COSIA CHALLENGE

Mobilizing the world's minds and resources to improve environmental performance.

cosia with Pathways Alliance

Transforming Seismic Exploration to Approach Zero Land Disturbance

SOLUTION DESCRIPTION:

Technologies and techniques that enable **SUBSURFACE** geology profiling without clearing vegetation.

UPDATED: October 23, 2020

All proposed innovations or technological solutions will go through a staged assessment process.

CHALLENGE CHAMPION:

COSIA's Land EPA has identified the Land Challenge *Transforming Seismic Exploration to Approach Zero Land Disturbance* that if realized, would contribute towards helping COSIA achieve its Land Aspiration.

Our Land aspiration is to be leaders in land management, restoring the land and preserving biodiversity of plants and animals.

COSIA has four Environmental Priority Areas (EPAs): Water, Land, Tailings, and Greenhouse Gases (GHGs).

For more information on COSIA Innovation Opportunities, please visit

www.pathwaysalliance.ca

SUBMIT YOUR IDEA **HERE**

Canada's Oil Sands Innovation Alliance (COSIA) is an alliance of oil sands producers, representing more than 90 percent of oil sands production, focused on collaborative action and innovation in oil sands environmental technology.

COSIA Challenges are one way we articulate an actionable innovation need, bringing global innovation capacity to bear on environmental challenges and opportunities in Canada's oil sands.

Canadian Natural · cenovus energy · ConocoPhillips Canada · Imperial · Syncrude · SUNCOR

#020: **Transforming Seismic Exploration to Approach Zero Land Disturbance**

THE SOLUTION WE ARE SEEKING

The COSIA Land Environmental Priority Area (EPA) has identified an opportunity to significantly reduce or eliminate vegetation clearing associated with exploration across the boreal forest and, in particular, within the oil sands region of northern Alberta, Canada, for in situ projects.

Successful techniques, technologies or approaches:

- Will be applicable for two-dimensional, three-dimensional and four-dimensional subsurface geologic profiling;
- will strive to eliminate the removal of pre-existing vegetation, in particular, trees.

WHAT TO SUBMIT TO COSIA

COSIA requires sufficient non-confidential, non-proprietary information to properly begin to evaluate the technology.

Some items that will be especially important to present in your submission are:

- Concept and basic unit operations
- Technical justification for the approach (e.g. laboratory batch or continuous experiments; pilot or demo plants; process modeling; literature precedent)
- Describe quantities and qualities of utilities and consumables that are required
- Energy inputs – quantity and type(s)
- Capital and operating cost estimates if available based on described capacity targets
- Basis of cost estimation, including estimation scope, contingency, etc.
- IP status of your proposed technology.
- What operating environment restrictions might your technology face:
  - Explosive atmospheres
  - Severe weather
  - Power fluctuations

FUNDING, FINANCIALS, AND INTELLECTUAL PROPERTY

COSIA Members are committed to identifying emerging technologies and funding the development of the technologies to the point of commercialization, while protecting the Intellectual Property (IP) rights of the owner of the technology. COSIA Members have funded over 1,000 projects to date, totaling over $1.4 billion.

Successful proposals may receive funding from COSIA members to develop and demonstrate the technology in an oil sands application. Multiple technologies may be funded, at the discretion of the Members.

HOW TO SUBMIT TO COSIA

Submit a summary of your solution through the Foresight COSIA Challenge page at:

https://foresightcac.com/cosia-challenge/

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DETAILED SOLUTION DESCRIPTION

COSIA is looking into:

- Investigating new and improved exploration techniques that would help lead COSIA member companies towards zero land disturbance from exploration activities when characterizing subsurface resources for in situ projects.

BACKGROUND: EXPLORATION ACTIVITIES ASSOCIATED WITH IN SITU DEVELOPMENTS

One of the challenges for resource development companies in the Canadian oil sands is the surface footprint associated with oil sands projects. Of the 142,200 km^2 of land that oil sands underlie in northern Alberta, a small portion has been mined (i.e. <1 per cent or 1000 km^2 in 2019). The majority of the oil reserves are deep underground (>75m).

Approximately 97 per cent of the oil sands that will be recovered will be by in situ recovery methods. While in situ projects require very little surface land disturbance - only 15 to 25 per cent of the land compared to 100 per cent for mining - these projects still have an impact on the boreal forest. On average, about 50 per cent of the land disturbed at in situ projects results from current exploration methods to delineate oil and gas reserves and regulations that require demonstration of cap rock thickness.

Successful resource recovery requires detailed information about the location and quality of the oil resources under the ground. Seismic and oil sands exploration well drilling are the exploration methods used to evaluate oil sands reserves.

Seismic exploration involves the production and analysis of underground sound waves to generate a computer model of subsurface geological structures. Corridors are cleared for access through the boreal forest to support safe passage of moving source equipment and people during the winter that either (i) directly delivers seismic energy to the earth by contacting the ground (e.g., vibroseis) or (ii) drills holes (normally 3-10 metres deep) to position dynamite explosives into the earth to create seismic energy upon detonation (Figure 2). Dynamic charges and vibroseis both effectively generate seismic sound waves.

By analyzing the time it takes for seismic waves to return to the surface, a geophysicist can map subsurface formations and anomalies and predict where oil may be trapped. As the charges are sequentially detonated or vibrations are injected, the sound waves are

reflected by subsurface geological formations and recorded at the surface using portable recording equipment called geophones.

Historically, seismic exploration would leave cleared lines in the forest up to eight metres wide for lengths that could stretch many kilometres. Technology enhancement and adoption have seen low impact seismic (LIS) become the predominant form of exploration in the oil sands region.

Exploration well drilling is most often done to collect sediment cores and, ultimately to delineate a potential resource. This includes developing access routes or roads for heavy equipment and clearing up to one hectare of area for each exploration well (Figure 1).

2D, 3D & 4D Seismic Explained

Two-dimensional (2D) seismic exploration occurs along a single line on the ground, producing a picture akin to a slide through the earth beneath that line. Three-dimensional (3D) seismic surveys have shot holes and geophones laid out in a grid system, resulting in multi-directional reflections that are recorded at the receiver geophone, creating a 3D image of the subsurface.

In some cases, seismic programs are repeated, over the same area, known as four-dimensional (4D) seismic, to monitor changes in the subsurface over time. The time between repeated programs varies from company to company (e.g. every six months to every three years). The 4D seismic approach is used for surveillance, to examine reservoir depletion and changes after a production well is installed and producing oil.

In terms of project phases, exploration occurs throughout the life of a project to support the following activities:

- Determine the deposit extent and commercial viability – systematic grid of core holes and 2D seismic exploration gathers coarse geological data used to delineate deposits;
- Design the Production and Well Placement – 3D models of the deposit are produced to aid in production pad and horizontal well placement; and
- Determine Reserve Depletion – 4D seismic monitors changes in the deposit over time after a production well(s) is developed.

Figure 1:Oil Sands Exploration (OSE) pads, the result of winter exploration well drilling, are typically about half a hectare in size. Un-reclaimed (left) and newly reclaimed OSE pads (right).

Figure 2 - (left) Equipment clearing corridors for low impact seismic exploration and (right) an aerial view of 2D seismic exploration.

Exploration approaches do not always result in development. Industry practice and the regulatory minimum (see next section for more detail) is to drill at least eight wells per section and shoot 3D seismic to delineate the geological formation (e.g., McMurray) for development (or alternatively, to drill at least 16 wells per section without seismic.)

Generally, for each section that is developed there will be one or more sections that are explored but deemed uneconomic to develop. In this case, there are typically less than four wells per section and 3D seismic may also have been acquired.

For more detail on current exploration activities, see Appendix A.

Meeting Today's Regulatory Requirements

Existing regulatory requirements dictate particular techniques and well densities that are required for exploring oil sands reserves. See: The *Oil Sands Tenure Regulation, 2010* (http://www.qp.alberta.ca/documents/Regs/2010_196.pdf) and the *Oil Sands Tenure Regulation, 2010 – Interim Approach Update Memo* (http://www.energy.alberta.ca/OilSands/pdfs/IB_2012-04.pdf).

For more information see the Alberta Energy Regulator's (AER) Draft Directive 023 (http://www.aer.ca/documents/directives/DraftDirective023_20130528.pdf).

For example, the *Draft Directive 023: Oil Sands Project Applications* indicates that the Energy Resources Conservation Board (ERCB), now known as the Alberta Energy Regulator (AER), expects applicants to have obtained an adequate amount of resource delineation to support their application.

The project area must be delineated adequately so that the applicant can demonstrate there is potentially recoverable bitumen within each section.

Why Reduce Exploration Footprints?

This Challenge is an extension of the evolution towards smaller clearings, with an ultimate goal of minimizing to the extent possible the exploration footprint of COSIA member companies. Thereis growing concern about the potential ecological impacts of low impact seismic lines.
Ecological implications related to the high density of low impact seismic lines have been documented, with particular emphasis on the amount of edge habitat created and changes to vegetation communities (Dabros et al., 2018) on cleared seismic lines. Researchers have also determined that recovery of trees and other vegetation on cleared low impact seismic lines is not guaranteed (Kansas et al., 2015), but rather is impacted by site conditions along cleared lines. The frequency of seismic acquisition (i.e., 4D seismic) is also projected to impact the rate of vegetation recovery along cleared seismic lines (Dabros et al., 2018). Concerns have also been identified with respect to potential methane emissions from seismic lines in the boreal forest driven by a reduction in peat height and an increase in water at the surface of peatlands (Strack et al., 2019).

COSIA is looking for exploration solutions beyond current and regulatory-approved exploration approaches. We encourage innovators not to limit their approaches to today's regulations if they have potentially better solutions to current exploration practices.

WORK COMPLETED TO DATE BY COSIA: A REVIEW OF EXPLORATION TOOLS AND TECHNIQUES

Since 2017, COSIA member companies have completed four technology pilots. In 2018, COSIA partnered with Fuse Consulting Ltd. (Fuse) and RPS Energy Canada Ltd. (RPS) to develop *A Review of Exploration Tools and Techniques to Support COSIA Land Challenge: Near Zero Footprint Seismic Exploration* ("Review of Exploration Tools and Techniques" report) (Larson et al. 2020). This report focused on uniting the ecological and geophysical aspects of seismic lines and multidisciplinary experts within a single project to identify opportunities to advance towards zero land disturbance seismic exploration (Larson et al. 2020). The project collated ideas using the following methods:

- Interviews with contractors, energy and petroleum company representatives;
- A global literature review of available and emerging technologies;
- A workshop with geoscientists and environmental scientists from COSIA member companies; and
- A qualitative assessment of the potential impacts of new seismic technologies on acquisition cost, seismic data quality and health and safety (Larson et al. 2020).

The comprehensive literature review identified a number of opportunity categories for approaching zero footprint seismic, such as:

1. **Modify and miniaturize existing methods** – Shrink the size of equipment and practices used today during seismic data acquisition.
2. **Leave the ground entirely by going airborne** – Move seismic survey equipment from the air.
3. **Leave the ground entirely by going underground** – Install all equipment in existing production wells so existing or planned production well site areas are being re-used for multiple activities.
4. **Use alternative seismic sampling theory** – Measure seismic waveforms differently (Larson et al. 2020).

PEFORMANCE METRICS FOR EVALUATING NEW TECHNIQUES

COSIA convened a multi-disciplinary technical committee in 2016 to draft this COSIA Land Challenge which seeks solutions that improve exploration footprint intensity and support boreal forest and caribou conservation efforts. The technical committee is composed of multi-industry members with diverse backgrounds, including expertise in biology, geology, geophysics, reclamation, regulatory, stakeholder engagement, innovation and industry collaboration.

The technical committee is responsible for ensuring that potential solutions address the range of needs across an individual company and industry. They have developed a list of performance metrics that proposed solutions must meet or exceed.

For more information, see Table 1.

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Table 1 – A list and description of the performance metrics that will be used to guide: (a) innovators in proposal development; and (b) COSIA during proposal evaluation and awarding of the winner(s).

Focus Area	Performance Target	Base Case	Description
Disturbance `Footprint	• Goal of approaching zero disturbance for exploration activities • Proposals outlining ≥50% reduction from base case will be considered	Average disturbance area per section is 33 ha	Today's technology standards and regulatory requirements for adequate reservoir delineation (e.g. core hole drilling and 3D seismic) result in ~50% of a project's overall disturbance (i.e. trees harvested; ~25% of total area) being caused by exploration activities in the oil sands region. Therefore, on average, any given section (1x1 sq. mi/259 ha) will have ~33 ha disturbed by exploration. COSIA is looking for innovative solutions that will result in a "step-change" or significant reductions in tree harvesting during resource exploration. See Appendix A for more detail. *Note: Disturbance area will vary from company-to-company due to numerous factors (e.g. depth of reservoir). An estimated regional average is used as the base case.*
Reservoir Data Needs	• Must obtain the following data: (a) lithology; and (b) oil, water and gas saturation.	Significant sections of the boreal forest are harvested to obtain an assortment of geobody data	Today, seismic and core hole drilling techniques provide a range of data that ultimately enables reservoir exploration and delineation, and production planning. New technology needs to continue collecting information that supports examination of the geobody and attributes of the geobody, including distribution of bitumen saturation and cut-offs and structural subsurface features (e.g. cap rock and disposal zones). The new method(s) must produce reliable and consistent data, which can be applied over the same geographical area numerous

			times, while significantly reducing boreal forest disturbance (see above).
Safety	• New technology does not result in any increased risks to people safety	Top priority	The oil sands industry's top priority is people safety. New technology must not result in any increased risks to people safety. Risks will be evaluated and mitigated prior to commercial implementation

APPROACHES NOT OF INTEREST

Approaches that do not produce an equal or greater resolution and quality than can be obtained from existing "low impact seismic" and core hole drilling will not be considered. Profiling results will need to meet or exceed the quality and resolution that is currently obtained from today's practices.

POTENTIAL SOLUTION PROVIDERS

Responses to this Challenge are welcome from anyone including:

- Companies (small, medium, or large);
- Academic researchers;
- Research institutes;
- Consultants;
- Exploration contractors
- Venture capitalists; and
- Entrepreneurs or inventors

COSIA encourages potential solution providers to partner with others, where the partnerships between geoscientists and environmental scientists, for example, will lead to a more complete and comprehensive solution.

ADDITIONAL INFORMATION

Seismic, electromagnetic, gravity or other technologies or methods that will result in approaching zeroland disturbance may be considered.

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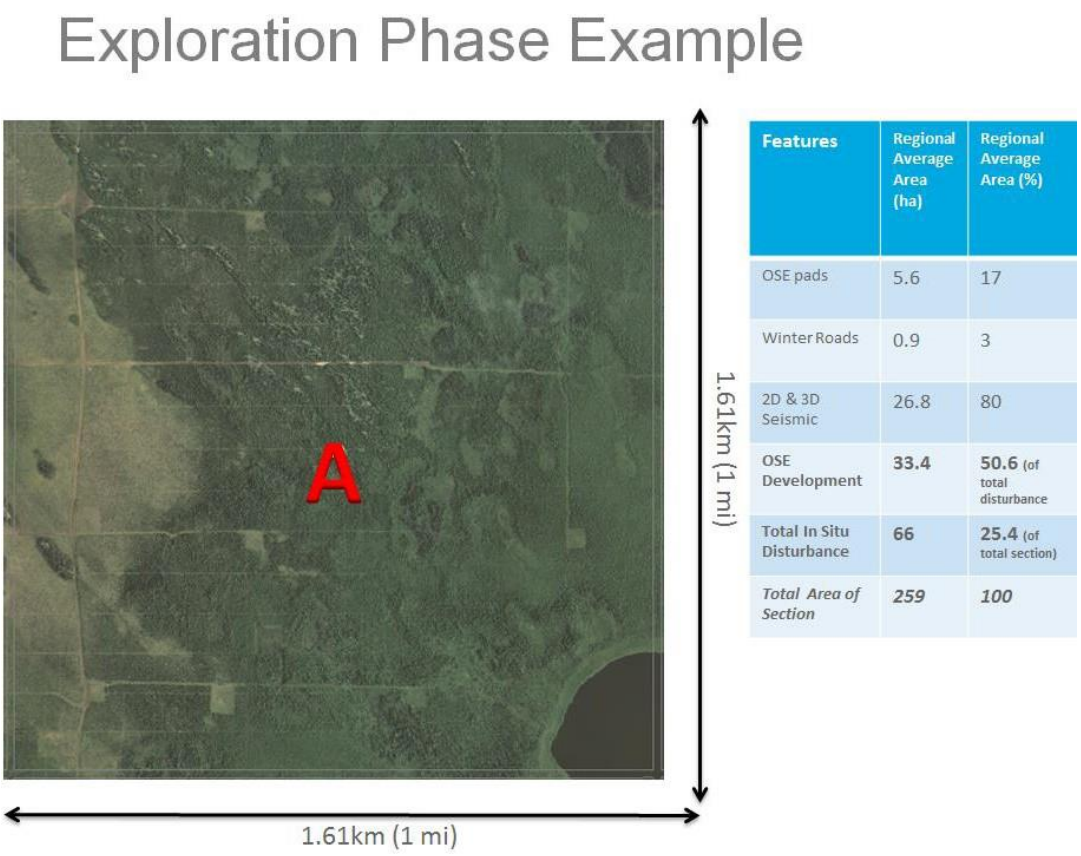
The image below illustrates an average and theoretical oil sands in situ exploration footprint, referred to as “Section A”. It is based on a “reasonable average” from an in situ footprint model developed by the Sustainable Ecosystem Working Group (SEWG) of the Cumulative Environmental Management Association (CEMA) using 2006 footprint data from eight oil sands operators (Silvatech Group, 2009).

According to the 2006 average, 66/259ha of a given section will be disturbed. Of the 66ha that is disturbed, 33ha will be disturbed as a result of exploration activities. Exploration footprint is divided between exploration pads developed by core hole drilling (6ha), winter roads (1ha) and seismic exploration (27ha). *Note: Disturbance area will vary from company-to-company due to numerous factors (e.g. the depth of reservoir, age of operator and year production commenced). Also, if the same exercise was repeated today, the average exploration footprint would likely be less than the 2006 reasonable average, since LIS exploration is now widely used across the industry.*

If the collected exploration data identifies that the reservoir underlying this is an economically viable reservoir, then the operator will develop and submit a D23 application to the Alberta Energy Regulator. If approved, the company will construct production well pad infrastructure over the area, effectively doubling the exploration footprint from 33ha to 66ha.



Features	Regional Average Area (ha)	Regional Average Area (%)
OSE pads	5.6	17
Winter Roads	0.9	3
2D & 3D Seismic	26.8	80
OSE Development	33.4	50.6 (of total disturbance
Total In Situ Disturbance	66	25.4 (of total section)
Total Area of Section	*259*	*100*