance to the List referred to in section 75.1 of the Act (unless the substance is already on that List), recommend the addition of the substance to Part 1 of the list of toxic substances in Schedule 1 to CEPA (for substances that pose the highest risk) or recommend the addition of the substance to Part 2 of the list of toxic substances in Schedule 1 to CEPA (for other CEPA-toxic substances).

Under sub-section 77(3), the Ministers are required to propose recommending the addition of a substance that poses the highest risk, as defined in paragraph (a), (b) or (c), to Part 1[5] of Schedule 1 of the Act and, in developing a proposed regulation or instrument respecting preventive or control actions, to give priority to the total, partial or conditional prohibition of activities in relation to the substance or to the release of the substance into the environment.

For other substances recommended for addition to Part 2 of Schedule 1 of the Act, the Ministers shall give priority to pollution prevention, and this could include regulatory or non-regulatory measures [such as prohibition if warranted].

The Ministers will take into consideration comments made by stakeholders and interested parties during the 60-day public comment period on the updated draft assessment for hydrogen sulfide and this risk management scope.

If the Ministers finalize the recommendation to add hydrogen sulfide to Part 2 of Schedule 1, risk management instruments must be proposed within 24 months from the date on which the ministers recommended that hydrogen sulfide be added to Schedule 1 of CEPA, and finalized within 18 months from the date on which the risk management instruments are proposed, as outlined in sections 91 and 92 of CEPA (refer to section 8 for publication timelines applicable to this group of substances).

3. Proposed risk management

3.1 Proposed environmental and human health objectives

Proposed environmental and human health objectives are quantitative or qualitative statements of what should be achieved to address environmental and human health concerns.

[5] Under subsection 77(3), a substance must be recommended for addition to Part 1 of Schedule 1 to the Act when the substance is determined to be toxic and the Ministers are satisfied that:

a) the substance may have a long-term harmful effect on the environment and
    i. is inherently toxic to human beings or non-human organisms, as determined by laboratory or other studies,
    ii. is persistent and bioaccumulative in accordance with the regulations,
    iii. is present in the environment primarily as a result of human activity, and
    iv. is not a naturally occurring radionuclide or a naturally occurring inorganic substance;
b) the substance may constitute a danger in Canada to human life or health and is, in accordance with the regulations, carcinogenic, mutagenic or toxic for reproduction; or
c) the substance is, in accordance with the regulations, a substance that poses the highest risk.

For hydrogen sulfide, the proposed objectives address the risks outlined in section 5 of this document. The proposed environmental and human health objectives for hydrogen sulfide are to:

- Reduce incidental releases to air of hydrogen sulfide to levels that are protective of the environment. The predicted no-effect concentrations (PNECs) in ambient air for plants and terrestrial mammals may be used as goals to achieve this objective; and
- Reduce exposure of the general population to hydrogen sulfide to a level that is protective of human health.

3.2 Proposed risk management objectives and options under consideration

Proposed risk management objectives set quantitative or qualitative targets to be achieved by the implementation of risk management regulations, and/or other instruments for a given substance or substances. In this case, the proposed risk management objective is to reduce incidental releases to air of hydrogen sulfide from inactive oil and gas wells to levels protective of human health and the environment taking into account technical and economic feasibility and consideration of socio-economic factors.

This objective will be refined on the basis of stakeholder and interested party engagement and information received regarding the proposed risk management, the outcome of the assessment, and socio-economic and technical considerations (refer to section 6). Revised environmental and human health objectives and the risk management objective will be presented in the Risk Management Approach document that will be published concurrently with the assessment for this substance.

To achieve the proposed risk management objective and to work towards achieving the proposed environmental and human health objectives, consideration is being given to the development of regulatory and/or non-regulatory tools. As outlined in section 7, all provinces and certain territories have a range of requirements and programs in place regarding oil and gas well management. These can include requirements for preventing and managing methane and hydrogen sulfide releases from active wells during drilling and production (for example, leakage detection equipment), proper methods for abandoning oil and gas wells, and programs addressing orphaned wells. As such, the current and proposed regulatory regimes and programs will be reviewed, including initiatives that may contribute to reducing incidental releases of hydrogen sulfide from inactive oil and gas wells. Gaps that are identified will inform potential risk management options. With this approach, the Government of Canada intends to explore options that may address identified gaps and incorporate best practices of existing federal, provincial, and territorial initiatives.

For protection of the general population, priority may be given to options that include a focus on inactive oil and gas wells in locations with higher population densities, as well

as locations known to have had previous or ongoing incidents. For protection of the environment, priority may be given to options that include a focus on inactive oil and gas wells located in proximity to natural lands or lands with sensitive ecologies.

Following the publication of this Risk Management Scope document, additional information obtained from the public comment period and from other sources will be considered, along with the information presented in this document, in the instrument selection and development process[6]. The risk management options may evolve through consideration of assessments and risk management options published for other CMP substances - or other Government of Canada initiatives - to ensure effective, coordinated, and consistent risk management decision-making.

3.3 Risk management information gaps

Information has been obtained through publicly available sources to inventory the number of oil and gas wells in Canada (see Table 1), and as feasible, to understand the geographic distribution and current lifecycle stage of these wells. However, data gaps remain. In order to make informed decisions on proposed risk management and take action at the federal level on the identified source of exposure of concern - incidental releases from inactive oil and gas wells - there is a need to develop a comprehensive map showing the locations and activity level of the wells at the federal, provincial and territorial levels. Therefore, more information is needed on the following:

1) Jurisdictional inventories of incidental releases of hydrogen sulfide from active and/or inactive oil and gas wells:
    - Dates and locations of these incidental releases;
    - Concentrations of hydrogen sulfide measured during these events;
    - Duration of the exposure or potential exposure of hydrogen sulfide to individual people or terrestrial plants and wildlife populations;
    - Recorded effects on exposed or potentially exposed individual people or terrestrial plants or wildlife; and
    - Any follow up actions taken in response to the incidents.

    This information may help Departments to identify locations with the greatest risk of incidental releases in close proximity to populated or sensitive areas, and natural areas, and identify priorities to inform risk management options.

    Authorities are encouraged to provide this information to enable a more comprehensive understanding of incidental releases of hydrogen sulfide from inactive oil and gas wells across Canada.

[6] The proposed risk management regulation(s), instrument(s) or tool(s) will be selected using a thorough, consistent and efficient approach and take into consideration available information in line with the Government of Canada's Cabinet Directive on Regulation (TBS 2018), Red Tape Reduction Action Plan (TBS 2012) and the *Red Tape Reduction Act* (Canada 2015).

2) Socio-economic impacts, and/or benefits associated with:
    - Incidental releases of hydrogen sulfide from inactive oil and gas wells;
    - Proper suspension and abandonment of orphaned oil and gas wells; and
    - Proper abandonment of inactive oil and gas wells including costs, and factors that may impact costs.

3) Technical factors related to:
    - Managing incidental releases of hydrogen sulfide from inactive oil and gas wells, such as monitoring programs or technologies, best practices, etc.

    Information on technical impacts and socio-economic factors (size of industry, contribution to Canadian market, etc.) will be considered in, and contribute to, the selection and design of risk management instrument(s) to meet the risk management objective.

4) Hydrogen sulfide may also be released from oil and gas wells in which the origin of the hydrogen sulfide is not from the petroleum reservoir. Recent findings from a study in southern Ontario suggest that methane gas from the ground may have seeped into groundwater reservoirs with high sulfate concentrations, leading to biogenically formed hydrogen sulfide which can subsequently leak from the old abandoned oil and gas wells in the area, which may have degraded over time (Jackson et al. 2020). This biogenic formation of hydrogen sulfide is potentially the source of hydrogen sulfide in Ontario where certain incidental releases have been described in the updated draft assessment. It is not known if these conditions also exist in other parts of Canada. Information related to the biogenic production of hydrogen sulfide is requested, including any analytical or case studies or research on this process, and the location of areas of groundwater in Canada with high concentrations of sulfate.

5) An overview of risk management measures for oil and gas wells in place at the provincial and territorial government levels has been presented in section 7.1.2. It is recognized that this is a complex and rapidly evolving regulatory environment, and thus corrections and/or updates where these actions may have been incorrectly characterized or noted are requested.

3.4 Performance measurement and evaluation

Performance measurement evaluates the ongoing effectiveness and relevance of the actions taken to manage risks from toxic substances[7]. Environment and Climate

[7] Performance measurement can be performed at two levels:

Change Canada and Health Canada have developed a Performance Measurement Evaluation Strategy that sets out the approach to evaluate the effectiveness of actions taken on substances found toxic under CEPA. The aim is to determine whether human health and/or environmental objectives have been met and whether there is a need to revisit the risk management approach for those substances. Selection of a substance for performance measurement evaluation is conducted through readiness, prioritization and work-planning as outlined in the Performance Measurement Evaluation Strategy. In evaluating progress and revisiting risk management, as warranted, these activities together will aim to manage risks effectively over time.

The Government of Canada may measure the effectiveness of the risk management action(s) and the progress towards meeting the risk management and environmental and/or human health objectives for hydrogen sulfide.

In addition, the Government of Canada plans to collect and analyze data, such as data on the number and location and lifecycle stage of inactive oil and gas wells and any incidental releases of hydrogen sulfide from these wells in order to establish a baseline for human and environmental exposure, which can be revisited over time to measure progress towards meeting the environmental and human health objectives.

The results of performance measurement evaluation will be used to inform whether further risk management action is warranted and will be made available to Canadians along with recommendations for further action, if applicable.

- Instrument-based performance measurement evaluates the effectiveness of an individual instrument in meeting the specific risk management objectives that were set out when the risk management tool was designed (that is, evaluate whether risk management objectives have been met); and
- Substance-based performance measurement considers performance of all final risk management instruments applied to a chemical substance and relevant data or indicators of exposure to the environment or human health (that is, evaluate whether human health and/or environmental objectives have been met). The results of performance measurement will help determine if additional risk management is needed.

For more information on performance measurement evaluation (including Health Canada and Environment and Climate Change Canada's Performance Measurement Evaluation Strategy) please visit Performance measurement for toxic substances - Canada.ca

4. Background

4.1 Hydrogen sulfide

4.1.1 General information

Hydrogen sulfide is a naturally occurring inorganic gas produced from the anaerobic degradation of organic matter and is therefore widely present in anaerobic sediments, water, and biological wastes. Hydrogen sulfide can be found naturally in crude oil, natural gas, volcanic gases, and hot springs and is released from these natural sources primarily to air and to water. It has the capacity to volatize from water to air but also to sink in air to ground level under quiet atmospheric conditions or when present in high concentrations.

Hydrogen sulfide is known to have a rotten egg smell and when present in oil and gas reservoirs is known as “sour gas”. Oil and gas wells emitting hydrogen sulfide are also known as “sour wells”, while those without hydrogen sulfide are referred to as “sweet wells”.

4.1.2 Current uses and releases

Hydrogen sulfide is used in the manufacturing of elemental sulfur and sulfuric acid, or used as a chemical intermediate in the production of dyes, rubber chemicals, pesticides, polymers, plastic additives, leather, and pharmaceuticals. No products available to consumers were reported for hydrogen sulfide for 2001 in a section 71 survey (Environment Canada 2004).

Hydrogen sulfide can also be released as a result of anthropogenic activities. Releases of hydrogen sulfide in air and water from industrial activities occur in Canada from various industrial sectors including the oil and gas sector, pulp and paper sector (kraft mills), livestock operations, non-metallic mineral products industries, primary metal industries and other manufacturing industries, and from the waste and wastewater sector (ECCC, HC 2020).

Data reported for 2017 to the National Pollutant Release Inventory (NPRI) indicate that the most significant industries contributing to hydrogen sulfide air emissions in Canada have been the oil and gas, pulp and paper, and iron and steel sectors.

4.2 Oil and gas sectors

4.2.1 Background information

The oil and gas extraction sector (upstream activities such as exploration and production) is the second largest contributing point source sector to ambient air emissions of hydrogen sulfide in Canada (NPRI 2019). Facilities whose only activities are exploration for oil or gas, or the drilling of oil or gas wells, are not required to report to the NPRI. In addition, active oil and gas wells do not typically trigger thresholds for reporting unless they are associated with combustion equipment or batteries with storage. Wells that are not active would also not be required to report to NPRI. For 2017, facilities from the sector that met NPRI requirements reported 313.2 tonnes of hydrogen sulfide releases to air from manufacturing and processing activities.

Oil and natural gas are extracted from reservoirs located beneath the earth's surface. The extracted oil and gas were formed millions of years ago from animal and plant matter buried in sedimentary rock. The hydrogen sulfide which can be present in the reservoir would have formed when the organic matter decayed without oxygen (CAPP [Modified 2019a, 2019b]). The major component of natural gas from the reservoir of a well is methane, but hydrogen sulfide can also be present.

As part of oil and gas production and processing activities, the hydrogen sulfide needs to be removed to meet product specifications. The removed hydrogen sulfide is either burned in flare stacks, returned underground, or turned into elemental sulfur and sold as a product.

Releases from the exploration and production activities are primarily managed at the provincial level, with some exceptions, such as on federal lands. More details on these management actions are provided in section 7.

4.2.2 Wells

4.2.2.1 Lifecycle stages

During their lifespan, the wells used to extract oil and gas can be described in terms of stages of development and activity. Different terms are used in different countries and their jurisdictions. The Government of Canada, provinces, territories, and stakeholders also have variable terms and definitions. Therefore, for the purpose of this document, these stages are defined and described as:

- **Completed**: A well that is ready for production after drilling, tubing, and casing operations but has not started producing yet.
- **Active**: A well that is in production (that is, producing oil or gas).
- **Inactive**: A well that has not been in production over consecutive weeks, months or years (depending on the jurisdiction, regulations or guidelines). For example, many provinces and territories consider a well inactive when it has not produced oil or natural gas in up to 12 months. In some jurisdictions, the time frame is six months for sour wells.
- **Suspended**: A well that is temporarily not in production and has been secured in accordance by applicable regulations or guidelines. A suspended well may continue production in the future or be abandoned by the well owner or operator.
- **Abandoned**: A well that has been decommissioned (dismantled and plugged) by the owner, as prescribed by applicable regulations or guidelines. An abandoned well is permanently taken out of production.
- **Reclaimed**: An abandoned well where the surrounding land has been returned to its original state (removal of equipment, surface reconstruction, etc.).
- **Orphaned**: A well that has no owner - legally or financially able party. A well can become orphaned at any stage of its life.

Note – for the purposes of this document, inactive wells encompass suspended, abandoned, and reclaimed wells, including those that are also in an orphan state.

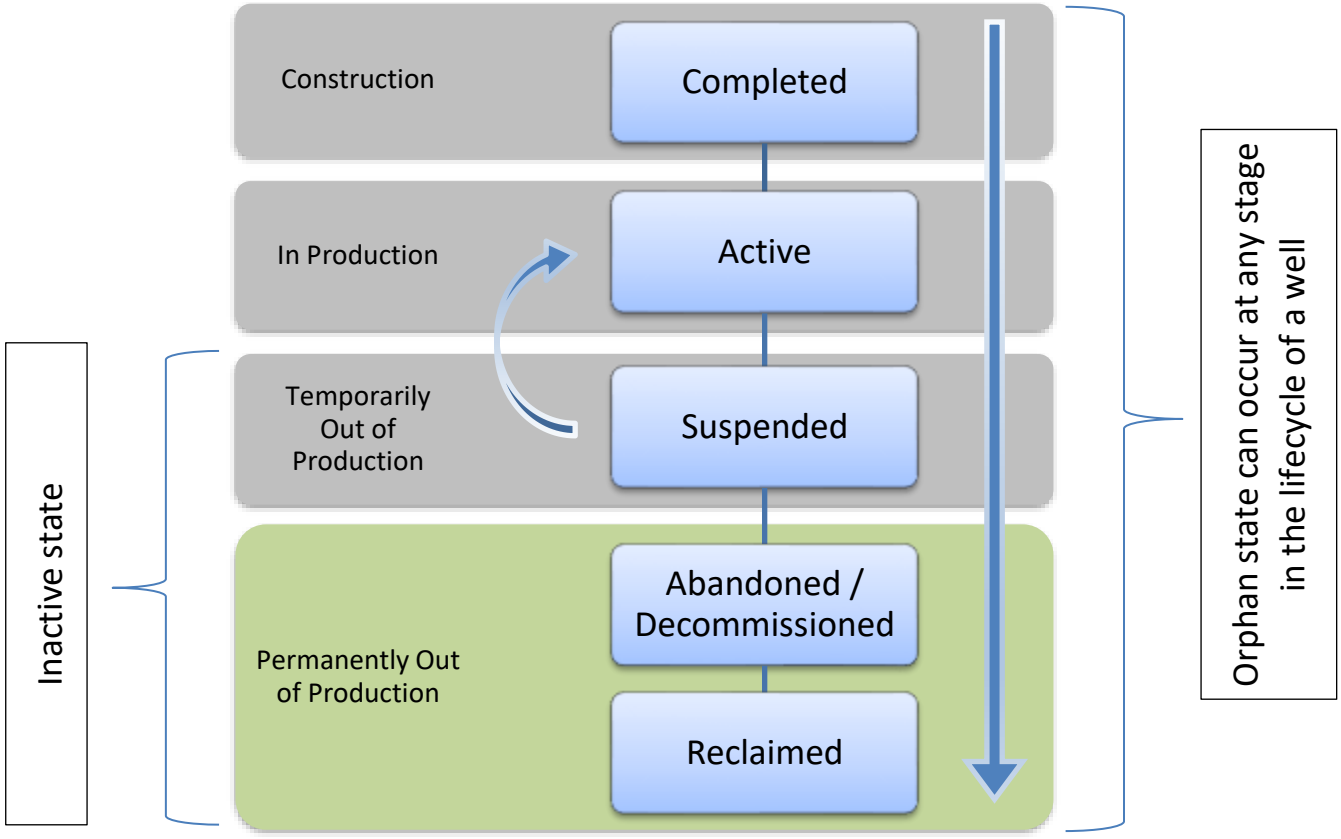

Figure 1. Nomenclature of oil and gas wells based on their lifecycle stage.

Long description for the visually impaired

This figure illustrates the nomenclature framework of oil and gas wells based on their lifecycle stage. Top nomenclature pertains to most early stages and goes down up to proper closure.

There are four larger groupings highlighted in grey and green and five smaller groupings fit within these, connected and highlighted in blue. On the far right, the whole figure is held within a bracket denoting that an "Orphan state can occur at any stage in the lifecycle of a well".

The top three rows are highlighted in grey, from top to bottom on the left side they are titled "Construction", "In Production", and "Temporarily Out of Production". In the center of each row there is one blue box, from top to bottom these boxes are labelled "Completed", "Active", and "Suspended". There is an arrow going from suspended to active denoting that "a well can be moved between these two states". The last row is highlighted in green, on the left it is titled "Permanently Out of Production", in the center there are two blue boxes labelled "Abandoned/ Decommissioned" and "Reclaimed". On the left side the bottom two rows are linked with a bracket labelled as "Inactive State". On the right side of the boxes there is an arrow going from top to bottom.

4.2.2.2 Inventory of oil and gas wells

According to the Canadian Association of Petroleum Producers (CAPP) Statistical Handbook, over 400 000 oil and gas wells were completed in Canada between 1955 and 2020 (CAPP [Modified 2020a]). Of these completed wells, approximately 99% were in Western Canada, with the remaining 1% in the rest of the country but primarily in Ontario. These statistics refer to all oil and gas wells; it is unknown how many inactive oil and gas wells are sour wells or have the potential to incidentally release hydrogen sulfide. Canada's oil and gas activity began in the 1850s and there may be inactive wells that are unaccounted for in existing inventories.

It is estimated that over half of oil and gas wells in Canada are not in active production (CAPP [Modified 2020]). Generally, if a well has not been producing oil or gas for six to 12 months, it can be considered inactive. There is some degree of variability related to the number of active and inactive oil and gas wells in Canada, as inactive wells can resume production (be considered active), and vice versa. Reactivating wells, or rendering them inactive, can depend on a number of different factors, including, but not limited to, cost, and remaining deposits available.

In Western Canada, the oil and gas sector is very sizeable, with the largest number of completed wells (see Table 1). However, due to economic downturns, there have been situations where oil and gas companies have filed for bankruptcy, resulting in an increase in the number of orphan wells and for which the responsibility for abandonment is shifted to the province or to landowners. It is estimated that there are approximately 3 000 orphaned wells in Alberta, with that number likely to increase (OWA 2020).

Ontario has a predominantly historic oil and gas sector and it is estimated that there are 900 inactive oil and gas wells in the province that do not have a legally responsible owner and may not have been abandoned properly (and thus fall into the orphan well category). In addition, even if the wells have been previously properly abandoned, the technology used to plug the wells may no longer be effective due to aging infrastructure, which could result in increased likelihood of incidental releases of hydrogen sulfide from the wells (Wisen et al. 2020).

Table 1. Inventory of oil and gas wells in Canada. Numbers can vary depending on sources, therefore these are approximate values; blank cells denote that no applicable data are available.

Province / Territory	Active Wells	Inactive Wells		
		Abandoned	Suspended	Orphaned
British Columbia	9 900 [a]	9 900 [a]	4 500 [a]	360 [b]
Alberta [c]	156 000	82 000	90 000	7 700
Saskatchewan	34 400 [d]	42 000 [d]	25 000 [d]	500 [e]
Manitoba [f]	5 200	4 200	210	N/A[p]
Ontario [g]	3 000	9 500	650	900
Quebec [h]	N/A	775*	*	*
Newfoundland	N/A	25 [i]	2 [j]	N/A
New-Brunswick [k]	N/A	800	N/A	N/A
Nova-Scotia [l]	N/A	150	10	N/A
Prince-Edward Island [m]	N/A	N/A	N/A	N/A
Northwest Territories [n]	N/A	600	85	N/A
Yukon [o]	N/A	60	15	N/A
Nunavut	N/A	N/A	N/A	N/A
Total	208500	150010	120470	9460

* In Quebec, inactive wells are not categorized as abandoned, suspended, or orphaned. Therefore, the number of 775 gas and oil wells represent all inactive wells categories in the table.

[a] British Columbia Oil and Gas Commission. 2020b. Data Centre, [Accessed 2022 April]

[b] British Columbia Oil and Gas Commission. 2021a. Dormant Sites [Accessed 2022 April]

[c] Alberta. 2022. Oil and gas liabilities management [HTML]. [Accessed 2022 April).

[d] Saskatchewan. March 2022. Mining and Petroleum GeoAtlas. [Accessed 2022 April]

[e] Saskatchewan. February 2022c. Orphan Inventory. [Accessed 2022 April].

[f] Manitoba. May 2020. Agriculture and Resource Development, Petroleum: Interactive GIS Map Gallery. [Accessed 2020 May]

[g] Oil, Gas & Salt Resources Library. June 2019. Petroleum Well Data – Ontario, Petroleum Data Download. [Accessed 2022 April]

[h] Ministère de l'Environnement du Québec.2021. Rapport sur l'état des puits d'hydrocarbures inactifs au Québec. [Accessed 2022 April].

[i] Newfoundland Labrador Canada. Natural Resources, Final Wells Reports. Accessed 2022 April]

[j] Newfoundland Labrador Canada. January 2019. Natural Resources, On shore Status Report. [Accessed 2022 April]

[k] Note NB Borehole Database indicates that are approx. 780 boreholes in NB, but only 300 are oil and oil & gas [Accessed 2022 April].

[l] Province Nova Scotia. June 2012. Onshore Petroleum Well Database. [Accessed 2022 April]

[m] There are currently 20 exploratory wells in Prince-Edward Island. [Accessed 2022 April].

[n] Northwest Territories. May 2019. Office of the Regulator of Oil and Gas Operations, OROGO Well Data. [Accessed 2022 April]

[o] Yukon. December 2014. Yukon Well Listing. [Accessed 2022 April]

[p] Not Available

5. Exposure sources and identified risks

5.1 Exposure effects

Inhalation is expected to be the predominant route of general population and animal exposure to hydrogen sulfide, and the human health effects assessment focused on data examining effects by this route. Available information does not indicate that hydrogen sulfide is genotoxic or carcinogenic.

For wildlife, hydrogen sulfide inhibits cellular enzymes, such as cytochrome *c oxidase* and the substance is expected to behave similarly in all vertebrate species that utilize aerobic metabolism, such as, birds, mammals, certain reptiles, and amphibians. Acute exposure affects their olfactory senses, irritates their eyes and mucus membranes, and decreases their feed consumption. As for terrestrial plants, exposure to high hydrogen sulfide concentrations in air results in reduced rates of photosynthesis and reduced root growth, and thus, yield reduction (ECCC, HC 2023).

5.2 Release of concern

Margins between upper-bounding concentrations of hydrogen sulfide in ambient air and levels associated with critical health effects (ocular, respiratory, neurological effects) are considered to be adequate to address uncertainties in the human health effects and exposure databases.

However, in addition to ambient air concentrations reported in the literature, there are reports of incidental releases to air of high concentrations of hydrogen sulfide in Canada. Taking into consideration input received from provincial and municipal jurisdictions in Ontario, there have been reported incidents of releases of hydrogen sulfide from inactive oil and gas wells, resulting in the potential for acute exposure of the general population and terrestrial mammals to levels approaching or exceeding those associated with adverse respiratory effects (ECCC, HC 2023). In some instances, releases of hydrogen sulfide can occur from these types of wells as a result of corrosion of well construction materials, improper abandonment, or damage during digging for other purposes. Although it is recognized that there are limitations associated with the nature of the incidental exposure data, given the magnitude of reported incidental concentrations, the level at which acute health effects can occur and given the number of incidents that were reported combined with the number of inactive oil and gas wells in Canada, it is considered appropriate to apply a precautionary approach when characterizing risk.

Accordingly, there is a potential concern for human health associated with incidental inhalation exposure to hydrogen sulfide released from inactive oil and gas wells.

Data from the above incident reports showed that the hydrogen sulfide concentrations were also above levels at which harmful environmental effects can occur. Although the exposure occurrences were sporadic and acute, the levels indicated for these locations would be high enough to result in adverse effects to plants and wildlife.

Adverse effects can include reduced growth or death in plants and for wildlife, irritation of eyes and noses, and reduced weight of adrenal glands and ovaries (ECCC, HC 2023).

The Ontario wells for which the concerns have been identified are primarily older inactive oil and gas wells. Some of the problematic wells may have been abandoned over 50 years ago, at a time prior to today's well construction and abandonment standards. In many of these instances, it is suspected that well encasements are corroded and thereby allowing methane (natural gas) to enter the groundwater aquifer.

The updated draft assessment takes into consideration that the available data concerning incidental releases may not adequately characterize the potential frequency and magnitude of these exposures across Canada. Although there are limitations to the data, the overall number of reports of incidental exposure, combined with the number of inactive oil and gas wells in Canada indicates the potential for concern from these incidental releases

6. Risk management considerations

6.1 Decommissioning oil and gas wells

As noted in section 4, there are over 400 000 oil and gas wells in Canada. It is estimated that over half are no longer active. Generally, a well becomes inactive when the production declines or commodity prices decrease such that it is no longer economically viable to continue production. Provincial requirements will dictate the steps that must be taken to abandon a well and may consist of plugging the wellbore below the surface, and locking the well so that it cannot be turned on without the permission of the licensed company.

Abandonment requirements vary from province to province, but typically include notifying the regulating authority, and can include planning, testing, and cement plugging and capping the well. No "one size fits all" approach is used across Canada as abandonment requirements take into consideration the type and location of the well. For example, in British Columbia, Alberta and Saskatchewan, specific well management requirements are based on the risk levels according to the hydrogen sulfide emission rates and proximity to local communities.

The Alberta Energy Regulator (AER) sets out minimum requirements for well abandonment for oil and gas well operators in the Directive 020: Well Abandonment (AER 2018). British Columbia requires licence holders to follow Alberta's Directive 020 for well abandonment, while Saskatchewan sets out requirements for abandonment of inactive wells in its Directive PNG 015 (Saskatchewan 2019).

In Directive 020, referred to in BC and AB, there are specific requirements for plugging critical sour wells (defined in AER's Directive 056 [AER 2019]). Saskatchewan's Directive PNG 015 includes specific requirements for plugging critical sour wells (Saskatchewan 2019). Both directives contain the same conditions for determining if a well is "critical sour" for abandonment purposes.

In general, "critical sour" wells are plugged with a longer cement plug over the plugging device and an additional zone is cemented to block perforations under the plugging device. In contrast, a standard well has a smaller cement zone over the plug and the perforations are not cemented.

There are standard methods to cap and decommission oil and gas wells; however, the requirements increase in stringency according to the potential for release of hydrogen sulfide in British Columbia, Alberta and Saskatchewan. In general, leaks from abandoned wells may occur due to improper abandonment, damage during digging, corrosion due to age, or exposure to the elements. Newer technologies to plug wells provide seals that are more durable and resistant to pressure than traditional cement plugs, but they are more costly. There also are technologies for fixing leaking wells using, for example, thermosetting resins that have better sealing properties than traditional cement.

6.2 Socio-economic and technical considerations

There are differences in the activity of the energy sector across Canada; for example, some provinces have a very active oil and gas sector, whereas others are much less active or have only a historic oil and gas sector. These differences will be taken into consideration when developing risk management strategies.

The average cost to abandon and reclaim an inactive well site in Canada is estimated at $100 000, although the cost can range significantly, from approximately $50 000 to several million dollars (Dachis et al. 2017; Muehlenbachs 2017), depending on the complexity of the well abandonment process. As outlined in section 7, most provincial and territorial jurisdictions require oil and gas operators to set aside funds or security deposits to cover the cost of decommissioning a well. In Alberta and British Columbia, the amount of the security deposit is typically estimated based on an operator's assets and liabilities; while in Ontario, for wells located on land, the operator constructing the well must establish a security in the form of a trust fund to cover costs associated with well plugging (Ontario 1990, 2002).

Information on average costs to clean up wells shows a large variance. The OWA's annual report for 2015-16 calculates the historical average cost to reclaim a well as being $304 448 (OWA 2016). The OWA 2018-19 report shows average cost to decommission a well stands at $57 446 (OWA 2018).

In April 2020, the Federal Government announced over $1.72 Billion in funding to the provinces of Alberta, Saskatchewan, and British Columbia as part of the COVID-19 Economic Response Plan in order to support jobs in the oil and gas sector in regional

economies dependent on it, while also addressing the cleanup of inactive and orphan well sites (for example, site abandonment and reclamation) (Canada 2020). This funding came at a time when oil prices had dropped to uneconomic levels at the onset of the COVID-19 pandemic. The Government of Alberta received up to $1 billion in funding, with an additional $200 million loan to the Alberta Orphan Well Association, the Government of Saskatchewan received up to $400 million in funding, and the Government of British Columbia received up to $120 million in funding. As part of the funding agreements, the governments of Alberta and Saskatchewan committed to strengthening regulations to significantly reduce the future prospect of new orphan wells. Additional information on the status of Alberta, Saskatchewan and British Colombia's progress can be found on their respective provincial websites.

7. Overview of existing risk management

7.1 Related Canadian risk management context

A wide range of existing risk management is in place for hydrogen sulfide at a variety of levels within Canada (municipal, Indigenous, provincial/territorial and federal). While this risk management scope document pertains to the risk identified, that is, exposure from incidental releases of hydrogen sulfide from inactive oil and gas wells, it is acknowledged that risk management actions to prevent or reduce hydrogen sulfide exposure to the general population and the environment from activities inside and outside of the petroleum sector are already in place at the federal and provincial/territorial levels.

7.1.1 Hydrogen sulfide management

7.1.1.1 Provincial/Territorial

Air quality controls and standards, regulations, and occupational health and safety requirements for hydrogen sulfide are in place at the provincial/ territorial level, and are summarized in Annex A. Notably, all provinces have ambient air quality standards or guidelines in place for the presence of hydrogen sulfide in air. The majority of these standards or guidelines pertain to human health and odour concerns.

7.1.1.2 Federal

Hydrogen sulfide is subject to a variety of risk management measures at the federal level. These include:

Air

- A Federal-Provincial Air Pollution Committee put forward a Recommended Air Quality Objective for Hydrogen Sulfide (Canada 1976, Canada 1985a)
    - Maximum acceptable: 15 µg/m^3 (1 hour), 5 µg/m^3 (24 hour)
    - Maximum desirable: 1 µg/m^3 (1 hour)

Environmental emergencies

- Hydrogen sulfide is listed under the *Environmental Emergency Regulations, 2019* (Canada 2019a). These regulations aim to help reduce the frequency and severity of accidental releases of hazardous substances into the environment. Made under CEPA, the regulations improve industry's capacity to deal with environmental emergencies that may occur at fixed facilities across Canada. These regulations require that any person who owns, has the charge, management or control of a regulated substance at or above certain quantities notify Environment and Climate Change Canada. For higher-risk facilities, an environmental emergency plan must also be prepared, brought into effect and exercised.

Water

- On behalf of the Federal-Provincial-Territorial Committee on Drinking Water of the Federal-Provincial-Territorial Committee on Health and the Environment, Health Canada published in 1992 the *Guidelines for Canadian Drinking Water Quality: Guideline Technical Document – Sulphide (as H_2S)* (Health Canada 1992). Guidelines for Canadian Drinking Water Quality set out the maximum acceptable concentrations of certain substances in drinking water. They are designed to protect the health of the most vulnerable members of society, such as children and the elderly. The guidelines set out the basic parameters that every water system should strive to achieve in order to provide the cleanest, safest and most reliable drinking water possible;
- Guidelines for Canadian Drinking Water Quality: Guideline Technical Document – Sulphide (as H_2S) (Health Canada 1992):
    - The presence of sulfide (as hydrogen sulfide) in drinking water results in disagreeable taste and odour; an aesthetic objective of ≤ 0.05 mg/L (≤ 50 µg/L) (expressed as hydrogen sulfide).

Others

- Hydrogen sulfide is on the list of reportable substances to the NPRI with a reporting threshold of 10 tonnes manufactured, processed or otherwise used. The NPRI is a legislated, publicly accessible inventory of facility pollutant releases (to air, water and land), disposals and transfers for recycling (NPRI [Modified 2019]);
- Hydrogen sulfide is listed on Schedule 1 "Pollutant Substances" of the *Vessel Pollution and Dangerous Chemicals Regulations* (Canada 2012), under the *Canada Shipping Act, 2001* (Canada 2001a). These regulations require that vessels in Canadian waters, and persons on them, must not discharge substances listed in the regulations, such as hydrogen sulfide, except in accordance with certain requirements or circumstances;
- Hydrogen sulfide is listed on Schedule 1 of the *Transportation of Dangerous Goods Regulations* (Canada 2001b) under the *Transportation of Dangerous Goods Act, 1992* (Canada 1992). These regulations set out Canada's rules for

transporting dangerous goods in an effort to promote public safety in the transportation of dangerous goods by all modes of transport in Canada (Transport Canada [Modified 2020]).

7.1.2 Oil and gas well management

Local, municipal, Indigenous, provincial/territorial, and federal governments in Canada all have different powers to manage their respective non-renewable natural and forestry resources. The Provinces and Territories (except Nunavut) are the regulators of oil and gas activities in Canada, while the federal government retains jurisdiction over federal lands within provinces and territories (NRCan [Modified 2017]).

7.1.2.1 Provincial and territorial

Provinces and Territories set requirements for the lifecycle of the development of oil and gas wells from application and construction to production through to the proper abandonment of wells. Most of them have requirements to properly abandon oil and gas wells. For some provinces, requirements can include timelines for when a well must be abandoned after it has been suspended or becomes inactive. In the case of orphaned wells, some provinces use levies from industry to manage the decommissioning of oil and gas wells, in the absence of a legally responsible owner. In Alberta, the independent non-profit Orphan Well Association manages the abandonment of oil and gas wells, while British Columbia, Saskatchewan, and Ontario have similar programs administered by regulatory agencies through the Orphan Site Reclamation Fund, Orphan Fund Procurement Program, and the Abandoned Works Program, respectively.

Care has been taken so that the information provided reflects the requirements in place in the provinces and territories; however due to their complex and rapidly changing nature, HC and ECCC cannot guarantee that all descriptions are accurate and up to date.

Table 3. Risk management requirements in place for provinces and territories in regards to oil and gas wells.

Lifecycle Stage	BC	AB	SK	MB	ON	QC	NB	NS	NL	PEI	YK	NT	NU
Completed	√	√	√	√	√	√	√	√	√	√	√	√	
Active	√	√	√	√	√	√	√	√	√	√	√	√	
Inactive	√	√	√	√	√	√	√	√	√	√	√	√	
Orphaned	√	√	√	√	√	√	√				√	√	

British Columbia

The British Columbia Oil and Gas Commission (BCOGC) is the entity that licenses and overlooks oil and gas wells under the *Oil and Gas Activities Act* and its related *Drilling and Production Regulation* and *Dormancy and Shutdown Regulation*

(British Columbia 2008, 2010, 2019). The latter, published in 2019, outlines the requirements for addressing abandoned, remediated, and restored orphan wells. Notably, licence holders are required to follow the abandonment procedure in accordance with Alberta Energy Regulator Directive 020 (AER 2018). Once a well is restored, a Certificate of Restoration is a document issued by the BCOGC certifying that an abandoned wellsite has been restored to meet regulatory requirements. In their Comprehensive Liability Management Plan released in 2019, the BCOGC has enforced a timeline of ten years for industry to clean up their inactive wells, in addition to an improved method of estimating liability depending on a well's site and activity. This includes adjustments to more closely monitor each well operator's progress in decommissioning and restoring sites (BCOGC 2019b).

An orphan designation is given by the BCOGC to wells and associated operating areas when the operator is insolvent or cannot be located. This can happen at any stage and allows restoration work to move ahead, paid through the industry-funded Orphan Site Reclamation Fund.

Alberta

A majority of the oil and gas activities in Canada are currently taking place in Alberta. Hence, the province has the highest number of active and inactive wells. The Alberta Energy Regulator (AER) is the entity that administers the various energy resource enactments. The energy companies operating in Alberta are subject to many acts – notably the *Oil and Gas Conservation Act* (Alberta 2000), regulations, rules, ministerial orders, codes of practice, and directives.

Under the *Oil and Gas Conservation Rules* (Alberta 2013), oil and gas wells must be suspended within 12 months for a non-sour well and six months for a sour well from becoming inactive using requirements specific to the risk level. Lower risk wells have no downhole requirements for well suspension. Medium to high risk wells, however, have risk reduction requirements and the highest risk wells require a permanent plug. In this province, suspended wells are defined as those no longer producing.

Alberta has a publically available incident reporting which includes hydrogen sulfide incidents from operations and wells. This information is available online to the public (AER [Modified 2020]). Oil and Gas Regulations include higher stringency requirements in known sour gas regions (Peace River).

Enforceable best management practices, called Directives, have been developed for energy companies operating in Alberta by the Government of Alberta and the AER and are expected to reduce the air emissions of pollutants. As indicated in section 6, Directive 020 sets out requirements for properly abandoning inactive wells.
The Orphan Well Association (OWA) is the authority to manage orphan wells in Alberta. Funds are collected from licensees according to a formula that takes into account the licensee's and industries' liabilities. A company's annual levy is based on its share of the industry's estimated liability, as determined by the Licensee Liability Rating Program. Companies who do not maintain a sufficiently high Liability

Management Rating need to make a security deposit to cover abandonment, remediation and reclamation costs. The *Orphan Fund Delegated Administration Regulation* notably specifies powers, duties and functions delegated to the OWA.

Saskatchewan

The Ministry of Energy and Resources is the entity that licenses and overlooks oil and gas wells under *The Oil and Gas Conservation Act* (Saskatchewan 1979) and its related *The Oil and Gas Conservation Regulations, 2012* (Saskatchewan 2012). These regulations address operational aspects of oil and gas production. There are also requirements for wells. Under these Regulations, an inactive well should be abandoned (plugged and cased) as soon as it is considered inactive. If the abandonment is delayed for too long, the Minister can notify the licensee to abandon it within 90 days. The Ministry has its Directive PNG 015 in place that sets out requirements for properly abandoning inactive wells.

Since 2018, Saskatchewan's incident tracking database has a requirement that hydrogen sulfide releases and public complaints from oil and gas operations must be reported, and this information is available online to the public (Saskatchewan, 2020b). The government has also invested in response capability for its inspectors to investigate incidents.

The province has the Orphan Fund Procurement Program (Saskatchewan 2020c), which is funded by oil and gas producers through the orphan fund/levy, orphan fund fee and a security deposit. It is monitored by the Fund Advisory Committee and the Ministry of Energy and Resources.

Manitoba

In Manitoba, the oil and gas sector activity is overseen by the Department of Agriculture and Resource Development, who administers provisions under *The Oil and Gas Act* (Manitoba 1993) and *The Oil and Gas Production Tax Act* (Manitoba 1996) relating to exploration, development, production and transportation of oil and gas.

Under these acts, oil and gas well operators must apply to suspend/abandon a well if inactive for six months; three years is the maximum for suspension then the well must be re-activated or abandoned. Once the operator has completed the abandonment process to the technical standards required, an inspector must issue a Certificate of Abandonment after inspection to ensure that the well is in accordance with the regulations. The operator is then liable for the land for six years after the Certificate is given. Through *The Surface Rights Act* (Manitoba 1987) the operator is responsible to return the land to as close as possible to its original conditions.

Manitoba has an Abandonment Reserve Fund established under *The Oil and Gas Act.* This reserve account is used when there is non-compliance under the Act regarding abandoning a well. The funds for this account come from levies put on the industry, interest on the fund and recoveries. There is a yearly report released by the

Manitoba government that describes how the funds had been used in the previous fiscal year, the amount of the current reserve fund, and the estimated expenditures for the next fiscal year.

Ontario

Oil wells were first installed in Ontario in 1858, with natural gas production starting in the 1900s (OPI 2017). The Ministry of Natural Resources and Forestry is the entity that administers the energy resource enactments. The Ministry licenses oil and gas wells under the *Oil, Gas and Salt Resources Act,* its *Exploration, Drilling And Production Regulations* and the companion 2002 Oil, Gas and Salt Resources of Ontario Provincial Operating Standards (therein known as the Provincial Standards) (Ontario 1990, 1997, 2002). This suite of requirements address the completion, operation, suspension, abandonment and reclamation of a well. While there are no reporting requirements, proponents must keep records throughout the operation and ensure an Examiner can verify the state of well operations at various stages in the well's lifecycle.

In addition, in order to obtain a licence, a proponent must also establish a security, per amounts prescribed in the *Exploration, Drilling And Production Regulations*, in the form of a trust fund for purpose of providing financial assurance that wells will be plugged and works completed in accordance with requirements. Prescribed amounts range depending on well depth and whether covered by water, from $3 000 to $15 000. The regulations also specify maximum security amounts but it is not clear when these would apply. These amounts range from $70 000 for wells on land to $200 000 for wells under water.

In Ontario, under section 7.0.1 of the *Oil and Gas Resources Act*, the Minister of Natural Resources of Ontario gives power to an inspector to order the operator to plug a well or decommission a facility if it represents a hazard or if the activity is suspended (Ontario [Modified 2019]). Under section 23 of the *Exploration, Drilling and Production Regulations*, O Reg 245/97 Exploration Drilling Production, the Minister has the authority to certify a Class I examiner that may examine wells with respect to well integrity, well control equipment and well plugging. The *Exploration, Drilling and Production Regulations* of Ontario, however, do not contain any specific provision related to hydrogen sulfide.

Ontario has also established the Ontario Abandoned Works Program which aims to help Ontarians plug orphaned oil and gas wells on their property (Ontario [Modified 2019]). Oil and gas proponents are responsible for plugging their wells that are no longer in use (that is, no longer producing oil or gas). If there are no oil or gas well operators found to be responsible for an oil or gas well, the landowner becomes responsible for plugging the well. Only certain wells are eligible for support under the program, including:

- Those drilled before 1963;
- Not tampered with;
- Visible from the surface; and
- There is no current operator.

Quebec

The first oil and gas wells date back to 1860. Oil and gas wells are mostly found on lands along the Saint-Lawrence River. The Ministry of Energy and Natural Resources is the entity that administers the energy resource enactments. The *Petroleum Resources Act* (Quebec 2016) came into force in 2018, and establishes a new regulatory framework for the hydrocarbon industry in Quebec. Before then, the now-repealed *Mining Act* governed the field of hydrocarbons with mining but requirements for licensing activities in the oil and gas sector, including decommissioning the wells, were limited.

Under the *Petroleum Resources Act* and the related *Regulation respecting petroleum exploration, production and storage on land* (Quebec 2018a), and *Regulation respecting petroleum exploration, production and storage licences, and the pipeline construction or use authorization* (Quebec 2018b):

- To obtain a licence for exploration or production, operators must submit a detailed closure plan that includes the anticipated cost to permanently close their proposed well.
- Licence holders must provide as a guarantee deposit, the anticipated cost of completing the work. Wells have to be ‘closed’ before the licence expires and restored through the site restoration action plan that was described at the start.
- A licence holder who ceases their work or activity at a well must close it temporarily or permanently. The licence holder must obtain written approval of the Minister to abandon a well, and follow any term or condition specified by the Minister.

In response to Section 139 of the *Petroleum Resources Act,* where the Minister must report to the government every three years on the condition of the identified wells that are ownerless or which are abandoned on the territory of Quebec, the Ministry started in 2018 to conduct an inventory of abandoned and ownerless wells on public and private lands. This work makes it possible to draw up a current state of conformity of inactive oil and gas wells – including stratigraphic survey wells - throughout Quebec to ensure the safety of people and property as well as the protection of the environment. An interactive map is available to the public with information of these wells, notably any work needed to secure them. The Ministry takes over the onus of the work needed for ownerless oil and gas wells.

New Brunswick

New Brunswick's Department of Natural Resources and Energy Development administers laws and programs for oil and gas wells in that province. Requirements for management of oil and gas wells fall under the *Oil and Natural Gas Act* among others (New Brunswick 1976). Well licences are issued under the *Oil and Natural Gas Act* and the applications are required to outline sufficient information to enable review and approval of the drilling of a well, as well as any environmental or land use concerns. A security deposit is collected when the licence is given, to be used by the department for rehabilitation, if the operator is unable to complete activities (such as suspension or abandonment) to the satisfaction of the Minister. The security deposit is prescribed in the amount of $50 000 per well (New Brunswick 2016).

New Brunswick' *Petroleum Act* (New Brunswick 2007) applies to anyone who is looking to explore for, develop, drill for or produce petroleum. Under the legislation, a well licence holder would be required to obtain written approval of the Minister to abandon a well. Abandonment must be done in accordance with the regulations and any term or condition specified by the Minister. Regulations prescribing the methods of operation to be observed in relation to the abandonment of any well can be made under the *Petroleum Act*.

In addition, in 2013 New Brunswick outlined requirements (Rules for Industry) for responsible management of oil and gas wells in that province, that are implemented for the most part as conditions to Approvals and Certificates of Determination issued under existing legislation. For well plugging and abandonment, New Brunswick will impose the procedures set out in the latest version of Alberta Energy Resources Conservation Board (ERCB) Directive 020, Well Abandonment (New Brunswick 2013).

Nova Scotia

Nova Scotia's Department of Energy and Mines is responsible for managing oil and gas resources within the province. Requirements relevant to developing and managing onshore oil and gas wells throughout their lifecycle fall under the *Petroleum Resources Act* and its regulations, including the *Onshore Petroleum Drilling Regulations* and the *Petroleum Resources Regulations* (Nova Scotia 1989, 2001a, 2001b).). Oil and gas proponents must seek various licences and leases in order to develop and produce oil or gas from onshore wells. In addition, oil and gas well operators must ensure that wells are drilled, re-entered, suspended, completed or abandoned in accordance with various legal or other requirements, including petroleum drilling practices. Petroleum drilling practices are defined to include recommended practices from Alberta, industry, and/or petroleum institutes, such as the American Petroleum Institute. When given an authority, the operator must provide a financial security sufficient to abandon the well and leave the drill site in a satisfactory condition (Nova Scotia 2001a).

Operators are also required to apply for an authorization to abandon a well, to have a well abandonment program that is consistent with good petroleum drilling practices and to abandon the well to prevent fluid from flowing through or escaping from the well. In addition, the operator must inspect the well each year or at an approved interval, and submit a report on the condition of the well (Nova Scotia 2001a, 2020).

No information was located on programs addressing orphaned oil and gas wells in this province.

Newfoundland and Labrador

The Department of Natural Resources is the entity that administers the energy resource enactments. In Newfoundland and Labrador, the onshore oil and gas resources are regulated by the *Petroleum and Natural Gas Act*, which is largely focused on the offshore oil and gas sector (Newfoundland and Labrador 1990).

The main regulation for onshore wells is the *Petroleum Drilling Regulations,* as many drilled test holes have not progressed to the producing stage of a well's life. The onshore oil and gas sector is currently inactive - there are only two wells listed (Newfoundland and Labrador 2019) as having onshore activity and both are in suspended status since 2019.

Prince Edward Island

The Prince Edward Island (PEI) Department of Transportation, Infrastructure and Energy oversee oil and gas activities in the province (PEI [Modified 2019]). Administration of oil and gas well management falls under the *Oil and Natural Gas Act* and its regulations, the *Oil and Gas Conservation Regulations*. Authorization for drilling or operating a well is issued under the Act. A well authorization will not be valid unless accompanied by a fee, drilling deposit or a greater amount as may be required by special circumstances (PEI 2015).

The regulations outline various operational requirements, including specific actions and equipment for concentrations of hydrogen sulfide of 1% or greater (for example, operation of flares, signage, provision of respiratory equipment, etc.) (PEI 1988).

The regulations cover the life cycle stages of well completion, suspension, abandonment and restoration to varying degrees. To abandon a well, permission must be obtained from the province and the application for abandonment must include an abandonment program. The Regulations outline certain specifications for well abandonment. A well site must be restored when the well is abandoned or as soon as weather and ground conditions permit to ensure the site is left in the conditions as close as possible to pre-existing conditions before the well was drilled or operated (PEI 1988).

Yukon

The Department of Energy, Mines and Resources operates primarily under the Yukon *Oil and Gas Act*. The Act covers a wide variety of areas, including regulation of activities, collection of royalties and ensuring protection of the environment (Yukon 2002). A security deposit is collected from the operator as part of applying for a well licence. This deposit is used to cover the cost of abandoning and reclaiming the well if the company is unable.

Northwest Territories

The Office of the Regulator of Oil and Gas Operations (OROGO) administers the *Oil and Gas Operations Act* (OGOA) of which the primary purpose is to ensure safety, environmental protection, and conservation of oil and gas reserves. The OROGO administers the OGOA for all of the Northwest Territories except in the Inuvialuit Settlement Region.

The Government of Northwest Territories Mineral and Petroleum Resources division is responsible for the issuance and management of exploration licences, significant discovery licences and production licences for the onshore of the Northwest Territories under the *Petroleum Resources Act*.

The revised version of OROGO's Well Suspension and Abandonment Guidelines and Interpretation Notes came into effect in May 2022 (OROGO 2022). Although the term "orphaned well" is not used, there is the requirement at the time of applying for a permit, for the operator to provide funds based on an estimated reclamation cost that will be used should they become insolvent before reclaiming the site.

If no owner can be found, responsibility for a leaking well rests with the landowner, usually the Government of the Northwest Territories (OROGO 2021).

Nunavut

The exploration, drilling, production, conservation, processing and transportation of oil and gas in Nunavut are regulated under the *Canada Oil and Gas Operations Act* (Canada 1985b) and several regulations including the *Canada Oil and Gas Drilling and Production Regulations* (Canada 2009a).

There was a historic oil production site in Bent Horn Nunavut but it was decommissioned in 1997. Nunavut does not seem to currently have any active oil and gas wells.

7.1.2.2 Federal government and the federal lands

No federal risk management was identified that specifically targets incidental releases of hydrogen sulfide from inactive oil and gas wells.

In order to understand certain principles and industrial practices currently existing in Canada, the following concept, and legislative and regulatory actions are defined:

Mineral Rights versus Surface Rights

In Canada, property rights are separate between surface and mineral rights and in many cases ownership of these rights can be different, are not exclusively held by governments and vary from province/territory to province/territory. Private individuals hold the surface and/or mineral rights which is particularly relevant in the Prairie Provinces, as surface and mineral rights were granted by the Federal Government as incentive for settlers to migrate west in the late 1800's and early 1900's.

Ownership of these rights can be further split between the Crown in the right of a Province or Territory and the Crown in the right of Canada within any one province or territory. This is an important distinction as different Provincial Crown regulations and legislation may be applicable to federal lands within the boundary of a province or territory.

Provinces/Territories may award leases for the development of mineral resources, such as oil or gas, for Provincial/Territorial land and Canada may awards/issues leases for mineral resources on federal lands within a Province/Territory. Once a company has secured mineral rights from the province, territory or federal government, it would have to acquire/negotiate a surface lease with the surface owner to occupy the surface to develop the mineral rights.

Regulatory framework

The primary Acts in Canada that govern onshore and offshore oil and gas activities for Federal lands excluding First Nation Lands (NRCan [Modified 2016]) are:

The *Canada Oil and Gas Operations Act* (COGOA; Canada 1985b) applies in respect of the exploration and drilling for and the production, conservation, processing and transportation of oil and gas, notably on federal lands, Nunavut, and Sable Island, territorial sea and international waters; and does not include areas controlled by the provincial government. The purpose of the Act is to promote safety, protection of the environment, the conservation of oil and gas resources, and joint production agreements. Notably under this Act, the *Canada Oil and Gas Drilling and Production Regulations* (Canada 2009a) establish provisions relating to the drilling or production for oil and gas, and authorization required to conduct this work or activities, including requirements for suspension or abandonment for oil and gas well termination as well as safety and environmental protection measures.

The *Canada Petroleum Resources Act* (CPRA; Canada 1985c) governs the issuance of title rights to explore for, develop and produce petroleum in areas under federal jurisdiction in Nunavut, in most offshore areas north of latitude 60, and in the Hudson Bay area. It also governs the administration of these rights and the setting of royalties on production. Under the CPRA, a company must get permission for oil and gas exploration and development of resources on frontier lands, and the federal government may attach exploration restrictions when granting rights. Under the Act, the Governor in Council has the power to stop work, under specific circumstances, including when an environmental problem of serious nature is present.
The Ministers of Northern Affairs and Natural Resources share responsibility of administering COGOA and CPRA. The Minister of Northern Affairs is responsible for the administration of the Acts where it applies in the North.

There are a number of regulations promulgated under these Acts, which outline safety requirements, along with financial requirements for companies undertaking oil and gas activities.

The Canada Energy Regulator (CER), an agency under Natural Resources Canada, administers the COGOA and certain provisions of the CPRA in Nunavut and Canada's offshore (except for areas covered by other provincial or federal agreements). The CER also administers the Northwest Territories' *Oil and Gas Operations Act* and certain provisions of the CPRA in the onshore areas of the Inuvialuit Settlement Region in the Northwest Territories.

The primary Acts in Canada that govern oil and gas development for First Nation lands are:

- *Indian Act* (Canada 1985d), the primary source for statutory rules governing the relations between First Nations and the federal government, including the development of mineral rights.
    - Notably under this Act, the *Indian Oil and Gas Regulations* (Canada 2019b) is the regulation under which First Nation lands and rights may be leased and under which oil and gas companies must operate to explore for, development and produce of oil and gas from First Nation lands.
- *Indian Oil and Gas Act* (Canada 1974) applies to the exploration, development and production oil and gas rights held in the name of Canada for the benefit of First Nations.
- *First Nations Oil and Gas and Moneys Management Act* (Canada 2005). There are two parts to the legislation. The first part enables First Nations to manage and regulate First Nation lands oil and gas activities. The second part enables First Nations to assume control of their capital and revenue trust moneys held by Canada. First Nations can choose to opt in to one or both of these options. In other words, a First Nation does not have to have oil and gas to take on moneys management.

- The provincial oil and gas regulators license the wells/pipelines on First Nation lands that Indian Oil and Gas Canada (IOGC) manages. So, the respective provincial *Oil and Gas Conservation Acts* apply on First Nation lands to ensure conservation of/prevent the waste of and ensure the safe and efficient practices in the locating, spacing, drilling, equipping, constructing, completing, reworking, testing, operating, maintenance, repair, suspension and abandonment of wells and facilities and in operations for the production of oil and gas or the storage or disposal of substances, etc.

The Minister of Indigenous Services Canada, through its Special Operating Agency, (SOA) Indian Oil and Gas Canada, is responsible for oil and gas development on First Nation lands.
Indian Oil and Gas Canada (IOGC) manages and regulates oil and gas resources on First Nation reserve lands (as defined in the *Indian Oil and Gas Act*) across Canada. The IOGC is a special operating agency within Indigenous Services Canada. The IOGC operates under the *Indian Oil and Gas Act*, and the *Indian Oil and Gas Regulations*, as well as other relevant legislation and guidelines. The Ministers of Crown-Indigenous Relations and Northern Affairs have the sole responsibility to Parliament for the *Indian Oil and Gas Act* (IOGC 2019).

Federal Contaminated Sites Action Plan

The objective of the Federal Contaminated Sites Action Plan (FCSAP) is to reduce environmental and human health risks from known federal contaminated sites and associated federal financial liabilities, while focusing on the highest priority sites. Over 23 000 sites have been identified, some of which include inactive oil and gas wells.

7.1.3 Related pollutants

In addition to hydrogen sulfide, methane can also be released from oil and gas operations, including from wells, over their life cycle. Given that the natural gas present in a sour oil and gas reservoir contains predominantly methane and often elevated hydrogen sulfide concentrations, there is a co-release of both methane and hydrogen sulfide (CAPP 2019).

Therefore, federal and provincial initiatives related to the reduction of methane emissions from oil and gas wells may have an impact on hydrogen sulfide emissions when this substance is released with methane. Likewise, a recent study has also noted that mitigation strategies targeting hydrogen sulfide from sour wells may also have an impact on methane emissions (Lavoie et al 2022).

7.2 Pertinent international risk management context

Internationally, there are measures in place for the risk management of hydrogen sulfide, and management of oil and gas well activities. There are no specific requirements to target incidental releases of hydrogen sulfide from inactive oil and wells. Some risk management measures are summarized below, not all are specific to inactive oil and gas wells.

7.2.1 United States

Hydrogen sulfide is listed as an active chemical on the US EPA's *Toxic Substances Control Act* (TSCA) Chemical Substance Inventory (US EPA [Modified 2020]). Similar to Canada, the United States has federal and state level controls relating to the transport of hydrogen sulfide, occupational exposure limits, waste and transportation requirements, and ambient air and drinking water quality guidelines or standards.

Oil and gas sector

Some risk management measures exist for oil and gas operations, including active oil and gas wells. Exposure limits and standards vary from state to state regarding exposure, safety, and release of hydrogen sulfide. The state of Texas has air quality standards for hydrogen sulfide downwind of oil and gas operations (Texas Natural Resource Conservation Commission 1997). Texas has also published a state-wide rule for hydrogen sulfide safety for oil and gas activities, including drilling, production and transportation (RRC Texas 2012).

In Colorado, operators must file a plan with the Colorado Oil and Gas Conservation Committee for oil and gas wells that are drilled in high sulfide rock formations. This plan must include hazard mitigation procedures upon accidental release of hydrogen sulfide (Colorado Oil and Gas Conservation Commission 2020).

Inactive oil and gas wells

In the United States, mineral rights can be privately owned, or owned by federal, state, or local governments, and vary from state to state. The Bureau of Land Management (BLM) has jurisdiction over oil and gas operations for federal lands.

The United States also has a similar approach to Canada as to what constitutes idle (term mostly used for "inactive"), abandoned, and orphaned oil and gas wells, which can vary from state to state. It is estimated that approximately 3.7 million oil and gas wells have been drilled in the country since 1859. The Energy Information Administration reported that there were just over 1 million active oil and gas wells in the United States in 2014, which declined to just under 1 million active wells by 2019 (US EIA 2019).

In the United States, abandoned wells include those wells with no recent production including inactive, temporarily abandoned, dormant and idle wells. These abandoned wells can be either not plugged, or plugged to prevent migration of gas or fluids. Orphaned wells are wells with no recent production, and no responsible operator or owner on record, including historical, or undocumented, wells, similar to wells considered orphaned in Canada. It is estimated that total number of abandoned and orphaned oil and gas wells in the United States range from over 2.3 million to approximately 3 million, 1 million of which are orphaned (US EPA 2018).

The length of time a well can remain inactive or abandoned varies from state to state. Most state regulatory agencies have a process to determine whether a well may remain inactive, before it needs to be plugged (or properly abandoned), or put back into use. Similar to the approach that some provinces have taken to address orphaned wells in Canada, many oil and gas producing states also have established orphaned well plugging programs with funds allocated to plugging, or properly abandoning orphaned wells, along with funding that comes from production taxes, fees, or other assessments of the oil and gas industry (IOGCC [Modified 2020]), with requirements varying from state to state.

For example, in Texas, orphaned wells are those wells that are inactive and non-compliant that have been inactive a minimum of 12 months, where the responsible operator has been delinquent for over 12 months. Texas sets out requirements for new operators wishing to take over orphaned wells, which include taking responsibility for regulatory compliance and proper plugging or abandonment of the well (RRC Texas [Modified 2020]). Other examples of these programs include, but are not limited to, California's Idle and Orphan Well Program; Louisiana's Oilfield Site Restoration Program; Michigan's Orphan Well Program; North Dakota's Reclamation Program; Ohio's Orphan Well Program; Pennsylvania's Abandoned and Orphan Well Plugging Program; and Colorado's Orphaned Well Program. Of note, North Dakota has recently amended their regulatory framework by updating the liability management system and introducing stringent timelines to better manage inactive wells. For example, as a timeline requirement, a well may be deemed as abandoned upon the removal of production equipment or the failure to produce oil or gas for one year. As for the liability system, the number of liabilities allowed on blanket bonds was decreased and the bonding requirements for abandoned wells was doubled. Furthermore, all abandoned wells are required to have a single well bond in place equal to the estimated plugging and reclamation costs before they can be transferred to a new operator.

7.2.2 Other jurisdictions

Similar to Canada, hydrogen sulfide is subject to a number of risk management controls relating to occupational exposure limits, waste and transportation requirements, and emission limits in the European Union (ECHA [Modified 2020]) and other countries such as Australia and Japan. Hydrogen sulfide is also a preregistered substance under the European Union's Registration, Evaluation, Authorisation and Restriction of Chemicals (ECHA [Modified 2020]). The World Health Organization has established an air quality guideline for Europe for hydrogen sulfide, based on health effects other than odour, at a level of 150 µg/m^3 (WHO 2017).

Oil and gas sector

Like Canada, some risk management measures exist for oil and gas operations, including active oil and gas wells in the European Union (EU). The EU sets occupational exposure limits (ECHA [Modified 2020]), for hydrogen sulfide, and standards related to exposure, safety, and release of hydrogen sulfide can vary among other countries. There are also a number of EU Directives that apply to oil and

gas operations, including industrial emission and air quality controls, surface and groundwater requirements, and storage and waste management controls (IMPEL 2019). The EU is calling for binding measures for authorities to adopt policies to ensure that abandoned wells where ownership can be documented, are capped or filled to stop methane leakage, which may also impact emissions of hydrogen sulfide (European Parliament 2021).

In the EU, national governments have control over the oil and gas in their territories. For example, under the United Kingdom's (UK), *Petroleum Act 1998*, all petrol and natural gas found belongs to the Crown unless the right had been expressly granted to the owner of the land (GOV UK 1998). Similarly, in Australia, mineral rights generally belong to the Crown, although in some cases minerals may be owned by the landowner (Australian Government 2020).

Inactive oil and gas wells

While there are requirements in the EU related to oil and gas operations, the criteria and timing for well suspension, abandonment and decommissioning vary among EU member states, along with what is considered to be an inactive well (IMPEL 2019).

There is no common registry in the EU recording the status of oil and gas wells, and the availability of information varies among member states. In the UK, it is estimated that of the over 2000 wells that have been drilled, approximately two thirds have been decommissioned (GOV UK 2019); and of the currently over 250 operating wells, 50 to 100 are orphaned wells, which have been deserted by companies which cannot pay to plug them (Davies et al. 2014). Norway's well statistics show that there are approximately 2200 wells in use, and more than 2000 wells that are not in use, or plugged/abandoned (Norwegian Petroleum Directorate 2020).

7.2.3 Alignment

Canada is generally aligned with the United States and the European Union with respect to controls that are currently in place domestically regarding hydrogen sulfide in ambient air and management of active and inactive oil and gas wells. However, by putting in place regulatory or non-regulatory controls to address incidental releases of hydrogen sulfide specifically from inactive oil and gas wells, Canada will be the first to do so.

In Canada, provinces and territories have established ambient air limits for hydrogen sulfide, mainly with respect to human health, and a similar approach is seen in the United States. Across Canada, provinces and territories have oil and gas well management requirements in place, as do states in the United States and countries in the European Union. No requirements specific to incidental releases of hydrogen sulfide from inactive wells were identified at the federal level in the United States or for the European Union.

8. Next steps

8.1 Public comment period

Industry and other interested parties are invited to submit comments on the content of this document or other information that would help to inform decision-making (such as outlined in section 3.3). Please submit additional information and comments prior to April 2 2024.

If the final assessment confirms that hydrogen sulfide is toxic, a risk management approach, outlining and seeking input on the proposed risk management instrument(s), would be published concurrently with the assessment. At that time, there would be further opportunity for consultation.

Comments and information submissions on the Risk Management Scope should be submitted to the address provided below:

Environment and Climate Change Canada
Gatineau Quebec K1A 0H3
Tel: 1-800-567-1999 | 819- 938-3232
Fax: 819-938-5212
Email: substances@ec.gc.ca

Companies who have a business interest in hydrogen sulfide are encouraged to identify themselves as stakeholders. Stakeholders will be informed of future decisions regarding hydrogen sulfide and may be contacted for further information.

Stakeholders and members of the public who are interested in being notified of CMP publications are invited to subscribe for the latest news on the CMP. Stakeholders and members of the public who would like to receive CMP Publication Plans on a quarterly basis by email, can contact: substances@ec.gc.ca.

8.2 Timing of actions

Electronic consultation on the updated draft assessment and risk management scope: February 3 2024 to April 2 2024. This should include the submission of public comments, additional studies, and information on hydrogen sulfide.

Publication of responses to public comments on the draft assessment and risk management scope: Concurrent to the publication of the final assessment and, if required, the risk management approach document.

Publication of responses to public comments on the risk management approach, if applicable and if required, the proposed instruments: At the latest, 24 months from the

date on which the Ministers recommended that hydrogen sulfide be added to Schedule 1 of CEPA.

Consultation on the proposed instruments, if required: 60-day public comment period starting upon publication of each proposed instrument.

Publication of the final instrument(s), if required: At the latest, 18 months from the publication of each proposed instrument.

These are planned timelines, and are subject to change. Please consult the schedule of risk management activities and consultations for updated information on timeline

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ANNEX A: Provincial Air Quality Controls for Hydrogen Sulfide (no requirements found in Territories).

Jurisdiction	Requirement / Reference	Overview
British Columbia	British Columbia. Modified 2020. Provincial Air Quality Objective Information Sheet. British Columbia Ambient Air Quality Objectives. [Accessed 2020 October] British Columbia. Modified 2018. Environmental Management Act BC Reg 254/2005 OIL AND GAS WASTE REGULATION. [Accessed 2020 October]	Pollution Control Objective for Total Reduced Sulphur measured as H_2S (for the forest products sector): 7 µg/m^3 (1 hour), 3 µg/m^3 (24 hour) The operator must ensure 1 hour average ambient ground level concentration of hydrogen sulfide due to the discharge of air contaminants from equipment or facility does not, at the perimeter of the property on which the equipment or facility is located, exceed 10 ppb by volume.
Alberta	Alberta. January 2019. Alberta Ambient Air Quality Objectives and Guidelines Summary [Accessed 2020 October]	Ambient air quality objectives: 14 µg/m^3 (1 hour), 4 µg/m^3 (24 hour)
Saskatchewan	Saskatchewan. March 2012. Air Monitoring Guideline for Saskatchewan. [Accessed 2020 October] Saskatchewan. Modified October 2018. *Oil and Gas Conservation Regulations, 2012, RRS c O-2 Reg 6, [*Accessed 2020 October]	Ambient air quality standards: 15 µg/m^3 (1 hour), 5 µg/m^3 (24 hour) No venting gas with hydrogen sulfide concentration above 10 ppm measured at edge of property
Manitoba	Manitoba. Modified January 2011. Drilling and Production Regulation, Man Reg 111/94. [Accessed 2020 October]	Ambient air quality concentration guideline (maximum acceptable level concentration): 15 µg/m^3 (1 hour), 5 µg/m^3 (24 hour)
Ontario	Ontario. Modified January 2019. O. Reg. 419/05: AIR POLLUTION - LOCAL AIR QUALITY under Environmental Protection Act, R.S.O. 1990, c. E.19. [Accessed 2020 October]	• Concentration if O. Reg. 419/05 s.19 applies: 10 µg/m^3 (½-hour averaging period); limiting effect health and odour. • Concentration if O. Reg. 419/05 s.20 applies: 7 µg/m^3 (24-hour averaging period, health); 13 µg/m^3 (10-min averaging period); odour. • Upper Risk Threshold (URT): 210 µg/m^3 (½-hour URT); 70 µg/m^3 (24-hour URT).
Quebec	Quebec. Modified May 2020. Chapter Q-2, r. 4.1 Clean Air Regulation under the Environment Quality Act. [Accessed 2020 October]	Air quality standards: 6 µg/m^3 (4 min), 2 µg/m^3 (1 yr)
Newfoundland	Newfoundland and Labrador. May 2004. NEWFOUNDLAND AND LABRADOR REGULATION 39/04. Air Pollution Control Regulations, 2004 under the Environmental Protection Act O.C. 2004-232. [Accessed 2020 October]	Ambient air quality standards: 15 µg/m^3 (1 hour), 5 µg/m^3 (24 hour)
New Brunswick	New Brunswick. Modified February 2018. *Air Quality Regulation, NB Reg 97-133.* [Accessed 2020 October]	Maximum permissible ground level concentrations: 15 µg/m^3 (1 hour), 5 µg/m^3 (24 hour)

Jurisdiction	Requirement / Reference	Overview
Nova Scotia	Nova Scotia. Modified February 2020. *Air Quality Regulations, NS Reg 28/2005*. [Accessed 2020 October]	Maximum permissible ground level concentrations: 42 µg/m^3 (1 hour), 8 µg/m^3 (24 hour)
Prince Edward Island	Prince Edward Island. Modified November 2004. *Air Quality Regulations, PEI Reg EC377/92*. [Accessed 2020 October]	Ambient air contaminant ground level concentration standards: 15 µg/m^3 (1 hour), 5 µg/m^3 (24 hour)
Northwest Territories	N/A	N/A
Yukon	N/A	N/A
Nunavut	N/A	N/A

Abbreviations: N/A = Not Available