Collaboration Opportunity Assessment

Water Collaboration Assessment for Unconventional Gas Development

Prepared for

Petroleum Technology Alliance of Canada

Integrated Sustainability Consultants Ltd. 14 July 2015

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Table of Contents

Tables within Text

Figures within Text

Appendices

1 INTRODUCTION

Integrated Sustainability Consultants Ltd. (Integrated Sustainability) was retained by Alberta Upstream Petroleum Research Fund (AUPRF) to investigate the potential benefits of collaboration between gas producers on water infrastructure projects supporting hydraulic fracturing for unconventional oil and gas (UCOG) development activities in the Western Canadian Sedimentary Basin (WCSB). The investigation of potential collaboration opportunities was broken-down into two project phases as detailed below:

Phase 1 (previous project) involved the facilitation of a workshop between shale gas producers (PTAC Water Collaboration Workshop) to collect information about previous experiences with collaboration, assess real and "perceived" constraints (i.e. regulatory, corporate, or other), and uncover potential opportunities. A summary of the workshop discussions and outcomes was submitted to Petroleum Technology Alliance of Canada (PTAC) on 20 June 2014 (Integrated Sustainability 2014) and is attached as Appendix 1.

Phase 2 (this project) has been designed to evaluate two potential collaboration opportunities that were identified in Phase 1, and address knowledge gaps around the constraints identified. Background research was conducted around potential constraints that currently affect each collaboration opportunity chosen for further analysis. The following report provides a summary of the findings.

2 PURPOSE

The purpose of this study is to expand on the discussions generated during the PTAC Water Collaboration Workshop by examining current and emerging regulations potentially affecting the ability of producers to achieve a collaborative solution, and by evaluating two of the identified water collaboration opportunities:

- Water intake sharing
- Groundwater monitoring data sharing

These two options have ben assessed to determine if they exist as viable, sustainable, and profitable activities to consider for future investment. In addition, this report can help guide discussions with regulatory agencies with respect to these two opportunities in order to promote collaboration in water infrastructure and assist in optimizing the regulatory process.

This report presents a summary of the research carried out on each of the two above-noted opportunities. Each opportunity was evaluated using a holistic approach, by taking into consideration the following criteria:

- Economic
- Operational
- Regulatory

- Legal and Liability
- Environmental

3 BACKGROUND SUMMARY – WORKSHOP RESULTS

On 14 May 2014, Integrated Sustainability designed and facilitated a workshop for members of Canadian Association of Petroleum Producers (CAPP). The goal of the workshop was:

> *To investigate innovative water stewardship practices through a collaborative model that ensures the protection of water resources and the sustainable development of Unconventional Oil and Gas (UCOG) in the WCSB, while ensuring continued benefits to industry, government, and the public.*

Topics discussed in the workshop included:

- Defining "collaboration" and creating a common understanding of the term
- Identifying potential regulatory, social, environmental, economic, operational, and technical opportunities and barriers to the collaborative approach

A total of 23 members from industry, representing 13 individual organizations, attended the workshop. These attendees represented a variety of disciplines and expertise including, but not limited to, well completions, well operations, regulatory, communications, and water management.

A summary of key discussion points, comments, and outcomes of the workshop was submitted to PTAC on 20 June 2014, and was used as the foundation to guide this second phase of the study.

3.1 Definition of Collaboration

During the workshop, participants were asked to provide a statement defining collaboration. The following four definitions were generated:

1) "To work with a common purpose to identify risks and opportunities in an orderly and timely manner that brings long-term value to industry, stakeholders, and regulatory management. A drive for consistent messaging."
2) "Working in a facilitative, cooperative environment, while maintaining a level of confidentiality to reach a common goal."
3) "A group of individuals with their own distinct goals and activity schedule that work together to achieve water security with impact reduction and shared economic benefit."
4) "Collaboration is mutually beneficial to industry, government, public, environment, and all stakeholders. It is self-determining, based on knowledge sharing, economic aspects, environmental footprint reduction, and social acceptance. Collaboration is effective communication and adaption."

These statements have been amalgamated and used as the basis to generate the following clear definition of collaboration with respect to water in UCOG development:

> *Collaboration is defined as the ability for multiple parties with distinct goals but a common purpose to work together in a cooperative manner, while protecting corporate interests, in order to achieve mutually beneficial results that bring both short and long-term value to all stakeholders.*
>
> *Effective collaboration relies on open and timely communication between parties, while taking into consideration factors such as shared economic benefits, water security, environmental footprint reduction, and social acceptance.*

3.2 Summary of Discussions

As a whole, the group expressed interest, and willingness to collaborate based on economic, social, and environmental advantages even while recognizing that there are major internal and external hurdles to overcome in order to achieve this goal. The real challenge the group articulated is the ability to set up a structure that would facilitate and gain consensus in order to drive investment in collaboration. There is an openness within the organizations to collaborate, but only if the group can move at a pace fast enough to meet business demands while protecting both confidentiality and corporate competitiveness.

It was clear that collaborative opportunities vary widely by resource play and the characteristics of each producer. The desire of the group was to use an approach that could be applied to varying sizes of working teams, including partnerships between individual companies up to, and including, regional collaborative opportunities. Work needs to be done to prove the business case that collaborative opportunities brainstormed in the session would achieve economic benefit in a reasonable return window. Without hard proof of cost savings, or operational efficiencies, many in the group felt obtaining the time and resources required to make collaboration effective could be difficult in the short-term, but not impossible. The group agreed that there is an opportunity to set up an organization, or framework, for information sharing, but it needs to maintain a trusted structure that makes it “safe to do so.” Existing models, such as Oil Sands Leadership Initiative (OSLI) and Canada's Oil Sands Innovation Alliance (COSIA), were identified as possible opportunities to leverage.

There are currently small successes being achieved by “on the ground” operations teams through local company-to-company contact. There is a lack of public awareness about collaborative activities that are already occurring within the industry, which is noted as a lost opportunity. Further emphasis should be placed on communicating these collaborative efforts and this should be the responsibility of both industry and the government. This increased awareness will help to increase investment in collaboration, as concrete gains have not been realized to date.

Questions arose during the workshop as to whether regulatory agencies are open to accepting industry ideas for collaboration and whether they are willing to expedite required policy changes in order to create a structure that supports the implementation of these ideas. Evidence was provided that Alberta is heading in that direction, with British Columbia beginning to align as well.

From a values perspective, the group agreed that there is corporate interest in seeing efficient use of natural resources and minimizing project-related impacts. The group recognized that in the longer-term, collaboration **must** happen for industry to be successful, and for the public to benefit. But the right way to build momentum to achieve this goal was unclear.

Collaboration is also recognized as a trade-off for individual control and that the payoff needs to justify any cost associated with compromises made. In order for industry to adopt collaboration, the benefits have to be attractive enough to persuade producers away from business-as-usual operations towards more innovative solutions.

The collaboration opportunity is seen as a way for UCOG industry to take a self-initiated leadership position on water stewardship and perhaps raise the "sustainability performance bar" for other jurisdictions in Canada, and abroad, facing similar challenges.

Participants in the workshop agreed that successful collaboration requires a solid and collectively agreed-upon facilitation framework.

4 REGULATORY FRAMEWORK

4.1 British Columbia Regulations

The British Columbia (BC) Oil and Gas Commission (OGC) is the independent regulatory agency responsible for overseeing all oil and gas operations in the province. The OGC regulates industry using the following key pieces of legislation:

- Oil and Gas Activities Act (OGAA)
- Petroleum and Natural Gas (PNG) Act
- Environmental Management Act (EMA)
- All associated guidelines (OGC 2014)

The OGC is the designated regulatory agency responsible for reviewing, assessing, and authorizing the use of surface and subsurface water in UCOG developments, in BC as well as regulating the operation of associated water infrastructure (OGC 2014).

In 2014, the Government of BC modernized their *Water Act,* and replaced it with the *Water Sustainability Act*, which aims to take steps to ensure that BC's supply of fresh, clean water is managed sustainably given the pressures of a growing population, a changing climate, and expanding development in the province. The current Water Act will remain in force until the *Water Sustainability Act* is brought into effect in 2016. At that time, the *Water Act* will be repealed.

4.1.1 Emerging Regulations

BC has seen a shift in resource development over the last 10 years, with increasingly significant investment being made in the province's UCOG sector. In an effort to protect the public's interest, the OGC has been shifting towards area-based analysis, which "facilitates and promotes up-front development planning and collaboration," (OGC 2013, p. 5) and "encourages more efficient use of planned and existing infrastructure - reducing costs and environmental impacts" (OGC 2013, p. 5).

In 2012, the Ministry of Energy and Mines released its natural gas strategy, which focused specifically on the development of the liquefied natural gas (LNG) sector within the province. The strategy made special reference to collaboration, stating: "exploring collaborative approaches to the development of pipeline infrastructure to support LNG projects is key to ensure our natural gas reaches markets" (BC Ministry of Energy and Mines 2012, p.7). Subsequently, in July 2014, the OGC enacted the *Liquefied Natural Gas Facility Regulation* (LNGFR) under the OGAA in order to address regulatory aspects associated with LNG facilities.

The OGC has been working closely with the Alberta Energy Regulator (AER), and taking some direction from Alberta's well-established regulatory regime around oil and gas development. This relationship with the AER is directly aligned with the strategic priorities set out in OGC's 2014/15-2016/17 Service Plan, which states that the OGC will "continue to seek early collaboration and build memorandums of understanding (MOUs) with partner agencies to drive efficient and effective joint federal/provincial reviews where necessary" (OGC 2014, p.13). As such, collaboration amongst the regulators will allow for more alignment in regulations between the provinces, which will provide greater clarity around regulatory requirements and will minimize inefficiencies for industry working in both provinces. This applies particularly to UCOG plays that extend across provincial borders (e.g. the Montney Formation of northwest Alberta and northeast BC).

Specifically, with respect to water, the emerging BC *Water Sustainability Act* states that if joint use of water diversion by two or more authorization holders would conserve water, or avoid duplication of works, joint construction or use may be ordered (Government of BC 2014).

4.2 Alberta Regulations

The Alberta Energy Regulator (AER), formerly the Energy Resource Conservation Board (ERCB), and Alberta Environment and Sustainable Resource Development (ESRD) are two key regulatory agencies in Alberta. Traditionally, the AER has been responsible for sub-surface and surface energy development projects and has issued permits relating to injection schemes, surface infrastructure and pipelines, metering requirements, etc. The ESRD has been responsible for air, land, water, biodiversity and waste stewardship and has issued land tenures, surface water withdrawals and waste discharge permits.

With the enactment of the *Responsible Energy Development Act* (REDA) in 2012, many of the traditional ESRD roles are being shifted to the AER (Province of Alberta 2012). The goal of the new Act and the change in designated responsibilities is to provide operators with a single-window approach to permitting upstream energy development projects, including managing all regulatory submissions. At a 2013 PTAC forum on water, Bob Willard, senior advisor in the ERCB's operations division, stated: "Enhanced planning, collaborative engagement, measured outcomes. Those are things you'll be hearing over and over from the new regulator" (Harrison 2013).

While the AER is ultimately responsible for managing water allocation, there are a host of other players shaping the future of water use in Alberta, including the Alberta Water Council, 11 Watershed Planning and Advisory Councils (WPACs), Watershed Stewardship Groups, as well as other grassroots organizations (Romanowska 2013).

New guidelines expected in 2015, which will come in the form of a revision to the Water Conservation and Allocation Guideline for Oilfield Injection 2006, will update the requirements for obtaining a term licence for water used in hydraulic fracturing as well as other oil and gas development activities. While the focus on collaboration is not novel, these new water-licensing requirements will require that industry collaborate amongst each other to identify more efficient solutions to water management. Modifications to the requirements specifically centered on collaboration are summarized in Section 4.2.1 below. The Water Conservation and Allocation Guideline for Oilfield Injection addendum is currently under stakeholder review, and will not be available for public viewing until sometime in 2015.

4.2.1 Emerging Regulations

Like the OGC, the regulatory environment, both historical and current, in Alberta is squarely in favour of collaborative efforts amongst UCOG companies located within similar development areas. For example, a discussion paper issued by the former ERCB in December 2012 states that:

> *the ERCB believes collaboration on play development plans is the most effective way to achieve regulatory outcomes and strongly encourages companies to consider play-focused operator groups early in the development process. Collaboration will allow optimization of infrastructure needs and placement, sharing of information and knowledge, and a one-window approach for communication with stakeholders* (ERCB 2012, p.3).

In addition, "increased emphasis on planning and collaboration among operators and other stakeholders within a play will be critical given the nature of unconventional resources— their large continuous extent, potential regional effects, the technology and infrastructure needed to exploit them, and the need to maximize economic efficiency" (ESRD 2012, p.12).

The following quote from the recently released Play-Based Regulation: Pilot Application Guide (AER 2014a) is also an indication of this position:

> *As part of the evolving regulatory process, AER is conducting the Play-Based Regulation (PBR) pilot to unconventional oil and gas development. PBR is a*

regulatory process to manage the risk of a play through collaborative planning by operators within an area to mitigate and minimize the effects of development. PBR is based on two principles:

1) *Risk-based regulation – regulatory responses are proportional to the level of risk posed by energy development, with a focus on those areas that present the greatest risk to achieving regulatory objectives.*
2) *Paly-focussed regulation – the regulatory approach is tailored to a resource "play" to achieve environmental, economic, and social outcomes set by the GoA.*

The movement towards collaboration will likely gain momentum in 2015/2016 with the release of the ESRD's "Draft Water Conservation Policy for Upstream Oil and Gas Operations," which is expected to focus on:

- Achieving cooperation and collaboration between industry operators and projects in each "play" area to minimize development impacts
- Results and practices in each "play" area that optimize development outcomes and minimize cumulative impacts
- Water conservation objectives and water allocation within play-based water management plans

The province is putting the onus on industry to develop and implement a suitable and effective system for water sharing within established watersheds, as it does not want to impose legislated requirements on industry for sharing the water during low flow times. The "[AER] want the group of companies, say in the Duvernay Fox Creek area, to work together, to collaborate on things like water sourcing, waste management, perhaps even the transportation planning... to find large-scale solutions" noted Bob Willard from ERCB (Harrison 2013). Another example is the *Lower Athabasca Regional Plan*, which provides guidance to all water users, including the oil sands operators, on the management of water within the Lower Athabasca Region. This plan has set out some ideas for collaborative water use amongst the mineable oil sands operators during low flow periods, which includes enhanced storage and a change in time of use (ESRD 2012).

Another form of collaboration currently being encouraged in Alberta is through integrated clusters, which could include upgraders, refineries, and associated petrochemical and chemical industries (eco-industrial complexes). Benefits of these integrated clusters include the reduction in the "overall environmental impact through reduced footprint, less waste produced, lower total impact on air quality (fuel efficiencies), more effective placement of emergency services and infrastructure, reduced or shared water use, and more effective waste water management" (Government of Alberta 2014).

4.3 Potential Regulatory Barriers to Collaboration

In both BC and Alberta, operators are challenged by a number of regulatory barriers that make it difficult to efficiently and effectively collaborate.

In BC, for example, there is currently no established regulatory framework that allows more than one company to operate a facility. However, operators are undertaking shared water infrastructure agreements on an as-needed basis, with the intent to maximize use of existing infrastructure and minimize the distance required to transport water. Based on the current regulatory framework, all regulatory licences and approvals are obtained under one company, considered "the operator." A company must then enter into a separate commercial agreement with another operator if it wishes to collaborate in order to capitalize on the benefits, which include cost and resource sharing. This requirement inhibits collaborating, as questions arise around who is legally liable if oil and gas activities that result in incidents, such as leaks, spills, and pollution, impact the environment. Legal liability consequences may include damages, administrative penalties, fines, complete shut-in of operations, and compensation awards. As such, there is a need for regulators to expedite changes to existing regulations by allowing joint operators and clearly defining the legal liability structure and management framework for this type of agreement, in order to provide incentive to companies to collaborate in the application process.

Under the Alberta *Water Act* the ability to establish water cooperatives presents an opportunity for UCOG companies. Under such a scenario, two or more companies would work together to establish a collaborative water supply system, which would then be managed by an established board. The benefit of such an approach is a streamlining (reduction) of numerous *Water Act* applications into one, leading to a more efficient regulatory and stakeholder review process, improved system management and reduce costs. It is believed that this approach has not yet been employed in Alberta, but certainly exists as a potential solution to water management challenges in the UCOG sector.

5 COLLABORATION OPPORTUNITIES DESCRIPTIONS

One of the goals of the Phase 2 Collaboration Opportunity Assessment is to identify two possible examples where collaboration could benefit the UCOG industry. The following sections highlight the two examples identified, which are:

- Water intake sharing
- Groundwater monitoring data sharing

5.1 Water Intake Sharing

5.1.1 Background

Modern hydraulic fracturing operations typically require large volumes of water during the completions phase. UCOG resource development in BC and Alberta typically occurs in areas that are considered to have abundant fresh water availability. These rivers are part of larger watersheds that drain runoff and discharge to the east and north across areas with low population density and little to no dependency from the agricultural industry.

Within the WCSB, the use of river intakes by UCOG producers for surface water collection is common. For oil and gas resources in close proximity to these surface water sources, rivers can offer a water sourcing option with relatively low environmental impact. In many instances, even at the high water demand rates required for hydraulic fracturing, only one river source is required to supply water for multiple operations.

Due to the nature of hydraulic fracturing operations, each producer may only require the use of an intake for short periods of time during the year, and often for only the first several years during start-up of individual resource plays. This demand-timing constraint presents an opportunity for sharing water intakes between multiple production companies working in a similar area.

The following assessment will compare the advantages and disadvantages of a shared water intake system. The potential benefits of sharing a facility between multiple parties could include reduced environmental impact, lower shared capital and operating costs, and increased regulatory efficiencies. The trade-offs to these benefits may come in the form of increased legal and liability considerations and operational complexity.

The intent of this assessment is to explore a scenario of water asset collaboration in order to determine the net benefit to the parties involved. By examining a simplistic case of collaboration between two operators from a holistic perspective, the overall net benefits should be better understood.

5.1.2 Scenario Framing

During the collaboration workshop held in Phase 1 of this project, the participants put forward water intakes as an asset type with high possibility for mutual benefit from a multi-user set-up. This was due to the high cost of such assets and the short period of use during the lifecycle of UCOG asset development.

Water intake systems vary widely in type, size, and the processes involved. In order to provide relevant and useable information in this review process, a system representative of what is commonly employed in UCOG operations was evaluated. The system type reviewed is a typical river infiltration gallery, located in either northeastern British Columbia or northwestern Alberta, sized for use in unconventional shale gas applications.

The status quo approach to development of an infiltration gallery is one producer taking on all planning, financing, construction, operations, maintenance, and decommissioning. The opportunity to be evaluated against this status quo approach is a scenario where two companies jointly share the production volume of one larger water intake facility. Although many potential variations of this particular intake-sharing example exist, in this evaluation, a scenario where one producer acts as the Facility Owner and the second as a Leasee is examined.

Table A outlines the responsibilities of each party in a shared intake agreement.

Table A. Outline of the responsibilities for each party in a shared intake agreement

<table>
<tr><th>Facility Owner</th><th>Leasee</th></tr>
<tr><td>

Finance development and operation of facility
Retain ownership of facility
Present commercial agreement to Leasee that defines:

All shared costs
Shared liabilities
Operating procedures

Subcontract Engineering, Procurement and Construction
Regulatory applications submission
Construction of facility
Operation of facility (personnel, safety, reporting, and maintenance)
Cost tracking and accounting
Meet water use regulation requirements

</td><td>

Sign commercial agreement
Meet contractual obligations including all financial obligations
Meet water use regulation requirements
Provide volume usage reporting to regulator (potential)
Qualified corporation, as required by the regulator

</td></tr>
</table>

The two scenarios will be compared using the following categories:

- Economic
- Operational
- Regulatory
- Environmental
- Legal and Liability

5.1.3 System Description

The intake design used for this evaluation is an infiltration gallery due to its common applicability and usage. An infiltration gallery consists of perforated pipes installed approximately 2 m below the base of a river or stream (see Figure A). The intake pipes are connected to an onshore wet well sitting below a pumping facility. The intake pipes are typically installed by directional drilling into the granular sediments comprising the riverbed.

Infiltration galleries are often used when there is a concern regarding river depth (for navigation purposes), the presence of high sediment loading (i.e. suspended solids management), ice accumulation in the winter, and/or sensitive fish species). The main source of failure for infiltration galleries is the ingress of fine material or the accumulation of anchor ice, which lowers the hydraulic conductivity of the riverbed material and hence the deliverability of water from the system. Back flushing using water or air is a system requirement for maintenance, especially for river systems transporting large quantities of fine sediment.

An intake building is constructed on top of the wet-well to house the pumping systems and all other axillary equipment. In more northern areas these buildings will require heating due to the lower seasonal temperatures and will need to be designed for operation in year round conditions.

Pipelines from the riverbed intake and wet well system convey water to site operations and/or storage. A single pump can be designed to convey water from the wet well to site operations via a permanent pipeline. In this example, site operations are assumed to consist of an above ground unpressurized tank with an elevation 10 m above the wet well.

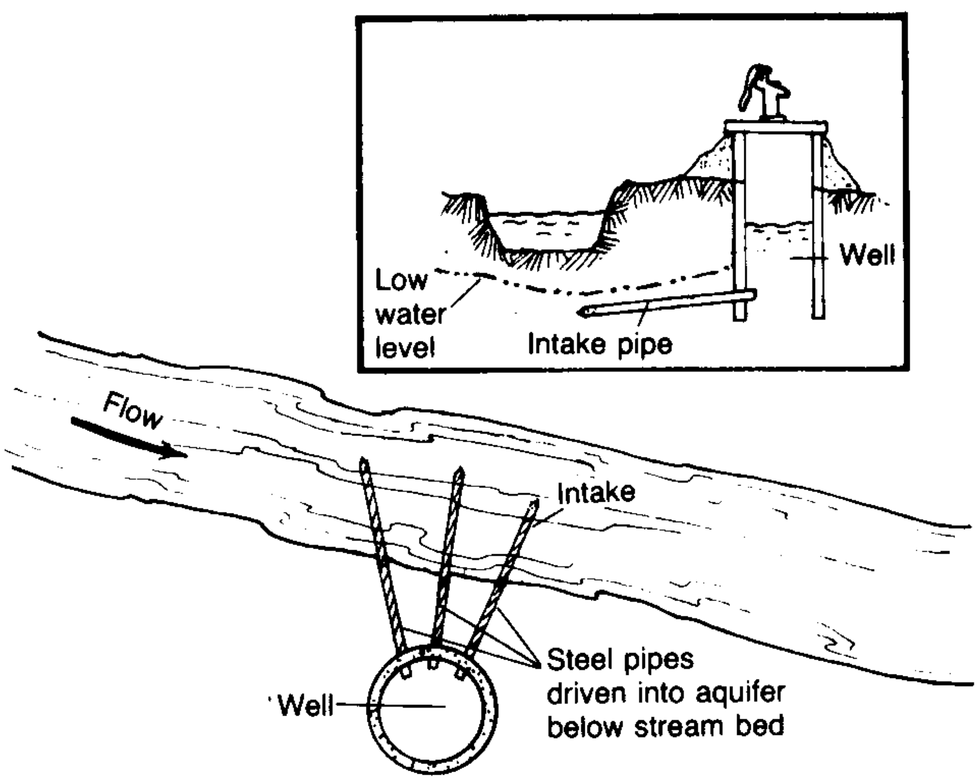

Figure A. Example of an infiltration gallery style water intake

(Source: USAID, n.d. Water for The World: Designing Water Intakes for Rivers and Streams – Technical Note No. RWS. 1.D.3.)

5.1.4 Scenario Assumptions

The two scenarios assessed focus on providing a realistic and relevant case for hydraulic fracturing operators in northeastern British Columbia or northwestern Alberta. A number of assumptions were generated to assess these scenarios from a holistic point of view. These assumptions for Scenario 1 and Scenario 2 are summarized in Table B. The assumptions made are based on the experience of, and conversations with, individuals from CAPP member companies (where not otherwise explicitly stated).

Table B. A summary of the two water intake scenarios

Scenario 1	Scenario 2
Two facilities, each with the following characteristics: ▪ Water production volume of 10 000 m^3/d ▪ One owner ▪ One operator ▪ Connection via a 5 km pipeline ▪ One pumping system	**One** shared facility with the following characteristics: ▪ Water production volume of 20 000 m^3/d ▪ Two owners ▪ One operator ▪ Connections via two 7.5 km pipelines (one to each operator site) ▪ Two pumping systems ▪ Commercial agreements defining: – Cost sharing – Liability sharing – Operating conditions

Figure B depicts the assumed configuration of Scenario 1 and Scenario 2. This configuration takes into account the optimal location trade-offs that may need to be made by each company when sharing a water intake.

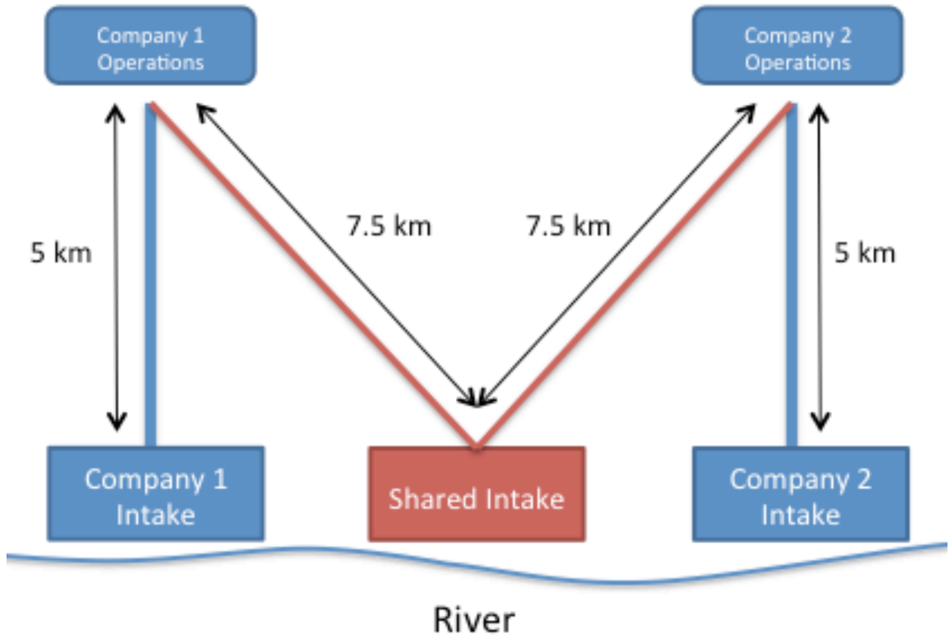

Figure B. Diagram of the assumed arrangement for the water intake scenarios

The capital cost estimation portion of the intake evaluation relies heavily on ideal site selection with compatible hydrogeological conditions. Some variations away from the assumed conditions are likely and would change the overall cost of the system. The cost escalation would, however, be similar for both scenarios. Further details on the assumptions used in the cost estimation process are provided in Appendix 2.

Scenario 2, as depicted, shows the most basic operational setup for an analysis of the opportunity for a shared intake. In reality, the tie-in to the operations of each company could be any distance apart and is unlikely to be equal. The exception being where two companies tie into an additional shared piece of infrastructure, located down stream, such as a trucking facility.

The benefits of a shared intake begin to decrease as the distance between the two companies operations increases. Due to the multitude of potential scenarios that exist, and the number of variables that must be considered in the analysis, no specific break-even point can be determined. Potential limiting factors for the use of a shared intake include access to alternate viable intake locations, pipeline costs, and regulatory restrictions. An analysis a kin to the one completed here should be completed to assess each individual opportunity for collaboration on a shared intake.

In addition, under Scenario 2, there are many possible ways of structuring a commercial agreement between two parties. One of the simpler approaches was assumed to minimize the overall legal and liability complexity. Details of this approach and the assumed risks associated with an intake facility are covered in Section 7.

5.1.5 Exclusions from Scope

For the purpose of this analysis, the focus was narrowed to a water intake and excluded all other infrastructure that is often associated with intakes. Exclusions from the scope of the intake system being evaluated include:

- Water treatment systems (solids removal, de-aeration, chlorination, etc.)
- Storage or equalization systems
- Any systems downstream of pipelines

5.2 Groundwater Monitoring Data Sharing

5.2.1 Background

By far one of the highest value/low cast opportunities in the water space for the UCOG sector is groundwater monitoring data sharing. This opportunity applies to all aspects of water, whether it is sourcing, or disposal. Knowledge of the subsurface is an area where significant opportunity exists for sharing information and refining understanding. Groundwater is becoming an important aspect to the development of unconventional oil and gas resources in Western Canada (i.e. oil sands, shale gas, other tight formations), or secondary and tertiary recovery schemes associated with conventional production.

Shallow groundwater is a renewable resource that is annually recharged from surface by infiltrating precipitation and surface runoff (i.e. rain and snow melt). The volumes of groundwater in Canada are significant, and are a viable water supply option when surface water sources are not readily available, or existing sources are unable to provide the volumes of water required when and where they are needed.

There are both shallow and deep groundwater systems across Western Canada with varying chemical quality (i.e. salinity) and associated capacity to deliver water. Shallower groundwater intervals tend to have better quality water than deeper systems, but have a greater chance of interacting with surface water bodies and wetlands. This latter aspect generates the perception that shallow aquifers are riskier prospects from a regulatory perspective. Nevertheless, the better quality conditions compared to deeper systems generally results in lower treatment costs, lower energy footprint, and less waste required to be managed.

Deeper aquifers typically contain older, more saline waters and are usually disconnected from near surface environments by layers. Given their depth, saline aquifers tend to be isolated from the near-surface environment by layers of low permeability rock. As such, the risk of interaction between deep aquifers and near surface systems (i.e. shallow aquifers and/or surface water bodies) is less than for shallow aquifers systems. Although the use of saline groundwater is perceived as a better option, the costs of establishing such systems including construction, operation, maintenance, water treatment and waste management are considerably higher.

Knowledge of groundwater systems in Canada is increasing as a result of exploration and development activities by oil and gas sector. For areas in the WCSB without access to sustainable (i.e. available and reliable) surface water supplies, an alternative is groundwater, which has become an essential supply source for the development of UCOG (i.e. shale gas and tight formations). Recent examples of surface water shortfalls in northern BC and Alberta has underscored the importance of groundwater in providing resiliency to some of these energy projects.

Exploration activities are an important component of finding an adequate groundwater source to meet operational demands as publically available information regarding the subsurface (i.e. geology, formation characteristics, water chemistry, aquifer yields) is often limited. Operators typically gather groundwater information for internal use only or to meet regulatory requirements; however, this information is not commonly shared between companies. As such, this typically results in overlap of information gathering activities in similar areas and budgetary redundancy. This may include numerous parties within the same operating area establishing unnecessary monitoring that is expensive and impactful to the environment, yet does not generate any greater understanding or knowledge of the subsurface systems. As such, groundwater knowledge sharing is a way to create business opportunity, while minimizing the costs associated with intrusive investigations and the associated environmental footprint.

Some of the areas of greatest opportunity with respect to groundwater knowledge sharing relate to the following:

- Development of a consistent conceptual understanding of groundwater systems and their potential interaction with the surface environment
- Development of broad-scale monitoring systems to assess impacts to groundwater sustainability from cumulative stresses (i.e. siting and installation of monitoring infrastructure)
- Gathering and management of monitoring data (i.e. database and GIS systems)
- Evaluation of monitoring data and communication of results in an understandable and meaningful way to regulators and key stakeholders

5.2.2 Current Examples of Groundwater Monitoring Data Sharing

Groundwater monitoring data sharing does occur in provinces such as BC, Alberta, and Saskatchewan. However, the majority of these initiatives are driven by government supported agencies and stakeholders and are regional in scale, with localized, inter-company data sharing being a less common scenario. In many cases, these initiatives occur when a threat to a water supply source or disposal interval is identified. A few examples of groundwater monitoring data sharing agencies and arrangements include:

British Columbia

- Geoscience BC is an industry led not-for-profit society that is funded by the provincial government and works in partnership with industry, academia, government, First Nations, and communities. In response to stakeholder concern for water security and management, Geoscience BC started developing the Montney Water Project in 2010. The purpose of this project is to create a database of surface water, groundwater and deep saline aquifers in the Montney region in northeast BC. This is a joint project with Geoscience BC, industry, government, and the University of Northern British Columbia in partnership with the City of Dawson Creek (Geoscience BC 2014).

- The Northeast British Columbia Aquifer Project has been established in BC to determine groundwater sustainability and incorporates private well survey and an expansion of the British Columbia Groundwater Observation Well Network (BC GOWN). Geoscience BC, the British Columbia Ministry of Forests, Lands and Natural Resource Operations, the British Columbia Ministry of Energy and Mines, the British Columbia Ministry of Environment, the Oil and Gas Commission, and the Climate Action, Climate Energy Fund provides funding for the aquifer project (Wilford et al. 2012).
- The OGC has developed and made available the NorthEast Water Tool (NEWT) and NorthWest Water Tool (NWWT). These are GIS-based hydrology decision-support tools developed in partnership by the BC Oil and Gas Commission and the Ministry of Forests, Lands and Natural Resource Operations. They provide guidance on water availability across northern BC and the support decision-making process for water use approvals and licences.
- The Water Portal, also developed by the OGC, is a map-based water information tool designed to provide public access to a wide range of water-related data and information in northeast BC The data is displayed with flexible charts and analytical tools to assist users to understand and use the data.

Alberta

- The Government of Alberta's Groundwater Observation Well Network (GOWN) is a network of monitoring wells throughout the province of Alberta. The network is managed by the ESRD and provides historical and current water level and quality data. This information can be used to establish groundwater trends for environmental reporting. This network supports Alberta's *Water for Life* strategy, focusing on water management (ESRD 2014).
- The Alberta Geological Survey (AGS), which is part of the AER, operates an open source website with geological information extending across the WCSB (e.g. Atlas of the Western Canadian Sedimentary Basin). The AGS recently established the Saline Aquifer Mapping Project as part of the Provincial Groundwater Inventory Program. The project will map saline aquifers for inventory and characterize them for groundwater supply potential, aquifer storage and retrieval schemes, geothermal energy production, waste disposal, and CO_2 sequestration. A saline aquifer under

Edmonton's Industrial Heartland has been selected as the pilot area for this project (AGS 2014).

- The Cumulative Environmental Management Association (CEMA) is a non-profit group consisting of stakeholders that advise on the management of cumulative effects from development on the environment in the Wood Buffalo region. CEMA established a Groundwater Working Group (GWWG) in June 2011 for the management of cumulative effects on groundwater systems in the Municipality of Wood Buffalo, Alberta (CEMA 2014).
- The Alberta Groundwater Management Areas (AGMA) consist of the North Athabasca Oil Sands (NAOS), South Athabasca Oil Sands, and the Cold Lake Beaver River. The AGMA's were created with groundwater monitoring networks to grow knowledge of naturally occurring groundwater variability, collect baseline data, determine how the surface environment affects the regional aquifers, and assess long-term trends in water level and quality. Monitoring objectives are established by a collaborative group of government and local stakeholders. Monitoring well inventory data, and the monitoring wells used for the network, were compiled from government and industry. The Monitoring Evaluation and Reporting (MER) Group is responsible for monitoring the network and determining if wells need to be added. This group is consisting of government, industry and academia members (CAPP 2013).
- The Athabasca Oil Sands groundwater technical working group, consisting of members from ESRD and oil sands industry, was initiated in 2007 to share information, knowledge, and groundwater monitoring information to support continued development in the Northern and Southern Athabasca Oil Sands regions (i.e. NAOS and SAOS, respectively).
- The Governments of Canada and Alberta committed to implement scientifically rigorous, comprehensive, integrated and transparent environmental monitoring of the oil sands region to ensure this important national resource is developed in a responsible way. As a result, an information portal was developed from which data can be accessed regarding water, and other environmental aspects regarding the implications of oil sands development.
- The Alberta Water Portal is a website and community of water users designed to provide the public access to the knowledge needed to make better water management decisions. The system was commissioned to address challenges and identify opportunities across many different jurisdictions, stakeholders and communities and to facilitate the protection, allocation, and management of Alberta's water resources. The goal of this system is to stimulate dialogue and networking, as well as coordinated efforts to explore and share data and experiences among water users, managers, and researchers.
- The Christina Lake Regional Water Management Agreement (CLRWMA) collective includes Devon Canada Corporation, Cenovus FCCL Ltd. and MEG Energy Corp.

These industry partners established CLRWMA to share groundwater-monitoring data from their operations located in the Christina Lake area. With CLRWMA, the members are developing a groundwater flow model to be used for application and evaluation, and are sharing source water and disposal strategies (Cenovus 2013).

Saskatchewan

- The Water Security Agency of Saskatchewan operates a network of monitoring wells located throughout the province. The network provides historical and current water level information as wells as groundwater quality data. This information can be used to assess groundwater trends in various areas of the province. This network supports the Saskatchewan's 25-year Water Security Plan.

A recent trend in the UCOG sector is the development of synergy groups, where multiple companies operating in a similar geographical area come together to share knowledge (and sometimes data) around operational challenges relating to water management. A couple of examples of these synergy groups include: i) the Fox Creek Operators Group, and ii) the Horn River Basin Producers Group.

The above noted examples of knowledge and data sharing across Western Canada provide valuable avenues for effective water resource planning and management activities. However, there is a limitation to the information provided, as it tends not to adequately represent more local geologic and hydrogeologic conditions related to specific project areas. As such, companies continue to conduct investigative and monitoring programs in areas where regional groundwater monitoring is, or may, be occurring (e.g. Athabasca Oil Sands).

5.2.3 Scenario Framing

For this assessment, a comparison will be made to determine the potential opportunity associated with sharing of groundwater knowledge and data for play-based monitoring versus each company having to generate its own, and manage the associated exploration and monitoring information separately.

5.2.4 System Description

Aspects of a typical groundwater investigation and monitoring program will consist of the following:

- Preliminary desktop review of available information to constrain the local and regional geological and/or hydrogeological setting
- Identification of drilling targets to confirm the local groundwater environment (pressure conditions and water quality) and facilitate testing of hydraulic properties and aquifer deliverability characteristics
- Installation of wells to facilitate confirmation of aquifer characteristics and monitoring activities

- Aquifer testing and groundwater sample collection for laboratory analysis
- Management of the data collected from well installation, testing, and monitoring programs
- Documentation and reporting of the information from exploration and monitoring programs to regulatory agencies and/or other stakeholder groups

5.2.5 Scenario Assumptions

This assessment is based on the assumption that multiple companies, located within a similar geographical area are each required to establish regional scale (off-lease) groundwater monitoring to assess potential effects from operational activities. The example used is a real one from the oil sands development area north of the City of Fort McMurray.

5.2.6 Exclusions from Scope

Exclusions from the scope for the assessment of groundwater monitoring data sharing includes:

- Costs associated with securing the land to establish monitoring infrastructure

6 CRITERIA DESCRIPTIONS

6.1 Economic Considerations

Capital and operational costs are evaluated for each opportunity, based on a Class 5 (Type 1) estimate, and are noted below.

6.1.1 Surface Water Source Intake

- Capital costs associated with the construction of a water intake (restricted to the laterals constructed within the river to the flange on water pipeline), include but are not limited to:
  - The Infiltration gallery system
  - Pumps, and pumping station
  - Pipelines
  - Labour
  - Mobilization and demobilization of equipment
  - Construction management and freight
  - Site preparations
  - Engineering, construction and procurement
  - Indirect construction costs
  - Price of power

- Contingency

- Operational costs associated with the operation of a water intake (restricted to the laterals constructed within the river to the flange on water pipeline), include but are not limited to:
  - Maintenance
  - Labour
  - Electricity Costs
  - Contingency

6.1.2 Development of a Regional-scale Groundwater Monitoring System

- Capital costs associated with establishing a regional-scale (i.e. play-based) groundwater monitoring and development of a data sharing system, include but are not limited to:
  - Monitoring well drilling, completion, and testing
  - Database development
  - Labour
  - Mobilization and demobilization of equipment
  - Construction management and freight
  - Site preparations and access development
  - Engineering, construction and procurement
  - Indirect construction costs
  - Contingency
- Operational costs associated with establishing a regional-scale groundwater monitoring network and data sharing system, include, but are not limited to:
  - Routine sampling and maintenance
  - Data evaluation and reporting (including data management fees)
  - Labour
  - Contingency

6.2 Operational Considerations

This criterion takes into consideration the operational and technical feasibility and reliability, such as operability, asset control, and management responsibility of each opportunity assessed, including planning, human resources, and maintenance,

Note that this criterion is not cost related. All financial components are captured under economic considerations.

6.3 Regulatory Considerations

Regulatory authorization requirements for BC, Alberta, and Saskatchewan are identified under this criterion for the development and implementation of each opportunity assessed.

6.4 Legal and Liability Considerations

Within this criterion, legal and liability considerations related to commercial agreements, including legal fees, liability issues, operational and administrative costs, information sharing, public communications, non-disclosure agreements, non-competition agreements, and non-solicitation agreements, tax implications, and employment laws, where applicable, were addressed.

6.5 Environmental Considerations

The following section outlines the specific environmental effects that were reviewed for each opportunity based on applicability, and provides a description of each associated criterion used in this study. These criteria have been taken from the PTAC study Environmental Net Effects Assessment of Saline Water (Integrated Sustainability 2014).

Ecosystem: Impacts on living organisms (biodiversity) and their habitats due to construction, operations, and reclamation activities.

- **Construction-related Impacts:**
  - Terrestrial Habitat Disturbance: Amount and extent of physical land disturbance (i.e. clearing trees, excavation, river diversion).
  - Aquatic Habitat Disturbance: Impact to the aquatic ecosystem, including lakes and streams, as well as wetlands and riparian habitats due to a physical disturbance.
- **Operations-related Impacts:**
  - Large Water Withdrawals: Withdrawal of large volumes of water from surface water and groundwater sources for operational use.
  - Aquatic Disturbance: Impact to the aquatic ecosystem, including lakes and streams, as well as wetlands and riparian habitats due to operational activities.
- **Reclamation Impacts:**
  - Reclamation: Effort required to return disturbed land back to an acceptable or equivalent state.

Air Quality: Greenhouse gas (GHG) emissions resulting from production and consumption of energy (i.e. diesel fuel use, electricity provided through the grid system) and the corresponding GHG emissions (gases emitted into the air from industrial processes.

6.5.1 Ecosystem

Construction-related Impacts: Terrestrial Habitat Disturbance

Ecosystems and terrestrial biodiversity communities (species that inhabit the land, i.e. waterfowl, birds, wildlife, vegetation) are impacted when endemic habitats are lost or substantially altered. Terrestrial disturbance occurs during construction activities, which may result in physical land disturbance, such as:

- Clearing and grubbing
- Grading
- Draining
- Excavation
- Landscape alteration (i.e. construction of embankments)
- Moving, depositing, stockpiling, or storing of soil, rock, or earth materials

The level of previous disturbance, whether an area is greenfield (undeveloped land that retains its natural ecosystem state) or brownfield (previously developed land), will influence the impact to the terrestrial community. Impacts are mainly applicable to facilities that will be constructed on greenfield sites. Ecosystem and terrestrial biodiversity impacts may include:

- Degradation or direct loss of vegetation
- Introduction of invasive species through vehicular traffic and construction equipment causing soil degradation, erosion, and disease of native and domesticated species and leading to extirpation or extinction
- Increased erosion and sedimentation
- Deterioration of soil quality (decreased moisture content, reduced water infiltration)
- Changes in natural drainage patterns
- Changes/disruption to migration patterns

In addition, land disturbance is a function of infrastructure and facility size and is dependent on:

- Volume of source water required
- Seasonal availability of the source water
- Source water quality

Construction-related Impacts: Aquatic Habitat Disturbance

Construction and operation of a water intake system may potentially impact in-stream aquatic habitats (i.e. benthic zones around lakes, rivers, and streams), as well as the out-of-stream habitat features such as wetlands and riparian areas.

Aquatic habitat disturbance, as a result of water intake system construction, has the potential to alter, degrade, and eliminate fish habitats, as well as impact fish populations.

Operations-related Impacts: Large Water Withdrawals/Aquatic Disturbance

During the operation of surface water and groundwater systems, the aquatic habitat and related communities may be affected if large volumes of water are withdrawn. Such diversions can lead to stream flow depletions, disruption of natural flow regimes, large drawdowns in aquifers, and interference with functional flows to wetlands and other water dependent ecosystems.

While water withdrawals directly affect the availability of water, water withdrawals can also affect water quality for surface water and groundwater systems. For example, withdrawals of large volumes of water can adversely impact groundwater quality by mobilizing naturally occurring substances, promoting bacterial growth, causing land subsidence, and mobilizing lower quality water from surrounding areas or formations (Cooley and Donnelly 2012).

Reclamation Impacts

Land reclamation is an integrated approach to returning disturbed land back to an acceptable or equivalent state prior to the initial disturbance. Regulatory requirements vary with respect to the extent of reclamation required. This criterion has been used to compare the levels of effort that would be required for reclaiming disturbed areas.

6.5.2 Air Quality

This criterion considers greenhouse gas (GHG) emissions resulting from production and consumption of energy (i.e. diesel fuel use, and electricity provided through the grid system) and the corresponding GHG emissions (gases emitted into the air from industrial processes) associated with the construction of water infrastructure and transportation of water.

To accurately compare multiple sources of air emissions for this study, individual fuel types are converted to CO_2 emission equivalents (refers to a number of GHGs collectively considered). The CO_2 equivalent of diesel fuel use is calculated using the revised Intergovernmental Panel on Climate Change (IPCC) Guidelines for National Greenhouse Gas Inventories (1996). The CO_2 equivalent of electricity from the grid for both Alberta and BC is obtained from the National Inventory Report 1990-2009: Greenhouse Gas Sources and Sinks in Canada (Environment Canada 2013).

The total water volume required during hydraulic fracturing operations, the proximity of the available water source, and the source water quality will dictate the quantity of GHGs resulting from water and waste conveyance and the water treatment processes.

7 INTAKE SHARING - OPPORTUNITY ASSESSMENT

Scenarios 1 and 2, as described in Section 5.1, are compared in this section based on economic, operational, regulatory, environmental, and legal and liability considerations.

7.1 Economic Considerations

An opportunity exists between the two intake scenarios in this evaluation, to realize a capital and operating cost savings. This section of the analysis examines these savings.

7.1.1 Capital Cost Estimate for Intake Infrastructure

This section compares the capital costs of two companies building their own facility against two companies building one larger intake.

Cost Estimate for Scenario 1: 2 x 10 000 m^3/d Infiltration gallery

This cost estimate reflects the case where each company constructs their own 10 000 m^3/d water intake. In this case, the cost incurred by each company will be the full cost of one intake as described below. The capital costs for this option include:

- Infiltration gallery system including: air burst cleaning system, screening, piping, drilling, sized for 10 000 m^3/d
- Pumping station: pump building, wet well, electrical equipment, valving, controls, instrumentation, 2 km power line tie-in, power supply, perimeter fencing
- 2 x vertical turbine pumps (10 000 m^3/d, @ 57 m of head, 2 x 100 % sparing)
- 1 x HDPE pipeline to operations (5 km) including site works and installation
- Mobilization and demobilization of equipment and labour
- Indirect construction costs, construction management, and freight
- Site preparations
- Engineering, construction and procurement

The total cost for each facility in Scenario 1 is estimated at approximately $11,370,000. The break down of the cost estimate can be found in Appendix 2.

Cost Estimate for Scenario 2: 1 x 20 000 m^3/d Infiltration gallery

This cost estimate reflects the case where two companies construct a joint water intake capable of delivering enough water to satisfy both companies' requirements. In this case the cost incurred by each company will be half the cost of the intake described below. The capital costs for this option include:

- Infiltration gallery system including: air burst cleaning system, screening, piping, drilling, sized for 20 000 m^3/d

- Pumping station: pump building, wet well, electrical equipment, valving, controls, instrumentation, 2 km power line tie-in, power supply, perimeter fencing
- 3 x vertical turbine pumps (10 000 m^3/d, @ 81 m of head, 3 x 50% sparing)
- 2 x HDPE pipeline to operations (7.5 km) including site works and installation
- Mobilization and demobilization of equipment and labour
- Indirect construction costs, construction management and freight
- Site preparations
- Engineering, construction and procurement

The total cost for the shared facility in Scenario 1 is estimated at approximately $21,313,000. The breakdown of the cost estimate can be found in Appendix 2.

The capital savings associated with sharing a facility are related to the reduction of required intake equipment and the concentration of operations to one building and site. The added length of pipeline required to reach each operator's site increases both the cost of pumps and the pipeline itself. In this case, the pipeline costs dominate the evaluation. Sites that provide a closer tie-in to infrastructure will achieve greater capital cost savings than the scenarios evaluated in this analysis.

7.1.2 Operating Cost Estimate for Intake Infrastructure

This section compares the operating costs of two companies building their own facility against two companies building one larger intake.

Cost Estimate for Scenario 1: 2 x 10 000 m^3/d Infiltration Gallery

The operating cost for this scenario is based on a single operator working six hours a day, 365 days per year and one pump running at six hours per day, 365 days per year. The operating costs for Scenario 1 are summarized in the below table.

Table C. Operating costs for Scenario 1

Cost Item	Cost	Basis
Mechanical Electricity Costs	$41,600	$0.20 per kwh; assume 6 h runtime per day per pump
Mechanical Equipment Maintenance	$4,200	10% of electrical cost
Contingency	$11,400	25% Contingency
Operator Labour	$273,800	$125 per hr; six hours per day, multiplied by 365 days
Total Cost	$331,000	Per year

In this scenario, both individual companies incur this cost resulting in a total of cost of $662,000.

Cost Estimate for Scenario 2: 1 x 20 000 m^3/d Infiltration gallery

The operating cost for this scenario is based on a single operator working six hours a day, 365 days per year and two pumps running at six hours per day 365 days per year. The operating costs for Scenario 1 are summarized in the below table.

Table D. Operating costs for Scenario 2

Cost Item	Cost	Basis
Mechanical Electricity Costs	$117,000	$0.20 per kwh; assume 6h runtime per day per pump
Mechanical Equipment Maintenance	$11,700	10% electrical cost
Contingency	$32,200	25% Contingency
Operator Labour	$273,800	$125 per hr; six hours per day, multiplied by 365 days
Total Cost	$434,700	

In this scenario, the two companies sharing the water intake asset will share the operating costs equating to a cost of $217,350 per operator ($434,700 ÷ 2).

7.1.3 Economic Consideration Summary

When comparing the two scenarios for economic considerations it can be shown that Scenario 2 provides an opportunity to reduce both capital and operating expenditure. The main assumption is that all capital and operating costs will be equally split between the two companies as per the commercial agreement. The results of the comparison are summarized in Table E.

Table E. Comparison of capital and operating costs for two scenarios

	Scenario 1	Scenario 2
CAPEX	$22,740,000	$21,313,000
OPEX	$662,000	$434,700
Costs Incurred by Each Company		
CAPEX	$11,370,000	$10,656,500
OPEX	$331,000	$217,350

The capital savings associated with sharing a facility are related to sharing of equipment and concentrating operations to one building and site. The added length of pipeline required to reach each operators site increases both the cost of pumps and the pipeline itself. In this case, the pipeline cost tends to dominate the evaluation due to the high cost of pipeline installation.

Sites that provide a shorter distance to infrastructure tie-in (<5 km) will achieve greater capital cost savings than the scenario evaluated in this analysis.

Operating cost savings are mostly a result of one operator running the shared facility as opposed to two operators running their own facility.

By sharing a water intake, the each company can save $713,500 in capital expenditure and $113,650 in operating costs per year.

7.2 Operational Considerations

This section compares the operational considerations between the two scenarios being evaluated.

7.2.1 Scenario 1: 2 x 10 000 m^3/d Infiltration Gallery

In Scenario 1, each Facility Owner will be responsible for all management of operations at each site including all regulatory requirements. They will also maintain full control of the facility with respect to where, and when water is allocated.

7.2.2 Scenario 2: 1 x 20 000 m^3/d Infiltration Gallery

In Scenario 2 all operations at the water facility that take place after commissioning will be the responsibility of the Facility Owner. The Facility Owner is responsible for managing the following:

- Operational staff who are trained and certified as required to ensure safe, efficient operation of the intake
- Electrical and utility requirements including all commercial agreements
- Management of on-going maintenance (including major work-overs)
- Cost tracking and accounting
- Clean up of any spills or leaks at site

The Leasee is mainly responsible for ensuring that their operations meet regulatory requirements related to their own water withdrawal license, which includes regular reporting of water withdrawal volumes to the appropriate governing body as required under the license agreement. The Leasee will not have direct operating obligations related to the ongoing operation and maintenance of the facility, which will decrease the amount of manpower commitment that the Leasee would need to provide.

Issues may arise in the operation of the water intake, when the full flow allocation of the two companies is not available. This may occur as a result of the following external circumstances:

- Natural low flow events, where limits are imposed by regulating bodies
- Damage or failure of system beyond redundancy measures
- Loss of access to site

In these scenarios, water will be allocated pursuant to the contract between the Facility Owner and the Leasee. In these cases, each company forfeits some control of the facility and may lose access to the water they require for operations.

Another challenge associated with sharing a water intake is the variable nature of hydraulic fracturing operations and the associated water demand. Investment planning cycles within organizations can have a high variability in timing, which may complicate development planning for shared water infrastructure. As such, matching two companies with similar construction schedules for a new facility may be a challenge and limit the number of operators able to collaborate on water infrastructure within a set timeframe.

7.2.3 Operational Considerations Summary

As discussed in this section, a major operational benefit of Scenario 2 is the consolidation of operations management to one company; however, it comes as a trade-off with the forfeiture of some control over the asset operations. Matching of company requirements for timing and location of a new water intake will also add complexity in Scenario 2 due to the variable nature of hydraulic fracturing operations.

7.3 Regulatory Considerations

The regulatory considerations for both scenarios are reviewed in this section. The regulatory requirements associated with the development of each company's pipelines are not discussed in this evaluation. These requirements are considered to be equal with the only difference between the two being the added distance in Scenario 2.

7.3.1 Scenario 1: 2 x 10 000 m^3/d Infiltration Gallery

The regulatory authorizations required for the development of an infiltration gallery are displayed in Table F.

Table F. Regulatory authorizations required for the development of an infiltration gallery in either Alberta or British Columbia

Alberta Authorizations	British Columbia Authorizations
Specific to One Province	
▪ *Water Act* - Approval to Construct ▪ *Water Act* - Term License or Temporary Diversion License	▪ Section 14 – Land Permit ▪ Section 11 – Changes In and About a Stream (dependent on proximity) ▪ *Water Act* Approval (based on current *Water Act*) ▪ *Water Sustainability Act* (expected in 2016)
Common to Both provinces	
▪ Department of Fisheries (courtesy notification) ▪ Development permit from county ▪ Building permit (Gas, Electrical, Plumbing) ▪ Third party electrical grid tie-in agreement ▪ Land disposition: Mineral surface lease or license of occupation ▪ *Navigable Waters Act* approval (if required) ▪ Well Authorization (see note below)	

** In Alberta a well authorization is required for water wells greater then 150 metres in depth (AER 2014b).*

A well authorization is required in BC for water-source wells greater than 300 m depth, or if located on private land at any depth, require application for a well permit (OGC 2015).

As a part of the regulatory application process, various notifications must be made to local stakeholders. Table G outlines the standard notifications required to construct a water intake.

Table G. Standard notifications required as part of the regulatory process to construct a water intake

Alberta Notifications	British Columbia Notifications
Specific to One Province	
▪ *Water Act* Term License ▪ *Water Act* Approval to Construct	▪ *Water Act* Approval

Alberta Notifications	British Columbia Notifications
Common to Both provinces	
▪ Land Disposition ▪ First Nations	

7.3.2 Scenario 2: 1 x 20 000 m³/d Infiltration Gallery

For the construction and operation of the facility in Scenario 2, one operator will act as the Facility Owner in order to decrease the complexity of the regulatory process. All costs and liability can be shared by the two operators through proper structuring of the commercial agreement between the two companies (this is further discussed in the legal and liability section). The Facility Owner will be responsible for filing all permits associated with the construction and operation of the facility. Both the Facility Owner and the Leasee will be required to file the proper applications and meet on-going requirements for the individual water withdrawal requirements. The following table outlines the permits that each operator will be required to file and hold.

Table H. Regulatory authorizations required by each party for a shared facility

	Required By:	
Regulatory Approvals	Facility Owner	Leasee
Alberta Requirements		
Water Withdrawal – Term License or Temporary Diversion License	✔	✔
Regular reporting of withdrawal volumes	✔	✔
Water Act – Approval to Construct	✔	✗
Navigable Waters Protection Act approval	✔	✗
British Columbia Requirements		
Water Withdrawal License	✔	✔
Regular Reporting of volumes	✔	✔
BC: Section 14 Land Permit	✔	✗
Navigable Waters Protection Act Approval	✔	✗
Approval to construct near a river	✔	✗

The same notifications are required in both Scenario 1 and in Scenario 2. Both companies may still be required to submit separate consultation packages, as both operators will be users.

7.3.3 Regulatory Considerations Summary

A shared intake has a higher positive perception by both the local stakeholders and the regulatory bodies, which should improve the application process and community engagement process respectively. However, compared to a single owner/user, a shared intake has greater regulatory complexity due to size of the water intake and associated infrastructure, which is generally larger than single proponent sites.

Collaborative water infrastructure may be at greater risk of triggering a Federal Environmental Assessment due to surface area, water diversion volumes, or location within a wildlife or migratory bird sanctuary area. The Regulations Designating Physical Activities (SOR 2012) outlines the Federal Environmental Assessment triggers associated with water diversion and storage projects.

The following provincial and federal regulations identify the circumstances in which an Environmental Assessment may be triggered:

- Alberta: Schedule 1 Mandatory Activities and Schedule 2 Exempted Activities under Environmental Protection and Enhancement Act, Environmental Assessment (Mandatory and Exempted Activities) Regulation, Reg. 111/1993
- BC: Water Management Projects, Water Diversion Projects and Groundwater Extraction Projects under Environmental Assessment Act, Reviewable Projects Regulation, Reg. 370/2002
- Federal: Schedule (Sections 2 to 4) Physical Activities, Canadian Environmental Assessment Agency under Canadian Environmental Assessment Act, 2012, Regulations Designating Physical Activities, SOR/2012-147

7.4 Legal and Liability Considerations

This section will evaluate Scenario 1 and Scenario 2 based on the primary legal and liability issues associated with owning and operating an intake facility.

This type of business activity has many complex legal and regulatory requirements that cannot all be address in this assessment. The following section is therefore limited to the primary legal and liability risks identified by the authors and consulted legal counsel.

7.4.1 Scenario 1: 2 x 10 000 m^3/d Infiltration Gallery

Aside from pre-existing contractual agreements, or sub-contractor agreements that may limit, or apportion liability, when a company owns and operates their own facility, in theory, they assume legal liability for the asset and all operational activities related to it.

7.4.2 Scenario 2: 1 x 20 000 m³/d Infiltration Gallery

In order for the two companies in Scenario 2 to equally adopt the risks and liabilities associated with owning an intake, they will enter into a commercial agreement. Under this agreement, one company will act as the Facility Owner and one company will act as a form of Leasee. Since a typical commercial arrangement of this nature would result in the Facility Owner taking on inherently more risk than a Leasee, the parties to the agreement must take contractual measures to agree to split the risk and facility costs equally.

The written agreement should take into account as many of the potential legal, regulatory and liability risks that might impact the facility, with mediation used as a forum to resolve disputes.

The major risks associated with two companies sharing a water intake are described in Table I. This table also offers possible contractual arrangements to mitigate and split the risks.

Table I. Risks to be covered in commercial agreement

Risk	Solution
Discontinuing operations of corporation due to bankruptcy, corporate restructuring, asset abandonment or any event where one party ceases to participate, or exist	▪ 10 year commitment to commercial agreement ▪ Penalty for breaking contract, over and above legal recourse ▪ Mandatory successorship plan in the case of the sale of a company ▪ Option to sub lease operations with approval of second party ▪ Priority creditor status in case of bankruptcy
Regulatory changes result in a change of the operational costs of the facility	▪ Variable pricing structure with quarterly, or annual reporting
Water source fails to meet demand of involved parties including withdrawal restrictions levied by regulatory bodies	▪ Plan for proportional allocation od available water in various circumstances
Spill, leak or other environmental impacts that require reporting, clean-up and/or reclamation	▪ Proportional liability written into contract ▪ All costs to be split by both Facility Owner and Lessee including all post operations obligations

Risk	Solution
	▪ Initial environmental assessment of the site, cost split by both parties, to act as a benchmark to assess contamination
Facility Owner not able to meet regulatory and construction deadlines to meet Lessee operations schedule	▪ Termination clause in case one party defaults on their contractual obligation ▪ Penalties/incentives to operating company to meet schedule requirements
Use and selection of subcontractors not agreed upon by both parties	▪ Agreed upon and pre-approved list of vendors and subcontractors ▪ Mandatory mediation for disputes

The main advantages to a shared water intake, where liability is split include:

- Shared liability, limiting the potential financial burden on a single company in the event of a legal claim
- Increased accountability and monitoring due to double oversight
- Sharing of expertise
- A proactive consideration of tax implications could provide opportunities for tax optimization

7.4.3 Legal and Liability Analysis Results

Compared to a single owner/user, a shared intake has greater legal and liability complexity and associated risk. While both scenarios have legal and liability issues, the commercial agreement described in Scenario 2 results in greater complexity. Achieving a mutually agreed upon and beneficial commercial agreement, where liability is split, while not impossible, would require a great deal of negotiation and contractual rigour. This would impact costs of the project in legal fees, as well as time required to come to an agreement. This complexity creates a disadvantage to shared water intakes.

7.4.4 Other Legal Considerations

The exact structure of the legal agreement between the two companies for a shared intake is outside the scope of this report, however there are many other factors that should be considered when constructing an agreement. Other legal considerations that would need to be addressed in a joint partnership include:

- Determine how operational and administrative costs would be divided.
- Information sharing to Board/shareholders:

  - Public companies have disclosure requirements to shareholders. A shared asset could mean potentially disclosing confidential information of the second company.
- Stakeholder communication:
  - Companies can be very protective regarding corporate messaging to outside sources. A communication strategy around the asset would have to include a form of shared accountability, or vetting of public communication surrounding the asset, even if legally required.
- Non-disclosure agreements, non-competition agreements and non-solicitation agreements would also have to be put in place to insure confidentiality and to protect the business interest in the partnership.
- Tax Implications:
  - Depending on how the deal is structured, various tax matters could be triggered, including taxable sale of assets, deemed asset sales, taxable mergers, and allocation. Tax implications are dependent on the structure and transactions affected. Business re-organizations or consolidations typically trigger on account of strategic business objectives. A proactive consideration of tax implications could provide opportunities for tax optimization.
- Various employment law matters could also be affected. These include:
  - Health Safety and Environmental (HSE) requirements. On top of statutory requirements, many companies have stringent HSE requirements. Responsibility for implement HSE standards would have to be delegated and any HSE standards would have to take into account both company's values and policies.
  - Workers Compensation Coverage and other Insurance coverage requirements. Determine which company would bear the insurance requirements of the proposed work.
  - Employees versus contractors. For employees working on site, would they considered be employees of one company, or subcontracted to the other company? This has serious implications for any Employment Standards claims, including wages and dismissal claims.

7.5 Environmental Considerations

This section of the report outlines the environmental impacts associated with the construction, operation and reclamation of an infiltration gallery for Scenario 1 and Scenario 2.

In both scenarios, the types of environmental impacts that will occur are the same. The net difference in impacts results from the scale of operations. This scale is estimated using the expected footprint for each scenario. The footprint of the infiltration gallery, pump house and pipelines are reviewed.

7.5.1 Ecosystem: Construction-Related Impacts Terrestrial

The main sources of construction-related impacts occur from the building of the surface infrastructure and the water pipelines.

The environmental impacts associated with constructing an infiltration gallery are:

- Drilling or auguring of infiltration gallery laterals into the riverbed may cause some disturbance of riverbed material during construction, which could lead to impact of the aquatic environment.
- Clearing and grubbing of surface areas required (pump house, wet well, pipeline), creating a physical disturbance to vegetation in the area.
- Unintended introduction of invasive plant species.
- Access road construction.

The surface infrastructure of the infiltration gallery used in this analysis is a footprint of 1600 m^2 for the facilities in both Scenario 1 and Scenario 2.

The environmental impacts associated with construction of pipelines are directly related to the path chosen and the design of the trench. A typical pipeline right of way is 15 m wide, with pipelines typically installed up to 3 m below ground. The trench itself is typically excavated 4 m deep to allow for pipe bedding materials, minimized settlement and protection from frost. Prior to construction, planners are expected to conduct pre-installation surveys to identify the best routes based on terrain conditions, wildlife habitat, river crossings, archaeological resources, soil type including depth and variability, farm management areas, forest and native vegetation resources, and proximity to inhabited areas.

Possible environmental risks of constructing and installing a pipeline include the following (Canadian Environmental Assessment Agency 2010):

- Soils can be eroded, compacted and mixed, or contaminated.
- Alterations of surface runoff, along with accompanying risks to safety and environment (increased siltation effects on fish habitat).
- Vegetation (including old growth forests and rare plants) can be affected by surface disturbance, changes in water flows, or introduction of invasive species.
- Risks to wildlife can be caused by the removal, alteration, and fragmentation of habitat, changing access and sightlines for predators, and the creation of barriers for movement.
- Water quality could be affected by erosion and river crossing excavations.
- Blasting, grading, and tunnel construction for pipeline placement could alter both surface and groundwater flow conditions.

In Scenario 1, a 5 km pipeline originates from both individual facilities for a total of 10 km of pipeline resulting in a disturbed area of 150 000 m^2. In Scenario 2, two 7.5 km pipelines originate from one shared facility for a total of 15 km, which would result in a disturbed area of 225 000 m^2.

The environmental impact associated with the construction of the facilities in each scenario is directly related to the footprint of the infiltration gallery system.

Table J. Environmental footprint impact of Scenario 1 and Scenario 2

	Scenario 1	Scenario 2
Facility Footprint	3200 m^2	1600 m^2
Pipeline Footprint	150 000 m^2	225 000 m^2
Total Footprint Impact by Each User	76 600 m^2	113 300 m^2

7.5.2 Ecosystem: Operations-Related Impacts – Aquatic Habitat Disturbance/Large Water Withdrawals

The environmental impacts associated with the availability of river water are highly dependent on both the physical character and flow dynamics of the river and the location chosen for the infiltration gallery. Each river experiences different flow volumes, sediment and nutrient loading and cycling, suitable habitat for wildlife, and seasonal flow variations.

The potential environmental impacts associated with operating an infiltration gallery that may impact the aquatic and terrestrial habitat are:

- Alteration of stream flow volumes (reduced flow can endanger fish populations)
- Alteration of channel depth/width (impact to habitat availability and/or suitability)
- Alteration of sediment/nutrient transport characteristics during water treatment system back-flushing

The main environmental concern is the potential for removing water volumes in excess of the available water during seasonal low flow periods, leaving insufficient water to sustain ecosystem needs. This could lead to a decrease in suitable aquatic habitat, lowering of the local water table, or restricting the supply of water to certain riparian species or functions, as well as affect a variety of organisms that may potentially impact their life stages (i.e. fish spawning).

When comparing Scenario 1 and Scenario 2, the main impact related to operations is the concentration of water withdrawal by two companies into one location. If the intake is not operated in compliance with government regulations around water withdrawal guidelines the potential for withdrawal exceedance exists.

7.5.3 Ecosystem: Reclamation Impacts

The reclamation impacts associated with the decommissioning of an infiltration gallery are mainly related to the footprint of the area used for wet wells, pump houses and pipelines. The environmental risks of the long-term reclamation of the wet wells and pump houses include:

- Construction equipment access to the site for demolition
- Removal and disposal of materials including concrete and pipe
- Back-filling of disturbed areas and grading to return to pre-disturbance runoff patterns, accompanied with the risk of invasive species populating of disturbed site
- Re-establishment of the site vegetation to prevent erosion

Once the infiltration gallery is no longer required, the perforated pipe sections would be capped and sealed, and the surface infrastructure removed. The water pipelines would be cut and capped and the associated surface equipment would be removed.

The footprint of these operations would be the same under both scenarios as the construction impact footprints detailed in the construction related impacts section above.

7.5.4 Air Quality Impacts

The intake infrastructure will result in air emissions from mechanical equipment, including pumping equipment required to convey the water from the intake to the usage point (storage pond, frac site, etc.), heating, lighting, and other electrical loads.

The GHG emissions resulting from Scenario 1 and Scenario 2 are calculated using the estimated electrical consumption from the operating cost estimate in Appendix 2. The GHG emissions for each scenario for both BC and Alberta are summarized in Table K. A large net difference in the GHG emissions results between scenarios where the grid connection is in Alberta versus BC. This is due to Alberta's power being produced primarily by coal and natural gas as opposed to BC's power generation, which is produced primarily by hydroelectricity. Alberta's grid intensity is 734 g CO_2-e/kWh and BC's is 11.1 g CO_2-e/kWh (Environment Canada 2013).

Table K. Air emissions for both scenarios in Alberta and BC

Air Emissions by Each User				
	Scenario 1		Scenario 2	
Power Usage	343 620 kWh/year		586 920 kWh/year	
	BC Grid	Alberta Grid	BC Grid	Alberta Grid
Total CO_2 by Case	4.6 tonnes	305 tonnes	6.5 tonnes	430 tonnes

Air Emissions by Each User				
	Scenario 1		Scenario 2	
Total CO_2 by Each User	2.3 tonnes	151 tonnes	3.2 tonnes	215 tonnes

7.5.5 Environmental Considerations Summary

The main difference in environmental impact found between the two scenarios is the scale of impacts rather than the types of impacts. The concentration of two wet wells and pump houses in Scenario 1 to one of each in Scenario 2 reduces the footprint of these facilities by 1600 m^2. The extra 5000 m length of pipe required to reach each the facilities in Scenario 2 results in a footprint increase of 75 000 m^2. This results in a greater impact by both companies in Scenario 2 for both construction and reclamation. The added length of pipeline also increases the GHG emissions of Scenario 2.

One noted difference is that the infiltration gallery design as described here does not result in major impacts to the riverbed. In cases where in-river excavation is required, the reduced impact of a shared intake on the sensitive ecosystem would be a significant factor in the analysis.

8 GROUNDWATER MONITORING DATA SHARING OPPORTUNITY ASSESSMENT

This section explores the economic, operational, regulatory, environmental, and legal and liability factors that should be considered when evaluating the potential opportunity associated with groundwater monitoring data sharing. Knowledge and data in this sense is information that supports an understanding or interpretation of a particular environmental setting, hydro(geo)logical system, and the interactions between them.

The sharing of groundwater monitoring data is not solely restricted to the industry space. Government agencies managing provincial resources also factor into the knowledge and data sharing space through regional monitoring initiatives and related databases and tools developed to support of use to the unconventional gas developers include (but are not limited to):

- Open file reports and mapping products available from Geoscience BC and the Alberta Geological Survey
- The North East Water Tool (NEWT) administered by the BC Oil and Gas Commission
- Alberta Water Well Information Database (AWWID) administered by Alberta Environment and Parks (formerly Environment and sustainable Resource Development)
- Alberta Groundwater Observation Well Network (GOWN) administered by the Alberta Environmental Monitoring Evaluation and Reporting Agency (AEMERA)

- Baseline Water Well Testing (AER Directive 35)

A collaborative system of monitoring between governing agencies and industry operators is seen as an advantage over current individual systems and an opportunity to enhance cumulative effects detection and management through the collection evaluation, and management of important data sets.

8.1 Economic Considerations

An opportunity exists to realize a collective cost saving through groundwater monitoring data sharing prior to any capital and operating expenditures. As discussed in Section 5.2, establishing effective groundwater monitoring programs is an important component of gaining adequate knowledge of the groundwater environment and the ability to assess the effects of human development. One of the challenges, however, is that publicly available subsurface information (i.e. geology, formation characteristics, water chemistry, aquifer yields) is often limited. Prior to establishing monitoring wells, a data review process and monitoring well siting exercise is required. Operators often gather groundwater information for either internal use, or to meet regulatory requirements; however this information is not commonly shared between parties, which inevitably results in overlap of effort and budgetary redundancy. The obvious risk is that numerous parties within the same operating area will establish unnecessary monitoring with associated impact to the environment from access road and well pad construction, yet the knowledge gained from the redundant information will not provided added benefit. As such, groundwater knowledge sharing will likely result in overall cost savings, while minimizing the environmental footprint associated with monitoring activities. An added benefit is the development of a consistent interpretation of the hydrogeological setting through the sharing process of the technical experts involved.

8.1.1 Capital Cost Estimate for Groundwater Monitoring Data Sharing

This section outlines the capital considerations associated with groundwater monitoring data sharing. In this scenario, the development of a regional groundwater monitoring network is assessed. The scenario considered relates to a real example in the Athabasca Oil Sands region of northeast Alberta, where a regional-scale groundwater monitoring initiative commenced in 2007. The purpose of the network was to enhance knowledge of baseline groundwater conditions in an 18 000 km^2 study area north of the City of Fort McMurray, and address mounting concerns relating to groundwater quality and impacts due to mine dewatering and thermal in situ development. Initial work conducted through CEMA's groundwater working group (comprising various oil sands operators, as well as ESRD and AER representatives) included completion of the following tasks, with approximate related costs:

Table L. Summary of initial work conducted for CEMA's regional-scale groundwater monitoring initiative

Task	Approx. cost
Technical workshops	$50,000
Unified database development, analysis, and visualization	$225,000
Conceptual hydrogeological model update	$100,000
Vulnerability and risk mapping	$100,000
Monitoring system design	$25,000
Monitoring plan development and documentation	$100,000
Total	**$600,000**

Although the original goal of the project was to drill and install new monitoring wells throughout the study area, through the process of knowledge, data and monitoring infrastructure sharing, a network of 65 monitoring wells (40 ESRD wells at 12 pads, and 25 oil sands operators at 19 sites) was configured (CEMA 2010). Vulnerability and risk mapping vetted through the technical working group provided the basis for final monitoring system configuration, which ultimately reduced redundancy in regional monitoring.

By comparison, the high-level estimated cost to establish a similar network today in the same locations would be in excess of $3,000,000, with a significant portion of the cost going to establishing new monitoring wells. The following assumptions form the basis of this estimate:

Table M. Summary of construction costs for the installation of individual wells

Task	Assumption	Approx. cost
Monitoring system design	(same as CEMA example above)	$225,000
Well installation (estimated average of $40,000 per well)	65 wells	$2,600,000
Database and visualization platform	(same as CEMA example above)	$225,000
Monitoring plan development and documentation	(same as CEMA example above)	100,000
	Total	**$3,150,000**

It is acknowledged that the cost of installing wells applies to both examples. However, the use of existing infrastructure established for other purposes (as noted in the CEMA example), as opposed to establishing new and likely redundant infrastructure, ultimately resulted in an overall reduction in dollars spent. An added bonus to the use of existing infrastructure was a reduced environmental footprint and access to existing monitoring information.

From an economic and environmental perspective, the opportunity of re-purposing or re-tasking existing well infrastructure in other areas of the province subject to unconventional gas development also exists. By taking a similar approach to that employed in the oil sands a leveraging of dollars already spent to drill and install monitoring or observation wells may be realized.

8.1.2 Operational Costs for Groundwater Monitoring Data Sharing

Once established, the operations and maintenance of a collaborative versus individual monitoring system would be relatively similar. There would, however, likely be some economies of scale associated with a collaborative system through the reduction in numbers of companies required to operate and maintain the network.

8.2 Operational Considerations

8.2.1 Operational Benefits

There are significant operational benefits of sharing groundwater knowledge and data. These benefits include:

- Development of a consistent understanding of the hydrogeological setting and basin dynamics (groundwater-surface water interactions, supply, demand)
- Better tracking and assessment of cumulative effects related to human development versus natural variability
- More effective communication of monitoring results based on a consistent platform and delivery system

Production companies could share the following pieces of information related to shallow and/or deeper groundwater systems:

- Various groundwater-bearing intervals, depths, and hydraulic properties
- Baseline water chemistry
- Water producing potential
- Water level information (spatial and temporal)
- Results of performance monitoring (e.g. water level fluctuations or drawdowns and temporal changes to water quality)
- Reservoir pressures conditions
- Geochemical compatibility issues

- Injectivity rates

Cumulative Effects and Risk Mapping

Currently, there is limited synthesized information available on non-saline groundwater in BC, Alberta, and Saskatchewan. As noted in the introductory section, there are information sources, related data sets, and supporting mapping products available through various provincial agencies; however, they currently exist in a fragmented manner. There is even less information with respect to saline water, as this resource is generally not subject to licensing at present. As such, an opportunity exists to gain a better understanding of the groundwater inventory and manage potential cumulative effects to the resource accordingly through a collaborative monitoring effort.

Through the collaborative process, a better understanding of the subsurface conditions in defined study areas can be accomplished since operators will have access to detailed data that is not publicly available. With regulatory compliance acting as the main driver in many cases, operators will have conducted targeted hydrological assessments of the areas in which they work, or propose to work. By having a more unified set of data, operators can then begin to more intelligently assess how their operation might affect other operations, and vice versa.

Groundwater withdrawals and injection practices could be considered collectively on a regional scale as a cumulative effects monitoring requirement by regulating agencies. As such, individual monitoring will not accomplish this goal. As well, individual monitoring will not identify locations outside of project footprints with heightened sensitivities to development activities. There is a benefit to identifying areas where water resources may be strained due to one's own operation or another's. Therefore, knowledge and data sharing can fill the information gap and reduce costs associated with broader-scale monitoring initiatives.

Industry Alignment

The benefits of industry working together will benefit regulators and the public at large in the following ways:

- Reduction in overall environmental footprint through development of a more strategic design to regional monitoring (i.e. less wells and associated pads, less access road infrastructure)
- More efficient use of resources
- Reduction in redundancy of monitoring infrastructure and data management systems
- Coordinated outreach and consistent messaging

However, the benefits to industry partners will only be realized by following an agreed upon path. It is best to address the smaller, localized issues first to gain momentum before attempting to address the more complex challenges. A successful partnership will require organization, and involves a clear desired outcome and consistency of objectives throughout the process. Interests and needs of all parties have to align. Once established, a partnership will require a well-defined management structure with an effective communication strategy. In addition, to drive progress and maintain focus there needs to be representative(s) to whom involved parties are accountable. Some form of compromise will likely be required to achieve alignment between the parties. Open-mindedness is key to reaching consensus on ideas and desired outcomes for collaborative initiatives. Industry has shown a willingness to engage in these forms of relationships when entering into joint-venture activities related to oil and gas development. The same formula could very easily apply to knowledge sharing, where each party benefits from what they, and others, bring to the process.

8.2.2 Operational Challenges

Challenges with sharing groundwater knowledge and data are obvious and can vary significantly based on individual circumstances. However, three factors that will invariably influence the overall level and success of collaboration between sharing parties include:

- The sharing mechanism
- The degree of sensitivity of the shared knowledge and data
- The complexity of the relationship between the sharing parties (i.e. level of competitiveness)

Groundwater Monitoring Data Sharing Mechanism

The groundwater monitoring data sharing mechanism must contain the necessary security infrastructure, access control (e.g. privileged access via password-protected web portals), and monitoring mechanisms to ensure continued satisfaction of the parties involved. The platform upon which data is shared between parties will require a level of agreement to address individual needs and provide the flexibility to work with common interfaces and programs. Given the large areas covered by regional monitoring systems, visualization of information typically provides the best avenue for interpreting and communicating results. Common platforms like ArcGIS or MapInfo are used to render spatial data, and export results to easily accessed desktop visualization platforms.

Ongoing management of any system of collated data and information does present a challenge. However it is important to establish a custodian and manager for the data and information to ensure consistency in acquisition and dissemination. Current models that exist include P3 (Private-Public-Partnership) agencies, such as AltaLIS, or government-sponsored agencies, such as the Geoscience BC and the Alberta Geological Survey. Ultimately, care, custody, and control of collaborative knowledge and data by an organization such as AEMERA, with funding support from industry and government, is one possible solution.

Data Sensitivity

Companies sharing data may confront a difficult challenge regarding what data to share and how much is enough, so that collaborative users will derive benefit without the loss of competitive advantages and valuable intellectual property. One solution to this challenge is limiting data sets and waiting for responses on whether the data is useful for the intended purpose.

All parties sharing knowledge and data must balance the benefit derived for all parties against potential drawbacks such as lack of openness, mistrust, frustration from incomplete or heavily redacted data sets, and lack of accountability and/or engagement by one or more of the data sharing parties involved.

Complexity of Relationship

The development of data sharing agreements can often be a complex process. To achieve a complete data sharing collaborative process there needs to be true and measurable benefits to all parties involved. A driving factor will likely involve cost savings, with the level of collaborative motivation not only differing based on how those cost savings will be achieved, but how much effort and investment went in to accumulating data to date and if those dollars can be recouped by data sharing. The following questions will likely be considered by data sharing parties prior to engaging in any data sharing agreement:

- Will one party save more money than another by using shared information?
- How will those cost savings be realized in the short and long term?
- How much information can be shared before internal drivers are compromised?
- Is there competition between parties and are there limited supplies of resources such as groundwater for operations?
- Will regulatory advantages occur by conducting collaborative efforts?

8.3 Regulatory Considerations

With the move to more play-based regulation, specifically in Alberta, it is clear that regulators are looking for more of a collaborative effort to address development pressures and elicit more strategic monitoring to address the challenges of cumulative effects. Sustainable use and management of provincial water resources is a mandate of all provincial regulators. Therefore, it is anticipated that regulatory acceptance will be more likely if a collaborative approach to water management is developed amongst industry players as opposed to being mandated as project requirements. By taking a leadership position, and working together, industry partners can achieve a consistent, efficient, and cost-effective platform for the exchange of data, information, knowledge and ideas. This, in turn, can inform cumulative effects monitoring activities and demonstrate to regulators cogent play-based development plans predicated on:

- Timely detection of unacceptable effects

- Identification of source and/or cause
- Deployment of effective mitigation strategies (if and when required)

Increasing interaction and collaboration between the OGC and AER suggests that a similar approach may eventually be applied to UCOG activities in northeast British Columbia. As such, the move to more collaborative interactions appears to gaining regulatory favour, while also achieving many other benefits, such as infrastructure footprint reduction and CAPEX and OPEX efficiencies.

8.4 Legal and Liability Considerations

There may certainly be some real and/or perceived legal and liability considerations regarding collaboration on the knowledge and data-sharing front; however, such challenges have been encountered and resolved before with respect to resource development. In particular, many joint venture agreements regarding oil and gas development have been successfully executed over the decades, predicated on sharing of knowledge, data, and capital dollars related to drilling and production activity.

Considering the successful execution of such agreements it would appear that a model already exists for collaboration, and would only need to be tailored to water management front as opposed to oil and gas development.

8.5 Environmental Considerations

With respect to individual monitoring systems, versus a collaborative one, the types of environmental impacts that would occur are the same. The net difference in impacts from such activities results from the reduced number of monitoring stations associated with a coordinated effort, leading to a potential elimination of redundancy. By coordinating efforts amongst operators and strategically locating monitoring infrastructure, an overall reduction in monitoring can be achieved without compromising coverage. Utilizing existing infrastructure (as described in the example above) will ultimately reduce the need to clear vegetation and establish access roads to commission new locations, resulting in a reduced environmental footprint and GHG emissions associated with road construction. As such this will reduce the impacts related to construction activities and reclamation.

9 CONCLUSION

9.1 Water Intake Sharing

The following table is a summary of the conclusions from each category of consideration in this analysis between Scenario 1 where each company builds it's own water intake and Scenario 2 where two companies build a joint intake.

Table N. Summary of considerations for Scenario 1 and Scenario 2

Summary Analysis Table		
	Scenario 1 Impacts per user:	Scenario 2 Impacts per user:
CAPEX	$11,370,000	$10,656,500
OPEX	$331,000/year	$217,350/year
Footprint	76 600 m^2	113 300 m^2
GHG Emissions (AB Grid)	151 tonnes of CO_2-e/year	215 tonnes of CO_2-e/year
	Net Advantage/Disadvantage Experienced by User	
Operational Considerations	Disadvantage – two operations teams required	Advantage - one operations team required
Regulatory Considerations	No Advantage – Evidence of collaboration may be required	No Advantage – Benefits from collaboration but added complexity
Legal and Liability Considerations	Advantage – Less complexity and more defined liability	Disadvantage – Complex legal agreement between two companies required

The analysis of the opportunity for collaboration on water intakes between Scenario 1 and Scenario 2 provides insight into the advantages and disadvantages of this type of collaboration. From the quantitative results we can see that there are capital and operating savings from Scenario 2 but a higher overall environmental impact. These results are dominated by the assumptions made regarding pipeline connections. As can be seen in the individual sections, the added length of the pipeline increases the overall capital cost and is mainly responsible for the increase in environmental impact. A shared water intake with closer proximity to both users would reduce the environmental impact and increase the capital savings, which would result in greater benefits associated with collaboration.

Efficiencies would be realized through the consolidation of operational control to one company, as per Scenario 2, including one operations management team; however, this comes at the expense of some loss of control over operations by both parties.

Collaboration on a shared water intake should result in preferential treatment from regulating bodies and project stakeholders. The increased complexity of regulatory applications due to a general lack of experience in this area may create challenges for regulatory planning teams.

Project success associated with sharing of water intakes (or similar types of infrastructure) between two hydraulic fracturing operators is greatly affected by timing of operations. Timing of water demand within hydraulic fracturing operations is highly variable both seasonally and from year to year. The competitive advantage of an operator is greatly influenced by its ability to vary the number and placement of wells drilled in a particular season based on budgets, adjacent well performance and rig availability. While permanent infrastructure can reduce costs, it tends to lock in operators to a particular drilling plan, which can limit flexibility. This effect is further compounded when a particular piece of infrastructure is to be shared by more than one operator.

While there are many benefits associated with a shared water intake with respect to legal and liability considerations, the increased complexity of a legal agreement between a Facility Owner and a Leasee is currently considered a significant barrier. Many similar agreements in industry do exist specifically related to joint venture operations, and these should be used as reference when constructing a water intake sharing agreement.

Overall it can be seen that in the scenario analyzed in this report that there are potential positive benefits that can be realized by two companies that collaborate on a shared water intake. However, to realize these benefits to the fullest extent in other applications, all the trade-offs should considered, with special attention given to the proximity and timing of water to operations.

9.2 Groundwater Monitoring Data Sharing

The analysis of the opportunity for groundwater monitoring data sharing demonstrates the following advantages and disadvantages associated with knowledge and data sharing.

Table O. Summary of considerations for groundwater monitoring data sharing

Summary Analysis Table		
Considerations	Advantages	Disadvantages
CAPEX	Significant cost savings associated with regional-scale groundwater monitoring initiative ($600,000) versus establishing a similar network through drilling and installing individual wells (excess of $3,000,000)	
OPEX	Reduction in numbers of companies	

Summary Analysis Table		
Considerations	Advantages	Disadvantages
	required to operate and maintain the network	
Operational	Consistent understanding of the hydrogeological setting and basin dynamics, better tracking and assessment of cumulative effects, and more effective communication of monitoring results	Securing and access control, data sensitivity, and complexity of relationship (data sharing agreements)
Regulatory	Regulatory alignment with emerging regulations	
Legal and Liability	Numerous examples of groundwater monitoring data sharing exist in industry	Complexity around knowledge and data-sharing
Environmental	Reduction in environmental footprint impact, and associated GHG emissions generated, by limiting vegetation clearing, access road and pad construction, and well installation activities	

As can be seen, the benefits of a collaborative effort around groundwater monitoring data sharing are significant and obvious, and relate to the following:

- Cost reduction related to required infrastructure due to a coordinated effort in monitoring system design (i.e. reduced redundancy)
- Reduced environmental footprint, and associated GHG emissions, related to more strategic placement of monitoring stations
- Consistent interpretation of monitoring data predicated on a collective interpretation and understanding of the hydrogeological setting
- Alignment with the goals and objectives of existing, and possibly emerging, policy regarding a play-based, collaborative, approach to UCOG development

9.3 Summary

Emerging regulations in both BC and Alberta will likely have increased focus on collaboration, requiring companies to demonstrate collaborative efforts.

There are many opportunities for collaboration in the unconventional oil and gas space ranging from infrastructure sharing to water supply and/or disposal sharing. The net benefits from such arrangements are dependent on many factors, including proximity between operators and proposed shared infrastructure, regulatory considerations, and legal obligations. In this assessment, two opportunities were identified and reviewed.

With respect to water intake sharing, there are many benefits to this approach; however, there are also certain obstacles, such as:

- Complexity of a legal agreements
- Loss of autonomy over operations
- Potential time and schedule delays
- Potential regulatory hurdles due to the general lack of experience with these types of application

However, there are capital and operational advantages, as well as positive social licence to operate aspects associated with this opportunity that may present considerable benefits, specifically in instances where operations are located in close proximity to each other. In these circumstances, opportunities for water intake sharing should be investigated further.

With respect to groundwater monitoring data sharing, the challenges are less and the benefits are significant, including:

- Reduced costs to establish new monitoring infrastructure by leveraging existing infrastructure or reducing the number of stations through strategic deployment
- Reduced environmental footprint via strategic monitoring deployment
- Greater alignment between industry, government, and stakeholders through consistent monitoring
- Better understanding hydrogeological conditions and basin dynamics
- Better cumulative effects assessment
- Consistent messaging with respect to monitoring results

As such, the opportunity for groundwater monitoring data sharing represents a relatively easy and low cost initiative to explore.

10 NEXT STEPS

The following section provides recommendations for some additional next steps that can be undertaken to further collaborative efforts based on the information gained from the PTAC Water Collaboration Workshop and the opportunity assessment associated with water intake sharing and groundwater monitoring data sharing.

10.1 Development of Detailed Regulatory Barriers Assessment and Regulatory Roadmap

In response to the growing expectation by regulators for industry collaboration, there is a need to clarify the meaning of the term, as well as guidelines and procedures around collaborative initiatives. During the workshop conducted in May 2014, the vast majority of participants were in favour of collaboration, but identified the following regulatory hurdles as major barriers preventing industry from successfully participating in collaborative efforts:

- Regulatory inconsistencies that make investments in collaborative initiatives problematic as it is difficult to determine which forms of collaboration will be received positively and approved.
- Exemptions in the current regulatory framework are not well understood as they apply to collaboration opportunities.
- Gaps exist in the current regulatory framework that hinder collaborative efforts (i.e. non-standardized water quality parameters for reuse/recycle applications, challenges with license sharing hindering water license partnerships, inter-basin transfer regime as it applies to groundwater, etc.).
- Governance structures and liability for collaborating "entities" can be complex, and are currently not well structured and/or understood.
- The *Water Act*, in its current form, is competitive and not conducive to promoting collaboration.

Participants agreed that there is an opportunity to simplify and speed-up regulatory processes and approvals through collaboration. However, participants expressed a concern that the degree of regulatory inconsistency and gaps within the current regulatory regime to support collaborative efforts may actually increase the complexity of regulatory applications and result in approval delays. This is mainly due, in part, to a general lack of experience in this arena, which may create challenges for regulatory planning teams. As such, the need for clear policies, regulations, and guidelines to ensure regulatory consistency and minimize uncertainty is critical to the success of collaboration.

Regulation can spur collaboration, if done correctly, by simplifying the process for applying for approvals, especially if clear net-benefits from a partnership/alliance are demonstrated. This has been the goal of the Play-based Regulation Pilot process currently being administered by AER in the Duvernay play area of northwest Alberta. The government has an opportunity to engage industry in providing input for policy amendments that promote collaboration, as well as help expedite required changes in order to create a structure that supports the implementation of collaborative initiatives. For example, a new stipulation or interpretation of existing stipulations may be required within the *Water Act to* enable water asset sharing, including providing guidance on the regulatory approval process for water infrastructure sharing, and structure for fines or penalties.

The following activities are proposed to support engagement between government and industry and help expedite policies and/or regulatory process changes to encourage collaboration:

- Review current *Water Act* regulations and any other related policy to support water collaboration, and identify areas that may create uncertainty and/or may hinder the process.
- Identify opportunities for changes to regulations through dialogue with industry and government discussing specific issues or challenges experienced that have hindered collaborative efforts and/or delayed the application and approval process.
- Facilitate an Open Forum, including a plenary session and workshop session, focused on specific issues or challenges identified in the previous bullet point. Information gathered from the above two noted bullets should be used as a "premier" for the Forum.
- Conduct a detailed assessment of the current regulatory barriers that hinder collaboration, and propose a policy modification and/or alternative solution.
- Develop of a "regulation roadmap" that details specific types of collaboration, their benefits and steps for implementation.

The information gathered from these activities can be used to formulate strategies around future policy changes and streamlining of regulations that would encourage water collaboration in oil and gas development.

10.2 Identification of Opportunities for Groundwater Monitoring Data Sharing

The importance of water to the development and ongoing operation of the unconventional oil and gas industry is obvious, as well as the need for the sustainable use of both land, and water (I.e. surface water and groundwater) to help protect our valuable watersheds. However, with rapid development in some play areas, it is also becoming evident that a coordinated effort will be required to ensure that this goal is achieved. As previously mentioned, with the move to more play-based regulation, specifically in Alberta, it is clear that regulators are looking to industry and related stakeholders to address development pressures and elicit more strategic monitoring and management to address the challenges of cumulative effects. In areas such as the Duvernay play in Fox Creek, there is already a significant effort by both government and industry to move a play-based approach forward. Although an overall development strategy has yet to be defined within this play area, there is a substantial opportunity to establish a regional-scale groundwater monitoring and data sharing system within the Duvernay play by drawing on existing data and infrastructure where possible in order to determine a baseline conditions for the area. A large co-ordinated effort will be required to implement a regional or sub-regional strategy for monitoring that allows for the optimization of infrastructure needs and sharing of information and knowledge that will benefit all participants.

Another opportunity for establishing a regional groundwater monitoring and data sharing process exists for the Montney play, also located in northwest Alberta. Although, this play may be a bit more challenging, considering that it transects provincial borders, a collaborative approach would help ensure the regulatory consistency and effective management strategies required to achieve the goal of sustainable resource development and waste management.

Collaborative efforts through industry participation groups, such as Oil Sands Leadership Initiative (OSLI) and Canada's Oil Sands Innovation Alliance (COSIA), have already established regional-scale initiatives around water management, including groundwater sourcing and fluid waste disposal. These industry collaboration models could be leveraged and built upon to successfully implement similar programs within the Duvernay play.

10.3 Evaluation of Additional Water Collaboration Opportunities

In addition to the collaborative opportunities identified within the workshop, summarized under Section 6 of Appendix 1, the following collaboration opportunities should be explored further:

10.3.1 Licence Transfers, Sharing Agreements, Cooperatives, and Play-based Approach

Transfer of water from unused portions of licences in good standing with ESRD is now becoming a means to access water for some water-dependant projects. Much of this activity has occurred in the South Saskatchewan River Basin since its closure to further Water Act applications for surface water and/or groundwater under the direct influence of surface water in August 2006. In reality, many licences granted access to water volumes through *Water Act* approvals do not use their full allocation on a regular basis. Estimates of the water allocations used in the province range from as low as 10% to as high as 50% or more (AI-EES 2014). Therefore, the respective individuals or entities have capacity, under the existing provisions of the *Water Act,* to transfer the unused portion of this water to another individual or entity for their use. Transfer of unused portions of existing groundwater licences presents an opportunity to access additional volumes of water, if required.

Sharing agreements provide another vehicle to ensure adequate supplies of water for those participating. The philosophy behind this approach is that multiple users of a particular supply source, like an aquifer, agree to manage that source in a way that ensures sustainable supplies for all parties. This might mean certain concessions to operating practices by each participating member. Similarly, management of the source would be conducted in a coordinated manner. Nevertheless, the goal is that all parties benefit from this coordinated approach versus competing against each other.

An industry model already exists along this line, although it is related to oil and gas development and not water management. This related to the concept of unitization, which is predicated on the notion of providing for the unified development and operation of an entire geologic prospect or producing reservoir so that exploration, drilling, and production can proceed in the most efficient and economical manner by one agreed-upon operator.

This same approach could be equally applied to water supply or disposal activities associated with UCOG development, likely resulting in similar benefits to operators and better management of potential environmental effects.

Another opportunity is to explore the possibility of establishing water cooperatives. This approach has been employed many times to address water needs in rural subdivisions. By extension, a similar approach could be applied to industrial users as long as the same guiding principles and rules under regulation are followed. As such, this presents an opportunity for UCOG companies to approach a water supply (or disposal) project in a coordinated manner, thus reducing the need for individual applications and the associated time and cost. This is somewhat different from the unitization idea in that a separate license to operate a water works is arranged versus the usual arrangement of individual licenses followed by the identification of a single operator to manage the system.

Regardless of the opportunities highlighted above, challenges remain with implementing such water security strategies. Much of this comes from the competitive nature of the oil and gas industry, and reluctance to relinquish access to one's water supplies in the event it is needed later. This is understandable, because without water unconventional oil and gas developments are unable to conduct the necessary drilling, completion, and well stimulation activities to evaluate and/or produce the hydrocarbon reserves. Better understanding of water inventories in the developing areas, and how the basins are responding to internal (i.e. human demand) and external (i.e. supplies affected by climate variability/change) stresses, would prove helpful in placing concerns relating to water sharing into perspective, particularly in areas considered water-abundant.

As the regulatory systems around water use in the western provinces continue to develop, an awareness of the challenges and opportunities to better manage water through collaborative efforts will likely evolve. Considering that industry has demonstrated the ability to collaborate on the development of other resources, like oil and gas, the opportunity exists. It may be the anticipated regulatory changes designed to drive more efficient use of water, like the pending Water Conservation Policy for Upstream Oil and Gas Operations in Alberta that provides the catalyst, or it may be more of a coordinated industry initiative through agencies like the Canadian Association of Petroleum Producers (CAPP). Either way, the desired outcome is a more sustainable use of water (non-saline or saline) to support oil and gas development.

10.3.2 Out-of-Stream Systems

An opportunity exists to establishing out-of-stream systems to reduce regulatory hurdles associated with in-stream works and permanent or semi-permanent structures. This technique is currently being explored and implemented by some UCOG companies.

11 CLOSURE

Integrated Sustainability would like to thank the Petroleum Technology Alliance of Canada for the opportunity to support the Collaboration Opportunity Assessment project. We trust that this report meets the needs and expectations of the Petroleum Technology Alliance of Canada. If you have any questions please contact the undersigned at any time.

Sincerely,

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