

REGIONAL WATER MANAGEMENT INITIATIVE PROJECT

SUMMARY REPORT

Introduction

The Regional Water Management Initiative project was carried out by Canada's Oil Sands Innovation Alliance (COSIA) Water Environmental Priority Area project team between 2012 and 2015. The project's objective was to explore opportunities to manage water in the Athabasca Oil Sands production region, seeking opportunities to minimize negative environmental net effect through the development of regional water reuse networks. The project was intended to extend the body of knowledge and the development of tools necessary to evaluate regional solutions, work that has been underway since 2009; initially through the Oil Sands Leadership Initiative (OSLI). Inside a sustainable water management framework for the oil sands, the regionalization of water systems represents one potential type of reuse application to be evaluated against a range of alternatives.

The project looked at three types of potential collaborative networks:

- Oil Sands Mine Oil Sands Process Water (OSPW) to In Situ Make-up
- In Situ Blowdown Regional Disposal
- Oil Sands Mine Depressurization Deep Well Disposal

Preliminary Project Work

Preliminary project work included identifying participation drivers for mining operators and in situ operators, data collection and preliminary supply-demand analysis, and scenario design. Since water volumes and qualities drive infrastructure needs, including water treatment facilities and piping facility capacities, these first steps to assess supply and demand volumes and screen possible scenarios were critical for the scoping study.

Participation Drivers

Oil sands mining and in situ operators were surveyed to determine the drivers for each group to participate in each of the three types of networks being analyzed.

Potential drivers listed by both types of operators included improved Environmental Net Effect (ENE), improved public perception of the participant and the industry, regulatory support, social license, and opportunity to reduce costs. Significantly, in situ operators were able to quantify economic drivers for participating in collaborative regional solutions, while mining operators were unable to do so; primarily because mining operators would not reliably have excess water to contribute to a regional solution.

Data Collection

The drivers identified above for each of the three types of networks were used to guide decisions on data collection, supply-demand analysis, and scenario development.

Data collection spreadsheets were developed and distributed to member companies. In situ operators were asked to supply make-up and disposal volumes, as well as high quality data for each of their current and planned projects for a period from the present through 2023, and to provide a probability rating for each project proceeding as planned. In situ operators were also asked to specify whether source water and suitable disposal options had been identified or allocated for each project and to provide at least the approximate geographic location of each project.

Oil sands mining operators were asked to provide data on annual volumes of OSPW and depressurization water as well as measures of water qualities.

Data from operators who were not members of COSIA was derived from public data (*Source: Oil Sands Review – August 2014*).

Scenario Development

Potential screening scenarios were developed based on in situ water demand and oil sands mine water supply volumes using data provided by operators. Scenario development assumed that there would be equal supply volumes from all five oil sands mines and that water treatment would be done at each oil sands mine site to prepare the water for delivery by pipeline to the recipients.

Elements considered in selecting the scenarios for analysis were:

- Broad participation categories
- Individual project timing
- Probabilistic adjustment of participation by category
- Project schedule slip volume adjustments
- In situ supply level of total dissolved solids (TDS)

For each of the three networks being studied, scenarios based on different assumptions were analyzed:

- A scenario in which two sets of facilities participated in the project
- A scenario where projects with a later start-up were de-emphasized and a risked scenario where they were not
- Scenarios with a *most likely* participation rate and a *conservative* participation rate
- Scenarios with two different OSPW water qualities

The combination of three potential regional networks with four scenarios for each resulted in twelve scenarios. The two conservative cases of the late project scenario were discarded,

reducing the number of scenarios to ten. Of those ten, the six most probable scenarios (based on the elements considered above) were analyzed in detail.

While the Regional Water Management Initiative (RWMI) project team felt these were representative scenario alternatives for the purposes of the current project scoping, the models developed for the analysis could be easily adjusted to examine other scenarios.

The following sections summarize the inputs and analyses conducted in the areas of supply and demand, pipeline networks, water compatibility, regional disposal locations, and disposal networks.

Analysis

Supply Demand Quantities

Project team members provided specific data on their current and future operations, including:

- Average annual in situ make-up water intake volume
- Average annual in situ boiler blowdown volume
- Average annual oil sands mine depressurization water volume

For in situ facilities located in the area of interest that are not operated or owned by project members, the data needed to come from publicly available sources. In nearly all instances, the only data publicly available on the non-member facilities was estimated annual bitumen production and, in the case of future projects, their estimated start-up year.

These two pieces of data for non-member in situ facilities were used as the basis for estimating more useful annual in situ make-up water intake and boiler blowdown volumes through the application of a set of assumptions:

1. The average amount of make-up required to produce bitumen, presently a ratio of 0.6 bbl. of water to 1 bbl. of bitumen, will steadily improve to 0.3 bbl. of water to 1 bbl. of bitumen between 2015 and 2050.
2. The volume of boiler blowdown brine produced by a warm lime softener-based water treatment plant is equivalent to 40% of the make-up water volume.
3. The water treatment plant configuration of a facility is assumed to be warm lime softening based, unless there is evidence to the contrary.
4. Each phase of an in situ facility will have an operating life of 25 years.

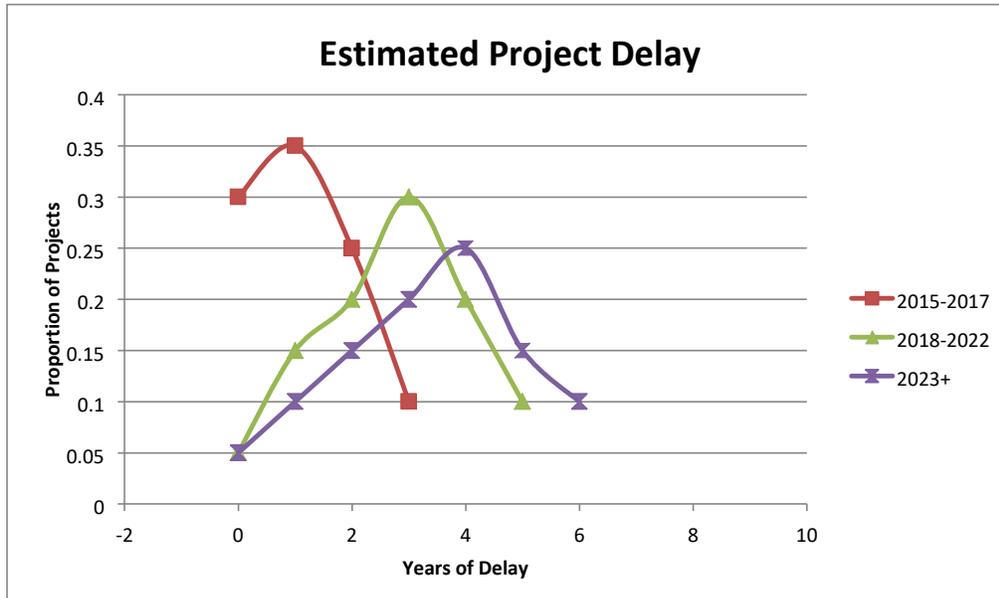
These same assumptions were used for project member facilities in instances when data was not otherwise available.

Project Timing

Another set of assumptions applied to in situ volumes was related to project timing.

Project team members identified that there would likely be shifts in the planned start-up year of future projects. Large capital projects often suffer delays, and projects scheduled to begin operating further into the future had potential to have more variability in their true start-up year.

The approach taken was to estimate a distribution of delays for future projects (i.e., some fraction of projects will start on time, some will be delayed by one year, some by two years, and so on). This distribution was then tailored for groups of projects associated by planned start-up year (i.e., projects with a scheduled start-up in 2014-2017, 2018-2022, 2023 and later). The resulting delay curves are shown in the figure below:



Estimated project delay as a function of project execution timing probability

Without the ability to specify exactly which projects would suffer exactly how much start-up delay, the make-up and disposal volumes for all future projects in a given category were passed through this filter, which had the effect of “fuzzing” when those projects would begin and cease demanding make-up water and producing blowdown brine.

Supply Demand - Quality

Water quality of each of the streams was examined for treatability, impact on the pipeline and compatibility between fluids to assess their ability to be combined.

Infrastructure

Infrastructure components of the RWMI project consist of treatment facilities, pipelines and disposal options that were considered and analyzed to develop this phase of the work.

Treatment

While there are many reasons for choosing individual water treatment plants over a centralized water treatment plant, the single most important reason relates to the volume of concentrate or rejects produced by each source oil sands mine. Most unit treatment processes do not destroy contaminants; rather they produce a clean stream and a more concentrated treated stream of wastewater. Concentrate can be between 3% and 40% of total flow depending on wastewater characteristics and the number and type of unit processes. The concentrate must be managed and, in the case of a centralized treatment plant, needs to have additional unit processes to convert the concentrate stream to a landfill ready material.

While concentrate treatment could be included in the design of a central treatment plant, it is far more economical to locally dispose of the concentrates into each oil sands mine's existing tailings ponds; creating a significant driver for decentralized treatment.

In conjunction with the rejects issue, there are environmental and economic justifications for choosing individual treatment plants:

- **Environmental Considerations:** A centralized plant would require transportation of untreated water, which would create a negative environmental impact in the event of a leak. Because untreated water is more corrosive, the probability of a leak from an untreated water line running to a centralized plant would be greater than one from treated water lines.
- **Economic Considerations:** The facilities required at each oil sands mine are modularized to an optimal size to capture economies of scale. Local treatment would also allow for a smaller pipeline diameter due to the reduced volume of treated versus untreated water, resulting in cost savings. Finally, untreated water contains solids that can settle in the pipeline, requiring design modifications and additional operational costs.

Conversely, a central plant would increase human resources efficiency since fewer operators would be required.

- **Operational Considerations:** Having multiple treatment plants in the region will allow redundancy in the event of plant failure. Additionally, if each operator retains the liability of their wastes on their site, the liability associated with waste management is clearer than it would be for treatment by a central facility.

Source: 2014 RWMI Decision Memo: Advantages of Individual Water Treatment Plants

The environmental, economic, and operational considerations in favour of individual plants outweigh the efficiency in human resources associated with a central plant. Based on these considerations, a series of individual plants at the oil sands mine sites would be the preferred option.

Pipelines

A pipeline study was executed as part of the project. The scope of work for the pipeline study included preliminary pipeline layouts, material selection, pipeline and pumping station design, a cost estimate, and the development of ENE parameters.

Water Chemistry and Compatibility

Co-mingling Water Streams

The RWMI project examined combining multiple fluid streams to improve the ENE and economics of water management; however not all streams are compatible. The project obtained a high level analysis of stream compatibilities to ensure fluids could be combined in regional pipeline networks. While the analysis was limited by available data, the project team was able to make some initial compatibility assessments.

As a result of this analysis the RWMI project considered the co-mingling of OSPWs, OSPW with depressurization water, and blowdown water in the individual networks. The table below shows the co-mingling potential of the various water streams:

	OSPW	Oil Sands Mine Depressurization	In Situ Blowdown
OSPW	Yes	Yes	N/A
Oil Sands Mine Depressurization		Yes	No
In Situ Blowdown			Yes

Stream Comingling Potential

The following conclusions were reached as a result of the high-level chemistry and compatibility analysis:

- In situ make-up water and oil sands mining process effluent water mixing between multiple facilities appears to have the most favourable water compatibilities between sites.
- In situ blowdown mixing between multiple facilities results in fairly compatible streams, but a requirement for managing pH to control precipitates might be cost prohibitive.
- Oil sands mine depressurization water had varied results depending on the operator's depressurization water chemistry, but generally this is the most challenging stream to mix with other water sources.
- Process effluent water and oil sands mine depressurization water mixing would require pH reduction to control precipitants, but the resulting destabilization of organics would be problematic.
- Oil sands mine depressurization water and in situ blowdown streams mixing would also result in challenges with precipitates and pH levels.

Criteria and limits for compatibility would need to be defined to determine which streams should be isolated from co-mingling applications. Next steps could include development of these criteria, as well as conducting a compatibility study between the waste streams and the receiving zones.

Regional Disposal Capacity

A regional-scale screening study of potential disposal zone targets was conducted as part of the RWMI project in 2014 to:

- Assess regional disposal potential, including the disposal demand balance of the South Athabasca Oil Sands (SAOS) area
- Identify gaps and detailed study requirements to conduct a quantitative assessment of the regional potential and demand balance over the life of the SAOS area
- Develop disposal scenarios based on input from COSIA member companies
- Identify economic, environmental, and social risks and technical and operational opportunities associated with these scenarios

The study looked at an area of approximately 141,000 km², from Township 55 to Township 101 and from the Saskatchewan border to Range 7 W5M.

Economic and Capital Cost Analysis

Economic analysis was conducted using a financial model developed by the RWMI team together with member economists.

The economics of regional solutions are complex. Such solutions must compete economically and fit within an operator's overall water management strategy. A key finding of the project was that the supply cost of potential regional solutions increased with increasing volumes and pipeline distances. Thus, optimum economics will likely result from networks in specific sub-regions; allowing for shorter pipeline distances. The analysis showed that the economics of regional oil sands mine depressurization management are poor and do not support further work.

Incorporating third party financing would significantly reduce overall cost. Rather than being financed as a third party private utility, the project could be executed as a Private Public Partnership (P3) which typically results in lower financing rates, or as a municipal utility which also has access to lower rates. Though discussed, these financing alternatives were not analyzed under the scope of this project.

Environmental Net Effects Analysis

The ENE analysis was conducted using the Environmental Net Effects Tool developed by CH2M Hill and the OSLI Regional Solutions team for the 2012 Regional Solutions project. This section presents an overview of the ENE analysis. ENE was analyzed for each of the three networks:

- OSPW to In Situ Makeup

- In Situ Boiler Blowdown to Regional Disposal
- Oil sands mine depressurization Water Regional Disposal.

ENE analysis compares the relative ENE of scenarios in each of the proposed regional networks to the sum of independent solutions, should a regional solution not be implemented.

The ENE analysis includes metrics for water, air, energy, land, waste, environmental risks, social impacts, and economics. Each of these metrics is weighted and the ENE tool converts various environmental inputs and weightings into a holistic score. The tool can evaluate eight alternatives on 32 sub-metrics under seven major metric categories through the use of a multi-objective decision analysis (MODA) calculation.

The results of the ENE analysis are best regarded and applied as decision aids. Results should inform rather than dictate decisions. The analysis provides a way of organizing and comparing complex information. In particular, the ENE tool can assist in project decision making prior to conducting an Environmental Impact Assessment (EIA).

For the most part, limitations of the tool are a result of user input values which can come in two forms. The first, and most obvious, is inaccurate data which results in inaccurate metrics and scoring. The second is from weighting inputs. The model is currently formatted so users input weightings for sub metrics and major metrics. While this flexibility is essential to prioritize specific regional issues it leads to some ambiguity, and likely disagreement, with weighting choices.

In the context of this project, analysis of the different regional network scenarios using the ENE tool was inconclusive, as the tool could not handle the differences between in situ and oil sands mining projects. To calculate a valid and representative ENE, each individual operator will need to conduct an ENE analysis weighting the metrics appropriately for their operations.

Risk Analysis

A risk assessment workshop was held with RWMI project team members in late 2014. Team members collaborated to brainstorm potential risks to RWMI at different phases in its lifecycle from design, through construction, to operations.

At this stage of risk review, the primary risk identified to implementing a regional water management system is getting enough companies to participate in the initial implementation. Operators have expressed concerns with participating given the level of uncertainty around costs and, for in situ operators, the reliability of supply. Companies are more likely to participate once a regional network has a proven track record.

Another primary risk to the initiative is the current lack of certainty regarding the likelihood of oil sands mine investment in TDS control, and the chance oil sands mining operators will choose other alternatives. This will need to be explored further.

The tabled risks have not been further analyzed or associated with probability weightings and severity ratings as an in-depth risk analysis was beyond the scope of this project. Any subsequent projects will require that further risk analysis be done.

Network Scenario Analysis Results

Network 1: OSPW to In Situ Makeup

The OSPW to In Situ Makeup Network transfers OSPW from oil sands mining operations to in situ operations, where it is used for in situ makeup. OSPW treatment is assumed to ensure high quality water is provided as the base case, but high quality water may not be needed by some in situ operators.

The two water qualities considered include a base scenario with pure OSPW at an assumed TDS concentration of 2,000 mg/L and a scenario where OSPW is blended with oil sands mine depressurization water to a TDS level of 6,000 mg/L. This level is still considered suitable for use as in situ make-up water and it would allow for oil sands mines to transfer high TDS depressurization water off their sites without a dedicated pipeline network.

After applying water compatibility, economic, and ENE analyses to the six test scenarios, and looking at participation drivers and infrastructure factors, the following conclusions were drawn regarding the viability of an OSPW to In Situ Makeup Network:

Participation Drivers

- While in situ operators were able to quantify drivers for their participation in an OSPW to In Situ Network, oil sands mining operators were unable to do so. This is due to the fact that, under normal oil sands mine operation, water intake is balanced with tailings consumption, meaning that typically an oil sands mine is net negative with regards to water during operation; that is, under normal conditions, oil sands mines would not have excess water to contribute to a regional system.
- As oil sands mines move from operation to closure and tailings are dewatered, the oil sands mine will become net positive and will need to release water from the site. For a few operators, there have been historical water management issues leading to the accumulation of excess water in the oil sands mine. This excess legacy water could be used in a regional system, however it would not be a sustainable source. In addition, one operator has already had success reducing excess legacy water by reusing it within their own operations. Consequently, supply volumes estimated to be available from mining operations are highly uncertain.

Technical Viability

Water Compatibility

- The water compatibility assessment carried out for the project indicated OSPW is generally compatible with oil sands mine depressurization water, which is expected

given that many oil sands mines add higher TDS depressurization water to their existing tailings ponds. Actual projects will need to conduct full water compatibility analysis as part of early scoping work.

- The OSPW to in situ makeup infrastructure includes OSPW treatment at the oil sands mines and a pipeline network to collect OSPW from the participating oil sands mines and distribute it to participating in situ facilities. OSPW treatment at individual oil sands mines has been assumed for all of the scenarios to ensure water transferred to in situ facilities meets required minimum water qualities for both in situ facilities and pipelines.
- The project team chose to scope the project using individual water treatment facilities at each of the supply sites as opposed to one central water treatment facility for reasons outlined previously in this report.

Pipeline

- Two OSPW water qualities were considered: 2,000 mg/L TDS and 6,000 mg/L TDS. Epoxy-coated steel pipe was the recommended pipeline material for all pipeline segments greater than 6 inches (~150mm) in diameter. FiberSpar® composite lined pipe was recommended for pipeline segments equal to or smaller than 6 inches diameter.
- The pipeline network has been laid out following existing pipeline rights of way whenever possible.
- Booster pumps are located at each of the oil sands mines and within the transmission system to maintain a minimum pressure within the pipeline and at each in situ facility where the OSPW is assumed to flow into an onsite storage tank.

Economics

- Supply cost of the scenarios studies increased with volume, thus the optimum economics will likely result from sub-regional solutions smaller than the volumes studies with limited geographical participation minimizing pipeline distances.
- Third party financing significantly reduced overall cost.

Environmental Net Effect

- The ENE analysis was inconclusive. The unweighted ENE tool could not handle the difference between the oil sands in situ and mining projects, so the scores are not useful for comparison purposes.

Gaps and Next Steps

- Further work on conceptual regional water solutions will not provide additional insight.
- Individual operators will need to further develop actual potential regional solutions to assess the technical-economic-environmental risk profile that would allow inclusion as part of an overall water strategy.

Network 2: In Situ Blowdown Regional Disposal

The In Situ Blowdown Regional Disposal Network would collect boiler blowdown from individual in situ operators and dispose of it in large regional disposal fields. This is in contrast to the current practice where each operator individually disposes of blowdown if capacity is available locally or, if not, switches to evaporation. The individual solution assumes complete management of TDS; i.e., through final disposal, including ultrafiltration, reverse osmosis, evaporation and crystallization/drying, and third party landfill disposal of the waste salt.

As with the OSPW to In Situ Makeup Network, six potential scenarios were modelled and, after applying the full analysis, the following conclusions were drawn regarding the feasibility of an In Situ Blowdown Regional Disposal Network:

Participation Drivers

- Drivers for participation for in situ participants vary by individual operator as a function of their individual access to makeup water and local disposal. While the analysis to date indicates there is regional disposal capacity, the information available is very high level and results are likely to change as additional information becomes available.
- Drivers for producer participation in a regional boiler blowdown disposal network include potential improved environmental performance and possible scarcity of local disposal. Arguments against a regional solution include the loss of operational independence, the significant degree of cooperation required to get such a system up and running, and potential upsets from piping blowdown water large distances with potential for leakage.
- A regional disposal network would feed a large regional disposal field, which would have efficiencies over individual operations, including greater understanding of regional geology and hydrogeology due to the large number of wells drilled, and supplier discounts for drilling and work-overs due to high volumes.
- Environmental benefit may be realized due to fewer wells and the avoidance of evaporation technologies in favour of lower energy technologies by those with poor or no local disposal capacity.

Technical Viability

Water Compatibility

- Water compatibility between in situ operations was analyzed and blowdown streams were found to be compatible for transportation in a single pipeline network.
- Disposal formation compatibility with the blowdown was not considered, but would need to be confirmed if this work progresses further.

Pipeline Network and Disposal Well Fields

- Based on disposal volumes estimated by the RWMI team and deep well disposal targets identified, the transmission networks were optimized to minimize overall pipeline length and make the most efficient use of disposal fields based on their configuration and structure.
- In situ participants deliver their blowdown to the network at specified pressures and temperatures. Additional pumping is provided as required to deliver the blowdown to the Woodbend and Elk Point deep well injection fields, where it is re-pressurized and injected through a network of pipelines.
- Due to the highly corrosive nature of the disposed fluid, all piping greater than six inches in diameter has been assumed to be high-density polyethylene (HDPE) lined steel. For piping less than 6 inches (~150mm), a composite material called Fiberspar® was assumed to be used.
- The HDPE pipelines assumed in the design can tolerate high TDS environments. This will allow them to transport blowdown brine with a range of qualities. Additional engineering will be required on pipeline design for the hot blowdown, but the technology exists and is currently being used by operators in current Once Through Steam Generator (OTSG) blowdown systems.

Economics

- The RWMI team did not compare the cost of an individual solution relative to a regional solution due to the complexity of the analysis, which would include costs associated with water sourcing, disposal, and process equipment. Operators without good local make-up and disposal availability typically resort to evaporation technologies which are expensive. The resulting complexities are beyond the capacity of this project to estimate with any accuracy.

NOTE: Individual producers will have to create supply cost scenarios to compare their costs to the regional costs.

- Three major cost drivers have been identified:
 1. High CAPEX - Current alternatives have a very high initial CAPEX due to the requirement to install the regional backbone pipeline. Some phasing of the disposal system has been assumed for the disposal fields which are expanded as required.
 2. In situ disposal proximity - In situ proximity to disposal has a significant influence on individual cost and thus on the relative cost of regional versus individual solutions.
 3. If in situ producers have to use highly saline water requiring desalinization, the additional cost would factor into an integrated water management options analysis between regional and local systems.
- Lowering the third party's weighted average cost of capital (WACC) through innovative financial solutions including third party utilities, P3 and municipal utilities might result in a

lower cost than a producer's owned solution due to a significantly lower WACC requirement.

Environmental Net Effect

- The In Situ Blowdown Regional Disposal Network ENE analysis compared the ENE of an individual in situ blowdown disposal solution -- assuming local disposal -- to the ENE of a regional blowdown disposal solution -- assuming a large remote disposal field. An analysis not conducted, but which would be valuable, would be the ENE of an evaporation-based solution which would be required by producers if their local make-up and disposal options are limited.
- The greenhouse gas (GHG) emissions intensity associated with regional blowdown disposal does not improve with a larger network. Deep well disposal GHG emissions result in a lower ENE relative to a blowdown evaporator solution.
- The ENE analysis showed the ENE of a regional in situ blowdown solution is very similar to that of combined individual in situ blowdown disposal solutions. As a result, ENE is not a deciding factor in the current alternatives.

Gaps and Next Steps

- Members with limited local disposal should consider regionalization of disposal versus the high-energy intensity of evaporation
- Develop economics and ENE for independent solutions including deep well and evaporation.
- Develop a solution combining the OSPW to in situ and in situ to regional in situ blowdown.

Network 3: Oil Sands Mine Depressurization Water Regional Deep Well Disposal

Oil sands mine depressurization water is natural groundwater which has not been part of the actual mining or processing operation. As an oil sands mine removes the layers of overburden and the ore, groundwater seeps into the mine pit. Operations use pumps to keep the groundwater out of the mine pit during operations. If the mining operations were not present, this groundwater would typically flow into the Athabasca River and its tributaries. Management of groundwater must consider this frame of reference.

Currently oil sands mines manage their depressurization water independently. Three options for handling depressurization water are: discharge to the river, evaporation combined with off-site disposal of the concentrated residuals, and regional deep well disposal.

The Oil sands mine Depressurization Water Regional Deep Well Disposal analysis examines the possible improved environmental and economic performance using collaborative networks to manage oil sands mine depressurization water; which would involve collecting depressurization water from oil sands mines and disposing via deep well in either a single field or in multiple fields. Due to the relatively small depressurization water

volumes in comparison with the overall volume of the Athabasca River it is also possible for operators to discharge depressurization water to the Athabasca with minor treatment. This alternative was not examined.

The analyzed network has three elements: collection from the oil sands mines, transmission to the disposal fields, and deep well disposal.

Analysis included:

- A regional network with regional disposal fields
- Independent solutions consisting of concentration, solidification, and third party landfill disposal of the solidified salt

The key to depressurization water management is to understand the volumes and characteristics of the water. Estimated liquid volumes and dissolved solids volumes are 16 million m³/year in 2025, and 600 metric tons per day respectively. In addition to depressurization water volumes and total dissolved solids, specific dissolved ions composition water must be considered in the selection of suitable solutions. Currently, oil sands mines are managing low salinity depressurization water by either blending it into their existing process streams, on site storage, discharge to receiving environment, or locally disposing of it into disposal fields through deep well injection (OSLI, 2012). Disposal fields are limited and now near capacity. Saline depressurization water management is going to require more active and energy intensive management in the future to manage the anticipated future volumes.

Participation Drivers

- Potential drivers for oil sands mines to participate in a regional depressurization network include improved ENE and economics.
- Participation will depend on mining operators' need to manage their depressurization waters. Currently several oil sands mines are producing high TDS depressurization water and many future oil sands mines will produce high TDS depressurization waters which they will need to manage. An inability to release to the river would be a driver for mining operations.

Technical Viability

Water Compatibility

- The Regional Depressurization Deep Well Disposal Solution has three elements: collection of depressurization water from each of the oil sands mines, a transmission main to transfer the collected water to the disposal field, and the regional disposal field. Prior to considering a regional disposal network, the individual oil sands mines' water compatibility was studied as part of the compatibility analysis. The analysis concluded that depressurization water is compatible and thus a common disposal network is feasible.

Potential Regional Disposal Areas

- A high level study of the region was conducted to identify potential areas for large scale deep well disposal. The study identified three areas with the potential to dispose of the required volumes: the Cambrian Sandstone, Elk Point Group, and Woodbend Group.
- In the Athabasca Regional Disposal Study, it has been assumed that Cambrian Sandstone would be used for the regional disposal of oil sands mine depressurization water. Although the Cambrian Sandstone is the furthest disposal location from the oil sands mines, Woodbend and Elk Point were allocated for in situ regional disposal. Should regional in situ disposal not proceed, or if there was sufficient capacity for both in situ and oil sands mine depressurization disposal, the transmission main could be reduced.
- The depressurization collection system and transmission main were located on existing rights of way to minimize disturbance wherever possible.

Regional Depressurization Disposal Field

- Each type of geological formation results in a unique disposal well layout. Based on formation details provided in the regional disposal analysis and the assistance of COSIA member hydrogeologists, a number of typical disposal well configurations were developed.
- Each well configuration considered a number of factors including disposal volume; average well life, and assumed drilling failure rate. These dictated the total number of wells required over the project life and when they were to be drilled. A number of these assumptions are conservative (e.g., assuming 60% of wells drilled will fail). Information obtained from future investigations will result in more accurate assumptions and reduce costs.

Pipeline Material Selection

- Due to the highly corrosive nature of the disposed fluid, all piping more than six inches in diameter has been assumed to be HDPE lined steel. For less than six inches, the use of Fiberspar® (a composite material) was assumed.

Economics

- Regional disposal requires the construction of large disposal fields. While efficiencies are expected from large disposal fields, industry has no experience in the construction of such fields. The estimates of efficiency are based on project members' estimates, but with little actual experience, the reliability of these estimates is low.
- For the volumes considered, initial unit water supply costs for regional network alternatives would be cheaper for some operators than the cost of individual solutions, though costs can be expected to rise as the project moves into more detailed design.

- Lowering the third party's WACC through innovative financial solutions including third party utilities, P3, and municipal utilities may result in lower costs than a producer-owned solution due to significantly lower WACC requirements.
- Current alternatives have a very high initial CAPEX due to the costs of developing pipelines and disposal well fields and are front-end loaded without much ability to phase in.
- In situ proximity to disposal has a significant influence on individual costs and, as a result, the relative cost of regional versus individual solutions.

Environmental Net Effects

- ENE analysis for the Regional Oil Sands Mine Depressurization Water Network is inconclusive.
- At a minimum, to conduct a representative analysis, the parameters must be weighted, which is beyond the scope of current analysis. However, even additional analysis with parameter weightings may prove inconclusive using the current ENE Tool as the independent and regional solutions have different parameters--something the ENE Tool is unable to deal with.

Gaps and Next Steps

- At this point a regional depressurization network does not appear to be economically viable and the environmental benefits are unclear. Operators will continue to pursue opportunities to manage oil sands mine depressurization water as needed and no further work on a regional solution is planned at this time.

Overall Conclusion and Next Steps

In agreement with past work, the RWMI project confirmed that regional solutions focused on the Athabasca oil sands production region as a whole are technically viable opportunities that can be engineered. However, participation drivers are complex and depend on many factors. While there are clear drivers for in situ operators to consider participating in regional networks, oil sands mining participation drivers are weak at best and potentially negative, due largely to a finite amount of excess legacy OSPW needing to be moved offsite. As a consequence, the primary water supply for in situ operators would be the Athabasca River. This has implications for stakeholders in the region; in particular for local Indigenous communities.

Overall, the RWMI project successfully developed the concept and tools to provide operators with information necessary to evaluate regional options as part of their overall water management strategy. Due to the complex nature of each operator's site asset base and operational history, it would not be beneficial to further develop a conceptual regional solution based on assumptions. Individual operators with strong drivers will need to assess and develop sub-regional solutions and collaborations to advance the engineering and produce technical, economic, and environmental risk assessments for enabling project sanction decisions.

While there are no definitive next steps for the RWMI project, COSIA's Joint Industry Project model can be used to launch ensuing sub-regional network projects.