waterSMART
Water Management Solutions

Petroleum Technology Alliance Canada (PTAC)

Jurisdictional Review: Alternative Water Transfers Using Temporary Layflat Hose

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Executive Summary

The draft Water Conservation Policy for Upstream Oil and Gas (October 2016) requires that the energy industry consider alternative water sources for operations use, when accessible, with the objective of minimizing industry use of high quality non-saline (HQNS) water. As the Alberta energy industry works to reduce HQNS water use, there is growing interest in transporting alternative fluids, including produced and flowback water (referred to as produced water, for simplicity) using temporary surface conveyance materials. Currently, layflat temporary hose (layflat) is considered to be of high interest for the industry, although there is openness to explore additional temporary surface conveyance materials. Layflat can eliminate truck traffic in rural communities, reduce emissions, and lower water management costs for operators. However, Alberta operators are currently unable to transport produced water in layflat for several reasons.

WaterSMART Solutions Ltd. (WaterSMART) was retained by the Canadian Association of Petroleum Producers (CAPP), under the Alberta Upstream Petroleum Research Fund (AUPRF), administered by the Petroleum Technology Alliance Canada (PTAC), to perform research to support future efforts to enable transportation of produced water via layflat in Alberta. CAPP will be presenting recommendations to the Alberta Energy Regulator (AER), sourced from this research, which are expected to inform policy, guidelines, and processes for the use of layflat to transport produced water.

This report includes a review of previous PTAC work relevant to transporting produced water; research into Alberta, British Columbia (B.C.), Colorado, and Texas to compare their regulatory mechanisms, risks related to transporting produced water, and approaches to risk mitigation (including common materials); and recommendations for the AER to improve the regulatory environment in Alberta to enable the transportation of produced water. At the direction of industry representatives (coordinated through PTAC), the research is focused on transportation of produced and flowback water via temporary layflat hose, although the recommendations provided are broadly applicable to all alternative water sources. Furthermore, it is recognized that temporary surface conveyance materials besides layflat may be explored by the industry.

The review of relevant PTAC projects reveals how successive projects built on each other to provide an understanding of current regulatory barriers and assess possible avenues for reducing them. The current definitions-based regulatory approach can limit reuse of alternative water. For example, produced water, classified as a non-hazardous oilfield waste, has restrictions placed on storage, which impacts the economics of broad reuse. Building on this, efforts were made to understand how transportation materials can be developed to safely transport produced water. This informed proposals for a risk-based regulatory environment, whereby risks associated with produced water transportation can be identified and appropriately mitigated.

For the review of Alberta, B.C., Colorado, and Texas regulatory environments and operational practices, desktop research was supplemented by conversations with several of our colleagues who have extensive

operational and regulatory experience in hydraulic fracturing throughout North America. Generally, regulations focus on minimizing the risk of leaks and spills during transportation. Common challenges include small leaks (e.g. at pumps, connection points, and pinholes); vandalism; material durability; and issues with freezing.

High density polyethylene (HDPE) pipe was identified as the most common material for produced water transport, as this meets the required engineering standards in each jurisdiction. None of the jurisdictions reviewed appear to use traditional layflat for the transportation of produced water outside of lease boundaries. In B.C., spoolable reinforced thermoplastic pipe is being used to transport produced water off lease in some cases, with strict mitigations and licence conditions.

Based on the desktop research and conversations within our network, and building upon past PTAC work, WaterSMART has prepared recommendations to inform future policy, guidelines, and processes for transporting alternative water (including, but not limited to, produced and flowback water) via temporary layflat hose. These recommendations aim to balance the needs and wants of both industry and the AER while accounting for economic, operational, practical, and environmental factors.

Overall Recommendation: The AER should transition from a definitions-based system for regulating the transfer of alternative water towards a blended risk-based approach which provides clear guidance to project proponents for assessing risks for high risk activities while allowing for rapid approval of designated activities which have sufficiently low risk and/or existing prescriptive guidance (e.g. standards, codes of practice, etc.).

It is envisioned that an application will be categorized as either a “Designated Activity” or “Higher Risk Activity”. Automatic initial screening of projects could be included in the AER’s existing OneStop platform for integrated applications Each category of activities will have its own approval pathway, which will be commensurate with the category’s risk. Note that this approach is envisioned as a dynamic system. Over time, as more Higher Risk activities are reviewed and approved, the mitigations and conditions necessary to enable approval can be formalized into prescriptive guidance, which will expand the list of Designated Activities. Piloting, which has been demonstrated in B.C., may be an effective tool for the AER and industry to develop acceptable mitigations and new prescriptive guidance. This approach requires both industry and the AER to think seriously about their respective tolerances for risks and appropriate ways to mitigate them.

It must be noted that recommendations to improve the regulatory environment for transportation of alternative water only address some of the challenges preventing operators from utilizing more alternative water. Storage is a critical component of alternative water use and reuse plans, and the economics of alternative water transportation in Alberta (via any means) are often challenged by how much operators can store. It is recommended the AER consider similar efforts to update the regulatory environment for produced water storage.

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1.0 Introduction

The draft Water Conservation Policy for Upstream Oil and Gas (October 2016) requires that the energy industry consider alternative water sources for operations use, when accessible, with the objective of minimizing industry use of high quality non-saline (HQNS) water. As the Alberta energy industry works to reduce HQNS water use, there is growing interest in transporting alternative fluids, including produced and flowback water (referred to as produced water in this report, for simplicity) using temporary surface conveyance materials. Currently, layflat temporary hose (layflat) is considered to be of high interest for the industry, although there is openness to explore additional temporary surface conveyance materials. Layflat can eliminate truck traffic in rural communities, reduce emissions, and lower water management costs for operators. However, Alberta operators are currently unable to transport produced water in layflat for several reasons, such as:

- regulatory guidelines and policies;
- lack of regulatory process for approving alternative water transfers;
- limited documentation and comparison of temporary hose technology and coupling/connection options;
- identified risks of using layflat technology and the absence of defined mitigations; and
- perceived risks from stakeholders, including regulators, and lack of awareness or documented successes/challenges from other jurisdictions.

WaterSMART Solutions Ltd. (WaterSMART) was retained by the Canadian Association of Petroleum Producers (CAPP), under the Alberta Upstream Petroleum Research Fund (AUPRF), administered by the Petroleum Technology Alliance Canada (PTAC), to perform research to support future efforts to enable transportation of produced water via layflat in Alberta. CAPP will be presenting recommendations to the Alberta Energy Regulator (AER), sourced from this research, which are expected to inform policy, guidelines, and processes for the use of layflat to transport produced water. Specifically, the following tasks were performed:

1. review previous PTAC work and document how these past efforts can inform future progress on transporting produced water via layflat;
2. compare four jurisdictions (Alberta, British Columbia [B.C.], Colorado, and Texas) and summarize:
    a. regulatory frameworks related to produced water transportation via layflat, including barriers and approval mechanisms;
    b. identified and perceived risks to transporting produced water via layflat; and
    c. mitigation strategies and technologies and materials utilized to manage and reduce the identified and perceived risks to transporting produced water via layflat.
3. summarize key learnings from the jurisdictional review; and
4. document recommendations for transporting produced water via layflat.

Note that “risk” in this report is inclusive of both the consequence and likelihood of an undesirable impact

occurring.

To complete the above tasks, WaterSMART built upon our recent work in this area[1] and leveraged our diverse network of colleagues and Special Advisors, with experience in hydraulic fracturing across North America. Files relevant to past PTAC work were provided by CAPP and many are available online. At the direction of industry representatives (coordinated through PTAC), the research is focused on transportation of produced and flowback water via temporary layflat hose, although the recommendations provided in Section 4.0 are broadly applicable to all alternative water sources. Furthermore, it is recognized that temporary surface conveyance materials besides layflat may be explored by the industry.

2.0 Review of Previous PTAC Work

Several projects have been undertaken by PTAC, funded through the AUPRF program, to understand the regulatory framework governing the transportation of produced water in Alberta and identify areas of potential improvement. WaterSMART reviewed these projects to assess how they relate to the AER's current efforts to improve the regulatory framework for transporting produced water in Alberta. The review is summarized below, with a detailed analysis of each project included in Table 1, which focuses on the projects' goals and recommendations. The recommendations from these projects fall into several related categories:

- updating regulatory definitions;
- assessing layflat materials;
- assessing risks; and
- mitigating risks.

2.1 Updating regulatory definitions

The project conducted by Matrix Solutions (#4) concluded that the current approach of defining alternative waters by their source rather than their water quality did little to promote water reuse, as these classifications do not properly describe the risk associated with alternative waters. The recommendation was that the definitions be updated so that, under certain circumstances, risk-based definitions can be used to regulate produced water conveyance activities. For example, there may be some instances where produced water, either via treatment or blending, meets water quality requirements for non-saline water (i.e. < 4,000 mg/L TDS).

[1] "Alternative Water Source Life-Cycle Management Framework" (WaterSMART & Catapult; Year 2019) and "Review of Water Use Data Sources & Comparable Water Reporting" (WaterSMART; Year 2020), in draft form at the time of submission

2.2 Assessing layflat materials

The project conducted by Paterson & Cooke (#2) concluded that no Canadian Standards Association (CSA) standard exists for layflat hose, so it is not possible to assess which, if any, materials would be appropriate for the transportation of produced water under the current regulatory framework, which references CSA standards. To address this, they recommended a suite of testing to assess the durability and material properties of the hose in the desired application, which could act as a stepping stone to building a material standard for layflat which, if followed, would reduce the risk of leaks or spills.

2.3 Assessing risks

The projects by Matrix Solutions (#4) and WaterSMART Solutions (#5) both concluded that a risk-based approach to the assessment of produced water conveyance would be more appropriate than the current definitions-based approach. This relies on the development of risk tools to aid the AER and industry in assessing the risk associated with the transportation of alternative waters. The WaterSMART project recommended a collaboration between regulators and industry to identify low risk projects where expedited approvals could be implemented and build an integrated risk tool that could be utilized by both parties to identify the risks associated with higher risk storage and conveyance projects.

2.4 Mitigating risks

Once project risks have been assessed, there may be opportunities to reduce risks to an acceptable level for an approval. Both WaterSMART Solutions and Integrated Solutions (#3) identified risk mitigation as a key part of the regulatory approval process. This approach may mean activities initially identified as higher risk can become low risk by appropriate implementation of technology, safety standards, and best management practices (BMPs). Integrated Solutions developed three BMPs that suggest risk mitigation practices for pressure testing, road crossings, and increased monitoring. The extent to which these BMPs were vetted with industry and regulatory representatives is unknown.

Table 1 Summary of select past PTAC projects and how they relate to the current effort to improve the regulatory framework for transport of produced water via layflat.

#	Report Details	Industry engagement	Summary of the project	Relevant project recommendations & applicability to current goals
1	**Title** Regulatory Challenges for re-using Produced Water and Flowback in Alberta **Year:** 2015 **Authors** Led by the University of Calgary: Allan Ingelson, Arlene Kwasniak, Nickie Vlavianos, Tilly McRae, Gopal Achari, Bernard Mayer, Paul Reid and Cooper Langford **File name(s)** Produced_Water_Paper_For_AUPRF-2015Dec31-15-WIPC-07	Not known.	**Project Context** Understanding the pathway to operators implementing the reuse of produced water in Alberta requires an understanding of the regulatory framework within Alberta and other jurisdictions, as well as municipal bylaws and existing produced water treatment technologies. **Project Goals** 1. Assess the responsibilities of the Government of Alberta under the existing regulation with regards to the recycling of produced water. 2. Summarize what activities are permitted under existing regulations in Alberta. 3. Summarize the water licensing and provincial legal requirements around the use of produced water and the effect of municipal bylaws on this water use. 4. Summarize relevant technologies that can aid the reuse of produced water. **Broad conclusions** The regulatory framework in Alberta does not outright restrict the use of produced water for well injection, but it also does not incentivize its use. There is a lack of specificity in the regulations regarding water quality requirements for reuse for oil and gas purposes. The regulations are too cumbersome for operators to invest time and resources into gaining approval.	**Relevant Recommendations** This report does not provide specific recommendations; however, the following applicable points are noted: The New Brunswick provincial government has created very specific guidelines to encourage recycling: "*Responsible Environmental Management of Oil and Natural Gas Activities in New Brunswick – Rules for Industry*". This document mandates the reuse of produced water and clearly lays out conveyance rules (Note: conveyance is by pipeline only, as opposed to layflat). Increased certainty in the Alberta regulatory system regarding technologies that would be approved and the conditions to be satisfied might increase the volume of produced water that is re-used and contribute to more responsible energy development. Alberta classifies produced water as a waste, meaning it is subject to waste regulations (Directive 058). This produces challenges for conveyance and storage where reuse is the goal.

#	Report Details	Industry engagement	Summary of the project	Relevant project recommendations & applicability to current goals
2	**Title** Use of Layflat Surface Hose for the Transport of Alternative Water **Year:** 2016 **Authors** Paterson & Cooke **File name(s)** Draft-35-0061-00-PR-REP-0001-Rev-B-Risk-Assessment	None.	**Project Context** Layflat hose is commonly used for transport of freshwater in Alberta. Because freshwater is transported, leaks and failures have little environmental consequence. If layflat were used for conveyance of alternative waters, a greater understanding of materials, standards, and potential mitigations is required to minimize risk**.** **Project Goals** Review and assess the different commercially available layflat materials for: compatibility with alternative waters, leakage rates, operational temperature range, and cost, then identify areas of potential added environmental risk. **Broad conclusions** Although the risk of catastrophic failure is higher with layflat than pipelines, small leaks (e.g. at couplings) can be managed with diligent pre-commissioning procedures.	**Relevant Recommendations** Since no performance guidelines exist, a suite of layflat testing could be developed to assess durability of layflat under different stress conditions. This would be a precursor to CSA standard development for layflat. The use of leak detection systems could prevent undetected pinhole leaks. Drip pans at couplings could mitigate the risks posed by small leaks at couplings. An environmental risk study should be conducted to assess the risk of alternative waters to wildlife and vegetation.

#	Report Details	Industry engagement	Summary of the project	Relevant project recommendations & applicability to current goals
3	**Title** Investigation into the use of Layflat Hose for Alternative Water Use **Year:** 2018 **Author** Integrated Sustainability **File name(s)** Final report not completed*	Not known.	**Project Context** Layflat hose appears to be commonly used in other jurisdictions to transport produced water. However, this is not permitted in Alberta. The risks of such conveyance are not well understood and there are currently no best management practices in place. **Project Goals** Develop best management practices for using layflat for conveyance of alternative waters and develop a risk assessment that can be used to assess environmental risk associated with alternative fluid transportation via layflat hose. **Broad conclusion**s Note: no final report was issued for this project. The work demonstrated the high degree of complexity associated with assessing risks for the transport and storage of alternative water.	A series of best management practices were identified for the use of layflat hose in the conveyance of alternative waters. Key points from these include: ***BMP-01*** - Crossing Procedure - Use culverts where possible, avoid high traffic areas, test road crossing to ensure there is no movement, ensure hose is not exposed. ***BMP-02*** - Monitoring & Inspection - Increase monitoring due to transportation of alternative fluids, have water technicians at each boost pump to minimize response times. ***BMP 03*** - Pressure Testing - Pressure test layflat with freshwater up to 1.5x operating pressure.

#	Report Details	Industry engagement	Summary of the project	Relevant project recommendations & applicability to current goals
4	**Title** Develop Definitions for Alternative Water Sources to High Quality Non-Saline Groundwater **Year:** 2019 **Author** Matrix Solutions Inc. **File name(s)** 18-WIPC-01-Final-Report 18-WIPC-01-BMP	Yes - PTAC members were involved in a workshop with Matrix and the AER to vet alternative water criteria.	**Project Context** The AER has recognized the need for use of alternatives to HQNS waters. However, available definitions are not necessarily quantified. Working with the AER, Matrix refined definitions for alternative and non-saline water that is impractical for potable water use. **Project Goals** 1. Define detailed criteria for alternative water sources for use in the upstream oil and gas industry. 2. Provide detailed criteria and definitions for non-saline water that is demonstrated to be impractical for drinking water use. **Broad Conclusions** Alternative water definitions need to support the Water for Life strategy. There is industry support for a risk-based approach to alternative water definitions and use.	**Relevant Recommendations** In certain circumstances, a risk-based approach could be used to determine the environmental and health risks associated with the use of alternative water sources. The AER list of alternative water sources should be expanded to include: - previously disposed produced water; - surface runoff from regulated petroleum sites that cannot be released to the environment; - impacted non-saline groundwater; and - wastewater that would otherwise be disposed.

#	Report Details	Industry engagement	Summary of the project	Relevant project recommendations & applicability to current goals
5	**Title** Alternative Water Source Life-Cycle Management Framework **Year:** 2019 **Authors** WaterSMART Solutions Ltd., *in collaboration with Catapult Water Midstream Inc.* **File name(s)** PTAC_Alt-Mgmt-Framework_Final-Report_2019-12-20	Yes - PTAC members were involved in the development of the screening matrix and providing industry insight into alternative water use.	**Project Context** The AER recognizes the need for alternative water use, but the current source-based definitions for water limit operators' ability to implement reuse. Industry desires a risk-based approach**.** **Project Goals** 1. Define alternative water sources in terms of their lifecycle risks and develop a screening level risk matrix (SLRM) that can be used to assess the risks to human health and the environment during the conveyance and storage of alternative waters. 2. Identify opportunities where the regulatory framework in Alberta could be improved to allow the use of alternative waters. **Broad Conclusions** Screening risks at a high level provides a steppingstone to a fully risk-based assessment. A future opportunity is developing technical and operational mitigations and analyzing how their implementation reduces risk, thus enabling approval of projects involving transportation and storage of alternative water.	**Relevant Recommendations** Use the SLRM as a pre-screening tool to identify project risks to humans and the environment and distinguish between low risk and higher risk projects. For higher risk projects, utilize the SLRM as a starting point for more detailed risk assessment, and work with the AER to identify and implement mitigations which reduce project risks to a level which can be approved. It is recommended the AER work towards the creation of a risk-based regulatory framework which can be used to assess alternative water use on a case-by-case basis. The framework should be structured such that high level sorting of low/higher risk projects can be done automatically, potentially enabling automatic approval of low risk projects through the AER's OneStop application system.

**Note: The following Integrated Sustainability files were reviewed: CP18-PTA-01-00_Parameters of Interest_RevC, CP18-PTA-01-00-FRM-PM-BMP1 Road Crossings-RevA, CP18-PTA-01-00-FRM-PM-BMP2 Increased monitoring, CP18-PTA-01-00-FRM-PM-BMP3 Pressure Testing, CP18-PTA-01-ME-LST-Risk Ident-Rev A, Risk_Assessment_PTAC_Draft_23_July_2018.*

Of the files reviewed, the following contained relevant recommendations: CP18-PTA-01-00-FRM-PM-BMP1 Road Crossings-RevA, CP18-PTA-01-00-FRM-PM-BMP2 Increased monitoring, and CP18-PTA-01-00-FRM-PM-BMP3 Pressure Testing.

3.0 Jurisdictional Review

At the direction of a PTAC Steering Committee, WaterSMART reviewed the legislation in Alberta, B.C., Colorado, and Texas to identify the regulatory instruments and approval mechanisms governing the transport of produced water in each jurisdiction. Desktop research was supplemented by conversations with several of our colleagues who have extensive operational and regulatory experience in hydraulic fracturing throughout North America. This provided additional insight into both regulatory requirements and operational norms in each jurisdiction. The results are summarized below and subsequently documented in Table 2 andTable 3. The results are split into separate tables for the sake of formatting and readability. A combined table is provided for reference in Appendix – Combined Jurisdictional Review Table.

Review of relevant reports and legislation from each jurisdiction revealed the regulatory framework under which operators are able to transport produced water, including barriers preventing operators from transporting produced water via layflat. For each jurisdiction, regulator reports, manuals, and legislation were reviewed to identify how risks were mitigated by the regulator. In general, regulations focus on minimizing the risk of leaks and spills during transportation[2]. Common challenges include small leaks (e.g. at pumps, connection points, and pinholes); vandalism (potentially leading to larger leaks and/or catastrophic failures and viewed as largely outside of operators' control); material durability; and issues with freezing. The high total dissolved solids (TDS) concentration, among other contaminants, in most produced water sources poses a significant risk to ground and surface waters and could cause significant environmental harm, especially to sensitive aquatic environments. One possible exception is in Colorado, where TDS in produced water is generally much lower than in other regions (although this varies by formation). The Colorado Oil and Gas Commission has identified areas of potential reuse of produced water, including dust suppression and irrigation.

Most regulators mitigate the risk of leaks and spills through a combination of engineering requirements and best practices. Best practices can include pressure testing requirements, specific monitoring programs, or a default requirement to bury pipelines unless an exemption is met, as is the case in Colorado. Most regulators guide operators in the design and construction of produced water transportation systems by referring to either material standards or specific materials when defining appropriate construction materials. Referencing material standards, as opposed to prescribing specific materials, appears to be favoured by regulators, since standards generally accommodate new technology development over time when testing requirements are met.

A notable regulatory environment is present in Texas. The Railroad Commission of Texas regulates oil and

[2] Regulations reviewed include the Alberta Pipeline Rules, B.C. Oil and Gas Activities Act, Colorado Flowline Rulemaking, and Texas Administrative Code. A complete list is available in Table 2.

gas development and waste handling (e.g. with Pipeline and Oil and Gas Wastewater departments), but does not have specific regulations for temporary layflat, neither for freshwater nor produced water transportation. Our research and discussions with colleagues active in the area suggest that authorizations are only needed for layflat when operators place them in state-owned right of ways (ROWs). In such cases, the Texas Department of Transportation handles authorizations and provides specific guidance for proponents (outlined in the Tables below). Outside of state-owned ROWs, and under the authority of the Railroad Commission, operators are expected to function in an environmentally responsible manner and must report and clean up spills of produced water, should they occur. Although the regulatory environment in Texas appears to allow transportation of produced water via standard layflat, our conversations indicate very few operators, if any, are comfortable doing so. In some cases, produced water has been transported with non-standard layflat, which is double-jacketed and utilizes modified couplings to reduce leaks.

Across all the jurisdictions, high density polyethylene (HDPE) pipe was identified as the most common material for produced water transport, as this meets the required engineering standards in each. In Alberta, HDPE is allowable under the Pipeline Rules, but it is not commonly adopted by operators as the ease of use and economics are not favourable when compared to trucking.

None of the jurisdictions reviewed appear to use traditional layflat for the transportation of produced water outside of lease boundaries, although there is some evidence it is permitted in Colorado under certain circumstances (possibly owing in part to the relatively low TDS in Colorado's produced water). In B.C., the B.C. Oil and gas Commission (BCOGC) appears to permit use of layflat within the lease boundary as long as the layflat meets ASME B31.3. The BCOGC has also approved spoolable reinforced thermoplastic pipe (RTP) for transporting produced water off lease in some cases, with strict mitigations and licence conditions in place. The RTP must meet the requirements of the CSA Z662 standard for materials or receive engineering sign off to deviate from these materials. There is evidence this would also be permitted in Colorado under the Flowline Rulemaking document, so long as the RTP meets the API 15S standard. As noted previously, non-standard layflat can be used to transport produced water in Texas, so long as operators are utilizing it responsibly (e.g. with correct engineering controls in place).

Numerous region-specific factors influence how each jurisdiction regulates and operationalizes the transportation of produced water. Factors such as climate, topography, freshwater availability (or scarcity), disposal availability, and surrounding geology, among others, are important drivers for water management strategies, and have material impacts on the economic viability of various approaches. The research has attempted to identify how these factors in each jurisdiction differ from Alberta. These differences are important to consider when comparing the regulatory environments and commonly used materials in each case. For example, the flat topography in Texas allows lower pressure systems to operate, while in B.C., disposal capacity is limited and expensive, driving operators to utilize more produced water and potentially install permanent transportation systems to accommodate this. Drivers to reuse produced water typically result in utilization of new technologies, such as RTP in B.C.

Table 2 Summary of the regulatory environment for each jurisdiction. Note that sources are included below Table 3.

Jurisdiction	Relevant regulatory instruments	Approval mechanisms	Regulatory barriers
Alberta	Pipeline Rules Directive 058: Oilfield Waste Management Requirements for the Upstream Petroleum Industry Oil and Gas Conservation Act & Regulation Directive 056: Energy Development Applications and Schedules Directive 058: Transportation and Storage of Oilfield Wastes *(indirect impact*)	*Pipeline Rules* - A licence for pipeline construction must be obtained via application to the AER in accordance with *Directive 056* for transportation of water via temporary hose where the source water contains produced or process affected water (note: this includes blended waters). No application is required for freshwater transportation through temporary pipeline. Applications do not need to be made for pipelines constructed within the facility lease boundary.	Applications for transport of produced water through temporary pipelines are not approved by the AER given, the high risks associated with leaks from layflat. Produced water spills contravene the *Environmental Protection and Enhancement Act,* leading to severe fines for operators (see Apache pipeline spill 2013). Produced water is defined as non-hazardous oilfield waste by Directive 058. Storage of produced water away from the well site requires regulatory approval as a waste facility, which is burdensome. The barriers to produced water storage mean conveyance by pipeline or layflat is less likely to be undertaken.

Jurisdiction	Relevant regulatory instruments	Approval mechanisms	Regulatory barriers
British Columbia	Oil and Gas Activities Act (OGAA) British Columbia Water Act Pipeline Regulation Drilling and Production Regulation	Temporary above ground pipelines designed to carry *freshwater* do not fall under the definition of a pipeline, as defined by the OGAA, and do not require a permit unless transported over Crown Land. Although a permit is not required, BCOGC approval is still required for these pipelines. The Pipeline Regulation legislates transport of fluids beyond the lease boundary. Under the Pipeline Regulation, all oilfield water must be transported by pipeline meeting CSA Z662 Oil and Gas Pipeline standard*. Temporary over ground pipelines are not regulated under the Pipeline Regulation. The *Drilling and Production Regulation* (DPR) legislates transport of fluids within the lease boundary. Under the DPR, all fluids within the lease boundary must be transported in pipelines meeting either the CSA Z662 or ASME B31.3 standards. Under the OGAA, a permit is required to transport oilfield water by pipeline. The BCOGC has approved the use of spoolable RTP for produced water transportation in certain projects where risks are deemed appropriately mitigated. Where materials used do not meet CSAZ662, engineering sign off is required from a B.C. registered Professional Engineer that the materials used are appropriate for the activity.	Under the OGAA, a pipeline definition includes the transportation of produced and flowback waters. *The Pipeline Regulation* states pipelines must also meet the design and construction requirements laid out in CSA Z662. The BCOGC has been working with industry to pilot projects using spoolable RTP, such as Primus Line, that meets different materials engineering standards, such as API 15S, for the over ground transportation of produced water. These require engineering sign off. Engineering sign off for alternative materials is permitted under clause 5.1.6 of CSA Z662.

Jurisdiction	Relevant regulatory instruments	Approval mechanisms	Regulatory barriers
Colorado	The Colorado Oil and Gas Conservation Commission (COGCC) 900 series for governing the management of exploration and production of waste Flowline Rulemaking	Off-lease flowlines must be registered with a designated Director or as part of a produced water transfer system.	Under the Flowline Rulemaking document 1100, it is possible to use flexible above ground piping with the written agreement of landowners if that pipeline meets the materials standards of ASME B31.3 or API 15S and the required pressure testing is undertaken. There is evidence operators utilize double-jacketed layflat materials with improved couplings for produced water transfer (e.g. TETRA Steel) under existing regulations. These materials may or may not comply with existing API or ASME standards, though vendors have internal quality control procedures.
Texas	Texas Administrative Code Texas Railroad Commission (RRC) – Responsible for disposal and recycling and fluid wastes associated with oil and gas operations, but not layflat transportation of produced water Texas Department of Transportation (TxDOT) – Responsible for leasing right of way for saltwater pipelines	There is no distinct approval/authorization process for layflat, unless it is placed in a state-owned ROW. In these cases, TxDOT handles approvals. There are two types of licences issued by TxDOT for produced water pipelines: 1. Short term (90-180 days), above ground, not intended to carry produced water. Water with a TDS > 10,000 mg/L cannot be transported through above ground temporary pipelines (typical Texas produced water exceeds 100,000 mg/L TDS). 2. Long term (90+ days), underground, intended to carry produced water.	The TxDOT regulations appear to prohibit transportation of water with TDS concentrations > 10,000 mg/L in above ground temporary pipelines. Conversations with individuals active in Texas suggest transportation of produced water in above ground temporary HDPE pipelines is common. Pipeline diameters are restricted to 12'' (30 cm), while layflat is typically 8-10'' (20-25cm) in state-owned ROWs. The Texas Administrative Code requires operating pressures of temporary pipelines not to exceed 60 psi (~413 kPa) at any point in state-owned ROWs. There is evidence operators utilize double-jacketed layflat materials with improved couplings for produced water transfer (e.g. TETRA Steel) under existing regulations. These materials may or may not comply with existing API or ASME standards, though vendors have internal quality control procedures.

Table 3 Summary of common risks, mitigations, and technologies and materials for transporting produced water. Sources are noted below the table.

Jurisdiction	Risks	Risk mitigation	Common technologies & materials	Differences from Alberta
Alberta	The AER has concerns over the risks to groundwater and fresh surface water sources, plants, and aquatic life from layflat leakages at connectors and catastrophic failures resulting in large volume releases of water.	**Leaks and Spills** The AER mitigates risks by only allowing transportation of produced water through pipelines meeting the CSA standards laid out in the *Pipeline Rules.* Truck transport of produced water is also permitted. For pipelines, pressure testing must be conducted to the CSA Z662 standard. **Additional Requirements** Surface pipelines must have additional features, such as temperature monitoring if the material has operational temperature limits.	**Materials** Steel and fibreglass pipelines are often used for transporting produced water in Alberta in non-temporary, licenced pipelines. There is recognition that corrosion issues exist with steel pipeline. From a regulatory perspective, it is possible to use HDPE for above-ground transfer of produced water. **Materials Standards** Pipelines regulated under the *Pipeline Rules,* including produced water transfer lines, must meet the following standards: - CSA Z245.11, Steel Fittings - CSA Z245.12, Steel Flanges - CSA Z245.15, Steel Valves - CSA Z662, Oil and Gas Pipeline Systems The *Pipeline Rules* state materials deviating from these standards can be used at the discretion of the Regulator; technical specifications regarding the construction materials, components, or maintenance methods must be provided.	N/A

Jurisdiction	Risks	Risk mitigation	Common technologies & materials	Differences from Alberta
British Columbia	The BCOGC recognizes there are risks posed by the transportation of alternative water in the form of contamination of freshwater sources, vegetation, and wildlife from spills and leaks. The BCOGC recognizes these risks exist to a lesser extent when transporting produced water via permitted pipeline conforming to the CSA Z662 standard.	**Leaks and Spills** The BCOGC mitigates the risks associated with the transport of produced water by only allowing off-lease transport through permitted pipeline meeting the CSA Z662 standard. Within the lease boundary, the risk of leaks occurring unnoticed is reduced. The BCOGC recognizes this and allows pipelines to meet the ASME B31.3 standard for certain activities. Truck transport is also permitted, as this is deemed lower risk. There is evidence the BCOGC works collaboratively with industry to implement new risk mitigation approaches (e.g. spoolable RTP). This is enabled by a more risk-based regulatory environment. **Monitoring** The OGAA states that monitoring must be undertaken to verify the integrity of a pipeline.	**Materials** The most common transport method in B.C. is trucking of produced water, though permitted pipelines and water hubs are becoming more popular. Common construction materials include HDPE. Engineered layflat has also been piloted and approved in some cases (RTP). **Materials Standards** Under the *Pipeline Regulation,* off-lease pipelines must meet CSA Z662. Under the *Drilling and Production Regulation,* on-lease pipelines must meet either CSA Z662 or ASME B31.3.	**Climate** Similar to Alberta; water is subjected to sub-zero temperatures. **Topography** Similar to Alberta; high pressure pumping is required to transport water over hills. **Water availability** Northeastern B.C. is subject to water withdrawal restrictions due to drought. **Disposal availability** Fewer disposal wells are available in B.C. compared to Alberta, generally speaking. This has encouraged the reuse and storage of produced water in B.C. **Risk tolerance** As in Alberta, there is low tolerance for spills or leaks resulting in environmental damage.

Jurisdiction	Risks	Risk mitigation	Common technologies & materials	Differences from Alberta
Colorado	Colorado produced water varies by formation. Many, though not all, formations have low TDS (< 10,000 mg/L), meaning there is less concern over salinity impacts to ground and surface water. Produced water reuse occurs, for example for irrigation and dust suppression.	**Depth of flowlines** Flowlines are to be installed below ground at a sufficient depth to protect them, except in cases where written agreement from surface owner can be secured to install flowlines with minimal cover or above ground. **Marking** Markings indicating the location of flowlines are required in Designated Setback Locations and at crossings with public/utility rights of way. **Leak and Corrosion prevention** Operators are required to prevent failures, leakage, and corrosion of pipelines by taking reasonable precautions.	**Materials** Materials must be compatible with transported fluids, of sufficient structural integrity for planned operations, and compliant with one applicable standard (of which there are six approved in the regulation). Double-jacketed layflat has been used in some cases. **Materials standards** Applicable standards for produced water transport approved in Colorado are: - ASME B31.3 Process Piping Guide; and - API 15S Spoolable Reinforced Plastic Line Pipe. **Pressure** Operating pressures cannot exceed manufacturer's specifications for any piece of equipment in the transportation system. **Monitoring** Automated, remote, real-time monitoring and control systems have been installed to reduce spill volumes and optimize performance	**Climate** Warmer climate with lower freezing risk. **Topography** Changes in topography are greater in closer proximity to the Rocky Mountains. Higher operating pressures may be required to overcome changes in elevation in the region. Eastern Colorado is flatter, potentially accommodating lower operating pressures. **Water Availability** Water scarcity in the state creates a high drive for reuse and alternative uses for produced water, such as road maintenance and crop irrigation. **Disposal Availability** Disposal well availability varies regionally, leading to local variations in the intensity of reuse. **Risk Tolerance** Salinity and TDS concentrations in some parts of Colorado are lower than in Texas and Alberta, enabling more management options, such as reuse.

Jurisdiction	Risks	Risk mitigation	Common technologies & materials	Differences from Alberta
Texas	There are concerns regarding operators incorrectly siting temporary pipelines in state-owned ROWs, exposing them to damage and interfering with other activities (e.g. road maintenance). Vandalism is a significant risk for above ground pipelines. Texas has produced water with high salinity (typically > 100,000 mg/L TDS), producing greater consequences for plants and wildlife. However, some areas have relatively sparse vegetation and wildlife. Use of metal pipelines are no longer permitted due to frequency of damage and leaks. Operators have noted traditional (single-jacketed) layflat is prone to leaks, particularly at couplings.	**Anchoring** Use metal stakes instead of wooden stakes for securing and anchoring above ground pipelines. **Ramps and Manifolds** Ramps and manifolds are used at property entrance crossings. These must be sufficient to hold vehicles. **Use of Culverts** Guidelines use a table to specify how many temporary pipelines can pass through a culvert at any given time. **Pressure Testing** All temporary pipelines should be pressure tested prior to operation. **Inspection Procedures, Salinity Basis** The guidelines specify varying inspection protocols depending on the salinity classification of the water (fresh, slightly saline, moderately saline, or saline). **Depth of Cover** The minimum depth of cover for saltwater pipelines is 48'' (122 cm). Pipelines are encased at right of way crossings.	**Materials** The TxDOT regulations appear to require buried HDPE for produced water, but practice (based on talking to colleagues familiar with the regions) suggests above ground HDPE is in use for produced water. As well, double-jacketed layflat with leak-reducing couplings has been used in some cases. Standard layflat hose can be used for water with TDS concentrations < 10,000 mg/L, which precludes typical Texas produced water. Metal pipeline materials, such as aluminum and steel, are not permitted for above ground temporary piping. **Monitoring** Automated, remote, real-time monitoring and control systems have been installed to reduce spill volumes and optimize performance	**Climate** Warmer climate; the risk of pipes freezing is very low. **Topography** A flat topography over great distances allows for the use of lower operating pressures. **Water Availability** Water scarcity in the state creates a high drive for water reuse. **Disposal Availability** Disposal in Texas is currently relatively inexpensive compared to disposal in Alberta. **Risk Tolerance** Regulations on the use of above ground temporary pipelines for produced water are strict. However, our conversations suggest operators are still using HDPE for moving produced water above ground. Notably, operators would not be comfortable using layflat to transport produced water, even if it were permitted, due to high TDS concentrations (often > 100,000 mg/L).

**Note: The goal of the CSA Z662 standard is to provide lifecycle engineering standards for the design, construction, and maintenance of pipelines along with the requirements for safety management systems. Further descriptive information on the content of the CSA Z662 standard is available in Appendix A of the B.C. Oil & Gas Activity Application Manual.*

The following references were utilized for each jurisdiction. Note the reference names are each hyperlinked to the source file, available online at the time of report completion.

Alberta: 1) Pipeline Rules; 2) AER News Release – Apache Produced Water Spill (2013); 3) Pipeline Materials overview CAPP corrosion report; and 4) EUB report on pipeline inventory Alberta (2007).

B.C.: 1) Pipeline Activity Guidelines; 2) B.C. Pipeline Regulation; 3) Oil and Gas Activities Act; 4) Oil and Gas Water Use in B.C. (2010); and 5) Review of B.C. Regulatory Framework (2015).

Colorado: 1) Colorado Health and Environment; 2) Oil and gas commission; 3) Department of Transportation; 4) Department of Natural Resources; 5) Colorado legislation on protecting welfare of oil and gas operations; 6) Evidence of Colorado using produced water for dust and ice suppression on roads; 7) Evidence of Colorado using produced water for irrigation; 8) Summary of produced water management regulations; 9) Colorado Flowline Rulemaking (2018); and 10) Colorado disposal well availability.

Texas: 1) TxDOT (Texas Department of Transportation) Leasing right of way for saltwater pipelines; 2) Texas A&M Transport Institute, Guidelines for Installing, Operating, and Maintaining Temporary Saltwater Pipelines; 3) Texas Administrative Code for buried pipelines; and 4) Railroad Commission of Texas.

4.0 Recommendations

Below are WaterSMART's recommendations to inform future policy, guidelines, and processes for transferring alternative water (including, but not limited to, produced and flowback water) via temporary layflat hose. These recommendations build on the past PTAC work completed under AUPRF (reviewed in Section 2.0), reflect insights from WaterSMART's jurisdictional review (summarized in Section 3.0), and leverage conversations within our network of Special Advisors and colleagues throughout North America. They aim to balance the needs and wants of both industry and the AER while accounting for economic, operational, practical, and environmental factors. The recommended approach is not meant to be overly prescriptive, but instead allows operators to innovatively solve problems, while providing clear direction on sufficiently low risk activities which can be approved rapidly.

Overall Recommendation: The AER should transition from a definitions-based system for regulating the transfer of alternative water towards a blended risk-based approach which provides clear guidance to project proponents for assessing risks for high risk activities while allowing for rapid approval of designated activities which have sufficiently low risk and/or existing prescriptive guidance (e.g. standards, codes of practice, etc.).

It is envisioned that an application will be categorized as either a "Designated Activity" or "Higher Risk Activity". Automatic initial screening of projects could be included in the AER's existing OneStop platform for integrated applications. Each category of activity will have its own approval pathway, which will be commensurate with the category's risk. The AER will need to provide clear direction to industry on how these activity categories are defined and how the approval process works for each type. For example, Designated Activities could be identified and approved automatically via OneStop, whereas Higher Risk Activities may be assigned to a specific representative within the AER for a detailed and potentially iterative risk assessment and mitigation process. It is understood the AER already utilizes an internal tool for assessing risk. It may be beneficial for the AER to share aspects of the tool with industry, such that there is clarity regarding which risks are considered important and how they are assessed.

Figure 1, below, demonstrates how the two approval pathways could be set up. Note that this approach is envisioned as a dynamic system. Over time, as more Higher Risk activities are reviewed and approved, the mitigations and conditions necessary to enable approval can be formalized into prescriptive guidance, which will expand the list of Designated Activities. Piloting, which has been demonstrated in B.C., may be an effective tool for the AER and industry to develop acceptable mitigations and new prescriptive guidance. This approach requires both industry and the AER to think seriously about their respective tolerances for risks and appropriate ways to mitigate them.

It must be noted that recommendations to improve the regulatory environment for transportation of alternative water only address some of the challenges preventing operators from utilizing more alternative water. Storage is a critical component of alternative water use and reuse plans, and the economics of alternative water transportation in Alberta (via any means) are often challenged by how

much operators can store. Designated Activities may become more attractive to operators if storage of produced water is enabled by updates to the existing regulatory environment. It is recommended the AER consider similar efforts to update the regulatory environment for produced water storage.

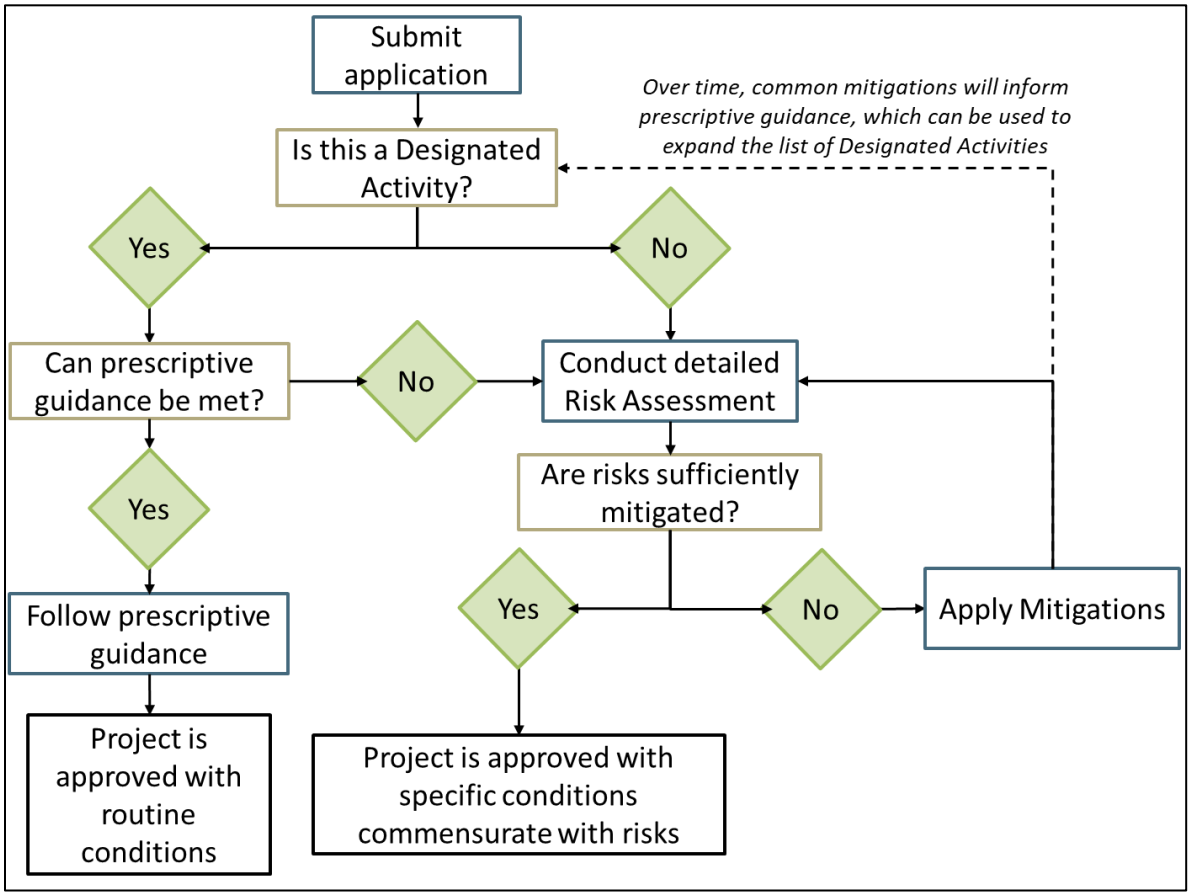

Figure 1 Flowchart depicting how Higher Risk and Designated Activities can be assessed and approved by the AER. Note that applicants may opt to abandon the projects during the "apply mitigations" phase, if the mitigations are found to be undesirable compared to the project benefits.

4.1 Designated Activities

It is recommended that the AER identify and communicate to industry which activities related to alternative water transfer can be Designated as appropriate for rapid and consistent approval. These will be activities which are considered to be sufficiently low risk and/or for which clear and prescriptive guidance exists (or is developed in the future), such as standards, codes of practice, and regulatory instruments.

Although Designated Activities may not provide operators with all the benefits of higher risk undertakings, particularly when this regulatory approach is first implemented, the industry is expected to benefit from the high degree of regulatory certainty which will be provided. Operators will know in advance which steps must be completed to gain an approval for a specific activity, and adherence to prescriptive guidance

will enable faster approvals. This should also free up resources within the AER to consider Higher Risk Activities.

An example of a sufficiently low risk activity which should be rapidly approved when prescriptive guidance is followed is the use of HDPE pipe for transporting produced and flowback water, either above or below ground. Alberta's *Pipeline Rules* direct operators to utilize conveyance materials which are compliant with CSA Z662. When projects satisfy existing requirements (e.g. controls on diameter, pressure, distance, fittings, and monitoring), the AER should be able to approve them relatively quickly. Proposed projects which do not conform to these requirements, such as produced water conveyance via layflat, would be categorized as "Higher Risk Activities" and require a more detailed risk assessment. Although HDPE may not be an optimal solution for temporary transfer of alternative water, operators will benefit from shorter approval timelines and clear regulatory expectations. It is anticipated that HDPE would still be subject to typical requirements under the *Pipeline Rules* (e.g. Directive 56 requirements for asset retirement obligations).

Over time, it is expected that additional standards and prescriptive guidance can be developed collaboratively by the AER and industry such that the list of Designated Activities grows. For example, The BCOGC has worked with industry to pilot projects using spoolable RTP which do not meet the typical requirements of standards currently referenced in the regulations (e.g. CSA Z662), but do meet other engineering standards, such as API 15S. Conceivably, existing and new engineering standards, combined with appropriate engineering controls (e.g. stamping by a registered Professional Engineer), could be adopted by the AER over time and used to provide prescriptive guidance to operators on new Designated Activities. Another example is the transfer of treated municipal effluent via layflat. This activity was identified as low risk in previous PTAC work, and operators would benefit from having a mechanism for rapid approval of these projects, once requisite guidance is in place.

4.2 Higher Risk Activities

For activities which are deemed to be higher risk, and for which prescriptive guidance does not exist, a risk-based assessment is recommended. WaterSMART's previous work to develop a Screening Level Risk Matrix (SLRM) (WaterSMART, 2019) can be leveraged to prepare a framework for assessing the proposed activity's risks to human health and the terrestrial and aquatic environment. Ideally, this framework will be transparently and consistently applied, such that industry is made aware of the criteria and priorities against which their proposals are assessed.

Once risks are identified and understood, mitigations can be applied to reduce risks to an acceptable level for approval. For each of the common risks noted in Section 3.0, technical and engineering solutions exist which can address them, if applied correctly. For example, leaking couplings could be addressed in several ways, such as reducing the number of couplings, utilizing advanced connection materials which leak less, increasing inspection frequency, installing drip trays, etc. A list of example mitigation approaches is included in Appendix – Example Mitigations.

The preparation and application of appropriate mitigations will require innovation and collaboration from industry and the AER. Over time, some preferred mitigation approaches are expected to emerge for specific aspects of alternative water transportation projects. These mitigations can be formalized into prescriptive guidance, such as codes of practice, manuals, and/or engineering standards, which are acceptable for both industry and the AER. The activities covered under newly developed guidance can then be considered Designated Activities and become subject to faster approvals when applicants adhere to the prescriptive guidance.

An effective way to collaboratively develop innovative mitigations and associated prescriptive guidance is through piloting. For example, the BCOGC utilizes a risk-based approach when piloting new or innovative technology. As noted, there is evidence that pipeline materials outside of those prescribed by CSA Z665 have been used in B.C. following an engineering assessment and engineering sign off by a Professional Engineer registered with the Engineers and Geoscientists British Columbia. Engineering sign off for alternative materials is permitted under clause 5.1.6 of CSA Z662. The regulatory framework that permits this piloting approach in B.C. also exists in Alberta under the *Pipeline Rules*, which also reference CSA Z662. It is recommended that the AER consider using engineering assessments to pilot new materials outside of those prescribed by the CSA Z665 standard. Other standards, such as ASME B31.3 Process Piping Guide and API 15S Spoolable Reinforced Plastic Line Pipe, can be utilized in Alberta, as they are in B.C. and Colorado.

4.3 Summary

A blended risk-based approach will evolve over time. At first, certain Designated Activities with sufficiently low risk and/or existing prescriptive guidance can be approved rapidly and consistently, while Higher Risk Activities will be reviewed to understand and mitigate their risks. Operators will have the flexibility to pursue either Designated Activities associated with regulatory certainty and short approval times, or Higher Risk Activities for which collaborative risk mitigation will be required. Over time, more and more activities will become Designated Activities, as prescriptive guidance is developed based on accepted mitigations. Piloting can be leveraged to identify acceptable mitigations (e.g. new materials) and develop prescriptive guidance. Using this approach, transferring alternative water, particularly produced and flowback water, via layflat could be rapidly approved in the future if prescriptive guidance is developed that operators follow guidance. In the meantime, a clear risk assessment pathway will be in place for operators to receive approval for Higher Risk Activities, while Designated Activities are available for more rapid approval.

Appendix – Example Mitigations

As noted in the body of the report, a multitude of technological, material, design, and engineering options exist to address common risks involved in transporting produced water via layflat. A suite of options will likely be required to address identified risks for Higher Risk Activities. Several of these options are listed below as examples. This is not intended to be an exhaustive list or endorsement of any one approach. Example mitigations include:

- improve the quality of water being transported via treatment, possibly blending;
- utilize alternative materials and designs to reduce leaks at common locations, such as:
    - pumps with improved seals;
    - alternative coupling/connection materials to reduce drips (e.g. flanged couplings);
    - couplings which have low risk of separation from hose;
    - drip trays at couplings; and
    - systems with fewer (or no) couplings.
- where appropriate, install containment within right of ways;
- increase inspections frequency (by both operators and regulators);
- utilize leak detection technologies and pressure transmitters;
- utilize automated, remote, real-time monitoring and control systems to minimize volumes spilled and optimize performance;
- install pressure relief systems;
- implement approaches to manage freezing (e.g. install bypasses to enable controlled emptying of produced water following end of use);
- develop and utilize quality control and assurance processes for conveyance materials (e.g. pressure testing with freshwater, verifying purchased materials are received);
- assess the complete transportation network to identify high pressure points (e.g. at the bottom of slopes) and revise system design to ensure pressures do not exceed material ratings;
- reduce the volume which can be spilled due to a failure (e.g. shutoff valves at short intervals);
- maintain material safety data sheets nearby to where produced water is transported so spills can be managed and communicated properly; and
- develop and maintain an emergency response and spill cleanup plan.

Appendix – Combined Jurisdictional Review Table

Jurisdiction	Relevant regulatory instruments	Approval mechanisms	Regulatory barriers	Risks	Risk mitigation	Common technologies & materials	Differences from Alberta
Alberta	Pipeline Rules Directive 058: Oilfield Waste Management Requirements for the Upstream Petroleum Industry Oil and Gas Conservation Act & Regulation Directive 056: Energy Development Applications and Schedules Directive 058: Transportation and Storage of Oilfield Wastes *(indirect impact*)	*Pipeline Rules* - A licence for pipeline construction must be obtained via application to the AER in accordance with *Directive 056* for transportation of water via temporary hose where the source water contains produced or process affected water (note: this includes blended waters). No application is required for freshwater transportation through temporary pipeline. Applications do not need to be made for pipelines constructed within the facility lease boundary.	Applications for transport of produced water through temporary pipelines are not approved by the AER given, the high risks associated with leaks from layflat. Produced water spills contravene the *Environmental Protection and Enhancement Act,* leading to severe fines for operators (see Apache pipeline spill 2013). Produced water is defined as non-hazardous oilfield waste by Directive 058. Storage of produced water away from the well site requires regulatory approval as a waste facility, which is burdensome. The barriers to produced water storage mean conveyance by pipeline or layflat is less likely to be undertaken.	The AER has concerns over the risks to groundwater and fresh surface water sources, plants, and aquatic life from layflat leakages at connectors and catastrophic failures resulting in large volume releases of water.	**Leaks and Spills** The AER mitigates risks by only allowing transportation of produced water through pipelines meeting the CSA standards laid out in the *Pipeline Rules.* Truck transport of produced water is also permitted. For pipelines, pressure testing must be conducted to the CSA Z662 standard. **Additional Requirements** Surface pipelines must have additional features, such as temperature monitoring if the material has operational temperature limits.	**Materials** Steel and fibreglass pipelines are often used for transporting produced water in Alberta in non-temporary, licenced pipelines. There is recognition that corrosion issues exist with steel pipeline. From a regulatory perspective, it is possible to use HDPE for above-ground transfer of produced water. **Materials Standards** Pipelines regulated under the *Pipeline Rules,* including produced water transfer lines, must meet the following standards: - CSA Z245.11, Steel Fittings - CSA Z245.12, Steel Flanges - CSA Z245.15, Steel Valves - CSA Z662, Oil and Gas Pipeline Systems The *Pipeline Rules* state materials deviating from these standards can be used at the discretion of the Regulator; technical specifications regarding the construction materials, components, or maintenance methods must be provided.	N/A

Jurisdiction	Relevant regulatory instruments	Approval mechanisms	Regulatory barriers	Risks	Risk mitigation	Common technologies & materials	Differences from Alberta
British Columbia	Oil and Gas Activities Act (OGAA) British Columbia Water Act Pipeline Regulation Drilling and Production Regulation	Temporary above ground pipelines designed to carry *freshwater* do not fall under the definition of a pipeline, as defined by the OGAA, and do not require a permit unless transported over Crown Land. Although a permit is not required, BCOGC approval is still required for these pipelines. The Pipeline Regulation legislates transport of fluids beyond the lease boundary. Under the Pipeline Regulation, all oilfield water must be transported by pipeline meeting CSA Z662 Oil and Gas Pipeline standard*. Temporary over ground pipelines are not regulated under the Pipeline Regulation. The *Drilling and Production Regulation* (DPR) legislates transport of fluids within the lease boundary. Under the DPR, all fluids within the lease boundary must be transported in pipelines meeting either the CSA Z662 or ASME B31.3 standards. Under the OGAA, a permit is required to transport oilfield water by pipeline. The BCOGC has approved the use of spoolable RTP for produced water transportation in certain projects where risks are deemed appropriately mitigated. Where materials used do not meet CSAZ662, engineering sign off is required from a B.C. registered Professional Engineer that the materials used are appropriate for the activity.	Under the OGAA, a pipeline definition includes the transportation of produced and flowback waters. *The Pipeline Regulation* states pipelines must also meet the design and construction requirements laid out in CSA Z662. The BCOGC has been working with industry to pilot projects using spoolable RTP, such as Primus Line, that meets different materials engineering standards, such as API 15S, for the over ground transportation of produced water. These require engineering sign off. Engineering sign off for alternative materials is permitted under clause 5.1.6 of CSA Z662.	The BCOGC recognizes there are risks posed by the transportation of alternative water in the form of contamination of freshwater sources, vegetation, and wildlife from spills and leaks. The BCOGC recognizes these risks exist to a lesser extent when transporting produced water via permitted pipeline conforming to the CSA Z662 standard.	**Leaks and Spills** The BCOGC mitigates the risks associated with the transport of produced water by only allowing off-lease transport through permitted pipeline meeting the CSA Z662 standard. Within the lease boundary, the risk of leaks occurring unnoticed is reduced. The BCOGC recognizes this and allows pipelines to meet the ASME B31.3 standard for certain activities. Truck transport is also permitted, as this is deemed lower risk. There is evidence the BCOGC works collaboratively with industry to implement new risk mitigation approaches (e.g. spoolable RTP). This is enabled by a more risk-based regulatory environment. **Monitoring** The OGAA states that monitoring must be undertaken to verify the integrity of a pipeline.	**Materials** The most common transport method in B.C. is trucking of produced water, though permitted pipelines and water hubs are becoming more popular. Common construction materials include HDPE. Engineered layflat has also been piloted and approved in some cases (RTP). **Materials Standards** Under the *Pipeline Regulation,* off-lease pipelines must meet CSA Z662. Under the *Drilling and Production Regulation,* on-lease pipelines must meet either CSA Z662 or ASME B31.3.	**Climate** Similar to Alberta; water is subjected to sub-zero temperatures. **Topography** Similar to Alberta; high pressure pumping is required to transport water over hills. **Water availability** Northeastern B.C. is subject to water withdrawal restrictions due to drought. **Disposal availability** Fewer disposal wells are available in B.C. compared to Alberta, generally speaking. This has encouraged the reuse and storage of produced water in B.C. **Risk tolerance** As in Alberta, there is low tolerance for spills or leaks resulting in environmental damage.

Jurisdiction	Relevant regulatory instruments	Approval mechanisms	Regulatory barriers	Risks	Risk mitigation	Common technologies & materials	Differences from Alberta
Colorado	The Colorado Oil and Gas Conservation Commission (COGCC) 900 series for governing the management of exploration and production of waste Flowline Rulemaking	Off-lease flowlines must be registered with a designated Director or as part of a produced water transfer system.	Under the Flowline Rulemaking document 1100, it is possible to use flexible above ground piping with the written agreement of landowners if that pipeline meets the materials standards of ASME B31.3 or API 15S and the required pressure testing is undertaken. There is evidence operators utilize double-jacketed layflat materials with improved couplings for produced water transfer (e.g. TETRA Steel) under existing regulations. These materials may or may not comply with existing API or ASME standards, though vendors have internal quality control procedures.	Colorado produced water varies by formation. Many, though not all, formations have low TDS (< 10,000 mg/L), meaning there is less concern over salinity impacts to ground and surface water. Produced water reuse occurs, for example for irrigation and dust suppression.	**Depth of flowlines** Flowlines are to be installed below ground at a sufficient depth to protect them, except in cases where written agreement from surface owner can be secured to install flowlines with minimal cover or above ground. **Marking** Markings indicating the location of flowlines are required in Designated Setback Locations and at crossings with public/utility rights of way. **Leak and Corrosion prevention** Operators are required to prevent failures, leakage, and corrosion of pipelines by taking reasonable precautions.	**Materials** Materials must be compatible with transported fluids, of sufficient structural integrity for planned operations, and compliant with one applicable standard (of which there are six approved in the regulation). Double-jacketed layflat has been used in some cases. **Materials standards** Applicable standards for produced water transport approved in Colorado are: - ASME B31.3 Process Piping Guide; and - API 15S Spoolable Reinforced Plastic Line Pipe. **Pressure** Operating pressures cannot exceed manufacturer's specifications for any piece of equipment in the transportation system. **Monitoring** Automated, remote, real-time monitoring and control systems have been installed to reduce spill volumes and optimize performance	**Climate** Warmer climate with lower freezing risk. **Topography** Changes in topography are greater in closer proximity to the Rocky Mountains. Higher operating pressures may be required to overcome changes in elevation in the region. Eastern Colorado is flatter, potentially accommodating lower operating pressures. **Water Availability** Water scarcity in the state creates a high drive for reuse and alternative uses for produced water, such as road maintenance and crop irrigation. **Disposal Availability** Disposal well availability varies regionally, leading to local variations in the intensity of reuse. **Risk Tolerance** Salinity and TDS concentrations in some parts of Colorado are lower than in Texas and Alberta, enabling more management options, such as reuse.

Jurisdiction	Relevant regulatory instruments	Approval mechanisms	Regulatory barriers	Risks	Risk mitigation	Common technologies & materials	Differences from Alberta
Texas	Texas Administrative Code Texas Railroad Commission (RRC) – Responsible for disposal and recycling and fluid wastes associated with oil and gas operations, but not layflat transportation of produced water Texas Department of Transportation (TxDOT) – Responsible for leasing right of way for saltwater pipelines	There is no distinct approval/authorization process for layflat, unless it is placed in a state-owned right of way (ROW). In these cases, TxDOT handles approvals. There are two types of licences issued by TxDOT for produced water pipelines: 1. Short term (90-180 days), above ground, not intended to carry produced water. Water with a TDS > 10,000 mg/L cannot be transported through above ground temporary pipelines (typical Texas produced water exceeds 100,000 mg/L TDS). 2. Long term (90+ days), underground, intended to carry produced water.	The TxDOT regulations appear to prohibit transportation of water with TDS concentrations > 10,000 mg/L in above ground temporary pipelines. Conversations with individuals active in Texas suggest transportation of produced water in above ground temporary HDPE pipelines is common. Pipeline diameters are restricted to 12'' (30 cm), while layflat is typically 8-10'' (20-25cm) in state-owned ROWs. The Texas Administrative Code requires operating pressures of temporary pipelines not to exceed 60 psi (~413 kPa) at any point in state-owned ROWs. There is evidence operators utilize double-jacketed layflat materials with improved couplings for produced water transfer (e.g. TETRA Steel) under existing regulations. These materials may or may not comply with existing API or ASME standards, though vendors have internal quality control procedures.	There are concerns regarding operators incorrectly siting temporary pipelines in state-owned ROWs, exposing them to damage and interfering with other activities (e.g. road maintenance). Vandalism is a significant risk for above ground pipelines. Texas has produced water with high salinity (typically > 100,000 mg/L TDS), producing greater consequences for plants and wildlife. However, some areas have relatively sparse vegetation and wildlife. Use of metal pipelines are no longer permitted due to frequency of damage and leaks. Operators have noted traditional (single-jacketed) layflat is prone to leaks, particularly at couplings.	**Anchoring** Use metal stakes instead of wooden stakes for securing and anchoring above ground pipelines. **Ramps and Manifolds** Ramps and manifolds are used at property entrance crossings. These must be sufficient to hold vehicles. **Use of Culverts** Guidelines use a table to specify how many temporary pipelines can pass through a culvert at any given time. **Pressure Testing** All temporary pipelines should be pressure tested prior to operation. **Inspection Procedures, Salinity Basis** The guidelines specify varying inspection protocols depending on the salinity classification of the water (fresh, slightly saline, moderately saline, or saline). **Depth of Cover** The minimum depth of cover for saltwater pipelines is 48'' (122 cm). Pipelines are encased at right of way crossings.	**Materials** The TxDOT regulations appear to require buried HDPE for produced water, but practice (based on talking to colleagues familiar with the regions) suggests above ground HDPE is in use for produced water. As well, double-jacketed layflat with leak-reducing couplings has been used in some cases. Standard layflat hose can be used for water with TDS concentrations < 10,000 mg/L, which precludes typical Texas produced water. Metal pipeline materials, such as aluminum and steel, are not permitted for above ground temporary piping. **Monitoring** Automated, remote, real-time monitoring and control systems have been installed to reduce spill volumes and optimize performance	**Climate** Warmer climate; the risk of pipes freezing is very low. **Topography** A flat topography over great distances allows for the use of lower operating pressures. **Water Availability** Water scarcity in the state creates a high drive for water reuse. **Disposal Availability** Disposal in Texas is currently relatively inexpensive compared to disposal in Alberta. **Risk Tolerance** Regulations on the use of above ground temporary pipelines for produced water are strict. However, our conversations suggest operators are still using HDPE for moving produced water above ground. Notably, operators would not be comfortable using layflat to transport produced water, even if it were permitted, due to high TDS concentrations (often > 100,000 mg/L).