Petroleum Technology Alliance Canada (PTAC)

Report: Identifying Barriers to Water Recycling in Alberta Hydraulic Fracturing

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Publicly available resources were consulted in preparation of this report. Information provided by project participants and industry contacts has been aggregated and anonymized to maintain confidentiality.

Executive Summary

The Alberta Water Conservation Policy for Upstream Oil and Gas Operations expresses a preference for utilizing alternative water sources in hydraulic fracturing (HF), such as recycled produced and flowback water, instead of high-quality non-saline (HQNS) water sources. Previous efforts by Alberta HF producers and industry organizations have helped to broadly define the barriers to produced and flowback water recycling throughout the water management process. Despite these efforts, Alberta operators still find that increasing their recycling rates is challenging, and there is a desire to better understand how these barriers compare to the ones in British Columbia (B.C.), where produced and flowback water recycling rates for the HF industry are higher.

To better understand these barriers in Alberta and how they compare to B.C., Petroleum Technology Alliance Canada (PTAC) engaged WaterSMART Solutions Ltd. to conduct interviews with representatives from 20 HF operators in Alberta (some of which are also active in B.C. and the United States). The interviews were informed and supported by a review of the regulatory context in Alberta and how this compares to B.C.

The interviewees identified many barriers to implementing and/or scaling up produced and flowback water recycling in their Alberta operations, as summarized in the table and figure below. However, all the technological, operational, regulatory, and stakeholder-related issues point to the same underlying barrier which disincentives water recycling: in Alberta, recycling produced and flowback water generally costs operators significantly more than the alternative of sourcing HQNS water and disposing of produced and flowback water. Conversely, operators in B.C. are impacted by many drivers which encourage produced and flowback water recycling, such as limited physical access to HQNS water sources, limited disposal capacity, and the benefit of previous infrastructure build outs. One key example of a barrier more prevalent in Alberta than B.C. is the presence of sulfur in produced and flowback water in parts of Alberta. This characteristic, referred to as sour water, increases the complexity of storage and conveyance activities for produced and flowback water, making it much more expensive and difficult to recycle.

90% of the interviewees showed interest in increasing their rates of produced and flowback water recycling, especially if the economics of doing so could be improved. Below are several barrier-reducing activities, suggested by interviewees, which PTAC can champion to help increase the rates of produced and flowback water recycling in Alberta:

- Initiate and facilitate workshops between the AER and Alberta operators who are interested in increasing their produced and flowback water recycling rates. These workshops could include knowledge sharing to increase mutual understanding of constraints and opportunities, as well as brainstorming on optimal regulatory compliance

pathways and solutions to address barriers.

- The collaborative process between operators and the AER for updating Directive 077 was cited by many interviewees as an example of successful collaboration at a working group level.
- Interviewees expressed specific interest in discussions with the AER regarding Directives 055 and 058 requirements for storage and oilfield waste management.

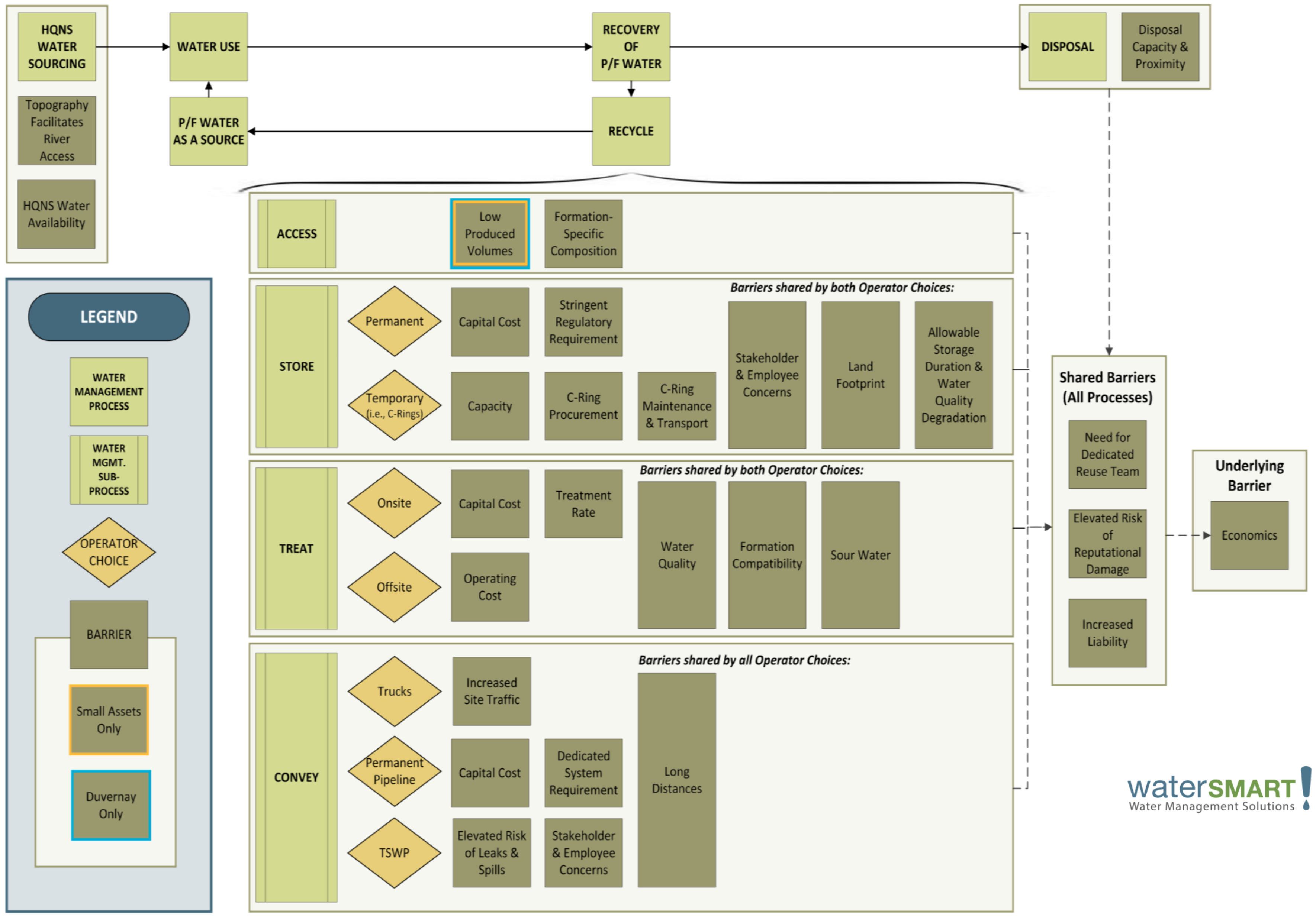
- In collaboration with the AER, develop a platform and/or toolkit which provides operators with detailed and actionable supports to understand and comply with regulations for produced and flowback water storage, treatment, conveyance, and reporting. This would help improve clarity amongst operators, reduce the administrative burden associated with compliance, and better enable smaller operators, who have limited personnel, to work through the regulatory processes for produced and flowback water recycling.
- Engage with operators and water technology developers in Alberta and B.C. to facilitate knowledge sharing regarding produced and flowback water recycling pilots, operational efficiency improvements, and lessons learned.
- Engage with operators and water technology developers to prepare recommendations to the Government of Alberta regarding financial incentives for produced and flowback water recycling. Many interviewees noted that a system of grants, royalty rate adjustments, and/or other positive financial incentives would greatly increase the appetite for operators to invest in produced and flowback water recycling (e.g., related to storage, treatment, and conveyance).
    - While not stated as a desirable option, 15% of interviewees acknowledged that having a financial penalty associated with high HQNS water intensity could incentivize reuse if the penalty were to cost more than the cost associated with recycling. However, these interviewees also cautioned that such negative financial incentives could have unintended consequences, for example related to competitiveness. Some operators noted they may opt to curtail operations in the face of HQNS water supply constraints, rather than pay the higher costs to recycle. Alternatives to financial penalties could include the establishment of recycling targets and associated rewards, either financial or reputational.
- Work with the AER and water midstream service providers to identify ways to reduce regulatory barriers to the water midstream business model. If the regulatory environment can enable third parties to effectively, safely, and economically treat and convey produced and flowback water, this will provide HF operators with another avenue to increase water recycling.
- Encourage HF operators in Alberta to explore additional opportunities to reduce HQNS water use beyond produced and flowback water recycling. This could include using other alternative water sources (e.g., municipal effluent) and piloting new technologies and

procedures to reduce total water requirements per well (which in turn would reduce HQNS water use).

Summary of all barriers to produced and flowback water recycling for hydraulic fracturing in Alberta. This table accompanies the subsequent figure.

<table>
<tr><th colspan="2">Water Management Process Category</th><th>Operator Choice
(where applicable)</th><th>Barrier to Produced and Flowback Water Recycling in Alberta</th></tr>
<tr><td colspan="2" rowspan="2">**HQNS WATER SOURCING**</td><td rowspan="2">All options</td><td>Topography facilitates river access</td></tr>
<tr><td>HQNS water availability</td></tr>
<tr><td rowspan="14">**RECYCLE**</td><td rowspan="2">**ACCESS**
Sourcing of produced water and flowback for reuse in hydraulic fracturing operations</td><td rowspan="2">All options</td><td>Low produced volumes</td></tr>
<tr><td>Formation-specific composition</td></tr>
<tr><td rowspan="8">**STORE**
Storage of produced water and flowback for reuse in hydraulic fracturing operations</td><td rowspan="2">Permanent storage</td><td>Capital cost</td></tr>
<tr><td>Stringent Regulatory Requirements</td></tr>
<tr><td rowspan="3">Temporary storage</td><td>Capacity</td></tr>
<tr><td>C-Ring Procurement</td></tr>
<tr><td>C-Ring Maintenance and Transport</td></tr>
<tr><td rowspan="3">Permanent and temporary storage</td><td>Stakeholder and Employee Concerns</td></tr>
<tr><td>Land Footprint</td></tr>
<tr><td>Allowable Storage Duration & Water Quality Degradation</td></tr>
<tr><td rowspan="2">**TREAT**
Treatment of produced</td><td rowspan="2">Onsite treatment</td><td>Capital Cost</td></tr>
<tr><td>Treatment Rate</td></tr>
</table>

<table>
<tr><th>Water Management Process Category</th><th>Operator Choice
(where applicable)</th><th>Barrier to Produced and Flowback Water Recycling in Alberta</th></tr>
<tr><td rowspan="4">water and flowback for reuse in hydraulic fracturing operations</td><td>Offsite treatment</td><td>Operating Cost</td></tr>
<tr><td rowspan="3">Onsite and Offsite treatment</td><td>Water Quality</td></tr>
<tr><td>Formation Compatibility</td></tr>
<tr><td>Sour Water</td></tr>
<tr><td rowspan="6">**CONVEY**
Conveyance of produced water and flowback for reuse in hydraulic fracturing operations</td><td>Trucks</td><td>Increased Site Traffic</td></tr>
<tr><td rowspan="2">Permanent Pipeline</td><td>Capital Cost</td></tr>
<tr><td>Dedicated System Requirements</td></tr>
<tr><td rowspan="2">TSWP (temporary surface water pipeline)</td><td>Elevated Risk of Leaks and Spills</td></tr>
<tr><td>Stakeholder and Employee Concerns</td></tr>
<tr><td>Trucks, Permanent Pipelines, and TSWP</td><td>Long Distances</td></tr>
<tr><td>**DISPOSAL**
Dispose of produced water and flowback, after one or multiple uses through a hydraulic fracturing operation</td><td>All options</td><td>Disposal Capacity and Proximity</td></tr>
<tr><td rowspan="3">**ALL PROCESSES**
Shared barriers across all processes, including HQNS water sourcing, recycling, and disposal</td><td rowspan="3">All options</td><td>Need for Dedicated Reuse Team</td></tr>
<tr><td>Elevated Risk of Reputational Damage</td></tr>
<tr><td>Increased Liability</td></tr>
</table>



Visual summary of all barriers to produced and flowback water recycling for hydraulic fracturing in Alberta.

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1.0 Introduction

Alberta's Water Conservation Policy for Upstream Oil and Gas Operations articulates a preference for the use of alternative water sources, including the recycling of produced and flowback water in hydraulic fracturing (HF), over high-quality non-saline (HQNS) water sources [1]. This preference is consistent with broad regulatory, societal, and investor pressures to reduce the environmental impacts of operations, including HQNS water use. However, HF operators in Alberta face many barriers to recycling produced and flowback water.

Operators in Alberta have made significant efforts to identify, understand, and address these barriers to water recycling, including working with the Alberta Energy Regulator (AER) on specific regulatory challenges. This prior work has helped to broadly define and start to reduce barriers to recycling in areas including regulation, environmental protection, technology, and cost. These barriers manifest throughout the water management processes undertaken by operators, which can be visualized in Figure 1. Despite this prior work, many Alberta operators still find produced and flowback water recycling challenging, and there is a desire to better understand the remaining barriers and how these compare to British Columbia (B.C.), where water recycling rates are much higher.

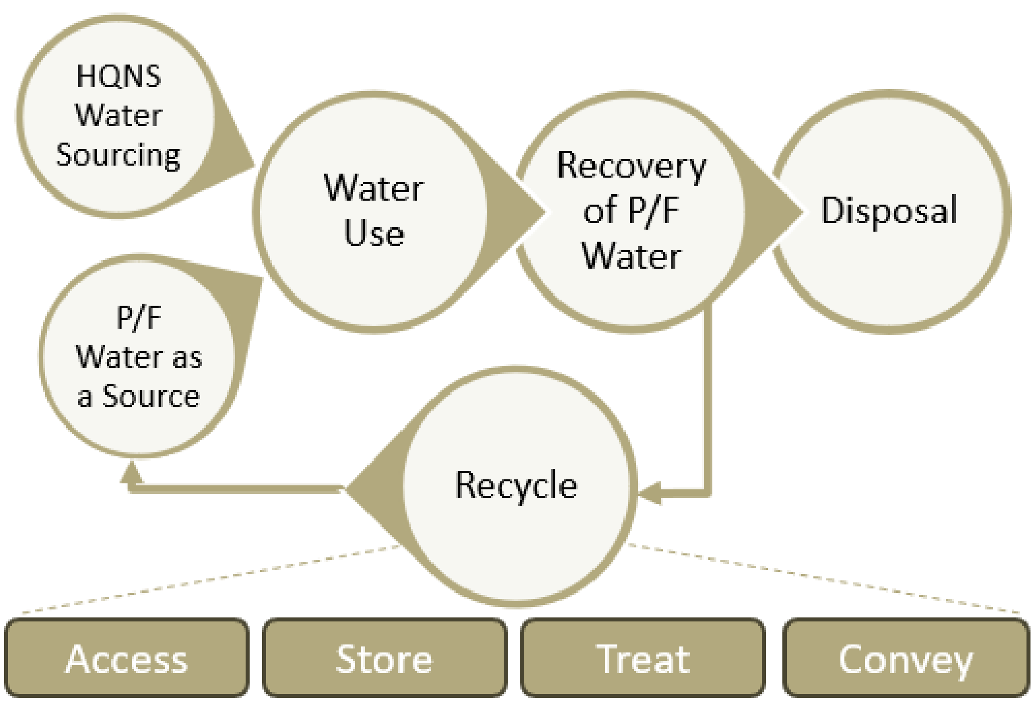

Figure 1: Visualization of the HF water management process, from sourcing to disposal. "P/F" refers to produced and flowback water in the context of recycling.

2.0 Project Scope

A key activity of this project was completing 20 interviews with representatives from HF operators based in Alberta, some of which also operate in B.C. Interviewees were selected based on several factors, with the intent of providing a diverse array of perspectives on produced and flowback water recycling. While specific operating locations cannot be disclosed to maintain interviewee confidentiality, the map in Figure 2 provides a representative overview of the primary formations within which the interviewee companies are active. The following criteria were used to select the interviewees:

- Annual production: Half of the operators were identified as producing more than 10,000,000 barrels of oil equivalent per year, while the remaining half operated below this threshold.
- Geographical location: Most operators were active in the Duvernay and Montney shale formations, amongst others across western Canada and the United States (U.S.).
- Water recycling rates: Selected operators had a range of produced and flowback water recycling rates and a range of HQNS water intensities.

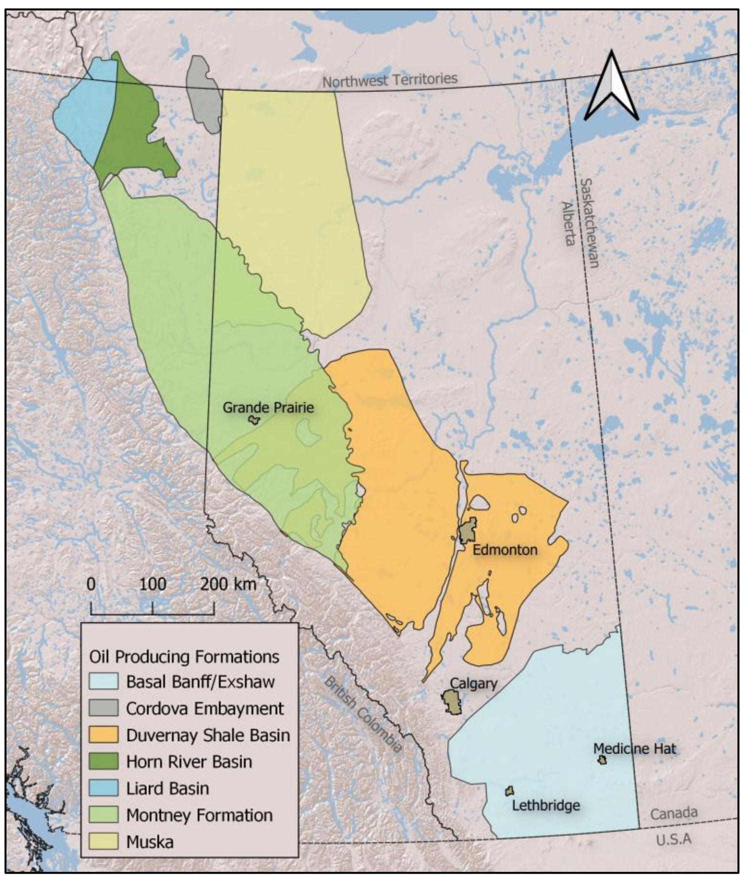

Figure 2. Approximate boundaries of the major stratigraphical units within the Western Canada Sedimentary Basin relevant to HF.

The interviews were supported and enabled through a review of the previous work noted in Section 1.0 and the regulatory context in Alberta, B.C., and some jurisdictions in the U.S. This review, together with direction from the Water Innovation Planning Committee convened by Petroleum Technology Alliance Canada (PTAC), helped define the structure and specific questions for the interviews. A copy of the interview questions is provided in Appendix A.

The following elements of water management for the HF process were a focus for this project:

- Operational factors, such as the ability to physically access HQNS water sources and secure regulatory authorization (i.e., licenses) to divert water from them; the availability of produced and flowback water (e.g., volumes recoverable at the surface); the ability to dispose of produced and flowback water; water requirements for completions; and economics.
- Social considerations, such as landowner concerns. Social considerations in favour of recycling, such as pushback against HQNS water use, were also investigated.
- Risk management, including environmental sensitivities of different regions and operators' risk tolerance for produced and flowback water spills and other impacts.
- Technical constraints, such as the quantity and quality of recovered produced and flowback water and formation compatibility requirements.
- Regulatory implications for water conveyance, water storage, and treatment technologies, including piloting. The ability of operators to function within the current regulatory environment and affect change as desired was also explored.

The project approach and findings are documented in the following report sections:

- Section 3.0 summarizes the regulatory context for HF in Alberta, which directly impacts how water is managed throughout the steps in Figure 1. Comparisons to similarly applicable regulatory instruments in B.C. are provided for each step.
- Section 4.0 documents the current state of water recycling in Alberta, as communicated by interviewees and through publicly available resources.
- Section 5.0 discusses the primary barriers to recycling HQNS in HF operations in Alberta and how these compare to B.C.'s own challenges.
- Section 6.0 highlights actionable next steps which PTAC can undertake to help improve the rate of produced and flowback water recycling in HF in Alberta.

3.0 Regulatory Context

Alberta's regulatory environment plays a critical role in how HF operators recycle produced and flowback water, and the extent to which this occurs. It provides an overarching context within which many other factors, like technology, risk tolerance, cost, and more, manifest and are influenced. Regulations are also an important, though not standalone, driver of differences between Alberta and other jurisdictions, such as B.C., when it comes to recycling produced and flowback water. Table 1 summarizes several key regulatory instruments impacting recycling in HF in Alberta, and compares them to the equivalent instruments in B.C.

Alberta's regulatory regime for HF includes a combination of provincial regulatory instruments which vary in type, level of authority, and enforcing body. For water, this ranges from statutes, such as the Alberta *Water Act*, to specific directives, such as Directive 055 – Storage Requirements for the Upstream Petroleum Industry. The AER enforces the *Water Act* and all other directives discussed herein for the hydraulic fracturing sector. In B.C., this role is played by the B.C. Energy Regulator BCER (previously the B.C. Oil and Gas Commission (BCOGC)). The *B.C. Water Sustainability Act* is the overarching statute, while the *Energy Resource Activities Act* [2], Pipeline Regulation [3], and Drilling and Production Regulation [4] regulate the permits, authorization, and orders for oil and gas related activities.

Table 1. Key regulatory instruments for produced and flowback water recycling for HF in Alberta and their equivalent in B.C.

	Alberta	B.C.
Overarching Legislation	**Alberta Water Act** The Alberta *Water Act* defines rules for diversion and allocation of water resources, including implications of water recycling and stormwater use projects on return flows and water balance. It also establishes a framework for prioritizing water use during times of scarcity based on precedence/seniority rights [5]. **Oil and Gas Conservation Act** This Act establishes a regulatory regime administered by the AER, for the development of oil and gas resources and related facilities in Alberta. The Act addresses water incidental to the drilling for, or production of, oil and gas [6].	**B.C. Water Sustainability Act** The B.C. *Water Sustainability Act* covers diversion and allocation of water resources, including specific provisions for regulating groundwater use. Precedence of rights differs from the Alberta *Water Act*; authorization dates, water use purpose, and critical environmental flow thresholds determine the precedence [7]. **Energy Resource Activities Act (previously the Oil and Gas Activities Act)** Regulates oil and gas and related activities in B.C., including wells, facilities, oil refineries, natural gas processing plants, pipelines, oil and gas roads, and water through permits, authorizations, orders, and regulations [2].
Water Conservation	**Water Conservation Policy for Upstream Oil and Gas (WCP)** Provides policy direction for water use in major upstream oil and gas operations where additional water conservation measures are encouraged. The AER has implemented the WCP via Manual 025 – Applications Under the Water Conservation Policy for Upstream Oil and Gas Operations [8].	**B.C. Water Protection Act** The B.C. *Water Protection Act* has the purposes of fostering sustainable use of water resources and conserving and protecting the environment. The Act defines concepts such as “large scale” projects, the major divisions between watersheds in B.C., and restrictions for removal of water from the province [9].

	Alberta	B.C.
Produced/Flowback Water Storage	**Directive 055 – Storage Requirements for the Upstream Petroleum Industry** *"Applies to any material that could adversely affect the environment and is produced, generated, or used under the jurisdiction of the AER."* [10] In this report context, D055 applies to the storage systems containing produced and flowback water, including: • Engineered containment ponds (ECPs) • Aboveground storage tanks/containers (e.g., C-Rings) • Underground storage tanks. Each storage system has different requirements; however, the following requirements apply for all: • Must include secondary containment systems for volumes over 1 m^3. • Must include leak detection systems. • Alternative water, including produced and flowback water, cannot remain in storage for more than 12 months. • The site location must minimize environmental risk and disturbance and must be specific distances from certain natural features. The largest allowable capacity of any single storage unit is 6,600 m^3, allowable in an above ground system (AWSS). Additionally, a site may only have 30,000 m^3 total in this storage form.	**Drilling and Production Regulation – Section 51** The regulation sets out requirements for lined storage solutions. For water with a concentration of solids greater than 4,000 ppm, the largest allowable above ground storage structure which uses a liner as the primary means of containment is 6,600 m^3 [4]. **Hazardous Waste Regulation – Section 15** The owner of a recycling facility where liquid waste is being managed must ensure that their equipment is compatible with hazardous waste and must provide an automatic means of stopping the process equipment and waste feed system [11].

Produced/Flowback Water Conveyance	**Directive 077 – Pipelines – Requirements and Reference Tools** *"Provides testing and operational requirements for ensuring pipelines, including temporary pipelines, are operated safely and in accordance with regulations and industry standards."* D077 complements the *Pipeline Act* and CSA Z662 standard. Directive 077 outlines the regulatory requirements for conveying water via temporary surface water pipeline (TSWP), based on the characteristics of the water as defined in three Groups: • Group 1: Water with a negligible effect on the environment or public safety if released (e.g., non-saline surface and groundwater with pH between 6.0 and 9.0, electrical conductivity <2.0 dS/m, chloride content ≤500 mg/L, no hydrocarbon sheen, no added chemicals prior to conveyance). • Group 2: Water that may have an environmental effect if released (e.g., treated drinking water, final treated municipal/industrial effluent, non-saline surface and groundwater different from Groups 1 and 2). • Group 3: Water that will have an environmental effect if released (e.g., saline groundwater, partially or untreated municipal/industrial effluent, produced water). Based on the water groups for TSWP conveyance, produced and flowback water, and any mixture containing them are classified as Group 3 (i.e., higher risk). Water cannot be	**Hazardous Waste Regulation – Section 15** The owner of a water recycling facility must use a containment system that provides equal or better protection than that of a dripless hose connection [11]. **Pipeline Regulation** This regulation covers construction, maintenance, use, and deactivation of pipelines. As it pertains to this report, the regulation sets forth design standards for all pipelines [3]. **Pipeline Crossings Regulation** This regulation defines distances for working near to, and for crossing, a pipeline and all associated costs [14].

	Alberta	B.C.
	conveyed via TSWP if it contains constituents at levels which could be an immediate human health hazard if released. TSWPs are exempt from requiring a pipeline licence, but they require an approval from the AER (Groups 2 and 3) or notification to the AER via OneStop (Group 1) [12]. **Pipeline Act** The *Pipeline Act* establishes a regulatory regime, administered by the AER, which is responsible for issuing approvals, enforcing rules, conducting inspections and investigations, and imposing sanctions for non-compliance in the construction and operation of pipelines [13]. The *Pipeline Act* also defines roles and responsibilities associated with spills [13].	

	Alberta	B.C.
Wastewater Disposal	**Directive 058 – Oilfield Waste Management Requirements for the Upstream Petroleum Industry** This directive identifies the requirements for handling, treating, reusing, and disposing of oilfield waste produced by the upstream petroleum and geothermal resource development industries in Alberta. It covers waste management responsibilities, activities and methods, classifications for waste as non-dangerous or dangerous, and the appropriate documentation required for transport [15]. Facilities to treat and store produced and flowback water (for recycling as an alternative to HQNS water) are regulated as oilfield waste management facilities with a waste storage activity. **Directive 051 – Injection and Disposal Wells – Well Classifications, Completions, Logging, and Testing Requirements** This defines the requirements and guidelines for injection and disposal wells in Alberta, covering deep well disposal and appropriate licensing requirements according to well and water classifications [16].	**Oil and Gas Waste Regulation – Section 7(1)** Operators of equipment or facilities are authorized to discharge produced water or recovered fluids from a well completion or workover to an underground formation in accordance with the *Energy Resource Activities Act* [17]. **Drilling and Production Regulation – Sections 37 and 75** If a well permit holder injects or disposes of water into an underground formation, they must submit a statement that indicates the volume injected, maximum wellhead or disposal pressure, and monthly operating hours. Permit holders must also maintain detailed records of the HF fluids used in a week [4]. ***Energy Resource Activities Act* – Section 111** This Act enables the BCER board to control and regulate the disposal of produced water into a storage reservoir [2].

	Alberta	B.C.
Produced/ Flowback Water Treatment	There are no directives or other implements with specific requirements for produced water treatment, beyond that which is required as it relates to storage and conveyance covered above.	There are no directives or other implements with specific requirements for produced water treatment, beyond that which is required as it relates to storage and conveyance covered above.

In addition to the key requirements in Table 1, Alberta operators must also work within AER Directive 056 – Energy Development Applications and Schedules. This directive defines the requirements for licence applications for the construction and operation of facilities, pipelines, or wells as part of an oil and gas, geothermal, or brine-hosted mineral resource development [18]. This has implications for enclosing produced and flowback water in tanks and pipelines when H_2S is present.

Additionally, Alberta's *Oil and Gas Conservation Act* aims to conserve and prevent the waste of oil and gas resources, to ensure safe and efficient practices; provide for the orderly and responsible development of the resources; protect the rights of owners; and control pollution. This mandate to avoid wasting oil and gas resources in Alberta introduces a layer of consideration and risk management to the HF industry's approach to recycling produced and flowback water, which is explored below.

4.0 Current State of HF Water Recycling and Management in Alberta

In Alberta's HF sector, operators use a multi-stage approach to water management, as visualized in Figure 1. The current state of these stages for Alberta operators is summarized below, based on input from interviewing various HF operators, as well as from the jurisdictional and regulatory review process. While this provides a high-level and generic summary of the current state of water use and recycling in HF in Alberta, it is important to note that individual operators use unique approaches based on their operating environments. The information in this section is specific to the Alberta context; a comparison to HF operations in B.C. is presented in Section 5.7.

4.1 HQNS and Produced and Flowback Water Use

Operators face a unique set of issues when sourcing water, as they need to balance HQNS water conservation with sub-surface resource conservation and operational requirements. In 2022, approximately 99% of the total water used in Alberta for HF was HQNS, while only 1% was recycled produced and flowback water [19]. This is in stark contrast to B.C., where over 50% of the water used for HF is recycled produced and flowback water [20]. Many Alberta operators primarily dependent on HQNS water sources have been actively exploring alternative water supply options, including but not limited to produced and flowback water recycling.

4.2 Produced and Flowback Water Recovery

Variations in produced and flowback water recovery volumes and quality across different geological formations significantly influence HF operations in Alberta. For example, the Montney formation (in both Alberta and B.C.) is notable for its comparatively higher recovered volumes of produced and flowback water. This means a greater volume is available to offset HQNS makeup water sources. Operators in the Duvernay reported much lower recovery of produced and flowback water.

Comparatively, formations in certain States such as the Permian Basin in Texas have been identified as significant providers of water, with much higher recovery rates than experienced in some Alberta formations. Based on a survey by the Texas Produced Water Consortium, 54% of the water used for fracturing in the Permian Basin is produced or flowback water [21].

In addition, many Montney operators in both Alberta and B.C. reported lower levels of sulfur compounds in their produced and flowback water, making it "sweet" in nature compared to some produced and flowback water recovered in other formations like the Duvernay. When produced and flowback water sources are sweet, this enables a more straightforward, and less expensive, water treatment process and greatly enhances the potential for water recycling. Another water quality consideration raised through the interviews is the presence of higher biological agent content in some formations, which leads to additional measures for water handling.

4.3 Produced and Flowback Water Recycling

Treatment is sometimes necessary to maintain water quality throughout the HF process. Technologies such as filtration and reverse osmosis are used to remove contaminants of interest and ensure that water is compatible with typical operations, formation chemistry, and regulatory standards. Produced and flowback water sources have highly variable qualities, and typically have greater concentrations of contaminants of concern than HQNS water sources. These variations in the physical and chemical characteristics of produced and flowback water mean that treatment typically incurs higher costs for operators than using HQNS water. Operators deploy treatment to address issues such as salinity and sulfur-based (sour) compounds. In addition, some interviewees reported needing to utilize additional friction reducers when injecting treated produced and flowback water.

Conveyance infrastructure also plays a crucial role in transporting treated water to well sites efficiently. Alberta-based producers generally operate over vast areas and face logistical issues and higher risks when transporting produced and flowback water from one point of their operations to another. The current preference in Alberta for using HQNS water over produced and flowback water recycling has been influenced by the high costs associated with constructing new permanent or temporary conveyance infrastructure. As discussed in Section 5.7.4, operators in B.C. tend to have denser operating fields and benefit from having constructed permanent infrastructure under favorable economic conditions in the past.

Storage facilities are important for maintaining a reliable water supply to meet varying operational demands, and in combination with higher water recycling rates, they help address short-term water supply disruptions. In Alberta, operators rely on above ground synthetically-lined wall storage systems (lined C-rings), tanks, and engineered containment ponds (ECPs) for storing produced and flowback water [22]. Lined C-rings are relatively small and are most often deployed as temporary storage options, while tanks are normally used when producers fracture nearby wells. ECPs require the highest capital expenditure and longer regulatory review processes. Interviewees suggested that the higher recycling rates in B.C. are enabled in large part by operators' previous investments in ECPs under favorable economic conditions in the early 2010's, which operators in Alberta did not make. The interviewees did not provide detailed perspectives on what made historic conditions in B.C. favorable for investment in ECPs.

4.4 Produced and Flowback Water Disposal

The interviewees generally did not express concerns related to capacity for disposing of produced and flowback water in Alberta. Especially compared to B.C., there is significant disposal capacity throughout Alberta, although regionally constrained areas do exist. Generally, interviewees discussed accessing disposal capacity in Alberta as an economic optimization exercise, whereas in B.C. it is thought to be a more significant limiter on development in the absence of water recycling.

In the U.S., midstream water management has steadily grown since 2017, driven by the expansion of midstream service companies that focus on water supply, treatment, storage, and disposal [23]. The midstream market in the U.S. benefits from the physical characteristics of operations (e.g., the proximity of operators and the volumes recovered from wells) and regulatory constraints on disposal (e.g., in Texas, where the regulator introduced disposal limits in response to local seismicity concerns).

4.5 Potential Benefits of Produced and Flowback Water Recycling

Although produced and flowback water recycling rates in Alberta are relatively low, many operators have expressed interest in increasing their water recycling rates due to the perceived potential benefits:

- Although water recycling is generally more expensive than sourcing HQNS water, it does provide a layer of water security for operators located in water-short areas.
- Increased treatment and/or storage costs for water recycling could be partially offset by a reduction in trucking for disposal and total volume requiring disposal.
- Produced and flowback water recycling would help to meet corporate sustainability goals in an ESG context (Environment, Social, and Governance).
- Operators may use produced and flowback water recycling as an avenue to align with the WCP and reduce their overall HQNS water demand.
- Water recycling presents an opportunity for further engagement and collaboration between HF operators.

While these benefits may apply to many operators in Alberta, individual circumstances and operational contexts vary, and not all operators exhibit the same potential or real gains from increasing produced and flowback water recycling.

5.0 Key Barriers to Water Recycling in Alberta

The interviewees identified many barriers to implementing and/or scaling up produced and flowback water recycling in their Alberta operations. However, all the technological, operational, regulatory, and stakeholder-related issues result in the same underlying barrier which disincentives water recycling: in Alberta, recycling produced and flowback water generally costs operators significantly more than the alternative of sourcing HQNS water and disposing of produced and flowback water. The interviewees also did not identify strong external driver(s) for seeking alternatives to HQNS water, whereas many such drivers are apparent in B.C. This lack of compelling need, coupled with the higher costs, appears to be at the heart of Alberta’s low produced and flowback water recycling rates. In addition, the interviewees expressed hesitancy to assume unnecessary liabilities and potential process disruptions which could be associated with produced and flowback water recycling (e.g., leaks in sensitive locations, inconsistent performance of new treatment technologies, etc.).

All the barriers discussed by interviewees are summarized below in Table 2 and the accompanying Figure 3 using relevant water management categories from Figure 1 (i.e., HQNS Water Sourcing, Disposal, and Recycle which includes Access, Store, Treat, and Convey for produced and flowback water). Due to Alberta’s varied geography and geology, several barriers are unique to specific areas. Furthermore, some barriers are unique to certain hydraulic fracturing techniques and/or asset sizes. Therefore, the barriers in Figure 3 apply to all operators, unless one of the following sub-classifications is specifically assigned, as communicated by the figure legend:

- ***Small Assets Only***
    - Smaller assets are operated differently from larger fields, typically resulting in fewer wells drilled overall and more time between well completions. This results in lower volumes of produced and flowback water recovered and the need for longer term storage of any water which is collected before it can be recycled.
        - Anecdotally, one operator noted that produced and flowback water recycling was only feasible on their 10-12 rig program because there was a constant generation and use of produced and flowback water.
- ***Duvernay Only***
    - Wells in the Duvernay tend to return lower volumes of water, making it more difficult for operators to rely on produced and flowback water for operations.
        - Anecdotally, one Duvernay operator quoted that one well produces only ~10-15% of the water volume they require to complete another well.

- ***Highly Populated Areas Only***
  - The impacts of some barriers are amplified for operations in highly populated areas, for example with greater stakeholder interest than in uninhabited areas.

Below Table 2 and Figure 3, each barrier in Alberta is briefly summarized in Sections 5.1 to 5.6. Potential options for addressing each category of barrier are also provided in each sub-section, based on interviewee input. These options reflect suggestions from individual interviewees and may not apply to all stakeholders in the HF industry, nor will they necessarily address all issues surrounding produced and flowback water recycling. Rather, these recommendations serve as a starting point for further discussions and collaborative efforts to address the barriers, which are discussed in Section 6.0. Section 5.7 discusses how the unique characteristics of B.C. impact produced and flowback water recycling as compared to Alberta. Note that the ordering of the below subsections does not imply relative importance.

Table 2: Summary of all barriers to produced and flowback water recycling for hydraulic fracturing in Alberta. This table accompanies Figure 3.

<table>
<tr><th colspan="2">Water Management Process Category</th><th>Operator Choice
(where applicable)</th><th>Barrier to Produced and Flowback Water Recycling in Alberta</th></tr>
<tr><td colspan="2" rowspan="2">**HQNS WATER SOURCING**</td><td rowspan="2">All options</td><td>Topography facilitates river access</td></tr>
<tr><td>HQNS water availability</td></tr>
<tr><td rowspan="7">**RECYCLE**</td><td rowspan="2">**ACCESS**
Sourcing of produced water and flowback for reuse in hydraulic fracturing operations</td><td rowspan="2">All options</td><td>Low produced volumes</td></tr>
<tr><td>Formation-specific composition</td></tr>
<tr><td rowspan="5">**STORE**
Storage of produced water and flowback for reuse in hydraulic fracturing operations</td><td rowspan="2">Permanent storage</td><td>Capital cost</td></tr>
<tr><td>Stringent Regulatory Requirements</td></tr>
<tr><td rowspan="3">Temporary storage</td><td>Capacity</td></tr>
<tr><td>C-Ring Procurement</td></tr>
<tr><td>C-Ring Maintenance and Transport</td></tr>
</table>

Water Management Process Category		Operator Choice *(where applicable)*	Barrier to Produced and Flowback Water Recycling in Alberta
		Permanent and temporary storage	Stakeholder and Employee Concerns
			Land Footprint
			Allowable Storage Duration & Water Quality Degradation
	TREAT Treatment of produced water and flowback for reuse in hydraulic fracturing operations	Onsite treatment	Capital Cost
			Treatment Rate
		Offsite treatment	Operating Cost
		Onsite and Offsite treatment	Water Quality
			Formation Compatibility
			Sour Water
	CONVEY Conveyance of produced water and flowback for reuse in hydraulic fracturing operations	Trucks	Increased Site Traffic
		Permanent Pipeline	Capital Cost
			Dedicated System Requirements
		TSWP (temporary surface water pipeline)	Elevated Risk of Leaks and Spills
			Stakeholder and Employee Concerns
		Trucks, Permanent Pipelines, and TSWP	Long Distances

Water Management Process Category	Operator Choice *(where applicable)*	Barrier to Produced and Flowback Water Recycling in Alberta
DISPOSAL Dispose of produced water and flowback, after one or multiple uses through a hydraulic fracturing operation	All options	Disposal Capacity and Proximity
ALL PROCESSES Shared barriers across all processes, including HQNS water sourcing, recycling, and disposal	All options	Need for Dedicated Reuse Team
		Elevated Risk of Reputational Damage
		Increased Liability

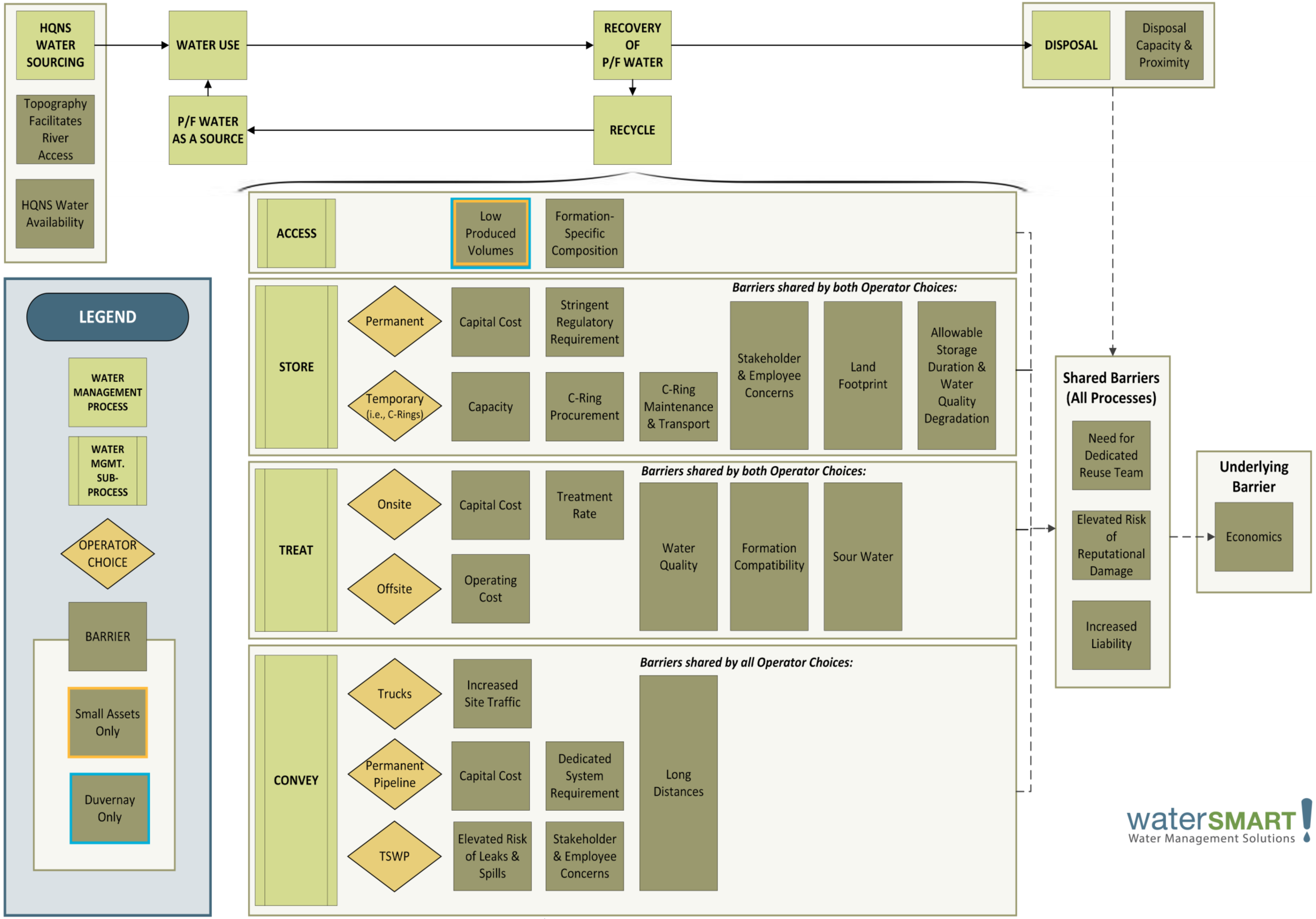

Figure 3. Summary of all barriers to P/F water reuse in HF in Alberta.

5.1 HQNS Water Sourcing

Many interviewees noted that HQNS water can be sourced relatively easily in Alberta with the required quality and quantity for operations. This ease of use poses a barrier to produced and flowback water recycling, which is generally more difficult, costly, and risky. Within this overall context, two specific aspects were discussed in the interviews.

5.1.1 Topography facilitates river access

Most Alberta HF assets are located along the foothills or plains, where rivers can be approached relatively easily. Water intake structures can be installed (either temporarily or permanently) without substantial challenges, and pumping water is relatively inexpensive and routine. Because HQNS water is relatively easy to physically access, there is less incentive to seek alternatives.

5.1.2 HQNS water availability

Availability refers to the presence of water physically in a source and “on paper”, via licenses under the *Water Act*. Alberta operators can typically obtain sufficient HQNS water licenses to support their operations, and the sources being accessed can typically support diversion of these licensed volumes in most flow conditions (e.g., drier years and average years).

The project team hypothesized that periods of water shortage and any associated water diversion restrictions would drive an increase in produced and flowback water recycling in Alberta. However, the interviews generally disproved this hypothesis. Instead, most interviewees have addressed short-term water shortages by building HQNS water storage that are filled in high flow periods (e.g., spring freshet) for later use. This investment in HQNS water has already been made, whereas investments to recycle produced and flowback water would be new and would typically be higher than for an equivalent volume of HQNS. In addition, some operators noted that they are more likely to curtail operations than to increase the recycling of produced and flowback water when faced with HQNS water restrictions. Economic factors were noted as the key driver in this decision-making.

5.1.3 Potential options to address barriers in HQNS Water Sourcing

Many interviewees noted that a system of grants, royalty rate adjustments, and/or other positive financial incentives would greatly increase the appetite for operators to invest in produced and flowback water recycling (e.g., related to storage, treatment, and conveyance).

While not stated as a desirable option, 15% of interviewees acknowledged that having a financial penalty associated with high HQNS water intensity could incentivize reuse if the penalty were to cost more than the cost associated with recycling. However, these interviewees also noted that such negative financial incentives could have unintended consequences, for example related to competitiveness. The costs would be likely to vary greatly among operators depending on existing infrastructure, water quality requirements, and more, and could be difficult to implement equitably. Furthermore, as noted, some operators might curtail operations rather than spend more to recycle produced and flowback water.

5.2 Produced and Flowback Water Sourcing

5.2.1 Low produced volumes

Interviewees operating in the Duvernay and/or with smaller assets indicated that insufficient volumes of produced and flowback water are recovered to support recycling programs necessary to reduce HQNS water use. This reflects the formation dynamics across the province, wherein some formations allow for very little water recovery, as well as operational dynamics, wherein the costs and effort required to utilize small volumes of produced and flowback water are not considered worthwhile by operators.

5.2.2 Formation-specific composition

Operators expressed hesitation to share produced and flowback water within their own operations and with other operators because of the sensitivity of their formations to water chemistry and the variability of recovered water compositions. Injection water chemistry requirements tend to be formation-specific, which limits the potential sources of water which can be used for recycling without significant risks to production (e.g., downhole fouling).

5.2.3 Options to address barriers in sourcing produced and flowback water

It was noted that recycling produced and flowback water is not the only avenue to reducing HQNS water intensity and perhaps the industry would benefit from broader recognition of this. For example, operators can reuse municipal effluent, deploy technologies and practices to reduce water needs, and implement non-slickwater completion techniques. Some operators emphasized the importance of "starting somewhere" in terms of reducing HQNS water intensity, for example with pilots, and gradually increasing recycling rates over time.

It was also noted that some form of incentive via specific grants, credits, or public acknowledgement (reputational benefit) for water recycling could provide meaningful incentive to increase recycling rates. Formally recognizing operators with lower HQNS intensities could be especially motivating during times of HQNS shortage.

One interviewee acknowledged that the new AER Manual 025 requirements for investigating alternative water sources as part of the licensing process may effectively increase recycling water rates upon licence renewals. As operators have been applying for recent licenses under Manual 025, some have invested the resources to utilize alternative water sources, including recycling. However, not all operators felt compelled to implement all of the HQNS water use reduction measures they identified, in large part due to the conditions in Section 4.0 and the barriers in Section 5.0.

It was acknowledged that many operators are open to collaboration (e.g., via regional synergy groups and operator groups); further efforts to define and implement opportunities for water sharing could be evaluated.

5.3 Storage of Produced and Flowback Water

5.3.1 Capital cost

The current economic climate in Alberta makes it less likely that operators will make large investments in storage infrastructure for produced and flowback water, which can be expensive. These investments have long payback periods, and most operators expressed a lack of confidence in realizing this payback. This lack of openness to major capital investments for storage means most interviewees rely on C-Rings, which can introduce logistical challenges and typically provide lower storage volumes than permanent structures.

5.3.2 Stringent regulatory requirements

Interviewees highlighted that it can be difficult (i.e., expensive and time consuming) to meet the strict requirements for permanent produced and flowback water storage in Alberta under Directive 055. Additional uncertainty can be added via Directive 058 when operators apply for an oilfield waste management facility with a waste storage activity for produced and flowback water. It was also noted that the regulatory and construction timeframes for permanent storage can sometimes mean the drilling program which would benefit from that storage is nearly complete by the time storage is available.

Furthermore, it was anecdotally communicated in one interview that a permanent storage design which was acceptable in B.C. did not meet the Alberta requirements, leading to confusion and frustration for the involved parties. This interviewee reported that constructing permanent storage for produced and flowback water is 3-4 times more expensive in Alberta than in B.C.

Small Assets Only: Several interviewees stated that alternative water storage requirements are so strict that they would require a specific water management team to deal with the regulatory and construction processes and associated logistics. Small operators often lack the staff capacity to support this, and it is not possible for completions engineers to do water recycling “on the side of their desk,” because the requirements are difficult to understand and implement.

5.3.3 Capacity

Operators which have not constructed a significant volume of permanent storage for produced and flowback water are typically limited to smaller volumes which can be stored in temporary structures. This can mean that produced and flowback water must be recovered and stored in small volumes across many locations. This can increase land footprint, capital costs, maintenance requirements, and conveyance costs, all of which are barriers to water recycling.

5.3.4 C-ring procurement

Interviewees noted that procuring C-Rings of an appropriate size can be a long, expensive process, especially given the global supply-chain constraints facing operators throughout, and in the aftermath of, the COVID-19 pandemic. Some interviewees highlighted the risk of further C-Ring supply tightening should more operators in Alberta participate in produced and flowback water recycling. This could slow the rate of increase for recycling province-wide; as more operators perform more recycling, it could become more expensive and difficult to do.

5.3.5 C-ring maintenance and transport

Interviewees noted that C-Rings are expensive to maintain and transport, further exacerbating the economic barriers associated with recycling produced and flowback water.

5.3.6 Stakeholder and employee concerns

Especially in highly populated areas, odour management and the risk of private land contamination from stored produced and flowback water can pose large challenges to operators. Some interviewees noted that unpleasant odours are also a challenge for on-site employees.

5.3.7 Land footprint

While this generally applies only to highly populated areas, any operator that works on private land faces footprint restrictions. C-rings and secondary containment take up a large area that some producers cannot accommodate.

5.3.8 Allowable storage duration and water quality degradation

Under Directive 055, produced and flowback water can be stored for up to one year in large, permanent structures (i.e., ECPs), with the requirement that any volume entering storge is offset by the same volume being removed within 12 months. However, most operators interviewed do not have these structures, nor are they planning to build them, as noted above. Interviewees utilizing temporary storage methods (e.g., C-Rings), highlighted that produced and flowback water can only be stored this way for up to three months. This relatively short storage duration makes it difficult to coordinate recycling programs, since a sufficient volume of produced and flowback water must be available for the right number of completions, at the right time and location.

Further complicating water storage, many interviewees also noted that storing produced and flowback water for long durations introduces operational risk, regardless of whether treatment has been applied. For example, sour water which has been treated initially can re-sour if stored too long and subsequently agitated. Bacterial growth is another concern associated with longer-term water storage.

Small Assets and Duvernay only: Low recovery volumes and intermittent drilling programs can make it difficult to fill available produced and flowback water storage quickly enough (i.e., within the required three month window for temporary storage) to be used for subsequent wells. Alternatively, if the storage infrastructure is taken out of service for longer than 180 days, recovered water stored in temporary structures must go to disposal as per Directive 055 requirements.

5.3.9 Options to address barriers to storage of produced and flowback water

Several options were suggested throughout the interviews to address these storage-related barriers:

- As more producers start to recycle, the availability of C-rings and crew to set them up needs to increase to support the demand.
- The AER should revisit their Performance Based Regulations in the context of making it easier to construct permanent storage for produced and flowback water.
- The AER and industry in Alberta can utilize knowledge sharing groups to share information on the potential risks and mitigations of produced and flowback water storage. Specific learnings from B.C. could also be sought.
- There may be opportunities in high-density areas for a water midstream industry to offer third-party produced and flowback water conveyance, storage, treatment, and delivery to facilitate recycling. However, it is acknowledged that this business model has been attempted in Alberta in the past.
- The AER should consider opportunities to reduce restrictions and provide clearer guidance via updates to Directive 055.
- The provincial government should consider grants or other financial incentives such as infrastructure royalty credits for constructing produced and flowback water storage, including both permanent and temporary structures.

5.4 Treatment of Produced and Flowback Water

5.4.1 Capital cost

As mentioned, the current economic climate makes it less likely that Alberta HF operators will install their own produced and flowback water treatment facilities. This is especially true for operators requiring significant treatment, such as those that recover sour water or require extremely high quality make up water due to formation-specific requirements (e.g., friction reduction, etc.).

5.4.2 Treatment rate

Produced and flowback water can rarely be used directly, instead requiring treatment and/or storage beforehand. In many cases, treatment can be a rate limiting step, with lower throughput than what is required for injection. This is especially challenging for operators with sour water. Anecdotally, one operator noted that the relatively slow rate of treatment has been a bigger barrier than the cost of treatment itself.

5.4.3 Operating cost

In some locations, operators have the option to contract third parties for offsite treatment of produced and flowback water and the delivery of treated produced and flowback water which is suitable for recycling. This approach largely trades capital costs (i.e., operators building their own treatment capacity) for operating costs, which were noted by interviewees as being too high in many cases to justify using such third-party services.

5.4.4 Water quality

Bacteria in produced and flowback water can be difficult to work with, especially during long storage intervals when bacteria can propagate. Total dissolved solids are another concern for long horizontal fractures because they can increase the friction which must be overcome to place the water. Operators must balance costs of treatment, pumping, and the use of friction reducers.

5.4.5 Formation compatibility

Produced and flowback water recovered from various locations in Alberta can be barium rich, sulfate rich, high in total dissolved solids, and/or sour. As noted, this can present formation compatibility challenges for operators. The variability across the province makes it difficult to implement common management processes and treatment technologies and thereby realize economies of scale and/or broadly applicable best practices. Furthermore, each operator has a different risk tolerance and openness to testing downhole compatibility.

Duvernay Only: Due to low produced and flowback water recovery volumes, Duvernay operators must mix in water from other sources during produced and flowback water recycling, which can increase the risk of negative downhole impacts (e.g., scaling).

5.4.6 Sour water

High levels of sulfur are not acceptable in makeup water for most operators. While treatment options do exist for sweetening sour water, they are expensive. Most operators acknowledged that they have never, and will never, consider treating and reusing sour water because of cost, health and safety risks, the risk of souring their formations, and logistical challenges (e.g., if the treated water is stored for too long and then re-agitated, it could re-sour). As noted above, the relative availability of HQNS water in Alberta further reduces the incentive to engage in the relatively risky activity of reusing sour water.

One interviewee's organization does obtain sour produced water and performs treatment to sweeten it before re-injecting it; however, this occurs only for their operations in B.C., where they have limited options for water sourcing and disposal. The risk appetite for this type of activity within the company is much lower in Alberta, mainly due to HQNS being an easier, cheaper, and safer alternative, as discussed throughout this report.

5.4.7 Options to address barriers to treatment of produced and flowback water

Several options were suggested by interviewees to address the barriers related to produced and flowback water treatment:

- The provincial government should consider grants or other financial incentives for constructing treatment capacity, especially for sour water.
- Technology developers should prepare and demonstrate a trusted technology for effectively treating bacteria in produced and flowback water. This would reduce some of the treatment and storage logistics challenges associated with recycling.
    - Interviewees expressed interest in treatment technologies trialed by a third party (i.e., in the service sector).
- The AER should consider defining thresholds for how much produced and flowback water can be mixed with a HQNS water source to achieve a lower risk rating for the water mixture. This could help reduce treatment requirements associated with conveyance and storage.
- There may be opportunities for a water midstream industry in high-density areas, although it is acknowledged that this business model has been attempted in Alberta in the past.
    - Interviewee opinions were mixed; some were interested in this model, while others expressed concerns based on chemical compatibility and noted that some source formations and destination formations would require highly specialized treatment.

5.5 Conveyance of Produced and Flowback Water

5.5.1 Long distances

Related to Alberta's geographic variability, many interviewees operate assets that are over 20 km apart. These distances make it inherently more expensive to construct infrastructure for the transportation of produced and flowback water, and the cost per unit of water moved is higher for smaller development footprints. The requirements relevant to route selection for TSWPs often cannot be met over these long distances without significant investment. Updates made to Directive 077 in November 2023 establish that the installation of a TSWP should pose minimal risk to public safety and the environment in the event of a release of conveyed water, with consideration given to specific land features.

Additionally, trucking produced water over long distances is cost prohibitive. Alberta operators often have access to nearby disposal which is closer than their nearest operating location where the produced and flowback water could be recycled.

5.5.2 Increased site traffic

An active fracturing site is already extremely busy in terms of vehicle and foot traffic. Produced and flowback water recycling requires additional personnel, facilities, and often trucks for conveyance. Operators noted that increasing the ratio of produced and flowback water in the makeup fluid typically increases the logistical complexity at the HF site, especially when trucking is used for transporting that water. This leads to staffing challenges and safety risks.

5.5.3 Capital cost

The current economic climate noted above has operators uncomfortable with the elongated payback periods associated with installing large, permanent pipelines dedicated to conveying alternative water. The economic challenges are amplified by the large distances that often exist between well sites in Alberta. In addition, smaller fields and development footprints with few permanent locations further extend the payback periods.

5.5.4 Dedicated system requirements

HQNS water mixed with any volume of produced or flowback water is considered a Group 3 water under Directive 077, which drastically increases the cost and complexity for installing conveyance infrastructure. To avoid having to build everything to Group 3 requirements, operators often run duplicate systems, with one carrying HQNS water and the other produced and flowback water. This amplifies barriers like maintenance, capital cost, and land footprint.

5.5.5 Elevated risk of leaks and spills

The environmental, financial, and reputational costs associated with produced and flowback water spills are significant. Many operators stated they would not use TSWPs for transporting produced and flowback water, regardless of regulations, due to the heightened risk of leaks and spills at valves and connection points (due to human error or other causes) and the risk of accidental puncture or vandalism along the route. These risks increase with the length of the TSWP.

Interviewees acknowledged that TSWPs are more commonly used for transporting produced and flowback water in B.C. It was hypothesized by Alberta-based interviewees that B.C. operators are willing to take on the associated risks because their operating environment motivates them to reuse produced water, as discussed in Section 5.7. Some went as far as to say that B.C. operators have no other choice but to recycle produced and flowback water given their operating environment. Many interviewees suggested that they would be willing to explore TSWPs for produced and flowback water if:

- There were more durable materials available.
- The TSWP providers introduced more redundancies to account for leaks when making connections.
- There were plans in place to protect from accidental puncture (e.g., if road crossings were signed and had bridges for vehicle traffic).
- Vandalism could be more reliably prevented. This was especially important to operators in highly populated areas, who have observed civilians accidentally or purposefully damaging company equipment.

Highly Populated Areas Only: Some landowners were reported to be extremely skeptical of TSWPs and associate them with increased risk of environmental damage to their land. Operators noted that many landowners will withhold consent for transportation of produced and flowback water via TSWPs on their land, even if the TSWPs meet all regulatory requirements.

5.5.6 Stakeholder and employee concerns

The smell and perceived negative health impacts of produced and flowback water are large social deterrents, and spills are challenging to clean up and carry reputational risks. Several interviewees noted that field-based workers are more resistant to transporting produced and flowback water via TSWPs. This resistance is linked to field-based workers being responsible for establishing line connections and dealing with potential spills. Further interviews with field-based staff would help better understand this hesitancy.

5.5.7 Options to address barriers to conveyance of produced and flowback water

Several options were suggested by interviewees to address the barriers associated with conveyance of produced and flowback water:

- The provincial government should consider grants, credits or other financial incentives for constructing long-term infrastructure for transporting produced and flowback water, such as pipelines.
- 45% of the interviewees noted that Directive 077 has been a step in the right direction for facilitating temporary water conveyance, but suggested that further updates could help transportation of produced and flowback water less expensive. Specifically, this could include more specific guidelines for temporary conveyance options, recognizing that different land cover types have different risks associated with them. It was also noted that human error and other causes of leaks should be accounted for in the AER’s guidelines on TSWPs.
- There may be opportunities for a water midstream industry in high-density areas, although it is acknowledged that this business model has been attempted in Alberta in the past.

- The AER and industry in Alberta can conduct combined knowledge sharing activities to help both regulators and operators better understand each other and the risks of produced and flowback water conveyance which each group is most concerned with. Mitigations which address the concerns of both the AER and operators could be discussed. Specific learnings from B.C. could also be sought.

5.6 Disposal of Produced and Flowback Water

5.6.1 Disposal capacity and proximity

There is less competition for access to disposal in Alberta than in B.C., although it is recognized that some regions in Alberta do face a degree of disposal limitations. The interviewees noted that disposal options in Alberta can generally be sourced cost-effectively thanks to relatively high disposal capacity, especially compared to B.C. Interviewees also shared that disposal is generally available nearby, whereas in B.C., it can be quite far away. As noted above, it can be challenging for operators in Alberta to justify recycling produced and flowback water when it is many times cheaper to dispose of it. Anecdotally, one interviewee noted that their access to disposal means it is approximately 40 times cheaper to dispose than to recycle their produced and flowback water.

5.6.2 Options to address barriers related to disposal of produced and flowback water

No specific recommendations to address this barrier were proposed by interviewees.

5.7 Comparison to B.C.

The preceding sub-sections highlight the barriers HF operators in Alberta face when it comes to recycling produced and flowback water. Within that context, this sub-section focuses on how things in B.C. compare, with the goal of answering the question, *"Why are water recycling rates for HF so much higher in B.C. than in Alberta?".*

5.7.1 HQNS water sourcing

Anecdotally, interviewees with operations in B.C. and Alberta noted that the process to apply for a water licence in Alberta is comparatively straightforward, whereas it is more difficult in B.C., where operators are less likely to receive new allocations to divert HQNS water. This reported constraint on new allocations for HQNS water drives B.C. operators to consider alternative sources, such as produced and flowback water recycling. Conversely, in Alberta, few interviewees reported facing material challenges related to restrictions on their ability to divert HQNS water. For example, the intermittency of HQNS water supply in Alberta is typically addressed via diversion during periods of high flow (e.g., spring freshet), storage in reservoirs, and development plan optimization, whereas in B.C. the supply is comparatively low and other options have been considered.

In addition to the constraints on licensing, B.C. operators also face physical challenges when it comes to accessing HQNS water. Interviewees noted that rivers in northeast B.C. generally flow through valleys surrounded by steep cliffs, which makes physically reaching HQNS water sources more complex and costly. These difficulties help make the economics more compelling for B.C. operators to consider recycling, since their HQNS options are already expensive.

5.7.2 Disposal capacity

Water disposal capacity is also generally more limited in B.C. than in Alberta. This drives up the price for B.C. operators to dispose of produced and flowback water, as opposed to recycling it, and can also introduce logistical challenges and operational risks associated with competition for disposal. Similar to HQNS water sourcing, the constraints on water disposal in B.C. help improve the business case for water recycling. As noted, most regions in Alberta do not face significant constraints on water disposal capacity. Interviewees acknowledged that in some areas, such as the Grande Prairie region, disposal is becoming more competitive. However, it remains generally much cheaper to dispose of water in Alberta than in B.C., with one interviewee noting anecdotally that disposal costs in B.C. can be twice as high.

5.7.3 Previous capital investments

In the mid-2010's, economic conditions in B.C. were supportive of large capital expenditures in the HF sector with significant payback periods. Enabled by these conditions and motivated by the constraints on HQNS water and disposal access noted above, B.C. operators took advantage of this opportunity to construct large storage ponds for produced and flowback water.

While not directly cited by interviewees, the B.C. Provincial Government established the Infrastructure Royalty Credit Program in 2018 to incentivize new capital investment in oil and natural gas infrastructure. Through this Program, operators could apply for a deduction (up to 50% of the cost of building roads and pipelines) to the royalties that they would otherwise pay under a competitive Request for Applications process [24].

As highlighted above, the economic environment in Alberta is now less favorable to these large capital investments, and interviewees expressed hesitancy toward making them. To an extent, HF operators in B.C. are recycling more produced and flowback water than in Alberta because they have enabling infrastructure already in place from prior investments. An average operator in Alberta would require significant new investment to achieve equivalent levels of infrastructure, which is much less likely to occur now than several years ago.

5.7.4 Single-formation operations

Produced and flowback water recycling in B.C. is enabled in part through produced water sharing. Interviewees with operations in both provinces noted they are more comfortable with produced water sharing in B.C. because the operations are largely within the same formation. This inherently reduces the water compatibility issues and risks of formation damage noted above, without requiring significant treatment. Conversely, Alberta operators are active within many different formations, with various downhole quality requirements and different constituents in the water which is recovered. These differences present barriers in terms of treatment costs and risk tolerance which are more prevalent in Alberta than in B.C.

Another implication of B.C. operators using the same formation is that they tend to be closer together and their fields tend to be denser than in Alberta. This significantly reduces the distances which must be covered to convey produced and flowback water for recycling, and it makes it easier to deploy permanent infrastructure to serve a larger proportion of the field. This allows B.C. operators to share produced water between their own assets, or with competitors, with lower transportation costs.

6.0 Conclusions and Recommendations

As Section 5.0 illustrates, HF producers in Alberta face a range of barriers to produced and flowback water recycling, particularly when compared to B.C. In addition, operators in B.C. are driven to recycle water by factors which are not applicable in Alberta, including low HQNS water accessibility and availability, limited disposal options, and the benefits of previous investments in permanent infrastructure.

Despite these challenges, the interviewees expressed interest in increasing their produced and flowback water recycling rates in Alberta. Some even went so far as to aspire to a 0% use rate for HQNS water. Many options were suggested by interviewees to address the barriers to water recycling in HF in Alberta, as noted above in relation to specific barriers. Several overarching opportunities are summarized below, reflecting the ideas most commonly offered by interviewees. Ultimately, the barriers identified tie to the economics of produced and flowback water recycling; anything which helps reduce the costs will help increase the rates of recycling in Alberta.

Barrier-reducing activities, suggested by interviewees, which PTAC can champion to help increase the rates of produced and flowback water recycling in Alberta include:

- Initiate and facilitate workshops between the AER and Alberta operators who are interested in increasing their produced and flowback water recycling rates. These workshops could include knowledge sharing to increase mutual understanding of constraints and opportunities, as well as brainstorming on optimal regulatory compliance pathways and solutions to address barriers.
  - The collaborative process between operators and the AER for updating Directive 077 was cited by many interviewees as an example of successful collaboration at a working group level.

    - Interviewees expressed specific interest in discussions with the AER regarding Directives 055 and 058 regarding storage and oilfield waste management.
- In collaboration with the AER, develop a platform and/or toolkit which provides operators with detailed and actionable supports to understand and comply with regulations for produced and flowback water storage, treatment, conveyance, and reporting. This would help improve clarity amongst operators, reduce the administrative burden associated with compliance, and better enable smaller operators, who have limited personnel, to work through the regulatory processes for produced and flowback water recycling.
- Engage with operators and water technology developers in Alberta and B.C. to facilitate knowledge sharing regarding produced and flowback water recycling pilots, operational efficiency improvements, and lessons learned.
- Engage with operators and water technology developers to prepare recommendations to the Government of Alberta regarding financial incentives for produced and flowback water recycling. Many interviewees noted that a system of grants, royalty rate adjustments, and/or other positive financial incentives would greatly increase the appetite for operators to invest in produced and flowback water recycling (e.g., related to storage, treatment, and conveyance).
    - Negative financial incentives to reduce HQNS water use were also suggested by a handful of interviewees, although such approaches were not favoured and could have unintended consequences, for example related to competitiveness. As noted, some operators would curtail operations in the face of HQNS water supply constraints.
- Work with the AER and water midstream service providers to identify ways to reduce regulatory barriers to the water midstream business model. If the regulatory environment can enable third parties to effectively, safely, and economically treat and convey produced and flowback water, this will provide HF operators with another avenue to increase water recycling.
- Encourage HF operators in Alberta to explore additional opportunities to reduce HQNS water use beyond produced and flowback water recycling. This could include using other alternative water sources (e.g., municipal effluent) and piloting new technologies and procedures to reduce total water requirements per well (which in turn would reduce HQNS water use).

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Appendix A – Interview questions

1. What is your current water management process?
   - *To what extent is reuse/recycling occurring in your hydraulic fracturing operations?*
   - *What treatment is currently used/needed for produced water in your operations?*
   - *How much does the quality of produced water influence your operations?*
   - *How often do you experience water shortages?*
     - *Do you track operational risk of water shortage? Is there an associated dollar value?*
     - *What actions have been taken to address low water periods?*
   - *To what extent do you have constraints on water disposal? To what extent do other operators influence this?*

2. What are the main reasons that flowback and produced water recycling are currently limited?
   - *To what extent is water reuse/recycling aligned with your corporate policies and decision making?*
   - *What are the biggest costs associated with reuse/recycling?*
   - *What operational barriers limit reuse?*
   - *Are there regulatory measures that impact reuse?*
   - *Are there any government incentives to reuse water?*
   - *To what extent are your stakeholders supportive of, or encouraging, recycling/reuse?*
   - *Given that water recycling is generally more expensive than freshwater use, why do some companies make the investment?*

3. What would you like to be able to do, ideally, in terms of water reuse/recycling?
   - *What is your biggest incentive for reuse/recycling? Where would you expect to see the benefits (e.g., reducing freshwater use, reducing disposal volumes)?*
   - *Do you anticipate a reporting burden associated with increasing water reuse?*
   - *Are there any data collection and monitoring gaps in assessing the environmental impacts and effectiveness of water reuse initiatives in hydraulic fracturing?*
     - *How can these gaps be addressed?*
   - *What is the current level of interest and openness to piloting water reuse in operations throughout your organization? Is interest increasing in the face of recent droughts?*
     - *Would investing in pilots for improving water reuse be economically valuable?*

4. Is water stewardship something that is currently considered at the corporate level?

- *Which water metrics do you measure and track internally?*
    - *Why were those metrics chosen?*
    - *Are there any new proposed metrics to be implemented down the line? If so, which ones?*
- *Do customers demand any metrics/information regarding your water stewardship?*

5. What are the biggest differences (e.g., technical, geological, access to disposal, managerial, etc.) that impact the extent of flowback/produced water reuse in Alberta versus B.C.?
    - *How much do produced water characteristics change between geological formations within AB?*
    - *What infrastructure limitations have you seen with respect to transportation and storage of flowback and produced water?*

6. What are the biggest technology gaps which limit reuse of flowback/produced water? What about other forms of alternative water use?
    - *Are you aware of novel technologies that support water reuse in hydraulic fracturing?*
    - *What can be done to make piloting new technologies more appealing for operators?*

7. Final thoughts: what actions can/should be taken to increase the rate of flowback/produced water reuse (e.g., industry, research, regulatory)?

- *Are there opportunities for knowledge sharing and best practice exchange among hydraulic fracturing companies to promote the successful implementation of water reuse technologies and strategies?*

Appendix B – Water-Related Regulatory Instruments for HF in Alberta

Current as of November, 2023.

	Name	Type	Issuing body	Approvals Issuer	Applicability	Relevance for hydraulic fracturing operators
ORDERED IN DESCENDING LEVELS OF AUTHORITY ---->	Historical Resources Act	Statute	Government of Alberta	HRMB	Obligates the reporting of historical artefacts when found on development sites	Could potentially apply to land clearing for water storage - A Historical Resource Impact Assessment (HRIA) would be required if items of historical interest were found.
	Environmental Protection and Enhancement Act (EPEA)	Statute	Government of Alberta	AEPA	Environmental risks, discharge to surface waters, design of wastewater treatment and waterworks systems, stormwater system design	By understanding the EPEA's framework, HF operations can ensure their operations comply with environmental regulations and minimize potential impacts on water resources.
	Public Lands Act	Statute	Government of Alberta	AEPA	Impacts to and occupation of land under and shoreline of Crown claimed water bodies, including wetlands that may be impacted by water reuse projects	Should a disposition be granted to use Crown land for any part of the operation (e.g. transport) then the operator must abide by the disposition as well the prohibitions laid out in Section 54.
	Water Act	Statute	Government of Alberta	AER for Energy projects. AEPA for non-energy	Diversion and allocation of water resources including implications of Water reuse and stormwater use projects on return-flows and water balance	Relevant for all water diversions within a watershed. TDLs and term license applications must be approved under the Water Act, as well as transfers of existing licences.
	Water (Ministerial) Regulation	Regulation	Government of Alberta	AEPA	Governs the issuing of temporary diversion licenses under the Water Act	All TDL's granted must adhere to the Water Regulation, this regulation mainly dictates what activities are approved and the conditions on the licence.
	Wastewater and Storm Drainage Regulation	Regulation	Government of Alberta	AEPA	Governs the reuse of treated wastewater	Relevant for the use of municipal effluent as an alternative water source.
	Pipeline Rules	Regulation	Government of Alberta	AER	Standards for installation of pipeline including temporary surface pipeline transporting produced water and (untreated) municipal effluent	Relevant for determining the pipeline type and material standards and requirements for spill mitigation.
	Alberta Wetland Policy	Policy	AEP	AEPA	Policy providing strategic guidance on minimizing the loss of wetlands	Relevant for activities located near wetlands; operators must ensure wetlands are not harmed by transportation or storage of water.
	Environmental Quality Guidelines for Alberta Surface Waters	Guideline	AEP	AEPA	Dictates water quality standards for surface waters	Only relevant if water is intentionally released to the environment.
	Directive for Water Licensing of Hydraulic Fracturing Projects – Area of Use Approach	Directive	AEP	AER	Provides direction to the AER for water licensing for hydraulic fracturing activities	This directive dictates parameters around licensing including that proponents must conduct an alternatives assessment before using non-saline sources.
	Directive 058: Oilfield Waste Management Requirements for the Upstream Petroleum Industry	Directive	AER	AER	Transportation and storage of oilfield wastes (produced and flowback waters)	Classifies wastewater storage and disposal of oilfield waste products.
	Directive 055: Storage Requirements for the Upstream Petroleum Industry	Directive	AER	AER	Outlines requirements for storage of water	Governs the storage requirements of fresh and contaminated waters, includes mandatory minimum design specifications for storage tanks and dictates requirements for spill mitigation.
	Directive 056: Energy Development Applications and Schedules	Directive	AER	AER	Contains requirements for licence applications to construct and operate facilities, wells, and pipelines	Contains the requirements for licence applications to construct or operate facilities, pipelines, or wells as part of petroleum industry energy development.
	Directive 077: Pipelines – Requirements and Reference Tools	Directive	AER	AER	Provides testing and operational requirements for ensuring pipelines are operated safely	Contains the requirements for building and operating permanent and temporary (surface) pipelines for processes in the oil and gas industry. It supplements the Pipeline Act and Pipeline Rules.

	Regulation		Issuing body	Approvals Issuer	Applicability	Relevance for hydraulic fracturing operators
	Fisheries Act	Statute	Federal Government	DFO	Management and control of fisheries, conservation and protection of fish and the protection of fish habitat	Relevant where there will be intentional discharge of water to the environment - Ensure that any deliberate discharge of substances do not harm fish species and ensure operations do not harm fish habitat.
	Canadian Environmental Protection Act	Statute	Federal Government	ECCC	Protection of the environment and human health	Relevant for the protection of humans and the environment from exposure to hazardous substances is in accordance with the Act (e.g. NORMS exposure from produced water).
	Canadian Navigable Waters Act	Statute	Federal Government	Transport Canada	Governs activities occurring over, under and in navigable waters	Only relevant where activities (e.g. point of diversion) occur on navigable waters. The act governs how activities on navigable waters should be managed. Navigable waters are listed online.
	Species at Risk Act	Statute	Federal Government	ECCC	Protects the habitats of species considered threatened under the Act	Relevant for activities occurring in areas where there may be threatened species as defined by the Act (e.g. points of diversion that may disturb aquatic habitats).
	Migratory Birds Convention Act	Statute	Federal Government	ECCC	Protects migratory birds and their habitats	Relevant for activities that may disturb or impact migratory birds, such as land clearing for water storage.