Mitigating Risks of Hydraulic Fracturing Wastewater Disposal Operations in Alberta through Water Policy

Mauricio Reyes Canales[1], Rabia Ladha[2], Melissa MacDonald[3], Sunghyun Park[4]
[1]Dept. of Physics, University of Alberta, Edmonton, AB, Canada T6G 2E1
[2]School of Public Policy, University of Calgary, Calgary, AB, Canada T2P 1H9
[3]Dept. of Geoscience, University of Calgary, Calgary, AB, Canada T2N 1N4
[4]Dept. of Civil and Environmental Engineering, University of Waterloo, Waterloo, Canada ON, N2L3G1
Corresponding author's email: rabia.ladha@ucalgary.ca

Abstract

The number of hydraulic fracturing operations in Alberta, which require the use of water to extract shale gas, are projected to increase to meet the projected world energy demand. In Alberta, current policies and regulations do not allow for the reuse of water once it has been classified as industrial wastewater. In 2017, only 4% of the water used in Alberta's hydraulic fracturing operations was recycled. The expected increase in water use across sectors along with uncertainty surrounding future climate change scenarios create a situation in which prudent management of water resources is imperative for Alberta and for the energy industry to maintain public trust in proper management of resources. Currently, most of the water used in hydraulic fracturing operations is disposed of in deep injection wells. Risks associated with deep injection wells are well managed, though, they cannot be eliminated due to uncertainties such as physical and chemical hydrogeological factors. The most effective way to eliminate these risks is to allow for and encourage water recycling. This paper review current regulation and legislation as well as current initiatives for reform in water management practices. A policy framework is proposed to update regulations that are barriers to using non-saline water alternatives and the implementation of a government-initiated incentive program appropriately rewards producers to pursue more recycling of produced and flowback water in their hydraulic fracturing operations.

1.0 Introduction

The number of hydraulic fracturing operations in Alberta, which require the use of water to extract shale gas, are projected to increase to meet the projected world energy demand.[1] In Alberta, current policies and regulations do not allow for the reuse of water once it has been classified as industrial wastewater.[2] In 2017, only 4% of the water used in Alberta's hydraulic fracturing operations was recycled.[3] While both water and shale gas are important resources to society, it is imperative to take steps to preserve Alberta's non-saline (fresh) water supply and increase the use of non-saline alternatives because the as the amount of hydraulic fracturing activity increases, the amount of water required will also increase. In addition, water use is also expected to increase across sectors including the agricultural and domestic sectors to keep up with population growth and expected improvements to quality of life.[4] This expected increase in water use along with uncertainty surrounding future climate change scenarios create a situation in which prudent management of water resources is imperative for Alberta and for the energy industry to maintain public trust in proper management of resources.

Along with domestic use, Alberta relies heavily on water use for a variety of its industries, such as energy, manufacturing and forestry, and agriculture. In 2013, over half of the province's GDP was either directly or indirectly reliant on water as an input.[5] While the shortage of water resources in across the province is not an imminent threat, certain communities in southern Alberta have been challenged by water supply.[6]

Currently, most of the water used in hydraulic fracturing operations is disposed of in deep injection wells. There are mechanical, geological, and hydrogeological risks associated with deep well injection such as the threat of groundwater contamination which is correlated to the amount, chemical composition, and geological locations of injected wastewater. However, many of these risks are well managed by the Alberta Energy Regulator (AER) through required minimum standards for each deep injection well.[7] While these risks are well managed, they cannot be eliminated due to uncertainties such

---

[1] International Energy Agency, "World Energy Outlook 2018," OECD/IEA

[2] Multi Stakeholder panel for the Area-Based Regulation Pilot, 2017, "Enabling the Use of Alternatives to High quality Non-saline Water by the Oil and Gas Sector in the MD of Greenview," https://www.aer.ca/documents/reports/AreaBasedRegulation_RecommendationReport.pdf.

[3] Alberta Energy Regulator, Alberta Energy Industry Water Use Report – Hydraulic Fracturing, Hydraulic Fracturing Water Use Summary, last Accessed May 9, 2019, https://www2.aer.ca/t/Production/views/HydraulicFracturingWaterUseReport/HydraulicFracturingWaterUseSummary?%3Aembed=y&%3Atoolbar=top&%3AshowShareOptions=true&%3Adisplay_count=no&%3AshowVizHome=no

[4] Waughray, D., "Water Security—The Water-Food-Energy-Climate Nexus." World Economic Forum Water Initiative; Island Press: Washington, DC, USA, 2011, http://www3.weforum.org/docs/WEF_WI_WaterSecurity_WaterFoodEnergyClimateNexus_2011.pdf; Alberta, Population Statistics, https://www.alberta.ca/population-statistics.aspx

[5] Alberta Water Portal Society, Work: WaterPortal Business and Technology Directory, Last accessed April 24, 2019, https://albertawater.com/water-catalog

[6] Alberta Urban Municipalities Association, Facts About Water, Last accessed April 26, 2019 https://auma.ca/advocacy-services/programs-initiatives/water-management/facts-about-water

[7] Alberta Energy Regulator (1994). Directive 051: Injection and Disposal Wells – Well Classifications, Completions, Logging, and Testing Requirements; Alberta Energy Regulator (2001). Directive 055: Storage Requirements for the Upstream Petroleum Industry; Alberta Energy Regulator (2011). Directive 077: Pipelines-requirements and reference tools; Alberta Energy Regulator (2017). Directive 071: Emergency Preparedness and

as physical and chemical hydrogeological factors. Therefore, the most effective way to reduce these risks is reducing amount of water disposed through deep injection wells by increasing the amount of water that is recycled. Some advantages of recycling water include reduced impact on local non-saline water resources, reduced need for long range trucking of non-saline water, potential for reduced costs related to transportation and treatment of water.

This paper reviews the current legislation and regulation regarding water allocation and use in Alberta's hydraulic fracturing industry and suggests policy and regulatory changes that would allow for better management of Alberta's non-saline water resources by allowing and encouraging recycling.

2.0 Review of Current Legislation and Regulations

Both resource development and water management fall under provincial jurisdiction in Canada. Hence, the allocation of water resources and the management disposal wells in Alberta are controlled and monitored as per provincial policies. The *Responsible Energy Development Act* gives the AER its regulatory power, including issuing of directives and enforcement of compliance.[8] The *Water Act* supports and promotes the conservation and management of water, including the wise allocation and use of water, while recognizing that water use is required for industrial economic interests among many other uses.[9] This act gives the AER the ability to manage water use in the energy development industry by issuing water licenses. Companies must apply for water licenses. These applications are reviewed and released for public consultation. A water license does not signify how much water is used by industry, but it conveys how much water is allocated for specific industrial purposes. In 2017, only 23% of the allocated 96M m^3 was used by hydraulic fracturing operators.[10] One reason for the difference in use and allocation is that hydraulic fracturing is a relatively new technology and it is expected that water use will vary as operators test different methods of production.

Wastewater is defined under the *Wastewater and Stormwater Management Regulation*, created in 1993 and last updated in 2012.[11] This regulation defines the term 'industrial Wwastewater' as the composite of liquid and water‑carried wastes from a plant. It also prohibits the re-use of industrial wastewater expect in the case of approved irrigation or other specifically approved uses.

To understand the water management as it relates to hydraulic fracturing, it useful to understand the water cycle, shown in Figure 1.[12] In 2017, 99% of the water sourced by hydraulic fracturing operations was from non-saline sources.[13] The goal of the policies proposed in this paper is to replace non-saline water sources with recycled flowback and produced waters from hydraulic fracturing operations. The decision between recycling water and disposing of water is driven by technical, environmental, and economic factors and is limited by regulation.

Response Requirements for the Petroleum Industry; Alberta Energy Regulator (2018). Directive 013: Suspension Requirements for wells.

[8] Responsible Energy Development Act, SA 2012, c R-17.3,

[9] Water Act, RSA 2000, c W-3

[10] Alberta Energy Regulator, Hydraulic Fracturing Water Use Summary.

[11] Wastewater and Storm Drainage Regulation, Alta Reg 119/1993, Part 1,

[12] Alessi, D., Zolfaghari, A., Kletke, S., Gehman, J., Allen D., Goss, G. 2017. Comparative analysis of hydraulic fracturing wastewater practices in unconventional shale development: Water sourcing, treatment and disposal practices, Canadian Water Resources Journal. 105-121.

[13] Alberta Energy Regulator, Hydraulic Fracturing Water Use Summary.

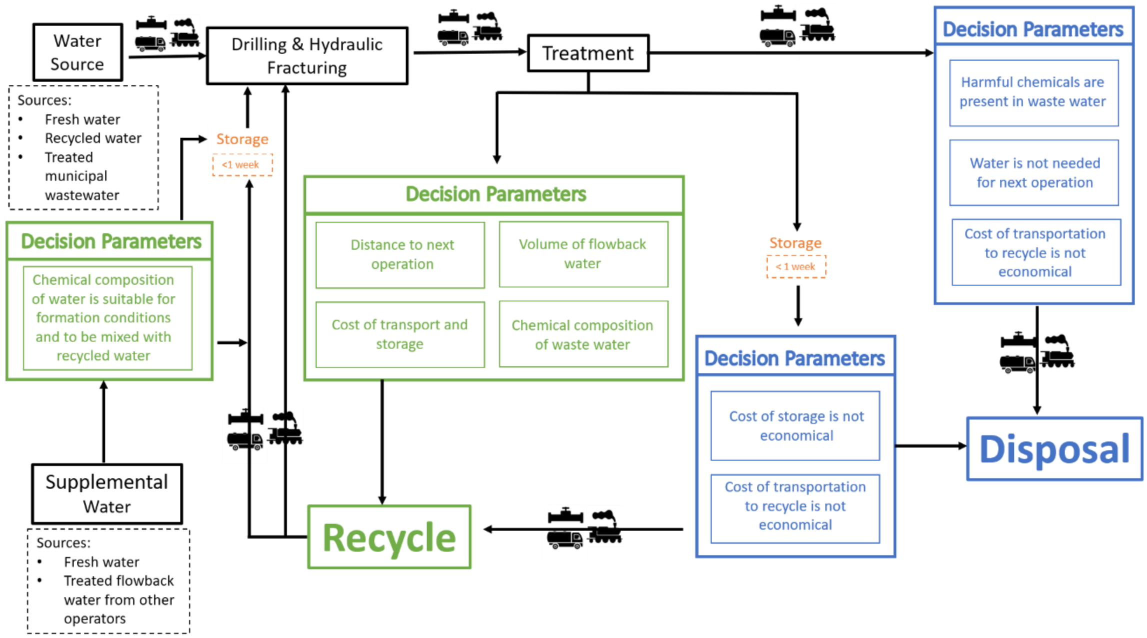

Figure 1. Hydraulic Fracturing Water Cycle

The AER is moving towards a more comprehensive approach for managing the multiple operations across the province by piloting approaches that involve collaboration between operators to mitigate and minimize the effects of development.[14] This includes grouping operators by geographic region and by play (the three dimensional space impacted by an operation). Through this process, the AER has identified barriers to reducing the use of non-saline water in hydraulic fracturing operations.[15] These barriers include regulatory definitions, conditions on water licenses that limit sharing, and the prevention of transfers between the various basins of water identified in Alberta.

3.0 Policy Options

To increase the amount of water being recycled in the hydraulic fracturing water cycle, the regulatory barriers preventing more non-saline water use identified by the AER must be addressed through updates in respective regulations and acts. First, the definition of types of water through the water act, related regulations, and directives from the AER do not adequately classify water based on the risk it poses based on its properties. Rather, water is classified by its source such as industrial wastewater. In addition, regulation limits the timeline over which industrial wastewater can be stored on a site which prevents feasible coordination between sites where the sharing and recycling of water may have been possible. Second, once allocated through a water license, the water is difficult to share with any other organization. Third, the prevention of mixing water from different basins means that operators are sometimes required to operate two separate infrastructures for water for the same

[14] Multi Stakeholder panel for the Area-Based Regulation Pilot, "Enabling the Use of Alternatives to High quality Non-saline Water."

[15] Multi Stakeholder panel for the Area-Based Regulation Pilot, "Enabling the Use of Alternatives to High quality Non-saline Water."

project. These barriers lead to over-allocated non-saline water resources. Over allocation of non-saline water resources leads to waste because once approved, the water allocated per project is the main constraint under which companies decide the economics of whether to obtain alternatives to non-saline water.

Progress has been made on some fronts regarding the identified barriers. The AER released the "Interim Guidance to Authorize Reuse of Municipal and Industrial Wastewater" in December 2015 and along with their work on an updated collaborative approach, they have created a Draft Water Conservation Policy.[16] However, these are interim initiatives that still have regulatory hurdles in order to achieve their intended goal. It is recommended that regulatory changes in terms of water type, storage limits, and sharing restrictions should be implemented as soon as possible for the hydraulic fracturing industry. The barrier on inter-basin transfer should be assessed to ensure that if inter-basin transfer could occur, any sources of cross contamination would be mitigated. Further research and diligent public consultation are recommended for pursuing this option.

In addition to updates in the regulations and legislation, a voluntary incentive program that encourages producers to recycle more of their produced and flowback waters instead of disposing of the wastewater in a well is recommended. An incentive program structure is recommended ensure that recycling initiatives do not add economic stress to projects in addition to ensuring that firms engage in this program quickly. The proposed program will be evaluated against set metrics and targets. The proposed metrics are water intensity, the volume of water intake per barrel of oil produced (BOE), and percentage of water recycled. In 2017, the AER reported water intensity of 0.59 barrels of water per BOE.[17] To ensure that there is an increase in the amount of alternatives to non-saline water being used, this metric should be reported for both saline and non-saline sources With water recycling in the industry only being at 4% in 2017, a tiered approach is recommended for setting the target. The incentive would be provided to companies that take up the voluntary program as tax incentives.

A similar program designed for the Eagle Ford Shale in Texas encourages the reduction of freshwater use by implementing a reduction on the rate of oil severance tax payed by the operator.[18] In Alberta, this would be comparable to a reduction to the rate of the Freehold Mineral Tax.[19] However, it is important to note that the program in Texas focuses mainly on the reduction on non-saline water by replacing it with brackish-water because it is a heavily water-constrained area and their main concern is

---

[16]Alberta Energy Regulator, Interim Guidance to Authorize Reuse of Municipal and Industrial Wastewaterraft Directive, December 2017 https://open.alberta.ca/dataset/e2d7d93c-8ce2-4db7-8356-2e6b844f5463/resource/b420cb8a-e317-46fe-b0b1-b7f6c2049415/download/reusemunicipalindustrialwastewater-2015.pdf ; Multi Stakeholder panel for the Area-Based Regulation Pilot, "Enabling the Use of Alternatives to High quality Non-saline Water."

[17] Alberta Energy Regulator, Hydraulic Fracturing Water Use Report Summary, last accessed May 1, 2019, https://www.aer.ca/protecting-what-matters/holding-industry-accountable/industry-performance/hydraulic-fracturing-water-use

[18] Arnett, Benton, Healy, Kevin, Jiang, Zhongnan, LeClere, David, McLaughlin, Leslie Roberts, Joey Steadman, Maxwell, "Water Use in the Eagle Ford Shale," The Bush School Of Government And Public Service https://bush.tamu.edu/psaa/capstones/projects/2014/Hydraulic%20Fracturing%20in%20the%20Eagle%20Ford%20Shale.pdf

[19] Alberta Royalty Review 2007, What are royalties, https://www.energy.alberta.ca/AU/History/Documents/InfoSeries-Report1-Royalty.pdf

water conservation. This differs from our goal of not only reducing non-saline water use but also increasing the recycling of flowback and produced waters.

In order to be successful, the proposed program design needs to adequately address uptake, risk mitigation, a balanced environmental footprint, and meaningful consultation with stakeholders. While the AER can modify regulations to require a specified amount of non-saline water use in hydraulic fracturing operations, it does not make sense to enforce a mandatory requirement due to the variability between the geological and hydrogeological features of formations that are being drilled and uncertainty related to acquiring non-saline water sources. In relation to the water cycle, advantages of recycling water include reduced need for long range trucking of non-saline water and the potential for reduced costs related to transportation and treatment of water to be disposed of. Though, there are costs associated with sharing water including storage, transportation, and potentially treatment to mitigate any risks from mixing various sources of recycle water. The tax incentive, in conjunction with regulatory changes, needs to make the option of recycling water more feasible than using allocated non-saline water.

The program design should also consider the environmental impact associated with using more non-saline water resources. There is a trade-off between energy use and conservation of water.[20] However, there is no level comparison that can be made to define it if better to use more energy and produce emissions to conserve fresh water versus the other way around. It is recommended that total surface and ground water resources in Alberta need to be mapped out to provide policy makers and industry with a baseline to make this decision.[21]

Important stakeholders in the design of this incentive program include industry, the public, indigenous communities, and the British Columbia Oil and Gas Commission (BCOGC). Consultation is required with companies to determine the adequate value of a tax incentive that would bring expedite uptake of the program. Public conversations consultations are required with Albertans, specifically those from indigenous communities. This reworking of the water management process is a substantial opportunity to address Truth and Reconciliation with Canada’s Indigenous peoples through resource management.[22] Due to the cross-border activity for hydraulic fracturing operations, it is vital to ensure that any new policy implemented in coordination with the BCOGC.

4.0 Conclusions

Current policy in Alberta prevents the reuse of industrial wastewater which results in hydraulic fracturing operations using more non-saline water resources than may be required. This paper proposes a policy framework to update regulations and implement a government-initiated incentive program which allows and appropriately rewards producers to pursue more recycling of produced and flowback water in their hydraulic fracturing operations.

---

[20] Paul, Kenway, and Mukheibir. "How Scale and Technology Influence the Energy Intensity of Water Recycling Systems-An Analytical Review." Journal of Cleaner Production 215 (2019): 1457-480.

[21] Chunn, David, Monireh Faramarzi, Brian Smerdon, and Daniel S. Alessi. "Application of an Integrated SWAT–MODFLOW Model to Evaluate Potential Impacts of Climate Change and Water Withdrawals on Groundwater–Surface Water Interactions in West-Central Alberta." Water 11, no. 1 (2019): 110.

[22] Ellis, Jim. Water Rites: Reimagining Water in the West. University of Calgary Press, 2018.

Based on the potential risks with wastewater disposal, which are well managed but still not eliminated, the goal to conserve of non-saline water sources, and the current public perception of hydraulic fracturing activities, this policy direction will allow producers to maintain the social license to operate while still preserving the economic freedom to determine how much recycling is feasible for each operation.

5.0 Acknowledgements

The authors have undertaken this study as part of the ReDeveLoP program. We would like to acknowledge support received from our academic advisor, Dr. Bernhard Mayer, our policy advisor, Dr. Jennifer Winter, and multiple industry advisors throughout the process.

6.0 References

Alberta Energy Regulator, Interim Guidance to Authorize Reuse of Municipal and Industrial Wastewater draft Directive, December 2017. https://open.alberta.ca/dataset/e2d7d93c-8ce2-4db7-8356-2e6b844f5463/resource/b420cb8a-e317-46fe-b0b1-b7f6c2049415/download/reusemunicipalindustrialwastewater-2015.pdf

---, Hydraulic Fracturing Water Use Report Summary, last accessed May 1, 2019, https://www.aer.ca/protecting-what-matters/holding-industry-accountable/industry-performance/hydraulic-fracturing-water-use.

---, Alberta Energy Industry Water Use Report – Hydraulic Fracturing, Hydraulic Fracturing Water Use Summary, last Accessed May 9, 2019, https://www2.aer.ca/t/Production/views/HydraulicFracturingWaterUseReport/HydraulicFracturingWaterUseSummary?%3Aembed=y&%3Atoolbar=top&%3AshowShareOptions=true&%3Adisplay_count=no&%3AshowVizHome=no.

---(1994). Directive 051: Injection and Disposal Wells – Well Classifications, Completions, Logging, and Testing Requirements.

--- (2001). Directive 055: Storage Requirements for the Upstream Petroleum Industry.

--- (2011). Directive 077: Pipelines- requirements and reference tools.

--- (2017). Directive 071: Emergency Preparedness and Response Requirements for the Petroleum Industry.

--- (2018). Directive 013: Suspension Requirements for wells.

---, Water, last accessed March 31, 2019 https://www.aer.ca/providing-information/by-topic/water.

Alberta Urban Municipalities Association, Facts About Water, Last accessed April 26, 2019 https://auma.ca/advocacy-services/programs-initiatives/water-management/facts-about-water.

Alberta Royalty Review 2007, What are royalties, https://www.energy.alberta.ca/AU/History/Documents/InfoSeries-Report1-Royalty.pdf.

Alberta Water Portal Society, Work: WaterPortal Business and Technology Directory, Last accessed April 24, 2019, https://albertawater.com/water-catalog.

Alessi, D., Zolfaghari, A., Kletke, S., Gehman, J., Allen D., Goss, G. 2017. Comparative analysis of hydraulic fracturing wastewater practices in unconventional shale development: Water sourcing, treatment and disposal practices, Canadian Water Resources Journal. 105-121.

Arnett, Benton, Healy, Kevin, Jiang, Zhongnan, LeClere, David, McLaughlin, Leslie Roberts, Joey Steadman, Maxwell, "Water Use in the Eagle Ford Shale," The Bush School Of Government And Public Service https://bush.tamu.edu/psaa/capstones/projects/2014/Hydraulic%20Fracturing%20in%20the%20Eagle%20Ford%20Shale.pdf.

Chunn, David, Monireh Faramarzi, Brian Smerdon, and Daniel S. Alessi. "Application of an Integrated SWAT–MODFLOW Model to Evaluate Potential Impacts of Climate Change and Water Withdrawals on Groundwater–Surface Water Interactions in West-Central Alberta." Water 11, no. 1 (2019): 110.

Ellis, Jim. Water Rites: Reimagining Water in the West. University of Calgary Press, 2018.

International Energy Agency, "World Energy Outlook 2018," OECD/IEA.

Multi Stakeholder panel for the Area-Based Regulation Pilot, 2017, "Enabling the Use of Alternatives to High quality Non-saline Water by the Oil and Gas Sector in the MD of Greenview," https://www.aer.ca/documents/reports/AreaBasedRegulation_RecommendationReport.pdf.

Paul, Kenway, and Mukheibir. "How Scale and Technology Influence the Energy Intensity of Water Recycling Systems-An Analytical Review." Journal of Cleaner Production 215 (2019): 1457-480.

Responsible Energy Development Act, SA 2012, c R-17.3.

Wastewater and Storm Drainage Regulation, Alta Reg 119/1993, Part 1.

Water Act, RSA 2000, c W-3.

Waughray, D., "Water Security—The Water-Food-Energy-Climate Nexus." World Economic Forum Water Initiative; Island Press: Washington, DC, USA, 2011, http://www3.weforum.org/docs/WEF_WI_WaterSecurity_WaterFoodEnergyClimateNexus_2011.pdf; Alberta, Population Statistics, https://www.alberta.ca/population-statistics.aspx.