

CLEAN RESOURCES FINAL REPORT PACKAGE

Project proponents are required to submit a Final Report Package, consisting of a Final Public Report and a Final Financial Report. These reports are to be provided under separate cover at the conclusion of projects for review and approval by Alberta Innovates (AI) Clean Resources Division. Proponents will use the two templates that follow to report key results and outcomes achieved during the project and financial details. The information requested in the templates should be considered the minimum necessary to meet AI reporting requirements; proponents are highly encouraged to include other information that may provide additional value, including more detailed appendices. Proponents must work with the AI Project Advisor during preparation of the Final Report Package to ensure submissions are of the highest possible quality and thus reduce the time and effort necessary to address issues that may emerge through the review and approval process.

Final Public Report

The Final Public Report shall outline what the project achieved and provide conclusions and recommendations for further research inquiry or technology development, together with an overview of the performance of the project in terms of process, output, outcomes and impact measures. The report must delineate all project knowledge and/or technology developed and must be in sufficient detail to permit readers to use or adapt the results for research and analysis purposes and to understand how conclusions were arrived at. It is incumbent upon the proponent to ensure that the Final Public Report **is free of any confidential information or intellectual property requiring protection**. The Final Public Report will be released by Alberta Innovates after the confidentiality period has expired as described in the Investment Agreement.

Final Financial Report

The Final Financial Report shall provide complete and accurate accounting of all project expenditures and contributions over the life of the project pertaining to Alberta Innovates, the proponent, and any project partners. The Final Financial Report will not be publicly released.

Alberta Innovates is governed by FOIP. This means Alberta Innovates can be compelled to disclose the information received under this Application, or other information delivered to Alberta Innovates in relation to a Project, when an access request is made by anyone in the general public.

In the event an access request is received by Alberta Innovates, exceptions to disclosure within FOIP may apply. If an exception to disclosure applies, certain information may be withheld from disclosure. Applicants are encouraged to familiarize themselves with FOIP. Information regarding FOIP can be found at <http://www.servicealberta.ca/foip/>. Should you have any questions about the collection of this information, you may contact the Manager, Grants Administration Services at 780-450-5551.

CLEAN RESOURCES FINAL PUBLIC REPORT TEMPLATE

1. PROJECT INFORMATION:

Project Title:	Steam Additive to Improve Thermal Bitumen Recovery
Alberta Innovates Project Number:	212201036
Submission Date:	March 17, 2023
Total Project Cost:	\$421,470
Alberta Innovates Funding:	\$195,090
AI Project Advisor:	Bruce Duong

2. APPLICANT INFORMATION:

Applicant (Organization):	ChampionX Canada ULC
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3. PROJECT PARTNERS

Please provide an acknowledgement statement for project partners, if appropriate.

RESPOND BELOW

A. EXECUTIVE SUMMARY

Provide a high-level description of the project, including the objective, key results, learnings, outcomes and benefits.

RESPOND BELOW

ChampionX has developed and patented a chemistry that enables significant reductions in Steam to Oil Ratio (SOR) at thermal bitumen production operations. This specialty chemical additive can be injected directly to steam and requires no solvent recovery equipment, making it easily deployable at brownfield or greenfield assets. It also has the potential to be compatible and complementary with other SAGD SOR reduction initiatives such as solvent-based steam additives. The project was initiated to confirm performance of the technology under steam assisted gravity drainage (SAGD) conditions. Results of the third-party investigation were very favourable and support advancing the technology to a field-scale pilot with a major producer in Alberta.

B. INTRODUCTION

Please provide a narrative introducing the project using the following sub-headings.

- **Sector introduction:** Include a high-level discussion of the sector or area that the project contributes to and provide any relevant background information or context for the project.
- **Knowledge or Technology Gaps:** Explain the knowledge or technology gap that is being addressed along with the context and scope of the technical problem.

RESPOND BELOW

Sector Introduction:

SAGD operations in the Alberta oilsands generate large amounts of steam for downhole injection to recover bitumen emulsion to process to sales-quality oil. Steam generation is a major component of operational costs and CO₂ emissions, whether generated on site or on behalf of the producer. In some cases, fresh water is also used and can become a constraint. A common metric employed to gauge the efficiency of these operations is the steam-to-oil ratio (SOR): the proportion of steam required to recover a given amount of bitumen. Reducing SOR is therefore a major commercial and ESG target for oilsands producers.

Knowledge or Technology Gaps:

ChampionX has developed a chemical technology and application to improve the SOR of SAGD and other thermal operations. While there are several ongoing developments to demonstrate solvents that may improve in-situ thermodynamic properties, advancement of chemistries to improve in-situ chemical properties have been limited. Porous media testing showed strong performance of the technology, but in discussion with potential end users we uncovered a technical gap in specialized larger-scale porous media results under SAGD conditions. This project successfully filled that gap with the goal of enabling a field pilot to begin in 2023.

C. PROJECT DESCRIPTION

Please provide a narrative describing the project using the following sub-headings.

- **Knowledge or Technology Description:** Include a discussion of the project objectives.
- **Updates to Project Objectives:** Describe any changes that have occurred compared to the original objectives of the project.
- **Performance Metrics:** Discuss the project specific metrics that will be used to measure the success of the project.

RESPOND BELOW

Technology Description: ChampionX's steam additive had demonstrated excellent performance in bench-scale porous media evaluations. ChampionX's additive has advantages over existing steam additive chemicals by exhibiting improvements in thermal stability, emulsion formation, and overall production improvements. The benefits of larger-scale testing on specialized gravity-drainage equipment, including better understanding of bitumen drainage and mineralogical interactions, were understood in pre-pilot discussions with potential users. This project was therefore undertaken to improve understanding of the technology performance under more representative conditions.

Updates to Project Objectives: The project was scoped with potential users before launch and there were no significant changes to the objectives.

Performance Metrics: Project KPIs were identified to be (1) significantly reduced SOR with treated steam relative to untreated steam and (2) low variation between duplicate tests to support high confidence in results.

D. METHODOLOGY

Please provide a narrative describing the methodology and facilities that were used to execute and complete the project. Use subheadings as appropriate.

RESPOND BELOW

Evaluations were conducted in two rounds of work at InnoTech Alberta facilities in Calgary and Edmonton. Initial tests conducted on the Steam Soak apparatus were performed with typical bitumen, sand and brine under representative temperature and pressure profiles to understand the response of SOR improvement to chemistry dosage. This was followed by evaluation by Gravity Drainage testing utilizing a more sophisticated test apparatus that measured steam injection and bitumen recovery with steam chamber development between a SAGD well pair analogue. This apparatus is acknowledged widely in industry as the gold-standard for steam additive evaluation.

E. PROJECT RESULTS

Please provide a narrative describing the key results using the project’s milestones as sub-headings.

- Describe the importance of the key results.
- Include a discussion of the project specific metrics and variances between expected and actual performance.

RESPOND BELOW

The Steam Soak Tests: These results demonstrated an SOR response proportional to chemical dosage of the steam, informing parameters for the following test and helping to inform expected results of pilot scale optimization protocols.

The Gravity Drainage Tests: Results of treatment with ChampionX’s technology showed an excellent SOR reduction relative to untreated steam. The low variation between duplicate tests also provided excellent confidence in the results to encourage a prompt field trial.

F. KEY LEARNINGS

Please provide a narrative that discusses the key learnings from the project.

- Describe the project learnings and importance of those learnings within the project scope. Use milestones as headings, if appropriate.
- Discuss the broader impacts of the learnings to the industry and beyond; this may include changes to regulations, policies, and approval and permitting processes

RESPOND BELOW

The key learning this project delivered was the significant SOR reduction provided by ChampionX’s chemical technology under material, pressure and temperature conditions representative of SAGD conditions. This result meets the project objective of advancing the development from a technology readiness level (TRL) of 6 to 7, thereby enabling a field pilot to accelerate commercialization. A field pilot with an industry partner on typical SAGD wells is planned in 2023.

G. OUTCOMES AND IMPACTS

Please provide a narrative outlining the project's outcomes. Please use sub-headings as appropriate.

- **Project Outcomes and Impacts:** Describe how the outcomes of the project have impacted the technology or knowledge gap identified.
- **Clean Energy Metrics:** Describe how the project outcomes impact the Clean Energy Metrics as described in the *Work Plan, Budget and Metrics* workbook. Discuss any changes or updates to these metrics and the driving forces behind the change. Include any mitigation strategies that might be needed if the changes result in negative impacts.
- **Program Specific Metrics:** Describe how the project outcomes impact the Program Metrics as described in the *Work Plan, Budget and Metrics* workbook. Discuss any changes or updates to these metrics and the driving forces behind the change. Include any mitigation strategies that might be needed if the changes result in negative impacts.
- **Project Outputs:** List of all obtained patents, published books, journal articles, conference presentations, student theses, etc., based on work conducted during the project. As appropriate, include attachments.

RESPOND BELOW

Project Outcomes and Impacts: The project successfully met the objectives by filling ChampionX's understanding of performance of the technology at lab scale with steam soak and gravity drainage tests, while observing steam chamber formation and quantifying SOR reductions. The SOR reduction achieved validated ChampionX's initial expectations and represents a material and significant improvement over existing SAGD baseline.

Clean Energy Metrics: The project achieved each established metric: TRL advanced from 6 to 7, a new product was developed and projected GHG reductions of several megatons were projected by 2030, depending on industry uptake and performance in actual well operations.

Program Specific Metrics: US Patent 11,236,595B2 was awarded in 2022; although it was applied for in 2018 prior to launch of this project, work conducted during the project confirmed our previous independent findings.

H. BENEFITS

Please provide a narrative outline the project's benefits. Please use the subheadings of Economic, Environmental, Social and Building Innovation Capacity.

- **Economic:** Describe the project's economic benefits such as job creation, sales, improved efficiencies, development of new commercial opportunities or economic sectors, attraction of new investment, and increased exports.
- **Environmental:** Describe the project's contribution to reducing GHG emissions (direct or indirect) and improving environmental systems (atmospheric, terrestrial, aquatic, biotic, etc.) compared to the industry benchmark. Discuss benefits, impacts and/or trade-offs.
- **Social:** Describe the project's social benefits such as augmentation of recreational value, safeguarded investments, strengthened stakeholder involvement, and entrepreneurship opportunities of value for the province.
- **Building Innovation Capacity:** Describe the project's contribution to the training of highly qualified and skilled personnel (HQSP) in Alberta, their retention, and the attraction of HQSP from outside the province. Discuss the research infrastructure used or developed to complete the project.

RESPOND BELOW

Economic: Deployment of ChampionX's technology will drive reduced SOR of thermal bitumen production, increasing the overall efficiency and capacity of the industry through:

- Reduced energy input and operating costs;
- Accelerated oil production per unit volume of steam;
- Increased revenue and accelerated capital returns.

Environmental: ChampionX's patented solution will improve environmental performance through:

- Reduced GHG emissions intensity through a reduction in steam requirements per flowing barrel;
- Reduced freshwater utilization at both sites licensed to do so and at greenfield sites during startup.

I. RECOMMENDATIONS AND NEXT STEPS

Please provide a narrative outlining the next steps and recommendations for further development of the technology developed or knowledge generated from this project. If appropriate, include a description of potential follow-up projects. Please consider the following in the narrative:

- Describe the long-term plan for commercialization of the technology developed or implementation of the knowledge generated.
- Based on the project learnings, describe the related actions to be undertaken over the next two years to continue advancing the innovation.
- Describe the potential partnerships being developed to advance the development and learnings from this project.

RESPOND BELOW

The next steps for deployment of the technology are already underway. ChampionX has been developing a pilot with a major oilsands producer in parallel to third-party evaluations. As the results have exceeded agreed KPIs, both parties are actively scoping a pilot to begin later in 2023.

With commercial success of this pilot, a launch throughout industry would allow broader uptake of the technology and scaling of the commercial and sustainability benefits.

J. KNOWLEDGE DISSEMINATION

Please provide a narrative outlining how the knowledge gained from the project was or will be disseminated and the impact it may have on the industry.

RESPOND BELOW

Knowledge gained from the project will be shared with industry through direct engagements with oilsands producers to identify opportunities to expand commercial and ESG benefits.

Findings from the project have also informed development of ChampionX's next-generation of steam additives. While the technology evaluated is expected to begin a field pilot in 2023, these future technologies will continue to mature for subsequent use in the oilsands industry.

K. CONCLUSIONS

Please provide a narrative outlining the project conclusions.

- Ensure this summarizes the project objective, key components, results, learnings, outcomes, benefits and next steps.

RESPOND BELOW

This project was undertaken to evaluate ChampionX's patented steam additive through large-scale third-party evaluations representative of SAGD conditions. Testing confirmed repeatable and significant SOR reductions through Steam Soak and Gravity Drainage testing at InnoTech Alberta. These results have enabled ChampionX to continue scoping work on a field pilot with a major oilsands producer. Following success of a field pilot, full commercialization will allow the oilsands industry to realize the GHG reductions, freshwater use reductions, operational cost savings and capital efficiencies the technology promises.