Towards a Shared Foundation: Data/Innovation – From the Ground Up… Way Up

June 16, 2025 Workshop

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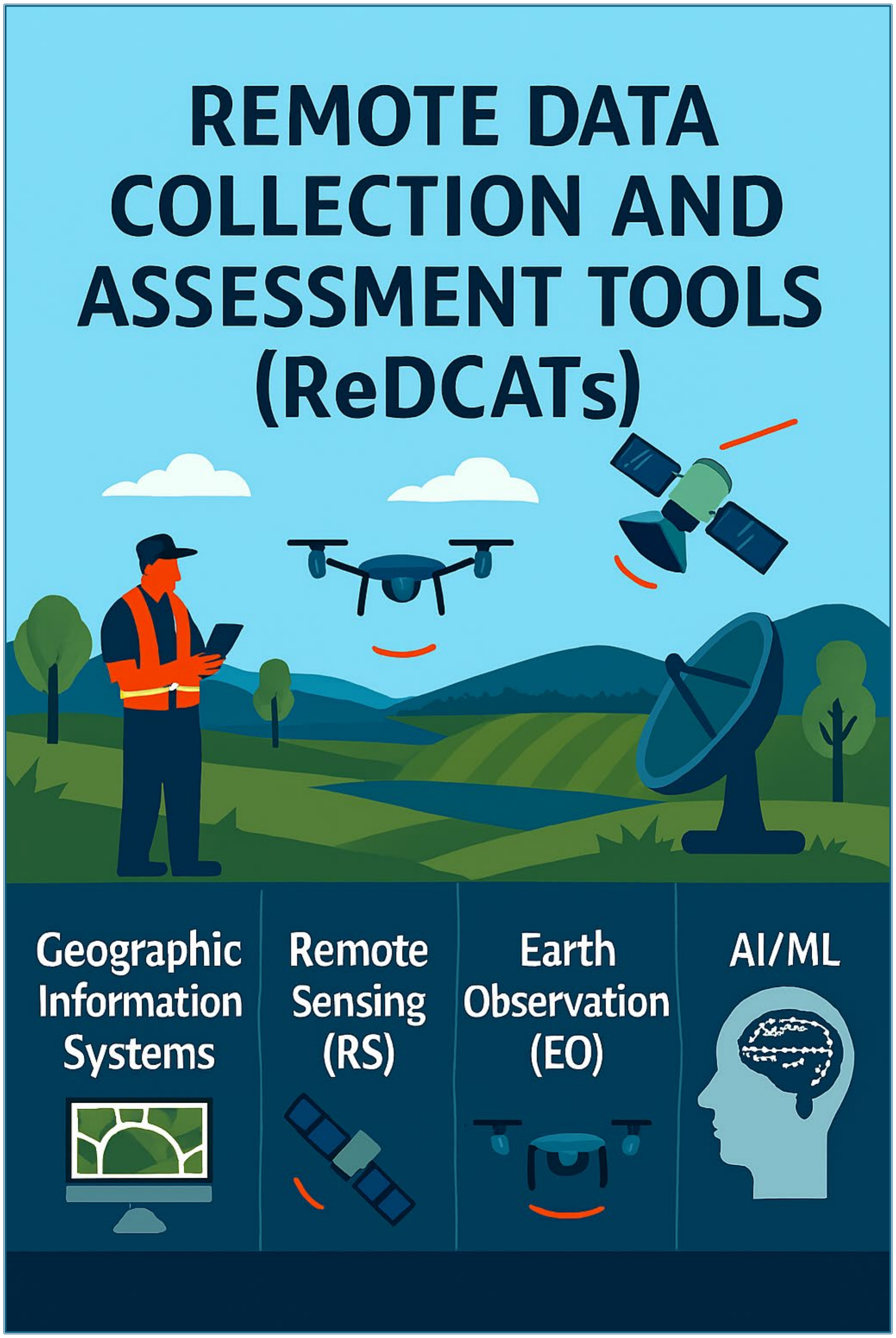

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List of Acronyms

AB – Alberta

ABMI – Alberta Biodiversity Monitoring Institute

ADP – Alberta Data Partnerships

AER – Alberta Energy Regulator

AESRD – Alberta Environment and Sustainable Resource Development (now Alberta Environment and Protected Areas)

AI – Artificial Intelligence

AHFMP – Alberta Human Footprint Monitoring Program

AITF – Alberta Innovates Technology Futures (now InnoTech Alberta)

AOI – Area of Interest

API – Application Programming Interface

AUC – Alberta Utilities Commission

AUPRF – Alberta Upstream Petroleum Research Fund

AWARE – Assessment of Wood Attributes from Remote Sensing

BC – British Columbia

BERA – Boreal Ecosystem Recovery and Assessment

C&R – Conservation and Reclamation

CARL – Conditional Adjustment of Liability

CCMEO – Canada Center for Mapping and Earth Observation

CER – Canadian Energy Regulator

CEOS – Committee on Earth Observation Satellites

CEOS, COVE - CEOS – Visualization Environment

CHM – Canopy Height Model

CLRA – Canadian Land Reclamation Association

COSIA – Canada's Oil Sands Innovation Alliance

CRR – Conservation and Reclamation Regulation

CRIN – Clean Resources Innovation Network

CRSS – Canadian Remote Sensing Society

CSA – Canadian Space Agency

DEM – Digital Elevation Model

DIDS – Digitally Integrated Disposition System

DND – Department of National Defence

DRAS – Digital Regulatory Assurance System

DSA – Detailed Site Assessment

DSM – Digital Surface Model

DTM – Digital Terrain Model

EAP – Environment and Parks (now Environment and Protected Areas)

EC – Electrical Conductivity

ECCC – Environment and Climate Change Canada

eDNA – Environmental DNA

EIA – Environmental Impact Assessment

ELC – Equivalent Land Capability

EnMAP – Environmental Mapping and Analysis Program

EM – Electromagnetic

EO4CE – Earth Observation for Cumulative Effects

EO4OG – Earth Observation for Oil and Gas

ERMP – Ecological Recovery Monitoring Program

ESA – Environmental Site Assessment

ESA – European Space Agency

ESAR – Environmental Site Assessment Repository

ESG – Environmental, Social, and Governance

ESRD – Environment and Sustainable Resource Development (now Environment and Protected Areas)

EO – Earth Observation

EPA – Environment and Protected Areas

EPEA – Environmental Protection and Enhancement Act

fCOVER – Fraction of Vegetation Cover

FOIP – Freedom of Information and Protection of Privacy Act

FRIAA – Forest Resource Improvement Association of Alberta

GEE – Google Earth Engine

GEO – Group on Earth Observation

GEOGLAM – Group on Earth Observation Global Agricultural Monitoring

GEOGLAM – RAPP: GEOGLAM – Rangeland and Pasture Productivity

GIS – Geographic Information Systems

GPT – Generative Pre-Trained Transformer

GoA – Government of Alberta

GoC – Government of Canada

GPS – Global Positioning System

GVI – Grassland Vegetation Inventory

HQP – Highly Qualified Personnel

HSE – Hazardous Substance Exposure

HSI – Hyperspectral Imagery

InSAR – Interferometric Synthetic Aperture Radar

IMSA – Interim Monitoring Site Assessment

IOGC – Indian Oil and Gas Canada

ISC – Information Services Corporation (Saskatchewan)

LAI – Leaf Area Index

LiDAR – Light Detection and Ranging

LT – LandTrendr

m – metre

ML – Machine Learning

MOPRA – Monitoring Procedures for Reclamation in Alberta

MS – Multispectral

NDVI – Normalized Difference Vegetation Index

NDYI – Normalized Difference Yellowness Index

NRCan – Natural Resources Canada

NSERC – Natural Sciences and Engineering Research Council

ODAA – Open Data Areas Alberta

OM – Organic Matter

ON – Ontario

OSIP – Oil Sands Information Portal

PDA – Pre-Disturbance Assessment

PDSA – Pre-Disturbance Site Assessment

PGC – Provincial Geospatial Centre

PTAC – Petroleum Technology Alliance of Canada

ODAA – Open Data Areas Alberta

OSRIN – Oil Sands Research and Information Network

QA/QC – Quality Assurance / Quality Control

R&D – Research and Development

RC – Reclamation Certificate

RCM – Radarsat Constellation Mission

RCSA – Reclamation Certificate Site Assessment

ReDCAT – Remote Data Collection and Assessment Tools

RGB – Red, Green, and Blue

RIS – Reclamation Information System

RITL – Registered Interest on Titled Land

RoO – Record of Observation

RPAS – Remotely Piloted Aircraft Systems

RS – Remote Sensing

RSTAP – Remote Sensing Technology Action Plan

SAR – Synthetic Aperture Radar

SaaS – Software as a Service

SAVI – Soil Adjusted Vegetation Index

SED – Specified Enactment Direction

SME – Subject Matter Expert

SME – Small-to-Midsized Enterprise

TIFF – Tagged Image File Format

UAS/UAV – Unmanned Aircraft Systems / Unmanned Aircraft Vehicles

USGS – United States Geological Survey

Yr – Year

Executive Summary

Data, and the information generated, are foundational pieces supporting informed decision making within regulatory frameworks. Traditionally, data collection has consisted of a mix of field level observations supplemented with aerial imagery. However, there has been a rapid development of platform technologies such as geographic information systems (GIS), remotely piloted aircraft systems (RPAS), earth observation (EO), artificial intelligence (AI), and machine learning (ML) that can also be used to collect and process data.

In the workshop and this report, a new acronym was created: **Re**mote **D**ata **C**ollection and **A**ssessment **T**ools (ReDCATs). The term ReDCAT collectively refers to the following:

- Geographic Information Systems (GIS);
- Remote Sensing (RS): active and passive sensor types;
- Earth Observation (EO): ground-based, Remotely Piloted Aircraft Systems (RPAS; also known as drones), fixed or rotary wing aircraft, and satellites; and
- Artificial Intelligence (AI) and Machine Learning (ML).

Collectively, these technologies enable the collection, processing and analysis of much more data, at greater frequency, finer resolutions, and across much larger areas. However, the rapid pace of technology development has outpaced the ability for policy makers and regulators to evaluate current policy and practices, such as field-level measurements and observations, resulting in a delay in both uptake and adoption within policy. The impacts of this delay may include missed opportunities for efficiency, and a lack of incentive for the development of relevant tools and processes.

The Canadian Land Reclamation Association's (CLRA) workshop in 2024 highlighted the need to continue demonstrating, and clearly communicating, operational and regulatory applications of these technologies by: comparing the value and costs of using ReDCAT technologies against current methods; and, understanding the value of the data and information derived from these technologies within various business contexts, to support building the business case for their integration and adoption. To build on the success of the 2024 workshop, the Alberta Chapter of the CLRA and Alberta Innovates co-hosted a workshop in Calgary on June 16, 2025. The intent of the workshop was to continue the conversation by identifying project concepts that promote opportunities for uptake by industry, regulators, and policy makers while continuing to foster innovation in this space.

The 2025 workshop resulted in several high-priority project ideas that propose a clear path forward for innovation and regulatory collaboration. Key examples include establishing a cross-sector technical committee for developing a ReDCAT framework and launching a pilot project to develop ReDCAT criteria for cultivated lands.

1. Introduction and History

In February/March 2011, a workshop involving government, regulators, and researchers took place in Edmonton, AB to discuss the potential for using Earth Observation (EO) to monitor various activities in Alberta's oil sands. A final report called *Earth Observation Monitoring of the Oil Sands in Alberta: Report on a Workshop* (Ryerson, 2011) was completed.

The 2011 workshop had six objectives:

1. To better understand the monitoring and surveillance requirements of the regulatory agencies with responsibilities in the oil sands in terms amenable to Remote Sensing (RS) and EO science;
2. To review the current capabilities of RS and EO technologies as they relate to the oil sands environment;
3. To better understand the potential for RS science and technology in the monitoring and surveillance of oil sands environmental performance;
4. To identify existing and proven technologies that can meet the regulatory information requirements now;
5. To develop concepts for potential operational projects; validation or demonstration projects; and research projects; and
6. To identify the gaps in information and the research and development needed to develop and demonstrate RS and EO technologies in the future to, where possible, fill these gaps.

Three categories of recommendations came from the workshop, summarized as follows (copied as written in the report):

1. Engagement – who else we recommend should be engaged, in what order, and why;
2. Data Assessment, Management and Delivery – the future success of any monitoring program will depend on a foundation of scientifically sound, complete, well managed and easily accessible data; and
3. Organizational Development – details the sort of organizational structure that began to emerge from the workshop.

The Remote Sensing Technology Action Plan (RSTAP) was a collaborative initiative led by Petroleum Technology Alliance Canada (PTAC) and LOOKNorth created to accelerate the development and adoption of innovative RS technologies in the oil and gas sector. Launched through a foundational workshop co-hosted by PTAC and LOOKNorth in May 2013, the RSTAP brought together industry, government, and service providers to identify high-priority applications. With advances in satellite, aerial, and ground-based sensing, reducing costs and improving performance, RSTAP sought to harness these innovations through structured engagement, technology screening, and demonstration projects. The program included industry-driven workshops, targeted outreach, and projects aimed at advancing practical solutions to enhance safety, reduce environmental impact, and increase operational efficiency. Through this initiative, PTAC and LOOKNorth created a neutral, collaborative platform to drive RS innovation forward and deliver measurable value to Canada's oil and gas industry.

In February 2015, another related workshop was sponsored by the Alberta Energy Regulator (AER), Alberta Environment and Sustainable Resource Development (AESRD), Alberta Innovates, Advanced Education, the Canadian Space Agency (CSA) and Natural Resources Canada (NRCan). The workshop brought together 57 participants from government, academia, and industry to explore the use of EO technologies in supporting Alberta's environmental monitoring and regulation, particularly in the oil sands region. The event showcased collaborative pilot projects by NRCan's Canada Centre for Remote Sensing demonstrating EO's potential for tracking land disturbance, vegetation change, and water dynamics, and emphasized the need for standardized data infrastructure, continued investment in expertise, and integration of EO into regulatory frameworks.

Key recommendations included developing a business case for EO adoption, fostering multi-sector collaboration, and leveraging open satellite data to enhance Alberta's Integrated Resource Management System. A five-year roadmap was proposed to guide EO implementation, with the workshop marking a pivotal step toward operationalizing EO for responsible resource development. The resulting report called *Earth Observation for Improved Regulatory Decision Making in Alberta – Workshop Report* (De Abreu et. al, 2015) is available online.

In April 2016, Alberta Innovates Technology Futures (AITF; now called InnoTech), collaborating with the Government of Alberta, Alberta Data Partnerships, TECTERRA, and LOOKNorth, organized two workshops in Calgary and Edmonton. These events created an opportunity for government and industry stakeholders to identify environmental management challenges that could benefit from integrated approaches. Additionally, they served as a platform for technology providers and researchers to showcase tools that could address these challenges. As per the final report *Commercializing Remote Sensing Technology for Environmental Management: Moving from Data to Decision* (Powter et. al., 2016), one of "the desired outcomes of the Workshops was the identification of possible Research and Commercialization Challenges that could be issued by the Alberta Innovates Corporations, like AITF, and organizations such as Alberta Data Partnerships (Data and Data Accessibility), TECTERRA (Geomatics and Visualization), and LOOKNorth (Data Analytics and EO) to technology solution providers, and in particular Small- and Medium-Sized Enterprises (SMEs) to fill these gaps. Ultimately these Challenges would lead to one or more demonstration projects, while also supporting technology commercialization and economic diversification in the province."

Prior to the workshop a survey was sent out to collect information regarding the current use and future needs for EO/RS in environmental management. Several presentations were made at the workshops and based on the discussions and survey responses, seven recommendations were developed, as follows (see the report for the potential champions and supporting organizations proposed):

- The Alberta Open Data Areas (ODAA) proposal should proceed and there should be rapid communication of the opportunities associated with the project to ensure the widest possible uptake.
- Government should collate and publish all existing EO/RS standards associated with regulatory requirements. This will help ensure common and consistent standards, and provide SMEs with targets against which to assess, modify and create products and services
- Government should identify all existing public data sources and data collected pursuant to regulatory requirements with an eye towards increasing open, accessible and free data sources. A business case for making data more open and freely accessible should be developed.
- Government and industry should strive to better articulate and publish EO/RS needs. Ideally this would be made available in the least number of locations practicable and updated on an annual basis.
- Government, the resource industry, the EO/RS industry, and academia should work together to develop a formal Community of Practice to enhance communication, education, and awareness. Efforts should be made to include broad participation by companies, organizations, and individuals with interest in advancing EO/RS technology development and use in Alberta.
- Government, industry, and academia should work together with the EO/RS sector to explore the opportunity to create an innovation cluster or consortia – exploring different models and building on the work of existing organizations and centres – to enable and enhance collaboration across the commercialization spectrum from the support of basic and applied research to aiding in the adoption of EO technologies. A key function of this cluster/consortium may be to facilitate implementation of the other six recommendations.
- Government, the resource industry and the EO/RS industry should explore the concept of an approved body to vet existing and new EO/RS technologies.

2016 also presented us with the *PTAC Ecological Forum Panel: Remote Sensing and Emerging Technologies*. A panel exploring the use of remote sensing and emerging cross-sector technologies to support environmental monitoring and decision-making was hosted by PTAC. The panel featured perspectives from government, industry, and academia, highlighting the potential for integrated data platforms and non-traditional collaborations, particularly with the aerospace and defense sectors.

A key takeaway from the panel session was that while data handling remains a challenge, collaborative efforts across sectors – including regulators, researchers, and technology developers – can drive innovation by enabling shared platforms and open data approaches. These integrated efforts can help uncover new insights to better inform environmental decisions.

Canada's Strategy for Satellite Earth Observation (CSA, 2022) outlines a national vision to harness space-based technologies for addressing climate change, supporting sustainable development, and enhancing public services. Led by the CSA in collaboration with federal departments, industry, and academia, the strategy emphasizes open access to satellite data, end-to-end innovation, and multi-sector collaboration. It aims to integrate EO into decision-making across sectors such as environmental monitoring, emergency response, and resource management. Key priorities include building domestic capacity, leveraging international satellite missions, and ensuring EO data supports science-based policy and economic growth. The strategy positions Canada to lead in EO innovation while addressing pressing environmental and societal challenges.

In 2024 the Alberta Chapter of the Canadian Land Reclamation Association (CLRA) held the *Reclamation Workshop: Towards a Shared Foundation for Innovation and Evolution* (Powter, 2024) which brought together ~80 reclamation practitioners from government, industry, consulting, academia, and the services sector to discuss specific issues facing industry, share potential improvement opportunities, and propose action items to develop solutions. This included discussions on new technologies that could help reclamation programs including data and information management (e.g., Geographic Information Systems (GIS), remotely piloted aircraft systems (RPAS) and earth observation (EO), and artificial intelligence (AI).

The outcomes from the workshop in 2024 highlighted the need to continue demonstrating, and clearly communicating, operational and regulatory applications of these technologies by: comparing the value and costs of using GIS/EO/AI technologies against current methods; and, understanding the value of the data and information derived from these technologies within various business contexts, to support building the business case for the integration (and adoption) within regulatory frameworks (De Abreu, et. al, 2015; Powter, 2024). A panel session that took place at the CLRA's 50th anniversary conference in 2025 also highlighted the importance of technologies such as GIS, RPAS, EO and AI in reclamation (Powter, 2025).

RPAS and EO platforms (and sensors) have unique attributes allowing existing (or new) indicators to be derived to support, or directly offset, field-level metrics currently being collected. This increases the need for a common understanding of the capabilities and roles of these technologies by:

- **Industry**: to determine if their use can meet one or more regulatory requirements.
- **Researchers**: to focus efforts on the data and information required by industry, policy makers, and regulators.
- **Policy makers**: to allow for incorporation, where applicable, into provincial conservation and reclamation (C&R) policies and outcomes (and to leverage the knowledge for other programs).
- **Regulators**: to provide assurance that their use fits with regulatory requirements to meet C&R outcomes.

Alberta has several success stories where the government has worked collaboratively with industry in areas such as data governance (e.g., Alberta Data Partnerships) and standardization of data formats (e.g., Digitally Integrated Disposition System (DIDS) and the Reclamation Information System (RIS) for oil sands), as well as research initiatives involving the use of RPAS/EO for environmental monitoring, including pre-disturbance, disturbance, and reclamation. While Government may want to promote innovation and ensure policy does not encumber innovation, it's typically not the government's role to "approve" the use of any given technology including RPAS, EO platforms (and sensors), and AI. Government may establish standards and criteria that set goalposts, and as new technology becomes available these policies may need to be updated.

Alberta, and elsewhere in Canada, encompasses both a practicing and working landscape, including the development of natural resources across multiple: landcover types landcover types (e.g., native grasslands, forested lands, cultivated lands, peatlands and mineral wetlands (GOA, 2025a)) and sectors including, but not limited to forestry, renewable energy, oil and gas, aggregates, and mining. For many of these activities, regulatory policy is established under the *Environmental Protection and Enhancement Act* (EPEA) (GOA, 2000) and underlying regulations, such as the *Conservation and Reclamation Regulation* (CRR) (GOA, 1993).

Alberta's regulatory framework provides an opportunity to serve as a testbed and evaluate against well-established policies and guidelines that have evolved overtime. Several indicators and criteria (AESRD, 2013; EAP, 2017; ESRD, 2010a,b,c) covering a suite of measured or visually assessed metrics have been developed which, in many cases, fall to one of the following assessment categories:

- Landscape Assessment: (e.g., drainage, contour);
- Soil Assessment (e.g., evidence of disturbance, topsoil depth, topsoil quality, erosion);
- Vegetation Assessment (e.g., crop health, plant heights, species composition, stems/ha); and,
- Surface Water Quality and Quantity (e.g., end pit lakes, wetlands).

Foundational to successful implementation of conservation and reclamation policy is the need for data collected in each of these four assessment categories. Data and the information generated become a foundational piece within this framework to support informed decision making on the return of disturbed land to equivalent land capability (ELC). Traditionally, the collection of data consists of a mix of field-level assessments and sample collection (where necessary), supplemented with aerial imagery. However, the rapid development of platform technologies such as GIS/RPAS/EO/AI enables the collection of much more data, at greater frequency, finer resolutions, and across much larger areas. The result is that technology development has outpaced the ability for policy makers and regulators to evaluate current policy and practices, such as field-level measurements and observations. While RPAS and EO are being used more frequently by environmental consultants to support/inform field-level assessments, these technologies are unlikely, at least in the near-term, to fully replace field-level assessments and sample collection using indicators to inform decisions such as determining whether ELC has been met.

As consideration is given to developing new, or updating existing C&R policy, the opportunity exists to incorporate the use of GIS/EO/AI technologies, while at the same time enabling different data collection and assessment methods to be developed and implemented. Examples of these approaches include enhanced assessments using GIS/EO/AI to directly monitor and assess reclamation success; or identification of areas of concern where site-specific interventions may be required to ensure reclamation progression. While this opportunity exists, there is also a need to recognize additional considerations, such as new metrics or thresholds for decision making, that may need to be included within the policy along with the need to develop evaluation criterion of these new metrics and thresholds.

To build on the success of the 2024 workshop, the Alberta Chapter of the CLRA and Alberta Innovates co-hosted a workshop in Calgary in June 2025. The intent of the workshop was to continue the conversation by identifying project concepts that promote opportunities for uptake by industry, regulators, and policy makers while continuing to foster innovation in this space.

2. Workshop Details

The workshop took place on Monday June 16, 2025, in Calgary, AB, one day prior to the 46th Canadian Symposium on Remote Sensing that took place in Lethbridge, AB. The alignment in timing was intended to allow for greater participation by those travelling from out-of-province.

The workshop was co-hosted by the Alberta Chapter of the CLRA and Alberta Innovates. Funding support was also provided by PTAC and the Land Environmental Priority Area (EPA) of Canada's Oil Sands Innovation Alliance (COSIA).

Tanya Richens, P.Ag. from TCR Environmental Consulting Ltd. provided facilitation services and has co-authored this report with Shane Patterson from Alberta Innovates. Amber Flamand, representing the Alberta Chapter of the CLRA provided introductory and closing remarks. Shane Patterson presented information regarding the context for the workshop and provided directions for the conversations.

2.1. Terminology and Acronyms

For this workshop, a new acronym was created: **Re**mote **D**ata **C**ollection and **A**ssessment **T**ools (ReDCATs). The term ReDCAT collectively refers to the following: Geographic Information Systems (GIS); Remote Sensing (RS) – active and passive sensor types; Earth Observation (EO) – ground-based; Remotely Piloted Aircraft Systems (RPAS; also known as drones), fixed or rotary wing aircraft, and satellites; and Artificial Intelligence (AI) and Machine Learning (ML).

Criteria and indicator are terms commonly used when discussing reclamation. The following definitions were provided at the workshop and are referenced in this report:

> **Criteria:** numeric limits or narrative statements intended as a general guidance for the protection, maintenance, and improvement of specific uses of soil, water, and land.
>
> **Indicator:** an attribute which can be measured or described and used to evaluate if a criterion has been met.

The *Conservation and Reclamation Regulation* (GOA, 1993) provides definitions for land capability and equivalent land capability (ELC), which are important concepts discussed within this report:

> **Land Capability:** … the ability of land to support a given land use, based on an evaluation of the physical, chemical and biological characteristics of the land, including topography, drainage, hydrology, soils and vegetation.
>
> **Equivalent Land Capability (ELC):** … the ability of the land to support various land uses after conservation and reclamation is similar to the ability that existed prior to an activity being conducted on the land, but that the individual land uses will not necessarily be identical.

2.2. Objectives

The objectives for the workshop were:

1. To better understand regulatory requirements for conservation, reclamation, and return of ELC in terms amenable to ReDCATs.
2. To review the current and emerging capabilities of ReDCATs as they relate to these requirements.
3. To identify the:
    a. Existing and proven ReDCATs that can meet the desired information requirements within the next 3 years where pilots or demonstrations are needed; or,
    b. Gaps in information where research and development (R&D) is needed to identify future use of ReDCATs.
4. To, where possible, fill these gaps by developing concepts for:
    a. Pilot/demonstration projects; and/or
    b. R&D projects.

2.3. Scope

In scope topics included:

- ReDCAT technologies, methodologies, or criteria that can or may be used to: identify, monitor, assess, and/or report on changes to infrastructure, landscape, soil, and vegetation at a given point in time or to show trends over time;

- Lands that have been reclaimed but not certified or are undergoing reclamation activities where the term 'land' refers to the following land cover types (as defined in *Alberta Public Lands Glossary of Terms*; GOA, 2025a): native grasslands, forested lands, cultivated lands, peatlands and mineral wetlands; and
- Activities in Alberta with conservation and reclamation obligations, referred to as specified land in EPEA (GOA, 2000), regardless of whether they require an approval or registration.

Out of scope topics included:

- ReDCAT technology, methodologies, or criteria for assessing spills and/or soil/water contamination/ remediation;
- Determining who is qualified to collect/interpret data acquired through ReDCAT;
- Changes to previous decisions for lands where a reclamation certificate has been issued; and
- Recommendations for specific changes not related to the use of ReDCAT, including but not limited to:
    - Data governance frameworks;
    - Electronic submission platforms (e.g., Digital Regulatory Assurance System – DRAS; OneStop); and
    - Liability management frameworks.

2.4. Participation

The list of participants is provided in Appendix 2: Participant List.

No comments have been attributed to any specific individual or organization within this report. The workshop was attended in-person by 79 participants from across Alberta and Canada. Participants represented a cross section of government, regulators, consultants, industry, industry associations, and data and service providers. Industry representatives from the coal mining, aggregates, and renewables sectors were not in attendance. Participants from the Canada Centre for Mapping and Earth Observation (CCMEO, Natural Resources Canada) presented one of their initiatives called Earth Observation for Cumulative Effects (EO4CE). All presentations from the workshop are in Appendix 9: Presentations.

3. Documentation

A master list of questions was used to request feedback from participants before the workshop, within the workshop at each table, and post-workshop. A link to the online questionnaire was provided before and after the workshop, with a request for participants to answer at least some of the questions in advance of the workshop. The answers received prior to the workshop were summarized and provided in the presentation materials at the workshop. The rest of the online responses were collected after the workshop. Interpretations were made where necessary.

3.1. Sessions #1 and #2

Microsoft CoPilot (AI) was used to summarize and collate the information collected from the handwritten notes taken by note takers at the workshop as well as the MeetGeek (AI) recordings to reduce duplication and present the information in a more readable fashion. The key points discussed by participants at the workshop are summarized in Section 4.2 (Session 1) and 4.3 (Session 2). Detailed documentation for each session can be found in: Appendix 3: Session #1 – Lifecycle (Temporal) Considerations & Reporting; Appendix 4: Session #2 – Remote Data Collection and Assessment Tools; and, Appendix 5: Session 3 – Project Concept Forms.

3.2. Session #3

Building upon the conversations at each table in Sessions #1 and #2, the intent of Session #3 was to develop actual project proposals that could be used to fill knowledge gaps identified throughout the workshop. The following summary was provided as directions to the workshop participants, and the results of the conversations are presented in Section 4.4.

> **Purpose:** Based on the group table discussions so far, identify project concepts to address the knowledge gaps that were identified. Projects may be pilot/demonstration (i.e., up to 2 years) or research and development (i.e., 2+ years). Multiple projects may be required.
>
> **Project Concepts:** Include the proposed title; targeted objective; targeted landcover type (cultivated land; forested land; native grassland; peatland and mineral wetland); type of project (pilot/demonstration; R&D); when it should be completed; who should be involved (industry/sector; academia; GoA; AER; consultants); data needs/specifications (if known), and potential funding sources.

Project concepts were to be divided into two categories – those that could be done in less than 2 years (called pilot/demonstration projects) and those that would take 2 or more years (called research projects). A form was provided in Session #3 to support the collection of project proposals. Participants were asked to provide the following information for the concepts being developed:

- Degree of difficulty to implement the ReDCAT and relative value of the data or research;
- Title and objective;
- Land cover type;
- Potential sources of funding; and,
- Potential project partners.

A summary of all project proposals can be found in Section 4.4.

4. Summary and Results

The workshop brought together a diverse group of experts from across the environmental and resource sectors to discuss the evolving role of data, technology, and policy in pre-disturbance assessment, reclamation and certification. For more information regarding the workshop, see the Workshop Summary Report (Supplemental Report) (Richens and Patterson, 2025).

All the objectives set out for this workshop were achieved (Table 1).

Table 1. Workshop objectives and outcomes.

	OBJECTIVE	OUTCOMES
1.	To better understand regulatory requirements in terms amenable to ReDCATs.	Participants discussed current regulatory requirements and opportunities and highlighted the need to continue conversations through workshops such as this event.
2	To review the current and emerging capabilities of ReDCATs as they relate to these requirements.	Workshop presentations and discussions outlined current opportunities for application of ReDCATs. Conversation outcomes are summarized in Sections 4.2 and 4.3.
3.	To identify existing and proven ReDCATs that can meet the desired information requirements.	Workshop presentations and discussions outlined current opportunities for application of ReDCATs. Conversation outcomes are summarized in Sections 4.2 and 4.3.
4.	To, where possible, fill these gaps by developing concepts for Pilot or R&D Project Concepts.	Participants identified several project concepts for both pilot/demonstration as well as areas where further R&D is needed, as presented in Section 4.4.

The following sections summarize the responses and key points identified during workshop discussions in response to the questions during the workshop and in the online questionnaire.

4.1. Questionnaire – Data Centres and Use of AI/ML

Participants were asked through the online questionnaire and during the workshop about the advantages and limitations of using AI/ML in ReDCAT assessments. A summary of these results are in Table 2 and Table 3 with compiled submission results in Appendix 6: Online Questionnaire: General Questions.

What are the advantages (or limitations) of using artificial intelligence (AI) and machine learning (ML) in ReDCAT assessments?

Artificial intelligence and machine learning are capable of processing large datasets and extracting information that otherwise may be overlooked. These methods are constantly evolving and learning, but the accuracy of interpretations is based on the quality of training data inputs. AI still requires review by qualified individuals with the appliable expertise in the topic being discussed.

Table 2. General Question – AI/ML: Advantages and limitations of using AI/ML in ReDCATs.

TOPICS	KEY POINTS
Advantages	
Scalability and Speed	- Can process imagery and data from hundreds or thousands of sites rapidly. - Enables batch processing and consistent scoring across large datasets. - Supports more frequent and widespread assessments, including remote or hard-to-access areas.
Enhanced Analytical Capabilities	- Detects subtle patterns in hyperspectral data (e.g., vegetation stress, hydrocarbon signatures). - Automates feature detection (e.g., tree heights, densities, land cover types). - Supports time-series analysis to forecast site trajectories and flag regressions early.
Improved Accuracy and Objectivity	- Reduces human bias in site assessments. - Produces reproducible results based on consistent algorithms. - Can outperform manual interpretation in identifying nuanced ecological signals.
Versatility and Adaptability	- Applicable across various land cover types and environmental conditions. - Can integrate multiple data forms (e.g., imagery; documents, sensor outputs). - Continuously improves through learning from new data (adaptive models).
Strategic and Environmental Benefits	- Supports Environmental, Social, and Governance (ESG) goals by enabling emissions monitoring and sustainability tracking. - Facilitates predictive maintenance and closure-cost planning. - Helps transition the industry toward data-driven, low-carbon operations.
Unlocking Unstructured Data	- Extracts insights from regulatory documents and operational records that would otherwise remain siloed.

Limitations	
Data Dependency	- Requires high-quality, labeled training data – especially scarce for rare ecosystems or early-successional vegetation. - Performance is only as good as the input data; poor data leads to poor predictions.
Model Complexity and Explainability	- Many AI models are "black boxes," making it difficult to explain or justify decisions to regulators. - Requires explainability tools (e.g., Shapley values) to build trust and transparency.
Ground Truthing Still Needed	- Field validation remains essential to verify AI outputs, especially in high variability environments. - AI cannot yet fully replace human expertise or contextual judgment.
Technical and Operational Challenges	- Building robust models requires expert knowledge and significant technical investment. - Errors can occur (e.g., miscounting tree stems, misclassifying vegetation). - Requires strong quality assurance and quality control (QA/QC) processes and quality management systems.
Policy and Regulatory Barriers	- Current assessment criteria may not align with AI-generated outputs. - RPAS (drone) policy limitations and data-sharing restrictions can hinder implementation. - Resistance to change and low confidence in AI among some stakeholders.
Trust and Adoption Issues	- Clients and regulators may be unfamiliar with or skeptical of AI-based assessments. - Concerns over data privacy, licensing, and proprietary algorithm.

What are the advantages (or limitations) of environmental data centres or co-operatives? For example, a provincial imagery (or Light Detection and Ranging (LiDAR)) co-op?

Data centres or co-operatives can provide cost savings to those who may not be able to afford to acquire or generate data for their own purposes. Data centres may require central coordination with data acquisition standards being a potential barrier.

Table 3. General Question: Advantages and limitations of data centres/co-operatives.

TOPICS	KEY POINTS
Advantages	
Cost	- Potential cost savings for imagery acquisition.
Accessibility and Storage	- Central repository for locations of where LiDAR/aerial/satellite imagery has been acquired. - Allows users who may not have the means to generate their own data to still complete meaningful evaluations of the data. - If more data were publicly available, it would allow for faster development and scale-up between data types (i.e., LiDAR and satellite imagery) because less time and money would need to be spent collecting data. The data could be used for many purposes.

TOPICS	KEY POINTS
Data	- Broad coverage, high res (1m) LiDAR is being rolled out across Canada, the completion and publication of that data would be very valuable. Also need to know the collection date.
Limitations	
Coordination	- Needs central coordination. - It is difficult to determine key areas of interest (AOIs) to image and how to get imagery into the hands of these organizations. - Companies may have different specs for data requirements
Data Privacy	- Data privacy could at times be an issue with publicly available data. - Not all information could be available publicly depending on where it's at in review/approval process (some information may be proprietary). Also, could be sensitive depending on whether an appeal is underway.

4.2. Session #1 – Lifecycle (Temporal) Considerations and Reporting

A central theme in Session #1 was the need for standardized, accessible, and high-quality data to support consistent and transparent decision-making. Participants emphasized the advantages of using RS technologies for large-scale, cost-effective assessments, while also acknowledging the limitations of satellite resolution, the need for ground truthing, and the challenges of integrating new tools with existing regulatory frameworks.

Concerns were raised about data licensing, confidentiality, and the lack of interoperability between systems, as well as the need for updated reporting tools and centralized data platforms. The potential of AI and ML to enhance analysis, detect subtle environmental changes, and automate assessments was widely recognized, though participants stressed the importance of explainability, data quality, and human oversight.

Discussions also highlighted the importance of collaboration across sectors, the need for professional training and certification in RS, and the value of hybrid approaches that combine traditional fieldwork with advanced technologies. Moving forward, participants called for improved governance, clearer regulatory guidance, and continued innovation to ensure that environmental assessments remain credible, efficient, and adaptable in a rapidly changing landscape.

The following sections provide a summary of the topics and key points for each question that were discussed by workshop participants.

S1/Q1a(i). What are the advantages (or limitations) of updating existing reporting tools such as the Record of Observation (RoO) or the Reclamation Information System (RIS) for use across other sectors?

Updating the RoO and RIS holds strong potential for modernization, efficiency, and alignment across sectors – but only if limitations are addressed with thoughtful design, sector-specific flexibility, and a clear governance framework. Key points identified are listed in Table 4.

Table 4. Potential advantages and limitations of updating existing reporting tools like the RoO and RIS.

TOPICS	KEY POINTS
Advantages	
Consistency and Standardization	- Promotes uniform reporting protocols across industries. - Facilitates cross-sector understanding and alignment with modern reclamation assessment and reporting practices.

TOPICS	KEY POINTS
Improved Data Utility	- Enables AI and spatial data integration (e.g., Normalized Difference Vegetation Index (NDVI), RPAS imagery). - Enhances data accessibility, quality assurance, and reproducibility. - Supports site-level and multi-temporal assessments.
Efficiency and Transparency	- Streamlines submission and review processes, reducing duplication and administrative overhead. - Public access to standardized reporting builds trust and regulatory confidence.
Cross-Platform Integration	- Tools like RIS can link operational, spatial, and environmental data for holistic reporting. - Some systems showcase real-time data capture, mapping, and team collaboration.
Scalability and Familiarity	- Builds on existing tools that practitioners already know. - Allows for province-wide digital modernization and easier expansion into sectors like renewables and mining.
Limitations	
Legacy Tool Constraints	- RoO's structure (e.g., spreadsheets, low-resolution photo uploads) is outdated and limits data richness. - No geospatial data requirement in RoO – undermines mapping capabilities.
Sector-Specific Needs	- One-size-fits-all design might not suit varying reclamation levels or sector objectives.
Technical and Operational Hurdles	- RIS lacks robust categorization and Application Program Interface (API) integration. - Varying platforms may pose compatibility issues. - Requires investment in coordination and system upkeep.
Cultural and Practical Gaps	- Adopting RoO in non-oil and gas sectors may be a steep learning curve. - Risk of misinterpretation or bias, especially if tools become too rigid or overly quantitative. - Existing formats lack support for ReDCATs or AI-enhanced indicators.

S1/Q-1a(ii). What are the key considerations for any updates/changes (if needed)?

Updates should consider use of interoperable formats to support flexibility for evolving ReDCATs. This approach should include training and additional guidance on ReDCAT use. Key points identified are listed in Table 5.

Table 5. Considerations when updating existing reporting tools like the RoO and RIS.

TOPIC	KEY POINTS
Policy and Framework Adjustments	- Provide regulatory flexibility for evolving tools like ReDCAT.
Sector-Specific Adaptability	- Customize approaches for different industries (oil and gas vs. sand and gravel) and landscapes (forested vs. cultivated). - Consider learnings from agriculture and pipeline sectors.
Data Integration and Accessibility	- Emphasize interoperability of systems and use of standardized formats (e.g., shapefiles, GeoTIFFs). - Ensure submission, storage, and accessibility of original/raw geospatial data for future reviews and audits. - Support integration with AI/ML platforms and RS tools.
Use of Advanced Technologies	- Promote AI to analyze raw data and reduce human bias, though legal and security concerns must be addressed. - Enable use of remote sensing, hyperspectral imagery, and Global Positioning System (GPS) technology to improve site monitoring and vegetation assessment. - Recognize limits of technology (e.g., ground-truthing still necessary).
Process Improvements	- Streamline processes using digital forms (e.g., OneStop-style forms), pre-populated fields, and accessible data fields for recommendations and next steps. - Improve feedback loops and reduce data collection burden by focusing on key outcome-based metrics.
Standardization and Training	- Develop clear guidelines on formats, metadata, resolution, and accuracy. - Offer training resources to support consistent data collection and analysis. - Encourage consistency to improve cross-dataset validation and model training.
Legal, Privacy, and Governance	- Address privacy considerations and long-term data ownership/stewardship. - Make reclamation certification data publicly available and accessible beyond requests under the *Access to Information Act* (ATIA) (GOA, 2025b).

S1/Q-1b. Are there other initiatives that would benefit from this approach? If so, please provide details.

Standardized formats can provide consistency and regulatory assurance cross-sector. Key points identified are listed in Table 6.

Table 6. Other processes or initiatives that may benefit from updating existing reporting tools.

TOPICS	KEY POINTS
Agriculture and Vegetation Monitoring	- Enhance yield verification in agricultural fields, especially where proxy data doesn't align with yield monitors. - Use remote sensing and AI to monitor vegetation health and productivity over time.

TOPICS	KEY POINTS
Cross-Sector Reclamation and Disturbance Verification	- Apply to industries like sand and gravel, oil and gas, and forestry to standardize how disturbances and reclamation are tracked. - Replace outdated, site-based tools (like RoO) with landscape-scale, scalable platforms focused on long-term outcomes.
Policy Reform and Future-Proofing	- Encourage building new regulatory frameworks envisioning a fully remote monitoring system by 2050. - Run legacy and new systems in parallel to smooth the transition and avoid bureaucratic hurdles.
Data Infrastructure and Platforms	- Establish dynamic data portals for original raster data and create standardized, expandable apps for data collection and reporting. - Support use of ReDCATs in flagging compliance issues, tracking land-use changes, and documenting site trajectories.
Legacy Site Assessments and Global Context	- Use tools to reconstruct site histories where data is incomplete or outdated. - Align with global regulatory models (e.g., European Union (EU) deforestation rules) through remote monitoring of historical land use.
Standardization and Human Oversight	- Develop standardized reporting frameworks for AI-assisted analysis, ensuring consistency and auditability. - Maintain professional sign-off to ensure interpretive accuracy and accountability.
Program Alignment and Industry Collaboration	- Initiatives like the Registered Interest on Titled Land (RITL) and the Alberta Human Footprint Monitoring Program (AHFMP) by the Alberta Biodiversity Monitoring Institute (ABMI), may benefit through improvements to spatial accuracy and regulatory integration. - Facilitate better inter-industry comparability, especially in how land disturbances (e.g., weeds, boundary encroachments) are addressed and reclamation plans are coordinated.

S1/Q-2a(i). Could data that is submitted as a regulatory requirement subsequently be used for: comparisons to other similar disturbance types; or, to update publicly available geospatial or land cover datasets?

Data included in regulatory submissions have value beyond meeting the regulatory requirements, providing data is submitted in a standard format and data frameworks have been established. Key points identified are listed in Table 7.

Table 7. Considerations when reusing data submitted as a regulatory requirement.

TOPICS	KEY POINTS
Broad Agreement on Utility	- There is strong consensus that regulatory data *should and could* be reused to support comparisons across disturbance types and enhance public geospatial/land cover datasets.
Conditions and Caveats	- Data must be non-confidential, with clear accuracy indicators. - Processes must be in place for data standardization, quality control, and privacy protections.

TOPICS	KEY POINTS
Potential Applications	- Develop benchmark recovery trajectories. - Track spatial and temporal recovery patterns for both anthropogenic and natural disturbances. - Support updates to public data layers like ABMI's Human Footprint or wetland inventories.
Existing Platforms and Gaps	- The Oil Sands Information Portal (OSIP) is a valuable tool, but the interactive map (and associated data) hasn't been updated since 2021.
Technical and Economic Considerations	- Systems must handle large data volumes and enable scalable dissemination. - Questions remain about industry's willingness to invest in data sharing.
Opportunities for Machine Learning	- Large, labeled datasets can fuel AI models to predict outcomes and support regulatory decision-making with precision.
Policy and Implementation Outlook	- To scale this approach, the province would need to establish data-sharing frameworks, access protocols, and financial incentives or mandates to encourage participation.

S1/Q-2a(ii). Is the data available electronically? Is it publicly accessible?

While data is submitted electronically it may not be in a format allows data to be easily extracted and used in other applications. A framework that considers standardization will be essential to support broader uptake. Key points identified during the workshop discussion are listed below in Table 8.

Table 8. Key points regarding public accessibility of data submitted as a regulatory requirement.

TOPICS	KEY POINTS
Current Availability	- Most regulatory data is submitted electronically (e.g., via DRAS or OneStop) and stored as attachments. - Some datasets are publicly accessible, such as reclamation certificate applications (via FOIP), or through platforms like the Oil Sands Information Portal.
Benefits of Public and Electronic Access	- Enables land use planning, environmental monitoring, cost-effective assessments, and scientific transparency. - Facilitates more effective site analysis (e.g., for wellsites, soil status, and habitat monitoring).
Policy and Governance Needs	- A standardized framework for data collection, sharing, and storage is essential. - Potential for policy amendments (e.g., under the *Conservation and Reclamation Regulation*) to ensure spatial data formats are used and publicly accessible. - Debate over centralized data repositories vs distributed control – balance between efficiency and liability.

TOPICS	KEY POINTS
Recommendations and Forward Steps	- All data should be electronically available, and ideally publicly accessible – at least in anonymized or aggregated formats. - Design for both screening and assessment-level use, depending on purpose, scale, and privacy considerations. - Encourage open standards to support transparency, reproducibility, and broader reuse.
Barriers and Considerations	
Access vs. Availability	- Data may exist but not be in user-friendly or extractable formats.
Technology Limitations	- Legacy systems and platform incompatibility within government hinder accessibility.
Privacy and Consent	- Especially relevant for data collected within culturally sensitive areas.
Licensing Restrictions	- Commercially sourced datasets (e.g., satellite imagery) often have use limitations.
Quality Concerns	- Not all “freely available” data meets the resolution requirements for all use cases.

S1/Q-2b. Which datasets could be used? For example: Pre-Disturbance Assessments, Detailed Site Assessments, Reclamation Certificate Application information.

Various regulatory datasets could be used in other applications or for other uses if reporting formats were standardized. Policies related to data accessibility would be useful for supporting further data reuse. Key points identified during discussions are listed in Table 9.

Table 9. Considerations for what type of regulatory data/reports could be used for comparisons.

TOPICS	KEY POINTS
Key Regulatory Datasets	- Pre-Disturbance Assessments (PDA) - Environmental Impact Assessments (EIA) - Detailed Site Assessments (DSA) - Reclamation Certificate Applications - Annual Conservation and Reclamation Reports - Forest establishment surveys and vegetation monitoring - Prohibited noxious and noxious weed locations - Remote sensing data, imagery, topography, photographic records - AI/ML vegetation classification and wetland inventories

TOPICS	KEY POINTS
Potential Uses	- Compare recovery trends across disturbance types (e.g., forest vs. oil and gas). - Improve public geospatial datasets (e.g., Grassland Vegetation Inventory (GVI)), crop type layers). - Support early identification of problematic sites using field validation. - Inform other sectors (e.g., wildfire prediction in forestry).
Technical and Governance Considerations	- Push for data sharing across sectors (forestry, industry, government). - Ensure data quality and validation – especially when integrating legacy or low-resolution records. - Address reluctance to share due to fear of misinterpretation or ownership concerns. - Explore tiered-access models (e.g., licensed user groups) for proprietary data. - Encourage collaboration without oversharing sensitive or commercially protected information.
Challenges and Opportunities	- Vast spatial datasets exist but are underutilized or siloed. - Misinterpretation is a risk – but also an opportunity for dialogue and refinement. - Calls for integration of environmental datasets to strengthen analysis. - Support digitization of legacy data (e.g., handwritten records) and develop strategies for aggregating and updating historical site information.

S1/Q-3a(i). What are the advantages (or limitations) of using ReDCATs for assessments compared to field-level assessments for detecting differences in landscape, soil, or vegetation?

ReDCATs offer tremendous value in scaling, repeatability, and safety – but they're best used in *conjunction* with field-level assessments, not as a full substitute. They're ideal for enhancing monitoring efficiency and strategic planning, so long as limitations are acknowledged and managed. Key advantages and limitations identified by participants are listed in Table 10.

Table 10. Advantages and limitation of using ReDCATs versus field-level assessments.

TOPICS	KEY POINTS
Advantages	
Broader Spatial Coverage	- Assess multiple or remote sites quickly and at a lower cost.
Improved Safety	- Reduces need for field staff in hazardous or inaccessible areas.
Efficiency and Cost Savings	- Faster data collection, fewer staffing demands, and less ground disturbance.
Repeatability and Consistency	- Reduces human bias and allows for standardized, long-term monitoring.
Temporal Analysis	- Supports change detection and landscape recovery trends over time.
Resource Allocation	- Allows triaging of sites for targeted field visits.
Technology Synergies	- Works well with drones, hyperspectral sensors, and AI/ML tools.

TOPICS	KEY POINTS
Environmental Co-benefits	- Supports emission reductions (e.g., drone vs. helicopter monitoring).
Cross-scale Utility	- From site-level to regional analyses, bulk applications, and large-area reconstructions.
Census-style Data	- Enables complete footprint mapping versus partial field sampling.
Supports Planning	- Helps with pre-disturbance assessments and construction/closure strategies.
Vegetation Insights	- Capable of distinguishing desirable/undesirable cover, stocking density, and presence and effect of weeds.
Limitations	
Soil and Subsurface gaps	- Cannot replace field soil sampling or detect below-ground conditions.
Species Level Identification	- Remote sensing struggles with detailed plant diversity and understory detection.
Trust and Accountability	- Lack of human judgment/context and concerns around data interpretation or model bias.
Data Quality and Accessibility	- Imagery can vary in resolution and consistency. - Some tools require costly subscriptions or infrastructure.
Cultural Sensitivities	- Limited engagement with land users (e.g., First Nations); relational insights lost.
Regulatory Uncertainty	- It's unclear what regulators will accept; protocols still evolving.
Complement, Not Replace	- Field validation remains essential, especially for nuanced ecological or land function insights.
Technical Dependencies	- Relies on strong data infrastructure, training data, and investment in tools and user training.
Limitations in Dynamic Environments	- Snapshots may not reflect real-time variability or rare events (e.g., casing leaks, animal signs).

S1/Q-3a(ii). Are there any additional considerations where two or more "point-in-time" assessments are used in decision making to support a reclamation certificate application? For example, are there trade-offs between imagery acquired less frequently at higher spatial resolution versus imagery acquired more frequently at lower spatial resolution.

A **hybrid approach** – combining targeted, high-resolution snapshots with frequent, broad-scale assessments – offers the most robust, cost-effective path forward. Advancing standards and tools will help integrate RS more fully into reclamation workflows, while field validation remains essential for credibility and completeness. A summary advantages and limitations of this approach is included in Table 11.

Table 11. Advantages, limitations, and trade-offs regarding frequency of ReDCAT acquisitions.

TOPICS	KEY POINTS
Advantages	
Improved Certainty Over Time	- Multiple assessments help track trends and seasonal variability, increasing confidence whether Equivalent Land Capability (ELC) has been achieved.
Efficiency and Safety	- Remote assessments reduce field time, lower costs, and improve safety by minimizing time spent in the field.
Scalability and Coverage	- Enables broader geographic assessment, targeting problematic areas with high-resolution data, while using lower-resolution data to monitor wider regions.
Audit and Justification Support	- Offers a richer historical record, helping regulators and auditors focus attention on non-compliant or uncertain sites
Strategic Use of Resources	- Time-series data guides fieldwork, allowing consultants to validate only where needed.
Insight Beyond the Site	- Broader spatial perspective supports understanding of off-site influences, cumulative effects, and landscape-level dynamics.
Limitations (and Trade-Offs)	
Spatial vs. Temporal Resolution	- Higher-resolution imagery offers detail but may lack seasonal context; more frequent, lower-resolution imagery improves trend analysis but sacrifices precision.
Data Quality and Processing	- High-resolution imagery increases storage and processing demands. Weather, clouds, and inconsistent sensors can affect data reliability.
Remote Sensing Gaps	- Understory species, weed presence, slope features, and soil conditions often require field verification.
Standardization Needed	- Varying practices across sectors highlight the need for data resolution standards, georeferenced submissions, and regulatory clarity.
Technology Maturity	- While mining leads in remote data use, sectors like oil and gas lag due to regulatory complexities and stakeholder sensitivities.
Timing Differences	- Differences between remote sensing and field assessment timelines can complicate application process.

S1/Q-3b. What standards should be considered for ReDCAT assessments? For example, minimum or maximum spatial resolution, similar platform/sensor type, data availability, data accessibility.

The implementation of a **hybrid approach** will require standards to be established that should be practical while also meeting regulatory requirements. Standards should address technical requirements while also maintaining the importance of field validation. A summary of standards that should be considered for implementing this approach are included in Table 12.

Table 12. Points to consider when developing ReDCAT criteria or assessment standards.

TOPICS	KEY POINTS
Spatial and Temporal Resolution	- Minimum spatial resolution depends on the site type and assessment goal: ▪ *Croplands*: ~10 – 20 m resolution sufficient for vegetation trends. ▪ *Forested/native lands/peatlands*: Higher resolution (e.g., sub-metre) may be needed. - Smaller sites need finer resolution than large landscapes. - Temporal resolution matters – frequent monitoring captures seasonal or annual changes.
Sensor and Platform Consistency	- Use the same sensor type across time-series assessments to ensure comparability. - Maintain standardized platforms and sensor types to reduce variability. - Consider limitations of drone data (e.g., cost, bulkiness) vs. satellite sources.
Accuracy and Field Validation	- Georeferenced data should be accurate within 1 metre, ideally supported with ground control points. - Field validation still critical, especially for soil, biodiversity, or species level observations. - ReDCAT assessments need to align with sampling design best practices and be repeatable.
Data Quality, Metadata, and Formats	- Submit in standard geospatial formats (e.g., GeoTIFF, shapefiles). - Include detailed metadata: acquisition time, resolution, sensor type, pre-processing and AI methods used. - Ensure auditability and transparency for regulators and stakeholders.
Sector-specific Flexibility	- Standards may vary by land cover, ecosystem type, and industry needs (e.g., forestry vs. agriculture). - Should support adaptive monitoring frameworks to reflect technological progress and ecosystem variation.
Regulatory and Practical Considerations	- Standards must balance regulatory defensibility with cost-effectiveness and ease of implementation. - Avoid rigid standardization that may stifle innovation or overlook applied realities in the field. - Regulations should guide when ReDCAT data is sufficient alone vs. when field work is required.
Broader System Design	- Enable submission platform consistency and automated compliance checks. - Build in mechanisms to evaluate data quality and model performance. - Acknowledge terminology inconsistencies across regions and sectors – shared language is essential.

S1/Q-4. Provide a list of possible secondary issues (or unintended consequences) that may arise from the use of ReDCATs. Consider: where the ReDCAT assessment for certification results in a failure because of increased spatial or temporal resolution, or where there is disagreement between different ReDCATs. Identify what mitigation strategies could be implemented to resolve issues or to prevent them to begin with.

Participants identified secondary issues (or unintended consequences) arising from the use of ReDCATs along with several mitigation strategies that could be implemented; these are presented in Table 13.

Table 13. Secondary issues, unintended consequences, and mitigation options when using ReDCATs.

TOPICS	KEY POINTS
Secondary Issues / Unintended Consequences	
Inconsistent Results	- Differences in imagery source, resolution, or acquisition timing can lead to conflicting model outcomes, undermining confidence.
Regulatory and Operational Risks	- High-resolution assessments might reveal new issues in previously certified sites, prompting re-evaluation or certificate withdrawal. - The ability to collect large datasets could inflate reporting burdens and slow review timelines.
Over-reliance and Misuse	- Risk of companies bypassing due diligence, relying solely on ReDCATs for reclamation certificate applications. - Loss of critical field context, such as species presence or site conditions, if ReDCATs are used without field verification.
Acceptance Challenges	- Lack of First Nations acceptance without ground truthing. - Legislative constraints may limit ReDCAT application in certain jurisdictions.
Technological and Interpretive Risks	- Disagreement in data interpretation may arise between professionals, industry, and regulators. - Tool misuse or outdated interpretation methods may cause inaccurate assessments.
Mitigation Strategies	
Ground Verification	- Require field validation where discrepancies or high-resolution issues are flagged.
Standardization	- Develop clear, defensible standards for ReDCAT use covering resolution thresholds, platform type, and data processing methods.
Transparency	- Treat higher detection rates as a strength. - Use results to support a more objective and robust decision-making process.
Scope of Use	- Limit ReDCATs to preliminary screening unless paired with ground-based verification.
Education and Training	- Ensure practitioners are skilled in data interpretation and tools are updated as technology evolves.
Governance and Oversight	- Create frameworks that define acceptable use cases and ensure consistency across sectors.

4.3. Session #2 – Remote Data Collection and Assessment Tools (ReDCAT)

In Session #2, participants emphasized the need to modernize policy to integrate advanced technologies – such as drones, satellite imagery, and AI tools – into assessment workflows, while maintaining the importance of ground truthing and human oversight.

Key concerns included data quality, licensing, and accessibility, as well as the challenges of harmonizing datasets across platforms and ensuring transparency in reporting. Discussions highlighted the limitations of current regulatory frameworks, the need for standardized data formats and submission processes, and the importance of historical and high-resolution data for accurate vegetation, soil, and crop assessments.

Participants also addressed the complexities of landowner consent, the economic feasibility of large-scale assessments, and the potential for AI to support weed detection, habitat monitoring, and climate impact analysis. The group called for improved collaboration across sectors, clearer regulatory guidance, and the development of centralized, open-access data platforms.

Overall, Session #2 underscored the importance of balancing innovation with accountability, and the need for flexible, scalable solutions that can adapt to diverse land types, evolving technologies, and changing environmental conditions.

S2/Q1a(i). For the existing criteria – Are there equivalent "ReDCAT criteria"?

There is broad agreement that many existing field-level criteria do have equivalent or complementary ReDCAT-derived indicators. However, some areas still require field validation or further research, and a distinct, dedicated set of ReDCAT criteria might eventually be needed to fully support ELC.

Table 14. ReDCAT options and research areas for alternatives to existing reclamation criteria.

TOPIC	KEY POINTS
Vegetation	- NDVI and other vegetation indices effectively estimate vegetation cover, health, productivity, and land use changes. - Canopy height and biomass can be assessed using LiDAR and drones. - Desirable species detection is emerging using high-resolution/hyperspectral imagery and AI/ML. - Dead vs. alive trees can be identified through spectral changes or LiDAR.
Landscape and Topography	- Digital Elevation Models (DEM), Digital Surface Model (DSM), and LiDAR capture slope, erosion, contour, and stability. - Photogrammetry and Synthetic Aperture Radar (SAR) can assist with drainage and terrain analysis.
Soil	- Soil moisture is measurable using SAR or multispectral imagery. - Soil colour and bare areas detectable via red/green/blue (RGB) or multispectral/ hyperspectral imagery.
Cumulative and Spatial Dynamics	- Time-series imagery can detect changes, acting as a trigger for further field assessment when the changes are unapproved or unexpected. - Edge effects and cumulative impacts can be observed by analyzing surrounding land use.

TOPIC	KEY POINTS
Limitations and Future Potential	- Some parameters like species composition and detailed soil characterization still need ground truthing. - Machine learning and imagery advancements hold promise for addressing current gaps. - ReDCAT can complement field methods now but may evolve into its own robust framework.
Research Needed	- Other soil indicators still need research or remain best assessed on the ground.

S2/Q-1a(ii). If not, should a ReDCAT criteria be developed and how would they be used to inform decisions related to ELC, or support a professional justification?

Yes, but with nuance. While there are areas where equivalent ReDCAT criteria don't currently exist, there's strong support for developing them – as long as they're used to complement, not replace, human-collected field data. Table 15 presents a summary of these considerations.

Table 15. Considerations for ReDCAT criteria development and use to inform decisions related to ELC.

TOPIC	KEY POINTS
Strategic Development	- New ReDCAT criteria should focus on achieving the goals of EPEA – rather than replicating traditional field practices – and be adaptive to emerging technologies. - There's a need for pilot testing and validation before ReDCAT indicators can be formalized for decision-making around ELC.
Regulatory Consideration	- Some responses suggest no new ReDCAT criteria are necessary if existing data collection standards can demonstrate closure effectively. - In those cases, updating existing criteria might be more efficient than inventing entirely new ones.
Complementary Use Preferred	- ReDCAT criteria should support or verify field-collected data, not serve as standalone evidence – except in remote or inaccessible areas where in-field data collection isn't feasible.
Professional Justification Support	- ReDCAT assessments can guide decisions, flag problem areas, and add weight to professional judgment – especially when used with field evidence.
Limitations and Gaps	- Some field-based criteria (e.g., soil texture, subsoil properties, chemical properties) are not yet measurable through remote sensing and thus need ground truthing or more research.

S2/Q-1a(iii). Are there data quality standards that need to be set? Is this influenced by land cover type?

In short, yes – data quality standards are necessary, and land cover type significantly influences how ReDCAT criteria should be developed and applied. These considerations are presented in Table 16.

Table 16. Considerations for data quality standards when developing ReDCAT criteria.

TOPIC	KEY POINTS
Data Quality Standards: Why and What's Needed	- Standards are critical to support trustworthy decision-making and maintain consistency across assessments. - Core standards should include: ▪ Minimum spatial, temporal, and spectral resolution; ▪ Calibration procedures; ▪ Metadata requirements; and ▪ Accuracy thresholds and validation protocols. - Standards should differ by the assessment goal (e.g., identifying invasive species vs. measuring canopy cover) and be tailored to client needs. - Emphasis placed on qualitative vs. quantitative clarity – it's important to define what is being evaluated and how.
Influence of Land Cover Type	- Yes, land cover influences requirements: ▪ Forested, grassland, wetland, cultivated, or wildfire-affected landscapes each need different approaches and resolution levels. ▪ Edge effects, seasonality, and vegetation complexity impact spectral signatures and classification accuracy. ▪ Higher resolution data (e.g., RPAS or LiDAR) may be essential for native grasslands or dense vegetation. - Three assessment tiers were proposed: ▪ Satellite-based broad coverage; ▪ Drone imagery for more detail; and ▪ Field validation for critical or ambiguous areas.
ReDCAT Criteria Development and Use	- Criteria should be standardized, but also flexible enough to adapt to different land uses and future capabilities. - ReDCAT is already functioning as a support tool within assessments. - It helps triage site concerns, guide professional judgment, and streamline regulatory oversight. - Government oversight or frameworks may be needed to ensure harmonization and accountability.

S2/Q-1.a(iv). Are there certification criteria that cannot (technical or technological impediment) vs. should not (preference, belief, bias) have ReDCAT criteria developed at all? If so, why?

Participants indicated that flexibility should be encouraged while also conveying that technical feasibility and contextual appropriateness must guide ReDCAT development decisions. ReDCAT should remain one part of a broader toolkit, used in tandem with field assessment, especially in complex or sensitive land types. Participants identified that government oversight is key for calibration, compliance, and innovation. The conversations highlighted that there are some ReDCAT criteria that *cannot* be developed due to technical or technological limitations, just as there are some ReDCAT criteria that *should not* be developed due to preference, belief, or regulatory comfort, as summarized in Table 17.

Table 17. Reclamation criteria that cannot (or should not) have ReDCAT criteria developed.

TOPIC	KEY POINTS
Land Cover Context and Future Potential	- Monocultures and tame pastures are easier to assess remotely than forested or variable native ecosystems. - Some aspects (e.g., plant community composition) may eventually be assessed reliably with future AI/ML tools. - Vegetation metrics like height, density, and cover can be captured with ReDCAT – especially where plant types are uniform. - Multi-year data and time series may improve ReDCAT reliability across seasons and crops.
Criteria That Should Not Be Fully Replaced	
Bias or Regulatory Preference	- Some regulatory systems rely on thresholds (e.g., Alberta's 85% vegetation benchmark) that may not translate smoothly into remote tools. - Field verification is still highly valued – e.g., species composition is partly about professional judgment, which is hard to automate. - Landowner input still matters and provides context remote sensing can't replicate. - There's institutional caution: preference to stick with familiar tools until confidence in remote tools improves. - Differences in consultant interpretation highlight the value of both tools and field checks to balance subjectivity.
Criteria That Cannot Be Remotely Assessed	
Technical Limitations	- Soil chemistry (e.g., EC, pH, salinity), subsoil properties, and soil texture cannot currently be derived from ReDCAT tools like imagery or LiDAR. - Groundwater-related parameters and tilth/compaction also fall outside ReDCATs reach. - Species composition and rare plant ID (e.g., in native grasslands) remain difficult to capture accurately without field-based "touch-and-see" assessments. - Remote tools are affected by environmental conditions (e.g., drones hindered by wind). - Current tools may lack resolution or spectral fidelity to distinguish between some vegetation types or soil health indicators.

S2/Q-1b. What are the costs or degree of effort needed to develop ReDCAT criteria using current technologies and practices? Which ReDCAT criteria would require additional R&D?

The topics in Table 18 were seen to be technically challenging due to either sensor limitations, biological variability, or the fine resolution required to make meaningful ecological distinctions.

Table 18. Cost and technical considerations when developing ReDCATs and ReDCAT criteria/standards.

TOPIC	KEY POINTS
Strategic Considerations	- Costs vary depending on land cover, assessment type, and resolution needs. - Shared funding models (e.g., COSIA, NRCan, the Forest Resource Improvement Association of Alberta – FRIAA) and cross-sector collaboration can lower costs and broaden accessibility. - Significant government involvement is needed to align with policy, platform access, and standardization. - Some technologies already developed may not be centralized or disseminated – a lost opportunity for efficiency.
Lower Cost/Effort	
Established Technologies	- NDVI, DSM, LiDAR: Moderate cost, widely used; many tools and data already exist. - Pilot projects (<2 years) with trained analysts are feasible for basic indicators. - Drones and satellite imagery are becoming more accessible, especially for uniform or remote sites.
Higher Cost/Effort	
Emerging or Specialized Technologies	- Hyperspectral imagery, ML for species classification, or soil indicators require high investment and more R&D. - Validation is key – ground truthing increases costs and timelines early on. - New model development (e.g., for species composition or plant community typing) still needs significant work.
Require Additional R&D	
Soils	- Topsoil depth, structure, chemistry inferred from spectral signals.
Species ID	- Detection of weeds, native prairie species, invasive plants via plant colour.
Wetland Classification	- Interest in mirroring wetland classification systems for ReDCAT use.
Community Typing	- Machine learning models for plant communities or habitat composition.

S2/Q-2a(i). For the evaluation of ReDCATs or ReDCAT criteria, is there a need to compare ReDCAT assessments/criteria to traditional field-level assessments /criteria? If not, why?

Most participants said that a comparison is necessary (at least initially). A summary of the points raised during the workshop is provided in Table 19.

Table 19. Considerations when comparing ReDCAT versus traditional assessments/criteria.

TOPIC	KEY POINTS
Why Comparison Is Needed	
Trust Building	- Comparing to field assessments increases confidence among regulators, professionals, landowners, and Indigenous communities.
Accuracy and Validation	- Direct comparison helps assess how reliably ReDCAT tools can replicate or complement on-the-ground results.
Economic Feasibility	- Understanding cost savings or trade-offs requires comparing methods side-by-side.
Establishing Baselines	- Field assessments can help calibrate and validate remote data, especially during early implementation phases.
Model Development	- Side-by-side trials are essential to "prove up" ReDCAT tools with real-world data (e.g., using 10% ground-truthing).
Policy Alignment	- Necessary for acceptance in regulatory processes – similar to historical transitions like GPS adoption in surveying.
Mixed Views – Comparison May Not Always Be Required	
Context-Dependent Scenarios	- In industries where ReDCAT methods are already well-established (e.g., agriculture, forestry), direct comparison may be unnecessary. - Not an “apples-to-apples” match: ReDCAT offers full-site statistical coverage vs. small, potentially biased field plots. - Focus should shift from matching traditional methods to rethinking outcomes (e.g., ELC, not a perfect data match).
Caution Against Over-reliance	- RS tools are not yet 100% reliable – often closer to 80% – so human review and judgment remain important. - Some parameters (e.g., seed length, species level identification) cannot yet be replicated remotely. - Data quality, sensor resolution, and site accessibility may influence when comparison is feasible. - There are concerns about human bias and inconsistent implementation of both in-field or tech-based assessments.
Conclusion	
Feedback Loop and Phased Adoption	- A “feedback loop” model was proposed: ReDCAT informs field assessments → which improve ReDCAT models → which refine future field efforts. - Ultimately, a hybrid approach (remote + field) is viewed as the most effective path – at least while trust, standards, and technology are evolving.

S2/Q-2a(ii). How would a "pass" vs. "fail" decision be made using ReDCAT criteria?

Use of ReDCATs can provide consistent approaches for assessing sites but participants recognized that ReDCAT data isn't perfect and should be supported through field verification; e.g., a hybrid approach. A summary of the points raised through the discussion is provided in Table 20.

Table 20. Considerations when establishing "pass" vs. "fail" decisions with ReDCAT criteria.

TOPIC	KEY POINTS
General Approach to Pass/Fail Determination	
Benchmarking with Certified Sites	- Begin by comparing ReDCAT outputs with field verified sites to develop confidence and calibrate thresholds.
Apply Thresholds and Deviation Allowances	- Use existing criteria (e.g., % vegetation cover, health, weed content) as benchmarks. - Allow for acceptable variability between onsite and offsite metrics – some suggested using statistical thresholds like ±2 standard deviations or Z-tests/F-tests on vegetation index data.
Statistical vs. Biological Relevance	- Consider whether differences detected and/or comparisons made using ReDCATs needs to be statistically relevant or biologically relevant.
Spatial Scale and Statistical Analysis	
Higher Data Density	- ReDCAT enables dramatically higher sampling (e.g., thousands of 3x3 m grids vs. a handful of manual points), allowing for: ▪ Granular variability analysis; ▪ Detection of statistically significant clusters of low-performance areas.
Comparison Against Controls	- Like traditional assessments, ReDCAT decisions would be informed by comparison to offsite control plots or local land variability. - Less variability in controls = tighter pass thresholds for the site.
Tools, Interpretation and Flexibility	
Use as a Screening Tool	- ReDCAT could provide a preliminary evaluation before field visits or formal certification applications.
Site- and Activity-specific	- Pass/fail might depend on the land use, ecological setting, or regulatory standard (e.g., slope compliance in gravel pits).
Professional Judgement Still Matters	- Especially where data limitations or regulatory comfort require nuanced interpretation (e.g., cultivated vs. variable landscapes).
Key Cautions	
Remote data alone isn't infallible	- Remote "passes" should be flagged for field follow-up if unexpected changes are detected – or if the technology misses something caught during ground assessment.
One-tool decisions are discouraged	- A blended system (remote + field + professional analysis) yields more reliable and defensible outcomes.

S2/Q-2a(iii). How might these be influenced by land cover type?

Land cover will influence the use of ReDCATs resulting in the need to tailor ReDCATs for each land cover type. Application of ReDCATs may not consider landowner or Indigenous uses and stakeholder acceptance should not be assumed. A summary of the points raised is provided in Table 21.

Table 21. Land cover and land use influences on ReDCAT criteria.

TOPIC	KEY POINTS
Land Cover Directly Affects Methodology	
Cropland / Cultivated Land	- Easier to assess due to uniform vegetation and predictable patterns. - Assessments can be based on yield metrics and typically require only limited field verification (e.g., weeds, soil). - Vegetation indices like NDVI or Normalized Difference Yellow Index (NDYI) are often sufficient.
Forested Areas	- ReDCAT is promising, particularly from a safety and access perspective. - Indicators include woody stem growth and absence of weeds. - Still requires field validation to check for desired and undesired vegetation and ensure natural regeneration. - Grass encroachment may go undetected remotely.
Native Prairie / Mixed Vegetation	- Much harder to assess remotely due to species diversity and lack of uniformity. - Drones may help with species identification, but satellite imagery is not yet precise enough. - Development of ReDCATs for these landscapes is still in early stages.
Peatlands / Wet Areas	- Present significant challenges: bryophyte cover, moisture retention, and seasonal variability lead to data gaps. - Requires multiple flights and heavy ground-truthing for reliable data.
Assessment Resolution Must Be Tailored	- The complexity of land cover drives the required resolution of imagery and metrics: ▪ Simple, uniform landscapes → lower resolution acceptable; and ▪ Complex, biodiverse sites → higher resolution and custom indices needed. - Vegetation index selection (e.g., SAVI vs. NDVI) should match land cover type and phenological stage.
Stakeholder Considerations	- Cultural or traditional land uses may not align with ReDCAT-driven assessments. - Use of ReDCATs may be easier on Crown land.
Site-to-Offsite Comparisons Vary	- The degree of acceptable variance between on-site and off-site controls depends on land cover similarity. - Large differences in elevation or vegetation type between sites can complicate comparisons.
Bottom Line	- Land cover type is a critical variable: it influences the tools, data resolution, index selection, and the level of field validation needed. - One size does not fit all when it comes to ReDCAT application.

S2/Q-2b. For the evaluation of ReDCATs or ReDCAT criteria is there a need to establish methodology to compare data collected from different platforms or at different spatial resolution? For example, data acquired by RPAS versus data acquired from satellites?

There is broad agreement that consistent methodologies and some level of standardization are essential for comparing data from different platforms and resolutions. An overview of the considerations discussed is provided in Table 22.

Table 22. Considerations for comparing ReDCAT data from different sources.

TOPIC	KEY POINTS
Resolution and Accuracy Considerations	- RPAS (drones) offer higher spatial detail but limited coverage. - Satellites provide broader coverage but lower resolution and may lose accuracy. - Trade-offs exist between platforms; not all are suitable for every application.
Height Data Usefulness	- Height data is not always necessary for cultivated areas but can help flag anomalies. - Precision data (e.g., from RPAS) can provide height but isn't always available.
Integration and Calibration	- Data should be upscaled/downscaled appropriately. - Use common calibration targets to align datasets. - Aim for "apples to apples" comparisons without stifling innovation.
Method Development	- Methodologies must be tested and adaptable to evolving technologies. - Understand platform-specific assumptions (e.g., noise increases with finer resolution).
Complementary Use	- RPAS and satellite data can support and enhance each other. - Field verification may still be needed, especially for RPAS data.
Client Expectations and Flexibility	- Clients may expect multiple data sources. - Frameworks must remain flexible to accommodate new tools and applications.

S2/Q-2c(i). For the evaluation of ReDCATs or ReDCAT criteria is there a need for dedicated areas to support: testing, evaluation, calibration, validation of existing or new ReDCATs?

There is strong agreement that dedicated areas are essential for testing, evaluation, calibration, and validation of both existing and new ReDCATs (Table 23).

Table 23. Considerations for dedicated areas for testing and validation ReDCATs.

TOPICS	KEY POINTS
Benefits of Dedicated Sites	- Simplifies the validation process. - Provides consistent, controlled environments for comparison. - Enables benchmarking of ReDCAT vs. in-field assessment performance.
Support for HQP (Highly Qualified Personnel)	- Known sites can serve as training and demonstration grounds. - Helps develop expertise and ensure quality in data generation and interpretation.

TOPICS	KEY POINTS
Site Selection Considerations	- Should include a variety of ecological and disturbance conditions, such as: ▪ Different ecosites; and ▪ Disturbance histories and types. - Sites like Peace River (a recognized Land Product Validation (LPV) Supersite) are good models. - Alberta-specific sites tailored to local needs would be ideal.

S2/Q-2c(ii). If so, would the Open Data Areas Alberta (ODAA) initiative fill this gap? If not, what is missing?

There is general agreement that ODAA has the potential to support ReDCAT testing, evaluation, and validation. It promotes data sharing and validation, aligning with the initiative's core goals. Cost-saving potential and support for AI training (e.g., weed species identification) are seen as valuable benefits. Key points for using the ODAA are listed in Table 24.

Table 24. Key points raised for using Open Data Areas Alberta to support the evaluation of ReDCATs or ReDCAT criteria.

TOPICS	KEY POINTS
Some Gaps Remain	- Field validation is still necessary, especially in early stages or in changing conditions. - Data quality and recency are concerns – some datasets (e.g., satellite imagery) are outdated. - Higher-resolution and newer datasets (e.g., hyperspectral imagery) are needed to enhance analysis.
Recommendations for Expansion	- Expand geographic coverage to include: ▪ Foremost, AB[1] unmanned aerial vehicle (UAV) test range (for testing vertical integration of data) ▪ Beaverhill area east of Edmonton (to include industrial Heartland) - Include a range of land use types (forested lands, native grasslands, peatlands and mineral wetlands) and disturbance types (e.g., wellsites, pipelines, access roads) for calibration.
Long-term Vision	- Consider the future trajectory of ODAA: What role will it play in 10 to 20 years? - Balance between simple vs. complex use cases (e.g., agriculture vs. forestry) in early implementation.
Additional Considerations	
Open data requirements	- Should data collected in test areas be mandated as open source?
Stakeholder engagement	- Requires time, resources, and specialized skills.
Responsibility for evaluation	- Unclear who should lead – government, academia, or private sector?

TOPICS	KEY POINTS
Funding challenges	- Consultants need financial incentives. - Federal support may be necessary.

[1]https://www.aerialevolution.ca/member-directory/#!biz/id/605a565b521137215f3a8fe3

S2/Q-3(a)(i). What would a "ReDCAT Detailed Site Assessment and Reclamation Certificate Application" consist of?

Site assessments, or Reclamation Certification Site Assessments (RCSA), completed using ReDCATs would parallel those undertaken using traditional field assessments. The additional detail provided through the ReDCAT should be supported by policy guidance developed within a multi-stakeholder technical committee. A summary of the topics discussed is listed in Table 25.

Table 25. Considerations when using ReDCATs for reclamation certificate site assessment/applications.

TOPICS	KEY POINTS
Core Components	
Remote Sensing Data and Imagery	- UAV orthomosaics, DSM, DTM (Digital Terrain Models), NDVI rasters. - Multispectral and RGB imagery. - Photogrammetry and LiDAR as needed. - Temporal data to track site evolution (especially for wetlands and slow-recovering areas).
Derived and Supporting Data	- Zonal statistics and interpretations. - Tabular and visual representations of site conditions. - Metadata: imagery type, acquisition date, resolution, etc. - Vector data: lease boundaries, sub-areas, rationale for zoning.
Narrative and Justification	- Explanation of how data supports ELC. - Comparison of on-site vs. off-site ReDCAT indices. - Justifications for passing if statistical thresholds aren't met (e.g., natural variability).
Technical and Procedural Needs	
Standardization and Guidance	- A tri-party technical committee (regulator, industry, SMEs) to define parameters. - Clear resolution standards and protocols for data consistency. - Spot-checking or field validation to confirm remote observations.
Assessment Enhancements	- Integration of standard assessments with 4+ years of multispectral data. - Consideration of terrain stability, erosion, surface water flow, vegetation health and height. - Special attention to wetland species and peat-forming vegetation.
Challenges and Considerations	
Data Consistency	- Varying imagery sources can lead to inconsistencies. - Need to balance simplicity (e.g., RGB) with detail (e.g., LiDAR) based on site complexity.

TOPICS	KEY POINTS
Operational Feasibility	- Earth observation programs should be supported by statistically significant physical monitoring. - Efficiency and scalability are key for long-term implementation.
Uncertainties	- Some aspects (e.g., species-level analysis in forests) remain difficult with current technology. - Clarification needed on how ReDCAT criteria align with existing certification criteria.

S2/Q-3a(ii). What is necessary to inform a decision that a reclaimed site is on a trajectory to achieve ELC?

Use of ReDCATs to inform ELC decisions will need to consider a range of data sources, and field verification. The points discussed on these topics are listed in Table 26.

Table 26. Considerations when using ReDCATs to inform ELC decisions.

TOPICS	KEY POINTS
Remote Sensing and Monitoring	- Use of satellite and drone imagery to assess: ▪ Bare soil presence; ▪ Vegetation cover and health; and ▪ On-site vs. off-site comparisons. - Temporal consistency is critical; data must be collected over multiple years - Include seasonal variation (spring, summer, fall) to ensure reliability
Data Integration and Diversity	- No single data source is sufficient – multiple data types (e.g., imagery, field data) are needed to make a robust determination - Pre-disturbance data is helpful but not essential; surrounding undisturbed areas can serve as reference points
Field Validation and Professional Oversight	- Ground truthing is necessary to validate remote observations. A hybrid approach can integrate limited fieldwork with ReDCAT analysis - Professional judgment is required. Confirmation by a qualified professional based on established, land-use-specific criteria.

S2/Q-3b(i). What ReDCAT data (e.g., raw imagery, processed imagery, interpreted imagery, derived data) would need to be included in the application?

Reclamation certificate applications using ReDCATs may include some key process differences from traditional approaches. Depending on the data sources used, ReDCAT submissions may include detailed imagery or time-series data. Key considerations for ReDCAT applications are listed in Table 27.

Table 27. Considerations for what ReDCAT data should be included in a reclamation certificate application.

TOPICS	KEY POINTS
Types of ReDCAT Data Required	
General Requirements	- A report with supporting statistics is generally expected.
Raw Imagery	- Needed to verify authenticity and allow reprocessing if necessary. - Especially important when interpretation is uncertain or contested. - Raw imagery may be needed to show processing steps and validate conclusions, though data sharing/intellectual property (IP) issues may limit access to original files.
Processed Imagery	- Demonstrates what transformations were applied to raw data. - Should be detailed enough to extract meaningful insights (e.g., NDVI, DSM).
Interpreted Imagery and Derived Data	- Final outputs used to assess reclamation outcomes: ▪ Vegetation cover, health, and productivity; ▪ Tree height and species diversity; ▪ Water body characteristics (hydroperiod, turbidity, optical depth, etc.); and ▪ Soil moisture and organic content (where feasible).
Time-series Data	- Multi-year datasets showing trends and stability over time. - Essential for demonstrating positive ecological trajectories.
Decision Support Outputs	- There needs to be flexibility early in the process development of ReDCAT decision trees. - Potential decision trees: ▪ Clear pass (all indicators positive); ▪ Uncertain (requires additional data or fieldwork); and ▪ Fail (require additional field verification).
Additional Supporting Information	
	- Evidence that the site is within the natural range of variability. - Comparisons to pre-disturbance conditions (if available) or nearby reference sites. - Landowner observations and other qualitative data (e.g. evidence of third-party use) may be included. - Metadata: acquisition dates, sensor types, processing steps, etc.

S2/Q-3b(ii). How is this influenced by land cover type?

ReDCATs can be applied across all land cover types. Reclamation certificate applications using ReDCATs will have general requirements along with the need to be tailored to specific land cover types. A summary of considerations of land cover influences is provided in Table 28.

Table 28. Considerations of the land cover influences for ReDCAT data.

TOPICS	KEY POINTS
Land Cover Sensitivity	- All land types are suitable for ReDCAT, but some are easier to assess than others. - Forested areas: harder to interpret due to mixed canopy and species complexity. - Agricultural lands: may still require ground truthing to verify remote data quality. - Wetlands: require temporal monitoring and detailed water-related metrics.
Similarity to Reference Sites	- What is considered an appropriate reference site is dependent on land cover type. - A multi-resolution approach is recommended – start broad, then zoom in with higher-resolution tools if needed.
Soil Considerations	- Soil indicators are the least developed in remote sensing applications. - Field visits are still necessary for soil depth, replacement, and weed assessments. - ReDCAT can support follow-up monitoring (e.g., stubble counts, moisture tracking).
Forested Lands	- Include: ▪ Raw imagery; ▪ Documentation of processing steps; and ▪ Statistical analyses used. - Evidence of growth trends and current vegetation status.
Cultivated Lands	- Require at least one initial field visit for validation. - Follow-up monitoring can rely on imagery (e.g., vegetation health and cover).
Native Grasslands	- Currently not feasible to assess reliably using ReDCAT alone – technology or methodology not yet sufficient.

S2/Q-3c. Are there barriers, such as data licensing, that might prevent certain data from being provided in an application?

Data licensing, privacy, and stakeholder acceptance are barriers likely to impact the uptake of ReDCATs for regulatory applications. A summary of the barriers discussed by participants is presented in Table 29.

Table 29. Key barriers that might limit certain ReDCAT data from being provided in an application.

TOPICS	KEY POINTS
Licensing and Intellectual Property (IP) Barriers	
Commercial Data Restrictions	- Imagery from providers is often licensed per organization and may not be shareable in public applications. - Data purchased for internal use (e.g., aerial photos) may be included in reports but typically carries copyright restrictions. - Proprietary file formats and software compatibility can limit accessibility for reviewers.
Licensing Enforcement Challenges	- Difficult to police how data is shared or reused. - Licensing terms vary widely and may restrict redistribution or public access.
Preference for Open Data	- Open-source imagery and transparent workflows are preferred to avoid legal and logistical complications. - However, open data often comes with caveats around resolution, accuracy, or metadata completeness
Confidentiality and Privacy Concerns	
Client-Owned Data	- Data collected on behalf of a client must be shared with the regulator but may not be made public without consent.
Technical and Standardization Issues	
Lack of Reporting Standards	- No consistent format for ReDCAT data reporting, analysis, or delivery. - Makes it difficult for regulators to interpret or validate submissions.
Platform Compatibility	- Regulators may not have access to all the tools or software needed to review raw or proprietary data.
Sensor Variability	- NDVI and other indices can vary by sensor, complicating comparisons and threshold setting.

S2/Q-3d. What changes to existing reclamation criteria may be necessary to support the ReDCAT application?

Where possible the use of ReDCATs should be incorporated into existing frameworks. Changes to existing criteria will need to consider practical approaches that are flexible and adaptable, recognizing the rapid evolution of ReDCATs while maintaining the importance of field verification. A summary of the points discussed by participants is presented in Table 30.

Table 30. Considerations for changes to existing reclamation criteria to support using ReDCAT.

TOPICS	KEY POINTS
Policy and Regulatory Adjustments	
Incorporate ReDCAT into Existing Frameworks	- ReDCAT data could be accepted as a variance under current criteria once regulators (e.g., AER) are confident in the methodology. - Changes to the RoO form may be needed to formally allow ReDCAT data in applications. - Equivalent rankings for ReDCAT-derived metrics should be established to align with traditional criteria.
Modernize Outdated Policies	- Existing guidance (e.g., 2010 Wellsite Criteria) is outdated – policies need to be updated to reflect current technologies and practices.
Policy Flexibility by Land Cover Type	- Criteria should reflect ecological relevance: ▪ Cultivated/grasslands: local controls more important; and ▪ Forested/peatlands: regional or ecological reference sites more appropriate. - Progressive reclamation (e.g., in mining) could benefit significantly from EO-based planning and assessment.
Data, Methods and Technology Integration	
Remote Sensing as a Supplementary Tool	- ReDCAT should complement traditional assessments, not replace them entirely. - Enables a more holistic, less biased view of site conditions than point-based field assessments.
Standardization and Transparency	- Need for clear methodologies, metadata, and documentation of data collection and analysis. - Encourage data sharing and integration across organizations (e.g., via ODAA).
Growth Curves and EO Signatures	- Develop EO-based growth curves and vegetation signatures to support trajectory assessments. - Could help define background conditions at macro or regional levels – possibly a regulator's responsibility.
Practical and Operational Considerations	
Field Validation and Site Selection	- ReDCAT could guide where field validation is needed, improving efficiency. - Allow ReDCAT data to influence site inspection locations and reduce unnecessary fieldwork.
Data Volume and Accuracy	- Applications may require more detailed data and methodological transparency depending on the precision of ReDCAT outputs.
Demonstration Sites and HQP Development	- Establish test sites to validate ReDCAT approaches and train Highly Qualified Personnel (HQP) for the use of ReDCATs.

S2/Q-4. Can ReDCAT produce other supporting evidence of impacts that may influence decisions on the "success" or "failure" with respect to ELC? If so, what are they? For example, human use, third-party, climate change.

In short, yes, ReDCAT can provide valuable supporting evidence. ReDCAT tools can detect and monitor a wide range of environmental and anthropogenic factors that may influence whether a site is on a trajectory to achieve ELC, including those listed in Table 31.

Table 31. Other supporting evidence provided by ReDCATs that may influence decisions on ELC.

TOPICS	KEY POINTS
Environmental and Climate-Related Impacts	
Climate Change Trends	- Long-term time-series imagery can reveal changes in vegetation health, wetland size, soil moisture, and temperature (e.g., rising nighttime lows). - Useful for tracking slow recovery in Arctic or climate-sensitive regions. - Historical satellite data (e.g., Landsat) can show pre-disturbance baselines and recovery gradients over decades.
Abiotic Limitations	- ReDCAT can help identify environmental constraints (e.g., drought, poor soil conditions) that prevent successful reclamation.
Hydrology and Watershed Dynamics	- Remote sensing is especially powerful for assessing surface water flow, wetland hydrology, and slope stability. - Tools like Green LiDAR and radar can detect water table levels, hydrocarbon presence, and subsurface features.
Human and Third-party Impacts	
Land Use and Disturbance Detection	- ReDCAT can identify third-party activities like grazing, vehicle trails, and unauthorized land use. - Human use patterns can be visualized and monitored over time.
Wildlife and Biodiversity Monitoring	- EO data can support habitat suitability assessments (e.g., bear dens, migratory birds, caribou). - Emerging tools like eDNA, thermal imaging, and wildlife cameras can complement ReDCAT data.
Technical and Analytical Enhancements	
Trend Analysis and Growth Curves	- EO signatures and multi-year data can build confidence in site recovery and end land use suitability. - Enables comparison of on-site vs. off-site vegetation and soil trends.
Advanced Tools	- Hyperspectral imagery, photogrammetry, and radar offer affordable and scalable options for detailed site analysis. - Thermal imaging and biomass estimation can support assessments of vegetation vigour and productivity.

Limitations and Considerations	
No “Silver Bullet”	- ReDCAT is a powerful tool, but not a standalone solution. No one tool will give us everything. - Consideration must be given to integrating field data, expert interpretation, and traditional knowledge (where applicable).
Regulatory and Methodological Challenges	- Methodologies must be certified by regulators. - Institutional, historical, and traditional knowledge is essential to interpret nuanced or ambiguous data.
Liability and Monitoring	- Could use ReDCATs for long-term monitoring to determine failures post-certification (e.g., tree die-off years later).

4.4. Session #3 – Project Concepts: Pilot (<2 yrs) and Research (+2 yrs) Projects

A central focus in Session #3 was the need to balance innovation with regulatory compliance, emphasizing early engagement with regulators, the development of standardized data collection methods, and the importance of ground truthing to validate remote sensing outputs. Participants discussed the integration of drones, LiDAR, photogrammetry, and AI for vegetation, soil, and species identification – particularly in challenging environments like wetlands, grasslands, and boreal forests.

The importance of historical and high-resolution data, as well as the creation of species recognition databases and multi-resolution frameworks, was highlighted to improve accuracy and support long-term monitoring. Challenges such as data licensing, accessibility, and continuity during company transitions were raised, along with the need for improved collaboration, mentorship, and public engagement through tools like hackathons.

Funding strategies, project prioritization by value and difficulty, and the role of academia and industry partnerships were also discussed. The workshop concluded with a call for enhanced data sharing, the development of open data areas, and the creation of technical reports and training standards to support ReDCAT adoption and environmental stewardship.

A summary of the project concepts identified by participants for the near-term (i.e., pilot/demonstrations) is provided in Table 32 (policy framework) and Table 33 (criteria for cultivated lands). Project concepts for the long-term (i.e., R&D needed; criteria for forested lands, native grasslands, peatlands and mineral wetlands) are presented in Table 34.

Table 32. Policy Framework – Concepts for the near-term; suggested timeframe <2 years.

PROJECT AREA / TITLE	PROJECT OBJECTIVE
Policy Framework	
Cross-Sector/Agency Technical Committee	To establish a Technical Committee / Working Group (WG) and a Terms of Reference: WG's role is to establish recommendations for a program approach or framework for the use of ReDCATs in reclamation.
Jurisdictional / Technology Review:[1,2,3] - What can be directly applied to existing reclamation criteria and indicators? - Is there existing technology that can be adopted short term?	To understand the existing methods and technology from other sectors and jurisdictions that have applications (e.g., adopt existing vs. developing new) for conservation and reclamation. Based on the review develop a technical document to establish program constraints.
	To build a concordance table against the 2010 Wellsite Criteria that identifies which criteria do/do not have ReDCAT equivalents. Identify gaps that might need to be filled in support of new/revised ReDCAT criteria. The table should also include cost-benefit analysis of each.
Testing Areas and Database of Training Data	To develop a repository of training data that is regularly updated for use in assessing and evaluating ReDCAT. Data could include that collected by academia, industry, or other organizations (e.g., InnoTech, ABMI).
	To update and expand (if necessary) the Open Data Areas Alberta initiative to reflect other areas of interest.
A Conservation and Reclamation Reporting Tool for All	Cross Sector Workshop: To conduct a workshop consisting of C&R professionals, policy makers, regulators, stakeholders to discuss needs for a C&R reporting standard.
	To develop a standard reporting template for all specified land activities to enable georeferenced: pre-disturbance site assessment (PDA), interim monitoring site assessment (IMSA), and reclamation certificate site assessment (RCSA).
ReDCAT: Spectral Libraries[4]	To understand what spectral libraries are available and if they are applicable to Alberta.
	To develop and/or update time series (spectral) signatures or growth curves[5] across different land uses (e.g., multiple ecosites) for key vegetations species to understand regional background conditions.
Peatland Record of Observation (RoO)	To develop a RoO form for peatlands.

[1]Alberta Reclamation Certification - Digital Technology Assessment (2022)
[2]Assessment of Remote Sensing Technologies for Regional Reclamation Monitoring in Alberta (2019)
[3]Monitoring Procedures for Wellsite, In-Situ Oil Sands and Coal Mine Reclamation in Alberta (MOPRA) – December 2014 Update
[4]United States Geological Survey (USGS) Spectral Library
[5]Baseline Growth Performance Levels and Assessment Procedures for Commercial Tree Species in Alberta's Mountain Foothills (1998)

Table 33. Development of ReDCAT Criteria on Cultivated Lands – Concepts for the near-term; suggested timeframe < 2 years.

PROJECT AREA / TITLE	PROJECT OBJECTIVE
Criteria: Establish requirements	To create specific standards for each ReDCAT evaluation criteria.
	To develop standardized methodology and criteria for using ReDCAT for vegetation assessments on cultivated land.
	To understand the advantages/limitations of different vegetation indices that could be used to assess ELC with respect to crop productivity. For example, plant health can be assessed based on different spectral signatures, remote sensing can be used to detect disease and evaluate health of cultivated fields.
Field Validation: Current and Retrospective Assessments[1]	To understand and demonstrate how ReDCAT can be used within a policy and regulatory context to: (1) monitor and evaluate policy outcomes, e.g., success/limitations of past practices; (2) Support Conditional Adjustment of Reclamation Liability (CARL) projections; (3) Support the reclamation certificate application; (4) Support regulatory assurance (e.g., compliance and/or enforcement) programs, e.g., Audit Program.
Data Analyses: Limitations and Reasons for Failures	To determine early warning indicators for changes in growth trajectories or reclamation outcomes (e.g., recovery). Detecting reclamation failures early-on to improve corrective actions pre-certification. To help find a high-value use case, with benefits on both/all sides of reclamation management (GoA/Regulator/Industry/First Nations). This project would seek to confirm the feasibility of detecting site-specific reclamation failures to identify capabilities of ReDCAT, to avoid the high cost of late-stage corrective actions.
	To understand why a site failed, e.g., if vegetation was bad was soil bad?
RPAS – Cultivated Assessments	To develop and refine methodology to assess different land uses/crop types; cultivated (wheat, oats, canola, peas), improved pasture. Replacement to assess yield, head weight, and seed health (e.g., based on NDVI yield measurement); availability of sites in different land uses.

[1] Monitoring Procedures for Wellsite, In-Situ Oil Sands and Coal Mine Reclamation in Alberta (MOPRA) – December 2014 Update

Table 34. Development of ReDCAT Criteria for Forested Lands, Native Grasslands, Peatlands and Mineral Wetlands – Concepts for the long-term (R&D needed); suggested timeframe >2 years.

PROJECT AREA / TITLE	OBJECTIVES
Development of ReDCAT Criteria	
Criteria: Establish Requirements	To develop specific standards for each evaluation criteria.
	To determine early warning indicators for changes in growth trajectories or reclamation outcomes (e.g., recovery). Detecting reclamation failures early-on to improve corrective actions. To help find a high-value use case, with benefits on both/all sides of reclamation management (GoA/Regulator/Industry/First Nations). This project would seek to confirm the feasibility of detecting site-specific reclamation failures to identify capabilities of ReDCAT, to avoid the high cost of late-stage corrective actions.
	To collect enough data during reclamation (earthworks and planting) and develop safe operating procedures (SOPs) for that collection to move forward with ReDCAT only processes.
	To define statistically-relevant field assessment methodologies to support EO area-based closure.
	To determine what is required to inform a decision for when a variance is required/not required for a reclamation certificate application.
Current and Retrospective Analysis[1]	To understand and demonstrate how ReDCAT can be used within a policy and regulatory context to: (1) monitor and evaluate policy outcomes, e.g., success/limitations of past practices; (2) Support CARL projections; (3) Support the reclamation certificate application; (4) Support regulatory assurance (e.g., compliance and/or enforcement) programs; e.g., Audit Program. For example, sites could be assessed using ReDCAT ~5 years before and ~5 years after certification.
Data Analyses: Limitations and Reasons for Failures	To understand why sites may have failed, e.g., if vegetation was bad was soil bad?
	To determine the relationship between site failures and identifying the key parameters that need to be evaluated. Based on these parameters, is further R&D needed?
Forested Lands	To assess the use of ReDCAT to determine soil moisture regime (e.g., surface water table) to aid in decision making and reclamation planning and monitoring.
	To assess forested sites using remote and traditional field level assessments to compare against current regulatory framework requirements to determine level of agreement across various assessment metrics including productivity; species diversity; moisture; weeds; forest trajectory; surface/subsurface flow.
	To understand what impacts wildfire may have on sites that have been reclamation certified, e.g., did the sites recover like offsite; what is the recovery curve for these sites?

PROJECT AREA / TITLE	OBJECTIVES
Forested Lands: OSE Sites	To determine the effectiveness of remotely collecting oil sands exploration (OSE) data by comparing field validated data with ReDCAT data to determine if enough information (e.g., collect remote data multiple times throughout a season) can be accurately collected to apply for a reclamation certificate.
Mineral Wetlands[2,3]	To evaluate the ability of ReDCAT to measure water retention capability of soil; depth of water and clay pad; berms; water level variability; littoral slopes/zones; other physical characteristics over time; which ReDCATs are best suited to wellsite/pipeline reclamation (small scale), etc.
Native Grasslands	To assess the use of ReDCAT for identifying and characterizing native grassland species.
	To determine if ReDCAT can differentiate graminoid species (e.g., incredibly small-scale spatial resolution to differentiate different types of grass species). To use RPAS to detect spread of clubroot along pipelines; beyond line-of-site is coming into play.
	To assess native grassland sites using remote and traditional field level assessments to determine level of agreement across various assessment metrics including productivity; species diversity; moisture; weeds.
Peatlands	To assess the use of ReDCAT to assess soil/water regimes in peatlands (e.g., soil moisture regime/surface water table) post pad/fill removal.
Soil Quality	To determine if the type of (un)desirable vegetation can be used as an indicator for soil quality.
	To determine if the sensor can provide data to inform soil metrics such as soil organic carbon, texture.
RPAS – Assessments[4]	To understand and test the reliability of using RPAS relative to in-field assessments by testing and ground truthing at accessible sites: Forested Lands / Native Grassland / Peatland / Mineral Wetlands.
Technology Validation	
Understanding Advantages and Limitations at Different Spatial Resolutions and Scales	To compare different resolutions when assessing / developing ReDCAT criteria to understand the advantages and limitations of different spatial resolutions.
	To understand economic costs of using different sensor resolutions at various spatial scales (e.g., site-level, local, sub-regional).
	To develop and demonstrate a framework for using ReDCATs at multiple scales to prioritize efforts for high-resolution ReDCAT data collection and field campaigns.
	To understand if/where high resolution imagery is needed and whether it needs to be updated annually.
Sensors for Species Identification	To determine sensors, such as hyperspectral, that can provide additional information for informing (un)desirable species classification.

[1]Monitoring Procedures for Wellsite, In-Situ Oil Sands and Coal Mine Reclamation in Alberta (MOPRA) – December 2014 Update
[2]Standard/Guideline: Alberta wetland mapping standards and guidelines: mapping wetlands at an inventory scale. Version 1.0

[3]ABMI Wetland Inventory Data
[4]Boreal Ecosystem Recovery and Assessment: A Multi-sectoral Research Partnership Supporting Restoration in Alberta's Boreal Forest

5. Next Steps

Throughout the workshop and reflected in each table discussion and in the online questionnaire, it was clear that there are both advantages and limitations to using ReDCAT to collect environmental information to be used for pre-disturbance assessments, reclamation monitoring, and reclamation certification assessments to confirm equivalent land capability.

Outcomes from the workshop can serve to inform:

- Development of future policy and regulatory guidance related to the use of ReDCATs; and,
- Funding initiatives to address the knowledge and research gaps identified.

Many of the themes emerging from the workshop were consistent with previous workshops related to ReDCATs, some of which are listed below, along with multiple considerations and possible next steps (where applicable).

5.1. Education and Training

Workshop participants identified that the application and use of ReDCATs within the resource development context will require a cross-section of skills and competencies. Successful implementation of ReDCATs within this context may require additional training and certification guidance to be developed.

- **Consideration(s)**: Organizations such as the CLRA and Canadian Remote Sensing Society (CRSS) are examples of organizations that are well positioned to support educational awareness, training, and certification for ReDCATs.

5.2. Regulatory and Stakeholder Acceptance

While the operational and regulatory use of ReDCATs may be at early stages, it's important to recognize that a number of these technologies have been well researched and are commonly used in other sectors such as agriculture and forestry. While the intensity of the disturbance of each activity type (e.g., roads, wellsites, mines) may vary across sectors, sectors also have many activities in common and often have similar reclamation objectives once the project is complete. ReDCATs may not be dependent on the type of activity or disturbance; they can provide a standard approach to assessing outcomes that can be flexible and objective.

- **Next Step(s)**: Establish a committee (or working group) to develop ReDCAT guidance, including representation from other groups beyond industry, government, or regulatory bodies and other sectors.

5.2.1. Need for Field Validation

It's also recognized that ReDCATs can provide a range of benefits for supporting resource development and environmental monitoring and assessment. However, the broader use and acceptance of ReDCAT data, especially early-on, will still require a component that involves field validation/verification. The *Coal and Oil Sands Exploration Reclamation Requirements* (AEP, 2015) is an example of reclamation policy which provides guidance using a hybrid approach involving both ground and aerial assessment of sites.

- **Consideration(s)**: Demonstration, research projects, and operational implementation of ReDCATs include hybrid approaches that need to include a field validation/verification component.

5.3. Innovation: Research Through Commercialization

Alberta continues to demonstrate leadership in the application and implementation of new and innovative technologies for resource development. This can also extend into the application of new and innovative ways to monitor and assess reclamation outcomes. Use of methods and data that are both credible and accessible are important components to enable research, demonstration, and operational implementation of ReDCATs. ReDCATs are rapidly evolving, triggering the need for ongoing funding and commercialization support, as well as areas for testing, evaluation, and validation of both public and commercially available datasets and analytical tools. This will require a range of knowledge and skills, partnerships, funding, and data frameworks.

5.3.1. Multi-disciplinary Project Teams

Future projects involving the use of ReDCATs should contain a clear description of the operational or business contexts. This includes but is not limited to: what regulatory/policy need is addressed; economic considerations that compare the value and cost of ReDCATs to traditional assessment methods; and use of multi-disciplinary teams.

- **Consideration(s)**: Multi-disciplinary project teams should include qualified individuals (those qualified to provide technical advice) related to conservation and reclamation, as well as individuals with the necessary training and expertise for using ReDCATs. These teams should also include policy makers, regulators, and delivery partners such as commercial data and service providers that are available to support further operational deployment of ReDCATs.

5.3.2. Funding Opportunities

There are several public and industry-led programs/organizations available to provide funding and support at various stages from research through to the commercialization of ReDCATs. These include but are not limited to: **Public –** Alberta Innovates; Emission Reduction Alberta; Natural Sciences and Engineering Research Council (NSERC); Canadian Space Agency (CSA); and, **Industry-led**: Petroleum Technology Alliance of Canada / Alberta Upstream Petroleum Research Fund (PTAC/AUPRF); Clean Resource Innovation Network (CRIN); and Canada's Oil Sands Innovation Alliance (COSIA). Previous workshops have demonstrated several successful outcomes on the use of ReDCATs, resulting from academic, provincial, and federal collaboration.

- **Consideration(s)**: Successful outcomes have resulted from approaches that consisted of: an initial session to define opportunities and knowledge gaps (such as those identified in this report); follow-up conversations between project teams and end-users; and, resourcing (e.g., funding, data, staff) and initiation of selected projects.
- **Next Step(s)**: Several project concepts were identified by participants that could serve as the basis for funding and investment decisions. Funding organizations should attempt (where possible) to coordinate funding calls or investment supports to avoid funding duplicate projects.

5.3.3. Testing Areas and Data Accessibility

Participants identified the importance of being able to access public and commercial datasets to support innovation related to ReDCATs. They also identified that one of the limitations of this approach, as well as for reliance upon environmental data centres, was the need for central coordination. The establishment of the Open Data Area Alberta (ODAA) was one of the workshop recommendations in 2015, and through a collaborative effort it was established in 2016 to serve this very purpose. It is currently managed by Alberta Data Partnerships (ADP). The ADP is a public-private-partnership (P3) governed by a board of directors who reflect the needs of the province of Alberta and its industries. The board is made up of representatives from the Government of Alberta, Alberta Energy Regulator (AER), utility companies, municipalities, forestry, oil and gas, and other stakeholder associations.

The ODAA includes 6 areas across Alberta; within each area various types of land (i.e., public, private), land cover (e.g., agricultural land, forested land) and activity types (e.g., pipelines, wellsites, roads) are represented. Each area includes publicly accessible data along with datasets contributed by several commercial data providers. The data is provided with a license adopted from Alberta's Open Government Program.

- **Consideration**: Given its current governance structure, ADP would be well positioned to serve as a flagship model for central coordination as an “environmental data centre”. ADP can also provide a conduit to match end-user needs with the data/service providers within Alberta’s innovation system.
- **Next Step(s)**: The ODAA initiative should be reviewed for the following possible opportunities: expand existing areas and/or add new areas to fill gaps; update the data available in these areas; and, within these areas, include data collected in the field to support field validation/verification. ADP should continue to support and maintain the ODAAs by providing data for testing in support of ReDCAT innovations.

5.4. Communication and Awareness

Workshop participants, like those that have attended similar events in the past, highlighted the need for continued dialogue to create awareness of the benefits of ReDCATs. They expressed the value of continued dialogue through similar events to promote the role that ReDCATs can have in the resource development sector including, but not limited to, supporting regulatory functions, industrial and ambient monitoring and assessment, and policy development.

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7. Appendix 1: Workshop Agenda

TIME	WHAT	WHO	LINKS TO WORKSHOP OBJECTIVES
8:00 to 9:00	Registration & Coffee	All	
9:00 to 9:05	Land Acknowledgement	CLRA	
9:05 to 9:30 (25 min)	Setting the Stage (Presentation)	Alberta Innovates	#1: AB C&R Policy & Reg Framework
9:30 to 10:30 (60 min)	State of RS/EO Technology (Presentation)	Canada Centre for Mapping and Earth Observation	#2: To review the current and emerging capabilities and uses of Remote Data Collection and Assessment Tools (ReDCATs)
10:30 to 10:50 (20 min)	Coffee Break	All	
10:50 to 12:10 (80 min)	Session #1: Lifecycle (Temporal) Considerations and Reporting	Table Discussion	#1: Specific to using ReDCATs, what is the role of time and how should it be considered in the determination of Equivalent Land Capability?
12:10 to 12:50 (40 min)	Lunch; Sponsorship Recognition	All PTAC; COSIA/Pathways	
12:50 to 14:20 (90 min)	Session #2: Remote Data Collection and Assessment Tools (ReDCAT)	Table Discussion	#2 & 3a: To identify the existing and proven ReDCAT technologies that can meet the desired data and information requirements within the next 1-2 years where pilots or demonstrations are needed.
14: 20 to 14:40 (20 min)	Coffee Break	All	
14:40 to 16:00 (80 min)	Session #3: Project Concepts: Pilot/Demonstration Projects (<2 yrs) and Research Projects (+2 yrs)	Table Discussion	#3b: To identify the gaps in information where research and field testing is needed to identify future use of ReDCAT. #4: To fill these gaps, where possible, by developing concepts for: 4a – pilot/demonstration projects; and 4b – research projects
16:00 to 16:15 (15 min)	Next Steps	CLRA & AB Innovates	

8. Appendix 2: Participant List

The role of the table leaders was to help drive conversation at the tables, ensuring the questions provided were answered, and timelines were met. The note takers managed the MeetGeek recordings and took handwritten or electronic notes of the table conversations (Table 35).

Table 35. Workshop Participant List with Table Leads (1) and In-Person Note Takers (2) Identified.

NAME	COMPANY/ORGANIZATION
Phaedra MacBeth	2164297 Alberta Ltd.
James Hymers	AbaData
Cynthia McClain	ABMI
Erik Holmlund	Alberta Data Partnerships
Alana DeBusschere[1]	Alberta Energy Regulator
Colin Peters[1]	Alberta Energy Regulator
Kirsten Horne[1]	Alberta Energy Regulator
Subir Chowdhury	Alberta Energy Regulator
Kyle Jones	Alberta Environment and Protected Areas
Shannon Yacyshyn	Alberta Environment and Protected Areas
Tyrel Hemsley[1]	Alberta Environment and Protected Areas
Chen Xu	Alberta Environment and Protected Areas
Sarah Khan[2]	Alberta Environment and Protected Areas
Shane Patterson	Alberta Innovates
Julian Marchand	ATCO
Steven Clark	Bear North Consulting Ltd.
HPeter White	Canada Centre for Mapping and Earth Observation / Natural Resources Canada
Richard Fernandes	Canada Centre for Mapping and Earth Observation / Natural Resources Canada
Darren Janzen	Canada Centre for Mapping and Earth Observation / Natural Resources Canada
Patti Dods	Canada Energy Regulator
Cassandra Atkins	Canadian Natural Resources Ltd
James Agate[1]	Canadian Natural Resources Ltd
Katie Howes[1]	Canadian Natural Resources Ltd
Bridget Facteau[2]	Canadian Natural Resources Ltd
Isabella Bagni	Canadian Natural Resources Ltd
Angeline Van Dongen	Canadian Forest Service / Natural Resources Canada
Harpreet Sandhu	Cenovus Energy
Jason Desilets[1]	Cenovus Energy
Albert Lee	Closure Liability Management

Tanya Yeomans	Consultant
Andrew Pylypchuk	EarthDaily
Amber Flamand	Earthmaster Environmental (CLRA)
Alexandra Gauvin[2]	Earthmaster Environmental Strategies Inc.
Elizabeth Russell[2]	Earthmaster Environmental Strategies Inc.
Nick Tumney	EarthScience Information Systems
Michelle Kingsmith	Ecosis Ltd.
Carlos Arregoces	Ecoventure Inc.
Erin High[1]	Ember Resources
Clinton Wells	Flint Energy Services LP
Tony Gregov	GCL Environmental Ltd.
Harikrishna Umat[2]	GCL Environmental Ltd.
Marc Lehmann	GDM Inc
Jesse Lawrence	Good Lands Environmental Inc.
Jill Caldwell	Good Lands Environmental Inc.
Olivier Tsui	Hatfield Consultants
Lori Neufeld	Imperial
Greg Cody	Imperial Ltd.
Kinzie Gray	Imperial Oil Resources
Moremi Omotoso	Indian Oil and Gas Canada
Stefan Schreiber	InnoTech Alberta
Hasmik Manandyan	Klohn Crippen Berger Ltd.
Carolyn Inglis	LiORA
Vincent Lam	Matidor.com
Britney Hammerlindl[2]	Millennium EMS Solutions Ltd.
Ian Mitchell	Millennium EMS Solutions Ltd.
Avery Braaten[2]	North Shore Environmental Consultants
David Simmill	North Shore Environmental Consultants
George Gaeke	Olds College
Celina Greer	Peloton Computer Enterprises Inc.
Cassidy Rankine	Planet Labs Geomatics
Jessee Avery	ProDelta
Tannis Such[1]	(PTAC) Petroleum Technology Alliance Canada
Stuart Widmer	Saige Environmental Inc.
Coral Fermaniuk	Silvacom

Libby Price[2]	Silvacom
Cara Kalancha[2]	SLR Consulting (Canada) Ltd.
Maria Kudienko	SLR Consulting (Canada) Ltd.
Shawna Adams	South Bow
Sathish Punati	Southern Alberta Institute of Technology
Matthew Woofter	Strathcona Resource Ltd.
Ararat Cheema	Suncor Energy
Mark Boulton	Suncor Energy
Sarah Kohlsmith	Suncor Energy
Tanya Richens	TCR Environmental Consulting Ltd.
Lily Delamare	University of Saskatchewan
Eduardo Loos	Vertex Resource Group Ltd.
Dean Mackenzie[1]	Vertex Resource Group Ltd.
Cory Sommer	Waterline Resources Inc.
Kurtis Broda	Wyvern

9. Appendix 3: Session #1 – Lifecycle (Temporal) Considerations & Reporting

The questions provided to the tables for discussion at the workshop are copied below. The table leads were provided with further context for each question (noted in italics at the end of the appendix) to help drive conversation and answer questions that may come up during the conversation.

Current Requirement: Under the *Conservation and Reclamation Regulation*, the objective of conservation and reclamation is the return of equivalent land capability (ELC).

Purpose: Discussion on ReDCAT assessments (and criteria) and the influence of time in the decision-making process related to whether equivalent land capability (ELC) has been met.

For example:

- Single "point-in-time" assessment: one assessment completed in a growing season.
- Multiple "point-in-time" assessments: two or more assessments completed within a single growing season or across multiple growing seasons; multi-temporal datasets used. May be used to show trends over time.
  - Enhanced: used to support reduced sampling intensity at a field-level; or
  - Hot Spot/Area of Concern: like the Enhanced approach; but used to identify areas of concern where site-specific interventions, or field confirmation, may be required.
  - Retrospective: used to assess older sites that differ for one or more reasons (e.g., historical policy; construction/reclamation practices), regardless of whether the surface reclamation liability period has expired.

The following text is a compilation of hand-written notes from each table for Session #1, combined with the responses received from the online survey questionnaire. It is this compiled set of information that was used to develop the summaries presented in Section 4.

S1/Q1a(i). What are the advantages (or limitations) of updating existing reporting tools such as the Record of Observation (RoO) or the Reclamation Information System (RIS) for use across other sectors?

<u>**Advantages**</u>

- There are rules for use/guidance in place already
- Publicly available/already known/easy to use
- The RIS includes internal company QA/QC steps
- The oil sands mine data is publicly available (up to 2021) through the Oil Sands Information Portal (https://osip.alberta.ca/map/)
- With all data coming in the same format you can use AI to process the data
- ABMI uses the data from the RIS. RIS is useful as an authoritative dataset for anthropogenic footprint (the limiting factor is that the RIS is not regularly updated online as per the original intent)
- Standard spatial reporting enables better alignment with monitoring technologies (e.g., EO) and incorporation of artificial intelligence
- Standardization of data reporting and ability to upload data in various formats
- It would standardize reporting and site closure province wide, regardless of industry
- Reclamation policies are being aligned across sectors and largely based on 2010 rec criteria so updating to expand RoO would be beneficial
- Integration of RoO and RIS allows integration of point data (RoO) with spatial boundaries captured in RIS

- Public availability of reporting outcomes may be an advantage in updated tools
- Updating the RoO or RIS to accommodate multi-sector land use types would promote consistency in how reclamation progress and ELC are reported. Additionally, sectors like renewable energy, mining, and pipeline operators could benefit from insights or formats originally developed in oil & gas – especially if retrospective assessments and multi-temporal data become more common
- Consistency and understanding across all sectors which would allow reclamation to be streamlined as everyone would be on the same page
- Modernizing these tools would allow for easier upload of geospatial layers, time-series data, and AI-derived indicators (e.g., NDVI trends, canopy metrics), enabling more robust and data-rich reporting. Routine ReDCAT-based observations (e.g., seasonal UAV imagery) could be linked to the reporting interface to provide more detailed insights
- Familiar format for all industries and easy to use amongst practitioners
- Having established tools would aid practitioners in meeting requirements. However, existing tools were developed based on traditional approaches and gaining the full benefit of new technologies likely merits a re-think
- Increase efficiencies
- Remove bias
- Improvements in the quality of data and the amount of data we are able to collect
- More assurance for consultants to be able to demonstrate ELC has been achieved and higher degree of confidence for decision makers to be able to certify a site
- View the site wholistically
- Can help reduce duplication by allowing integration with platforms like ours, where operational data, environmental risk factors, and spatial overlays are already in use
- Modernizing the reporting tools to allow submission of high-quality data would streamline the submission and review processes. This could include RPAS imagery, raster data, etc. The submission process could be standardized across all sectors which would ensure that assessments are completed to a standard, are auditable and reproducible, which would provide confidence to industry, regulators and other stakeholders
- RIS software offers significant benefits for businesses of all sizes by streamlining processes, enhancing operational efficiency, and improving communication. It helps reduce reliance on paper-based systems through mobile apps and real-time data collection, which minimizes errors and redundancies. Some platforms enable easy integration of various systems, automating administrative tasks and centralizing information management, thereby saving time and reducing costs.
- Key features of RIS software include improved team communication, easy access to critical data, and efficient project management, leading to better decision-making and increased employee satisfaction. Additionally, it enhances budget monitoring, reduces liability by ensuring compliance with regulations, and improves worker safety through accessible resources. The ability to visualize projects geospatially contributes to clearer communication with stakeholders.
- As a consultant, if you know and have used the RoO for oil and gas it's not a huge deal to maintain consistency across sectors, but for those who haven't, it's a large leap to go to a RoO from current practices.
- Modernizing reporting tools, could accept high quality data (RPAS imagery, raster data and derivatives), and streamline submission and review processes
- There is an opportunity to standardize data formats and processing / protocols to ensure the assessments done meet a minimum standard, and the data could be auditable, and reproducible, giving confidence to industry, regulators and landowners.
- Transparency across agencies
- Online tool is easy to access

Limitations

- Current RoO template for photos distorts the quality of photos. Providing high quality/high resolution photographs is important
- An Excel spreadsheet form (like the RoO tool) allows for necessary fields to be missed
- Current RoO template doesn't allow for submission of usable data
- Within the RoO there is no requirement to submit spatial information. Any information submitted related to reclamation certificates should be submitted geospatially. It makes sense to know where the assessment point is
- RIS – there are limitations with how to categorize the data
- RIS and related – the regulator would need to develop standards for the collection and presentation of baseline datasets (e.g. software (e.g. ESRI versus other) could be an issue)
- On private land, the regulators and landowners don't always agree on the criteria to be met
- RoO tool is very vague for landscape criteria – use of ReDCATs could improve this.
- Reclamation certification criteria should be standalone from the RoO tool. There needs to be more of a decision tree format because different scenarios require a different path in the framework
- The RoO tool has made things too quantitative for something that should allow for interpretation
- Needs someone/organization to coordinate and maintain updates
- It would become more complex because different industries/sites require different levels of reclamation effort and assessment
- It would be difficult to implement and train all sectors
- There may not be a common understanding to interpret the data as presented
- Could be some hesitation when reviewing new way of information compared to old way
- Budget/time constraints
- Bias
- One point in a grid
- Legacy tools may not be equipped to handle AI-enhanced analysis
- Reporting needs to be collected for the outcome it was intended for. Other sectors may require different reporting tools
- RoO tables have their limitations. Data collection is onerous for some land uses and should be reviewed based on the years of data obtained i.e., does collection of head weight actually provide data that illustrates equivalent land capability or is it the collection of various other data that demonstrates equivalent land capability?
- No API connection to platform
- Continued advances in technologies and science applications allows for new (and potentially more accurate and robust) reporting. As older tools are discovered to be insufficient in some aspect, option for application of new tools is needed.

S1/Q-1a(ii). What are the key considerations for any updates/changes (if needed)?

- How would any updates to the system be addressed (e.g. on a go-forward basis, or would it trigger a review of previous submissions)?
- A RoO tool for peatlands would be useful, as each consultant has developed their own.
- Current tools do not support geospatial data uploads. Georeferenced imagery and data should be able to be submitted.

- Georeferenced imagery would allow for multiple assessments of a single site to be more clearly demonstrated.
- Could use AI to interpret raw data (and determine why a site failed, for example).
- The use of AI could bring legal data security issues.
- Some consulting companies are already using AI to assess drilling reports, tour reports, even written reports (one example is Generative AI – Intelligent Project Solutions Inc.). Data is required to teach and develop these tools.
- Diversify the reclamation requirements based on land use/land type.
- Allow for submission of original data/raw data (including original sized photos, georeferenced data, shapefiles, GeoTIFFs), and allow it to be publicly accessible.
- Make the original data/raw data (including original sized photos, georeferenced data, shapefiles, GeoTIFFs), available to companies during mergers and acquisitions. It's important to protect the information over time.
- Reclamation certification information submitted through any system should be publicly available.
- Submission of accessible original data/raw data would allow for the trajectory of the site over time to be better understood.
- A digital form (similar to OneStop) could ensure that all necessary fields are filled out.
- In the Green Area: Allow for and identify measurements take at the time of reclamation versus in later years.
- Create larger area data sets.
- With less field work there would be less human interpretation bias… but technologies would introduce different biases.
- Include a recommendations/next step field. If this information was easily available to every consultant with the site information, less work would be repeated.
- Consider SiteView, but it only uses PDF information (dead data).
- The regulators should be requiring georeferenced data.
- Storage of data must be a consideration. If more data is being submitted, it needs to be organized, stored, safe, and accessible over time. Who will own the storage set and how will it be maintained over time? How can it be made public?
- Use remote sensing to compare NDVI onsite versus offsite for RoO.
- These kinds of assessments are already used in agriculture (Olds College SMART Farm, precision agriculture, etc.).
- You could forgo the soil assessment since crop productivity/vegetation growth is the goal and will be a reflection of soil quality.
- Hyperspectral imagery can be used to differentiate species of vegetation. It gives the chemical signatures of various plants.
- Consider invasive plants versus native plants; plant health.
- Any data set needs to be open source.
- Require use of GPS equipment when collecting information, to ensure locations are accurate. GPS on photos is not accurate; metadata should be collected/used as intended.
- Can current methods and tools be revised to reduce human error during assessment? Can we use prepopulated forms to ensure accuracy?
- We must consider the land type (i.e., forested versus cultivated) and determine what method is more valid/most appropriate and look deeper into it.
- The timeframe should be longer as the limitations of LiDAR and similar could need more specific data than what we collect in the field. The feedback loop is different between field data and imagery data.

- Ensure there is standardization with data collection to ensure everyone collects the right information and it helps train and improve the models that are used.
- Overall, ensure that whatever approach is chosen works for the measurements you typically take in the field.
- There’s currently a lack of cross-pollination between datasets, no source of truth or consistency between data, and a lack of standardization. Data is not publicly available. There are inconsistencies between data – quality, type, and access.
- There are privacy considerations.
- Reclamation certificate applications and approvals should be publicly available (not just FOIP’able).
- Consider cost sharing for data sets (as already seen in remote sensing).
- Why not use the RoO tool for pipelines and transmission lines?
- Saskatchewan has something similar to the RoO tool.
- If the RoO tool were to integrate the use of remote sensing, drones, etc. it would need to be improved. It is limited when it comes to geospatial data. If ReDCAT technologies were to be used as a proxy for density, this won’t replace ground-truthing in the field.
- Needs to be flexible enough to be adaptable to different spatial resolutions of imagery. Reclamation policy is often based on spatial thresholds for areas within a disturbance (e.g., wellsite maximum of 40 x 40 metre grid), this could easily be applied to EO technologies such as imagery as most publicly or commercially available imagery has spatial resolutions <20 to 30 m (e.g., Landsat; Sentinel-1/-2; Worldview; Planet; etc.).
- What data formats are allowed, metadata requirements, and requirements in terms of accuracy, resolution, etc.
- Consider that the current requirement (ELC) may be outdated and unable to address loss of habitat for threatened species. Consider that restoration objectives, standards and criteria are different.
- There would need to be clear guidance on how ReDCAT data types meet or supplement regulatory thresholds/assessments.
- An "outcome first" approach should be the starting point – i.e. what are the actual required outcomes under EPEA rather than what are the measurements made during current approaches.
- What is the meaningful data that indicates a site meets criteria? Can data collection be reduced to what is scientifically defensible and must have versus desired to have?
- Ease of use and flexibility in terms of site locations and disturbance level.
- More flexibility from AER regarding the use of ReDCAT for upstream oil & gas sites.
- Do potential changes enhance the process (i.e., reduce bottlenecks, save time)?
- Have these new processes been proven in other sectors (i.e., vegetation assessments in the agriculture industry)?
- Ensure data collection is presented clearly and in an accessible format.
- The primary key consideration is interoperability or the ability to integrate with platforms that use spatial data, AI/ML, and real-time feeds.
- A good understanding of data collection, processing and using it to compliment ground-based assessments by all stakeholders.
- Training resources for users to properly use new data formats and tools.
- Data security and privacy – consider platforms like GitHub as a model for organizing data, processing scripts and outputs in a version-controlled, auditable way.
- The data layers should be stored in a way that a regulator or audit could reproduce the assessment (at least the ReDCAT part).
- The changes should be mindful of future advances as ReDCAT is a rapidly accelerating field.

- Different industries across Alberta don't function the same as oil and gas and the requirements for pre and post disturbance assessments are different. Sand and gravel sites can be sections in size and sampling intensities need to be reflective of that difference, as an example.

S1/Q-1b. Are there other initiatives that would benefit from this approach? If so, please provide details.

- Vegetation assessments in agriculture fields (yield) – the proxies for yield don't always match the yield monitors that the farmers use.
- Verification of disturbance.
- Sectors: sand and gravel versus oil and gas versus forestry, etc.
- Get rid of the RoO tool – create something better from scratch that has scalability in mind and a longer-term vision. The current system is archaic, site-based instead of landscape-based, and short-term.
- What would the regulations look like if in 2050 we had a 100% remote system? We need to build a new path rather than band-aid the existing system to fit our needs. Run the two processes in parallel until the new one is complete.
- Cons with this proposed approach: Lots of change, how will the change progress within the policy/regulatory space? We don't want extra bureaucracy.
- Develop a standardized app that has certain criteria included. One that can be expanded and modified (unlike the RoO tool).
- AI will use the data. Make human-intervention a sign-off.
- Old sites can be challenging as imagery is not as readily available. Europe's deforestation regulations requires that products being imported are not the result of deforestation. Imagery allows for them to see and collect this information.
- Everyone who uses AI does it differently. We need to standardize reporting methods with room for change over time.
- We can use the tools to collect robust records of sites that are far out, or do not have any affiliation. Use the tools to collect more information of what was done in the past when regulations were different.
- Are there companies that routinely do fieldwork to monitor a site more accurately than a RoO? Can land-based remote sensing tools be leveraged instead? A lot of the pre-disturbance information is already lost by those who collected the data.
- AER OneStop uses proprietary data.
- How does it make sense to approach weeds on a coal mine different from on a well site?
- GOA needs a standardized process.
- You could set up a data portal that contains the original raster data. Not static data but dynamic, via a data portal.
- The economic aspect and proprietary datasets need to be considered, which creates limitations on the data being freely available. Site-specific nuances might be lost.
- RITL – spatial reporting of activity boundaries across sectors.
- Alberta Human Footprint Mapping Project – spatial boundaries reported by industry would replace estimated boundaries (private lands).
- A ReDCAT-informed approach could enhance RITL outcomes by:
    - mapping actual vs. approved land use
    - detecting unreported disturbances or encroachments through UAV or EO trend analysis
    - automated flagging of reclamation obligations or compliance issues
- ReDCAT tools could support liability closure by:
    - Providing time-series vegetation or soil productivity data to demonstrate land recovery
    - Mapping "hotspot" areas where additional work is needed to achieve ELC

- Offering a less resource-intensive path for verifying reclamation of legacy sites (especially for inactive wells or mining features)

- It is fully possible to use ReDCAT data to develop a monitoring system of sites.
- The key is ensuring access to authoritative data that can be integrated into operational platforms and regulatory workflows.

S1/Q-2a(i). Could data that is submitted as a regulatory requirement subsequently be used for: comparisons to other similar disturbance types; or, to update publicly available geospatial or land cover datasets?

- Yes.
- Yes definitely, if no data is confidential.
- This would be a great source although accuracy would need to be clearly indicated.
- Yes, submitted data may provide valuable opportunities for comparative tests. Are anthropogenic disturbances recovering in a pattern in space and time that is comparable to non-anthropogenic disturbances? Are there opportunities to improve on the pattern of disturbance and recovery in support of purposeful social and ecological objectives?
- The Oil Sands Information Portal (OSIP) exists and was for that, but it hasn't been updated since 2017. The GOA should be regularly updating it.
- ABMI could leverage the OSIP data for footprint mapping.
- Investment into training datasets is needed and needs to be standardized.
- Big question: will industry want to pay for something like this?
- This presents a valuable opportunity to leverage existing data and scale the use of remote sensing and Earth observation technologies in support of regulatory decision-making. However, a key challenge lies in data accessibility. Companies that have invested in acquiring such data for proprietary analyses may be reluctant to share it openly. While the use of submitted data for comparative analyses across different disturbances would offer significant benefits, establishing appropriate data-sharing agreements to facilitate this may prove difficult.
- Yes, regulatory ReDCAT submissions could help develop benchmark recovery trajectories across industries (transmission line vs. well pad) and identify factors that drive faster/slower ELC outcomes such as soil handling practices or revegetation strategies.
- ReDCAT submissions could be used to improve the temporal accuracy and resolution or ABMI human footprint layers. UAV/AI-derived classifications from reclamation submissions could support the identification of shifts in native vs. tame species coverage at fine scales in GVI. UAV/SAR-based wetland presence and permanence data could also be used to fill gaps in ephemeral or constructed wetland layers.
- Yes. ML approaches in particular would benefit from large data sets relating observations to eventual endpoints.
- Yes, and it should in my opinion, with any necessary limitations/ protections put in place.
- The option is there, but with regards to upstream oil & gas sites the information may not be useful due to the (typically) small footprint of the sites.
- Yes, however this would require processes and systems that can handle the volume of data, compile it all and disseminate it in a manner that is useful.
- Yes, this is a core function of our business. We regularly use regulatory data submissions to support comparisons across similar disturbance types and to enhance our geospatial datasets. By integrating this data into our platform, we help industry, regulators, and researchers understand patterns in land use, infrastructure development, and environmental impact.
- Yes, public datasets should be updated with data collected from reclamation completed across the province.

S1/2a(ii). Is the data available electronically? Is it publicly accessible?

- Is a commercially available product considered publicly accessible?
- If there was a standard for data collection and submission, then the data could be more easily used in other areas. Regulatory standards are required.
- Data is publicly available through FOIP.
- Benefits of publicly accessible/electronic data:
- Allows us to do more things with wellsites
- Can better understand site status
- Can use it for land use planning, soil data, etc.
- Public transparency
- Cost effective
- Basic scientific benefits
- Barriers to making data publicly accessible/electronic:
- Information might be available, but not necessarily accessible
- Within the government, systems are built on variable technology that can't do things without a certain application
- Not everyone has the same modern technology
- Who will have access to the data sets?
- Culturally sensitive areas – especially LiDAR data
- If there is a centralized data repository – is it a liability to have one organization control the data? Storage of large amounts of electronica data can be challenging.
- What about consent? Who governs the information?
- Producers don't want to share certain kinds of information. It's hard to understand the gaps that exist because of this. If the data is related to production there is reluctance to share.
- Concerns regarding the quality and resolution of the data if it is free and sourced by the anyone.
- Possible restrictions imposed by a provided once you've purchased data from them. Would they want their data being used in an open format?
- There is large amounts of data being collected and modeled together.
- We would have to look at greater trends and influence as things come in. Example is the Northern Artic trends. It is dependent on the region. May change the timelines of the assessments. Also need to figure out which trend.
- It should not be either electronic or publicly accessible – it should be both.
- Sometimes the data shows more of a yes or no than a trend, but a trend may sometimes matter more.
- The scale matters – is it one or multiple sites. Cost and feasibility are important.
- Are we talking about a screening or an assessment point? Is the data to verify and confirm? Where can we get to that point from screening?
- Reclamation certificate applications are technically publicly accessible, so the uploaded data should be accessible.
- Wildlife monitoring/habitat monitoring – the caribou recovery strategy is a national standard but in AB, with ABMI, the data standard is much higher than other provinces. The quality could be higher in some areas but this could sacrifice the quality in other areas.

- For reclamation certificate applications, the information in the RoO tool needs to be accessible and extractable, not in PDF format.
- If it isn't, policy could be drafted to require reporting of data and information in a spatial format under Section 3 of the *Conservation and Reclamation Regulation*. This policy could be broadly applied across all specified land activities.
- All data should be available electronically. Some data is publicly accessible already.
- Since regulatory data is already submitted electronically through DRAS and OneStop, in most cases this data would be available electronically as attachments. This data would typically not be publicly available but could be shared under data agreements.
- Some data is available electronically and to the public. However, some of that data is not usable for all types of assessments. In addition, some data that might be used will not come with a public access license. For example, freely available satellite imagery was found to not be at a high enough resolution for vegetation assessments on cultivated sites. Higher resolution satellite imagery was used instead but the usage license for that imagery would not allow it to then be used by another company or the public.
- We believe that all data used for government and regulatory decisions should be publicly available and accessible to ensure transparency, accountability, and broader use across industry and research applications.
- Yes, it is electronic data. It is not currently publicly accessible, but with proper privacy controls in place, it could potentially be used by public enterprises.
- All of our old soils mapping isn't. As for current datasets, we don't have a geospatial dataset of all the sand and gravel pits in Alberta. In Ontario, they do and it is very valuable.
- ReDCAT data should be available electronically – it doesn't need to be publicly accessible but it should be organized to be able to grant access to certain parties. It can be hard to anonymise geospatial data, but aggregated data could be useful to all stakeholders.
- The Oil Sands Information Portal Data Library: http://osip.alberta.ca/Library/Browser

S1/2b. Which datasets could be used? For example: Pre-Disturbance Assessments, Detailed Site Assessments, Reclamation Certificate Application information.

- Data could be shared with the forest industry – for wildfire prediction. This could require different collection methods.
- AGRASID is easily available but the information that feeds it is disconnected from new data that is more current.
- There's a new system being developed to integrate soil information across Canada that is tied to the Canadian System of Soil Classification.
- Across all the different industries that use ReDCATs, can we have open-source data across all sectors (forestry, government, consulting, industry, etc.)?
- Pre-disturbance assessments could be sorted by area/ecotype/disturbance years/reclamation years.
- Field validations could be centralized and used by the AER to help predict problem sites before they become too problematic.
- Note that there is already a ton of spatial data out there... companies do not want to share it! There is not always collaboration.
- Companies are reluctant to give out their data due to fear of misinterpretation. However, there will likely be misinterpretations anyway, so we may as well be ready for that and give/compile the information ahead of the curve (i.e. landscape disturbance levels).
- Regulators may think it is too much information; generally, they're not as experienced or educated as consultants going into the field.
- Government using data given by companies and displaying it publicly: would be helpful, but companies do not want to do that because they paid for the data. We do not want to overshare; is there a mid-point?

- i.e. group with the data is capable of interpreting the data OR ‘public’ datasets that require a certain licence/login access (multiple companies, people, etc. can have access)
- ex. ABMI, EPEA: public dataset with research but most of the data is likely from public/boreal land
- ex. Reclamation liability costs: we are already publishing liability + spend + etc. for individual counties
- Must ensure data being submitted is valid.
- Regulatory system is so rigorous; people are not understanding how much data we actually have.
- Data discrepancies do not necessarily mean the data is incorrect: allows for refined datasets.
- Remote sumps/associated facilities on sites may not be accounted for.
- There is value in integrating industrial and environmental datasets.
- We could have a lot more information and in-depth information about wellsites.
- How do we analyze these (think hand-written, from the 50s, etc.)? Past failed attempts at analysis and compiling of data.
- Still need to be able to share/add to the data.
- Vegetation assessments could be made publicly available to provide interesting insights into biodiversity in certain areas.
- Pre-disturbance assessment (PDA)
- Environmental Impact Assessment (EIA)
- Detailed Site Assessments (DSA)
- Reclamation Certificate Applications
- Annual Conservation and Reclamation (C&R) Reports
- Forest establishment surveys and other vegetation monitoring and assessments
- Noxious weed locations
- All, plus actual imagery if data sharing agreements can be developed.
- Remote sensing imagery
- Topography
- Photographic records
- AI/ML vegetation community mapping/ecosite phase
- Wetland inventory
- Pre-Disturbance Assessment data would be very useful for updating provincial datasets, such as the GVI.
- Detailed Site Assessment data could be useful as a ground truthing and refining tool as well.
- Reclamation Certificate Application information could also be used to ground truth such datasets as AAFC's yearly crop type dataset and other land use datasets.
- Any well detailed and demonstrated dataset

S1/Q-3a(i). What are the advantages (or limitations) of using ReDCATs for assessments compared to field-level assessments for detecting differences in landscape, soil, or vegetation?

Advantages

- Increased accuracy, reduced sampling effort
- Actual amount of area you can assess
- And the safety factor of this – not having to send people out into the field
- Quickly assess remote areas
- Change detection over time
- There could be differences in assessment with field teams
- Repeatability factor
- Vegetation monitoring can be part of reclamation work
- Emission reduction – using drone vs helicopter (also safety)
- Seeing if there is anything on a site – cost savings
- Less ground disturbance via this monitoring
- Potentially better data – greater accuracy
- We can strategically allocate resources to places where the imagery is most uncertain
- Triage sites/areas
- Saves money, effort, resources. Not limited to constrained staffing resources.
- You can cover much larger areas with a much lower cost, however, you will not be able to match the granularity and subsurface and vegetation observations from a boots-on-the-ground site visit. They can work in conjunction and have humans spot check ReDCAT assessments.
- ReDCATs can define better polygons
- Pre-disturbance assessments – gives you a better understanding of the construction and soil removal etc. that you need for the closure plan.
- Wildfire mapping – GIS field mapping – almost live to office-based people
- ReDCATs help to evaluate the off-site areas to compare the conditions.
- Addresses the current limitations on work force to complete cultivated assessments in a limited time window.
- Allows for soil assessments from field data then additional assessments for vegetation using ReDCATs to be added, allowing for a longer time scale assessment.
- Provide a site-level view and assessment of the entire site, rather than a % of the site when assessed at a field level
- Allows multiple sites (or activities) to be assessed at the same time across a given area
- Covers a broad range of scales – site level; field level; (sub-)regional level
- Can be timesaving compared to field work which provides an economical advantage.
- It might be more accurate. But some field validation is often required, at least when starting to use new techniques.
- Large areas covered consistently
- Bulk reclamation certificate applications
- Long time series monitoring of quantitative variables
- Ability to census conditions instead of survey.

- Ability to rapidly assess conifer stocking.
- Less human bias. Using ReDCATs removes the human bias inherent in field-level assessments (i.e., following sprayer tracks in a canola field for easier access to assessment points). In this way, the assessments are equivalent, both on and off lease.
- Ability to rapidly and economically conduct repeated measurements to quantify growth and density and identify areas of arrested succession.
- Ability to collect comprehensive census data that covers the entire footprint.
- Field assessments, by their nature, are rarely random enough to ensure an objective evaluation. Limitations such as restricted access, logistical convenience, and inherent biases often lead to uneven coverage. In contrast, geo-referenced census data provides a consistent and spatially complete dataset, which is especially valuable for monitoring reclamation success over time. Unlike repeated field-level assessments, this approach enables robust temporal comparisons and a more accurate understanding of landscape recovery.
- Reduces the need for on-site personnel in hazardous or hard-to-access locations
- Landscape and vegetation data can quickly be obtained and evaluated to determine assessment results and the need for mitigations if applicable
- A different prospective. The data captured for photogrammetry and veg assessments offer a whole site view that is hard to see from the ground.
- ReDCATs have much better spatial coverage compared to field-level assessments. The focus should be on using ReDCATs to complement, direct and interpret field-based assessments.
- Can cover more ground and within a smaller timeframe, but the detail might be missing in some cases depending on resolution.
- ReDCATs allow for wider regional evaluation and interpretation, both spatially and time series.
- Landscape:
    - Scale and low cost
    - You can study the anomalies
    - ReDCATs better than humans with temporal aspect
    - Terrain stability
- Soil:
    - Hyperspectral has potential to support soil parameters
    - Soil moisture is radar detectable
    - Change detection
    - Agriculture already uses soil moisture
    - Supports peatlands reclamation
    - Temporal relationship is likely key to support these analogues
- Vegetation
    - Able to say ‘desirable’ vs ‘undesirable’
    - Agriculture industry uses remote sensing.
    - Can build criteria around land cover
    - Lots of historical forest remote sensing work done through the years, LiDAR, machine learning to develop species maps – learn from that

- Likely to use vegetation as an indicator for soil
- Looking at weeds – can support weed control programs

- Outside of speciation, ReDCATs work equally as well as humans

Limitations

- Data can introduce its own biases
- Soil sampling needs to be done in the field
- Have to validate remote data with people out in the field
- Not necessarily seeing understory species
- Not getting wildlife signs from remote sensing
- The imagery being inconsistent depending on who/what took the image
- Hybrid approach that utilizes both ReDCATs and field work – is it more effort?
- Doesn't seem viable: different technology, data processing, and software
- Will need to have government-imposed limitations
- This could be a biased perspective: is more frequent data gathered by technology necessarily 'better'?
- Lack of context and situational awareness without people
- People are held accountable, AI and technology is not. People used to falsify information and that is why legislation was updated; people can now be held accountable (i.e. fired, written up, professional designation removal, etc.)
- Even if mistakes are made, a professional should be able to stand behind their work
- Tools should be used as support, not to rely on exclusively
- Doesn't really simplify anything
- First Nations relationships are not addressed
- High value walking the land; would the regulator accept only remote data?
- Professionals can assess beyond shapes, contours, etc. (i.e. ecological/land function, species, interactions, etc.)
- People can also assess what data is actually helpful; don't let technology tell the whole story! Technology may not understand context and nuance
- Imagery relies on a single snapshot of a dynamic environment; conditions on different days are different (note: same goes for a field assessment/field inquiry)
- Do you have enough data to conclusively confirm reasonings, outcomes, etc.?
- Soil – not a lot of opportunities to use ReDCATs
- Hardware support. On the server side, sometimes data doesn't sync smoothly
- Price – different user accounts have to pay more.
- What is the regulator willing to accept?
- We're building a paradigm shift
- Need for links between field validation, remote sensing, model outcomes
- Need lots of training data to improve model outcomes
- Need willingness to invest in the data – but need confidence in outputs / regulatory approval
- Need to recognize investment into monitoring

- Balancing commercial to public data
- Important to make all datasets and models public to get regulatory support e.g. LEAF dataset
- Need for a framework for remote assessment protocol
- Want to understand opportunistic wetlands and reflect in the annual reporting & closure plans
- Lose detail / location specific data/information that may be necessary to support the assessment (e.g., plant community composition)
- Limitations could arise with sensitive landowners for sites that have not had field level assessments.
- Potential for casing leaks etc. to be missed when using ReDCATs
- There could be trust issues with the data collection process or the way information is interpreted and presented to regulator.
- There is no ReDCAT capable of completing soil assessments
- Detailed vegetation assessment – looking for the presence or absence of specific plants, diversity assessments – how can this be done remotely?
- Field level assessments will always be required to some degree.
- Resolution challenges
- Experience outside of O&G reclamation shows that sites will follow “normal” path, but don’t understand the exceptions
- Species level identification remains a challenge
- Most publicly available data can’t support individual plant species.

S1/Q-3a(ii). Are there any additional considerations where two or more “point-in-time” assessments are used in decision making to support a reclamation certificate application? For example, are there trade-offs between imagery acquired less frequently at higher spatial resolution versus imagery acquired more frequently at lower spatial resolution.

- Data should be georeferenced when submitted to the regulator to ensure that anyone working on the site has access to historical data.
- Resolution needs depend on what you are trying to assess e.g. vegetation cover versus health. There are trade-offs between spatial and temporal resolution. Increased temporal resolution allows for capture of seasonal variability.
- Should use satellite to monitor vegetation
- Remediation – may have to go back and look – can use satellite instead
- General challenge – take a snapshot once and it’s hard to quantify – thus frequency is the key driver of certainty and uncertainty in the assessment
- How often do we need to measure, how often do we need to report?
- Reclamation is slow moving – higher resolution less often may be more beneficial to get a good snapshot
- We know when change is going to happen, target those times to see the change
- Use a multi-resolution approach – target certain spots in larger areas
- Advantage: so many more data points over larger areas, more accurate canopy cover calculations, regeneration surveys over time LIDAR efficiency
- Disadvantage: probably not going to find weeds, cost versus quality would need to be standardized, understory limitations would require expensive LiDAR systems and computer processing
- Depends on the surrounding land use and size of the disturbance

- High resolution – NDVI – almost made it too muddy in assessment (50 cm might be too much but 10 x 10 might be too far out).
- Location of site – remoteness.
- Allows you to do more point in time assessments which improves data.
- Native prairie – focusing on disturbance – directly around your disturbance there's no crested wheatgrass, but the source may be on a site slightly outside the direct area. ReDCATs help provide justifications for unwanted species by giving you a larger perspective of conditions outside the site.
- This could improve knowledge about the cumulative effects of disturbances.
- Opportunity for more efficiencies with less field time and spending more time on problem sites, streamlining process
- For safety – less time sending people in the field is better.
- Further discussion around data resolution standardization are required
- Survival requirements – tick box tied to survival rate?
- Certificate can be withdrawn (major headache for companies) (note: issue exists regardless if ReDCATs are used)
- Data can be used to help audit process by allowing auditors to focus their time on problem sites, focused less on straightforward cases
- Single accessible data source, integrated land use with integrated regulation
- Field assessment important to assess data not available using NDVI tool alone, distinguish slopes.
- Soil assessments done on the spot (Ecosis) e.g. salinity crop impact zone unchanged. AI-driven mass spec. Can help with delineation.
- Mining industry leverages remote data extensively, ahead of the curve of oil and gas.
- Miners don't [always] face private landowners/regulators.
- More investments poured into exploration than reclamation data.
- Trade-off is multiple assessments may be more informative of whether ELC has been met as it takes into account within/between year comparisons and trends as compared to a single-point in time.
- The spatial resolution and sensor used at each point-in-time must be considered when comparing data from different sources. Higher temporal resolution allows for a better understanding of how data may be changing over time while spatial resolution allows for more detailed assessments of a certain landscape.
- This question likely should be expanded beyond reclamation certificate application. This is an area of rapid technological change allowing rapid data collection, prices will come down and we likely can frequently acquire high resolution data in the future. The data can be used for evidence-based adaptive management in connection to environmental performance improvement.
- Some considerations are weather and cloud constraints - if data is collected less frequently these factors are more likely to affect the quality of the data. While higher spatial resolution allows for identifying features like plant density and bare soil in more detail, it misses seasonal dynamics that may be important for assessment. Additionally, the higher the spatial resolution the higher the storage and processing requirements.
- Yes there are trade-offs. The higher resolution is important to assess various deficiencies and uncertainties on-site where a lower resolution/higher frequency dataset can allow for assessors to understand the seasonal fluctuations in the site health.
- Only when difficult stakeholders are holding up the reclamation closure process.
- If an assessment is done utilizing RPAS, the consultant must travel to the site anyway. The ReDCAT data can be utilized to inform the assessor of locations to specifically assess, rather than having to assess the entire site, saving time overall.

- For landscape assessments, an initial high res assessment of the site, with additional assessments as required (such as erosion problems). Additional assessments for continual monitoring after certification is redundant. For veg assessments, the proposed 4-year requirement for the use of remote sensing data before application, seems strange to the 2 year requirement for application using field assessments only.
- Yes, you will always trade off spatial resolution for temporal resolution with remote sensing (correction, with cost-effective remote sensing solutions).
- The advantages of multi-point-in-time (time series) analytics far outweigh any gains in spatial resolution for vegetation and ecological function assessment, not only in terms of cost and practicality (fully remote assessments vs on-site data collection), but in overall accuracy of information derived which is supported by an enormous 20+ year library of peer reviewed studies.
- Point-in-time assessments should, in addition to the reporting aspects that the assessment is being performed for, be open for use in further calibration and validation of remote sensing imagery. Similarly, changes in imagery should help drive the point-in-time assessments. This has to be an actively accepted two direction process.
- Depending on the data provider there can be significant challenges with data quality, which would need to be mitigated when using multi-temporal data. There is a large gap between the quality of publicly available imagery (e.g., Landsat, Sentinel-2) and private satellite data providers.

S1/Q-3b. What standards should be considered for ReDCAT assessments? For example, minimum or maximum spatial resolution, similar platform/sensor type, data availability, data accessibility.

- Accepted accuracy for georeferenced points (within 1m of a point is considered a new point)
- Arrowgoal gives a few cm of accuracy- talks to the satellite but it is bulky to carry around
- Time-series are important – vegetation changes throughout the year
- Standards should be specific to what you are measuring
- Is it more consistent to analyze data versus people in the field analyzing it
- The subjective nature of sampling and sampling design versus a census
- We need soil data for reclamation certification – can't get that from remote sending data
- There are degrees of uncertainty from a remote sensing standpoint as opposed to having people there
- Aim for consistency in platform and censor type
- Have methods that are consistent in monitoring
- Repeatability and standards – e.g. how often should data be collected?
- The more the technology evolves, the smaller the cost and accuracy gap reduces
- Does this make it a limitation? – e.g. for certain land types
- Forestry may be easy, native grasslands and peatlands will likely be harder
- Standards may be different for differing land types
- Standards based on generations of technology
- Global standards from the geospatial world
- Spatial resolution for weeds – should we care if the canopy is established in Green Area especially, stem counts, species diversity counts
- Submission platforms being made consistent
- Cost is the biggest thing as clients do not always want to pay.
- Availability and accessibility of data and technology

- Be realistic at what its reporting. Seismic lines will not be good at 10 m, or shadows? Species growth patterns for the index also matter.
- Standard specific to what you measure. Species differences.
- Remote sensing temporally and spatially is different. Have you seen something different that you can't explain because of climate or a special situation? Monocultures are easier to evaluate, but while in trees, it may be different.
- Variations in province, would need training data for each location that you're working with.
- Reference points. Try to have data match nearby for regulations.
- Could look at who is providing the information. The data products can be of different a standard, the experience matters.... Drone data especially. We are slowly getting past that point with more material collected.
- Get training data from sites worked on to test it out.
- Standard needs to be set but needs to allow for technological advances.
- How to build the acceptability of the ReDCAT assessment? How much field data do you need to validate the ReDCAT data?
- From the data side – how to do you comply with the standard? The data that is received can be problematic. If people change templates or don't submit the data in the right format.
- Regulatorily there are alternative methods that are allowed but must be approved for use.
- Soils are a big limiting factor
- Understanding of terminology is not always consistent. Some things are interpreted incorrectly. Important for a system to be applicable to a wide audience not just one sector or province.
- Remote sensing needs are different for different sectors – cropland (private land, even, flat terrain) vs. forested (public land, rough, bumped, uneven)
- 10 m resolution for cropland good, same for forestry (more of a focus on coarse woody debris)
- EDNA species/biodiversity assessments – process that's becoming cheaper (than a population assessment) and more common. (note - this came up during the discussions around several questions. It could provide insight into regulatory requirements (and their validity/justification), and guide both restoration and reclamation efforts)
- Genome Alberta
- Grow Group, U of A – collaborative research group
- Change over time is easier to see using ReDCATs
- Depends on the metric and land cover being assessed, for example:
    - Agricultural lands: max resolution ~20 m; publicly accessible; (bi-)weekly imagery within a growing season;
    - Native Grassland/Forested Land/Peatlands: higher resolution imagery; commercially accessible; tasked within a growing season
- All of those examples should be considered. The requirements will depend on the assessment that is being done, but no matter what, detailed metadata is necessary to understand the basis behind the assessment.
- Analysis methods should be reported on and reviewed for accuracy. standard reporting on model performance requirements would help.
- Spatial resolution requirements will need to depend on the type of assessment. Spatial resolution will need to be higher for determining vegetation structure or bare ground mapping verses broad vegetation analysis or trend analysis.
- The same sensor type should be used across all time points for time-series data.

- Metadata should include date/time of acquisition, the sensor/platform used, the resolution and coverage area, as well as processing methods used (e.g., AI classification, cloud mapping). The submission of field validation points or ground control markers for spatial accuracy should be encouraged.
- Long-term data accessibility is needed to support reassessments or audits.
- Regulatory guidance should focus on method validation, resolution thresholds, and appropriate use cases (e.g., when ReDCATs alone may be sufficient vs. when field confirmation is still mandatory).
- Minimum spatial resolution requirements based on the assessment objective and to ensure defensibility in regulatory or operational decisions.
- The standards need to be established by the AER such that the market can choose how to proceed forward.
- Spatial resolution should be considered, and reflections on site size should determine what resolution is acceptable. Additionally, which indices multispectral data is evaluated by should be considered.
- Whatever standards are applied, we must have a human review the data and not leave determinations up to AI/ML.
- For my current work, data would not be shared. It would be most beneficial if platforms and sensors provide information that can be compared without requiring a lot of processing or conversion. But in any case, this would not replace ground assessment of the site.
- All assessments being of the same resolution seems to be reasonable requirement. I think there are many issues in making all private land operators make their own data publicly available, including for business competition.
- Standards should take cost and practical implementation into consideration (applied solutions).
- You can get very high-resolution drone data that is very slow and expensive to collect and analyze, which may have results that are more accurate than satellite data, but are not fit for purpose due to practical considerations.
- The resolution question should probably be a function of the size of the site. a 30m x 30m resolution is not useful for a 1-acre site. It may be useful on a 160-acre site. Data should be stored in standard geospatial formats (GeoTIFF, shapefile, etc.) with complete metadata to ensure assessments can be reproduced, compared, or audited in the future.
- This would have to depend on the physical modelling and interpretation of ReDCAT imagery, and review of advances in this interpretation that could be beneficial in re-evaluation of sites.
- In addition to what is mentioned in the question, data quality, pre-processing, and analysis steps.

S1/Q-4. Provide a list of possible secondary issues (or unintended consequences) that may arise from the use of ReDCATs. Consider: where the ReDCAT assessment for certification results in a failure because of increased spatial or temporal resolution, or where there is disagreement between different ReDCATs. Identify what mitigation strategies could be implemented to resolve issues or to prevent them to begin with.

- Disagreement in model outcomes for the same site where different sources of imagery were used; or timing was different for acquisitions.
- Sites that were previously closed could raise issues if they are no longer deemed to meet reclamation standards.
- The requirements for reporting data may increase since there is an ability to collect large amounts of data. This would also increase the amount of time that is required to review this data.
- Ground truthing can help with that.
- It may become a catch all for high turn around companies that will use it to justify reclamation certificates without proper due diligence.
- Establish a standard that is defensible and can be replicated by regulators and stakeholders. Some ReDCAT technologies do not have the resolution to be reliable. Where discrepancies exist field verification should be a requirement.

- When sites are evaluated using high resolution information, there is an increased chance for reclamation certificate failures. However, this data should only be utilized to inform the on-the-ground assessor.
- For First Nations lands there is not likely to be acceptance of ReDCAT without ground truthing. I would recommend its use only for preliminary assessment, determining if a site should be visited (stage of revegetation), but not for submission of reclamation application.
- Note: Current IOGC legislation requires an inspection by the IOGC Environmental Analyst – not delegated to consultants.
- There is a chance of more "failures" when higher resolution data reveals problems not seen in field checks. However this should be viewed as a more transparent methodology. In the long run a more transparent and objective process is better for industry and landowners or stakeholders.
- There is a risk of over-reliance on remote data which can miss important context from a boots-on-the-ground perspective.
- As technologies improve and availability increases, everyone will have access to ReDCAT and as driven by interests everyone can apply their own interpretation to the data provided them. It is thus on us to make sure tools used in image interpretation are properly defined and understood, and keeps up with latest advancements.

S1/Supplemental Information:

The following supplemental information was provided to the table leads to help drive conversation, if needed:

Reporting Frameworks:

Alberta had developed standardized reporting tools including the Record of Observation (RoO) Tool for the upstream oil and gas sector; and, Reclamation information System (RIS) for the oil sands mining sector. RoO is a MS Excel workbook capturing data at point locations, which aren't captured spatially (i.e., GPS coordinates aren't required to be reported) at this time while RIS is a file geodatabase framework that captures changes in the spatial boundaries through the lifecycle of a project.

While these sectors (mining, sand & gravel, well-based (oil, gas, geothermal, minerals) development, pipelines, and renewables like solar and wind) regulated under EPEA may have different disturbance intensities through the lifecycle of their activity (i.e., construction, operation, reclamation) they often similarities in terms of reclamation outcomes; e.g., reclaiming back to a native plant (forest/native grassland) community or, back to agricultural production.

By standardizing reporting across sectors:

- Could this data be useful to support development of reclamation/recovery models?
- What opportunities for innovation could be available?
- Could this information allow comparisons among similar (or different) disturbance types? For example, comparing minimal disturbance wellsites on forested lands to harvest areas in the same area?
- Are there benefits to other initiatives in the province that rely on spatial boundaries or site level data?

Single vs. Multiple "Point-in-time" Assessments:

ReDCAT provides the opportunity to assess and monitor sites remotely multiple times vs. traditional field-level assessments completed one or more times by a qualified professional. Field assessments typically rely on the qualified professional making in-field decisions based on their judgement of how representative a sampling location may be of the surrounding area of a certain size (e.g., 1,600 m2 or, 40 x 40 m grid). While a ReDCAT assessment provides the opportunity to assess multiple areas using an equivalent ReDCAT criteria across the entire site.

When considering single vs. multiple "point-in-time" assessments:

- What ways could this information be summarized to support a reclamation certificate application? For example, for a reclaimed gravel pit or wellsite – If vegetation productivity was monitored and assessed remotely across the entire site more than twice a month from seeding through to harvest?

- In-field site assessments, at multiple times within a growing season or multiple years, may be required if the site isn't assessed within a "prime assessment stage". Could ReDCAT allow an assessment to be completed within a single growing season?
- When ReDCAT assessments are being considered such as the examples provided for the "Enhanced" or "Hot Spot/Area of Concern" assessment approaches – what information would need to be considered and how might this change based on land cover type (e.g., native grassland, forested land)? What assessment approaches might be missing? For example, assessing a 5 ha disturbance using a 40 x 40 m grid (1,600 m2) would require ~32 grids versus satellite imagery that has a resolution of: 10 x 10 m (100 m2) ~ 500 grids OR 20 x 20 m (400 m2) ~ 125 grids).

10. Appendix 4: Session #2 – Remote Data Collection and Assessment Tools

The questions provided to the tables for discussion at the workshop are copied below. The table leads were provided with further context for each question (noted in italics at the end of the appendix) to help drive conversation and answer questions that may come up during the conversation.

Current requirement: Provincial reclamation policy has developed several criteria and indicators used in field level reclamation assessments to inform decisions on whether ELC has been met. These assessments have traditionally relied upon visual, physical, biological, or chemical measurements; including, aerial assessments for inaccessible sites with visual assessment of plant health and species composition.

Purpose: Where possible, match the appropriate technology with current and/or future criteria. Consider the current requirements related to field-level assessments and identify if appropriate ReDCAT criteria (for example, NDVI) can be used instead.

The following text is a compilation of hand-written notes from each table for Session #2, combined with the responses received from the online survey questionnaire. It is this compiled set of information that was used to develop the summaries presented in Section 4.

S2/Q-1a(i). For the existing criteria – Are there equivalent "ReDCAT criteria"?

- While some existing ReDCAT criteria can inform current assessment frameworks, I believe a distinct set of ReDCAT criteria will ultimately be needed to evaluate ELC in a way that fully leverages the strengths of remote sensing and Earth observation technologies. In the meantime, identifying and aligning comparable ReDCAT criteria could be a practical step toward encouraging the integration of these technologies into current reclamation certification processes.
- Many field assessment criteria have equivalent ReDCAT proxies. NDVI or other vegetation indices can estimate percent cover or productivity. Photogrammetric DSM can assess topography, erosion, and drainage. High-resolution RGB supports bare soil or weed mapping, but species composition and soil characterization still require ground assessment. Species composition could be addressed with low altitude imagery and machine learning in the future.
- There are equivalent ReDCAT criteria that can complement or substitute field-based assessments. Example includes water drainage patterns can be analyzed using hydrologic modeling built on national water datasets and enhanced through tools like stream order
- NDVI for veg cover, health, land use changes → spectral signatures over time
- DEM for slope/stability, changes in topography
- LiDAR or drones for canopy height models, dead vs. alive trees
- Average height within the assessment area
- Nitrogen has a spectral signature that can be detected to determine where fertilizer should be applied
- Old crop material can be measured, but if litter is low there will likely also be bare areas and other criteria that fails so it isn't as important to measure
- Cumulative effects by looking at surrounding areas
- Edge effect – more animals using land on the edges of certain land types
- Soil colour and moisture can be measured and used to further calculate other indices
- Yes, for vegetation assessments there are NDVI and other indices that can be used. Soil moisture can be measured, but other soil indices require more research.

- Many field-level criteria used to evaluate ELC can be complemented or partially replaced by ReDCAT-derived indicators. For example, vegetation cover and health could be completed using an NDVI analysis.
- Yes, for OSE wells
- No. Upstream Oil & Gas uses 2010 Reclamation Criteria (July 2013 Update)
- Yes, but not NDVI
- Mobile Compatibility and Real-Time Connectivity: Mobile applications enable technicians to access real-time updates, job details, and maintain communication with the office, which enhances service efficiency and safety.
- Real-Time Analytics and Reporting: Real-time data analytics allows for performance tracking, predictive maintenance, and informed decision-making, helping businesses optimize operations and drive profitability.
- Seamless Integration with Other Systems: Integration with CRM and ERP systems ensures data consistency, enhances collaboration, and improves customer experiences through personalized service.
- Enhanced Customer Communication and Self-Service Portals: Features like automated notifications and self-service options empower customers, improving satisfaction and reducing administrative burdens.
- Yes, the new 2025 Sand and Gravel rec criteria has allowances for it.
- There many spectral indices which can be used in the development of some sort of criteria (https://github.com/awesome-spectral-indices/awesome-spectral-indices?tab=readme-ov-file)
- Fundamentally, a change in the imagery (either spatially or from time series) that follows an unapproved or unexpected change would indicate a field-level assessment is suggested. The time series or spatial detail could be driven in part by past experience from field-level assessments modelling what could be seen as significant in remotely acquired imagery.
- Landscape:
  - Contour – LiDAR metrics, photogrammetry
  - Erosion – optical (MS/hyper) imagery
  - Drainage – optical (MS/hyper) imagery, LiDAR, synthetic aperture radar (SAR)
  - Slope
  - Topographic/Drainage analysis – LiDAR, DEM, DSM
- Vegetation:
  - Health/productivity/biomass: optical (MS/hyper) imagery
  - Canopy structure/height: LiDAR; photogrammetry
  - Vegetation health & productivity – Vegetation Indices (NDVI SAVI, NDYI)
  - Vegetation growth – LiDAR, DEM, DSM
  - Desirable Species - high res imagery with AI/ML, hyperspectral imagery
- Soil:
  - Bare areas: optical (MS/hyper) imagery, (SAR)
  - Soil moisture: SAR; optical (MS/hyper) imagery

<u>Additional Statements from Table Notes:</u>

- An advantage of the way the regulatory framework is set up.

S2/Q1a(ii). If not, should a ReDCAT criteria be developed and how would they be used to inform decisions related to ELC, or support a professional justification?

- ReDCAT criteria should not be developed for areas that require more research such as evaluating soil texture, subsoil characteristics, and soil quality/chemistry.
- Some criteria, like subsurface soil texture and lab-analyzed chemical parameters cannot be fully replaced. ReDCAT criteria should still be developed though as complementary to field data. For example, NDVI time series data can be used to verify regrowth trajectory and identify areas where field follow-up should occur.
- ReDCAT criteria should be based on the intended outcomes under EPEA (equivalent land capability) – there is an opportunity to look at how ReDCAT can collect data to support this without being held to past practices.
- Yes it should for very remote areas; however, it should be used to support human collected data and not used as stand alone, unless circumstance does not allow for reasonable and economical human access.
- It would be extremely helpful to have ReDCAT criteria but that would likely require a complete overhaul to the currently used criteria.
- ReDCAT can measure some of the same things as the current field method. However, criteria still need to be developed and tested to determine how ReDCAT data should be analyzed and evaluated in the different assessment areas.
- No ReDCAT criteria needed, just AER approved standards that enable data collection to demonstrate closure to existing criteria. Existing criteria may need to be altered where data being collected is not providing value to determining closure.
- Yes
- Remote sensing assessments by their nature are proxies. Combining remote sensing assessments with field observations can support an assessment, guide field efforts, decision making, etc.

S2/Q-1a(iii). Are there data quality standards that need to be set? Is this influenced by land cover type?

- Habitat fragmentation – remote sensing could allow for new regulatory criteria to be added relating to habitat fragmentation
- Hyperspectral – invasive vs. native species – requires more research
- Wetland classification – machine learning
- Absolute vs. relative moisture – relative moisture is easier to be developed
- Is there a ReDCAT criteria for assessing plant density?
- Supporting professional justification – this will further develop the market in the industry which will hopefully eliminate the need for some boots on the ground
- Research into how LiDAR penetration provides information about soil type (moisture, compaction, texture)
- That's a government question
- Where does science need to progress?
- Need to see the forest through the trees
- Don't seek perfection, seek progress towards something attainable
- Use remote sensing to triage (utilizing resources more effectively, prioritize) and better inform regulators/operators (auditing by professionals on what needs to be done; may for industry to be more accountable – stops them from solely addressing low hanging fruit)
- If government knows % chance of failure, they can better audit as well! Forces industry to reclaim properly
- Reliability of consulting: different consultants will have different conclusions on a site (too interpretive)

- Remote sensing gives you a level of sensitivity (can better quantify which consultant is correct on difficult sites) that otherwise would not exist
- Using a handheld device to direct you as you asses the site
- Remote sensing/ReDCAT is already part of an assessment (i.e., DSA) as a TOOL, so what we have been talking about all day is just adding tools and information to reports
- Increasing data, allows you to go back if something goes wrong on the site with all that information
- Use a red box as a reference point and have it managed by the government??
- People expect AI to do everything, but it can't
- REDCAT criteria needs to be developed and it needs to be specific to land use type.
- Should it be primarily satellite based?
- Tiered criteria: 1. Satellite based, 2. Closer drone imagery required. 3. Field visit
- There should be criteria developed to standardize data collection
- Criteria will need to vary by land use/land type and future land use
- Collaboration within industry and regulators and ReDCAT professionals to develop necessary data collection standards
- Yes it should be developed and yes it is influence by land cover type.
- Categories, specifications, accuracy.
- Canopy height, vegetation type, soil quality, cultural value of land capabilities, wildlife would all be hard to measure.
- Quality standards need to be set. Very broad but might be more towards data quality. What are you evaluating? Qualitative and quantitative assessments should be different.
- Differs on the needs to the client. Ultimately comes to accuracy, remote sensing is inherently uncertain. Clients are all after different things, those with less EO experience may expect more than what they actually need. Needs some understanding of the end product.
- Forests have a longer growth period, should we compare to a timeframe or a trajectory? Plants have different sensitivities, so should we look at crop time or variability? The how and the scales are needed. Need to have the same mindset as the RoO tool.
- Need something automated that shows if a change has occurred in the area. But this won't work with data that doesn't harmonize with each other, then it has to be completed by man. It takes time for the data to be harmonized.
- Spatial and temporal resolution and sensor type depend on land cover type. Spectral signatures vary throughout the growing season. Time-series (high temporal resolution) can provide information about the trajectory of a site.
- Some data may be open-source while others will require commercial data (high resolution, LiDAR).
- Pixels in between two land types may lead land to be classified incorrectly: edge effects.
- Wildfire affected sites – if you have ReDCAT data available you can still use this data.
- Higher resolutions will be necessary to support use of EO for plant community composition (e.g., native grasslands)
- Yes. I think the standards depend more on the type of assessment being conducted than the land cover type. For example, assessments like using ML with remote sensing data to identify invasive species will require a certain level of spatial resolution and accuracy of the machine learning model. Whereas, measuring vegetation cover could use a lower spatial resolution but would require a higher temporal resolution.
- Yes standards are important to provide confidence in decision making.
- Yes, data quality standards like spatial, temporal and spectral resolution as well as accuracy thresholds should be set. Land cover type would influence the ReDCAT as the resolution requirements will vary by the feature being evaluated.

- Yes. When using vegetation index imagery for cultivated sites, too low of a resolution (10 m satellite imagery) is not usable due to geolocation shift and the narrowness of some access roads. Too high resolution (8 cm RPAS) leads to skewed results due to the introduction of non-vegetative objects into the datasets.
- Yes. Minimum spatial resolution, calibration, and metadata standards are needed. Standards may differ by land cover, as complex sites (e.g., forested or mixed grassland) need higher quality or additional ground truthing.
- For landscape assessments, a proper DEM with slope analysis should be completed on all sites to maintain compliance with sloping requirements and to spot potential issues. This should be done on bare earth when doing photogrammetry or using LiDAR when veg covered.
- Yes. Minimum spatial resolution, calibration, and metadata standards are needed. Standards may differ by land cover, as complex sites (e.g., forested or mixed grassland) need higher quality or additional ground truthing.
- Data quality standards need to be reported, and their implications on evaluation documented. These standards will revise as technology and application development advances. For specific applications, it is good to develop an understanding the spatial and time series requirements are to detect a change that should be noted.
- I would consider data quality and processing effort a significant concern. While land cover may influence this, it is also a platform- and scale-dependent concern. Land cover type can have a significant impact on the RS analysis results. Not all land cover types may be suitable.

Additional Statements from Table Notes:

- Where would you store that information (single site = terabyte of data)? Unlikely to store it
- If government knew this data existed, they would want you to store it indefinitely
- Storage costs a ton of money!
- Drives the need to have a one-stop-shop for data; will also allow us to combine multiple forms of data
- But the same problem comes up, how to we combine this data? It's all different, everybody is off a little bit, etc. Would need someone very smart with a lot of programming resources

S2/Q-1a(iv). Are there certification criteria that cannot (technical or technological impediment) vs. should not (preference, belief, bias) have ReDCAT criteria developed at all? If so, why?

- Soil, native vegetation – at this point it's not possible
- Yes land cover differences and any potential change of land use would influence what data needs to be collected
- Forested criteria is already behind modern reclamation techniques (mounding)
- In Alberta for the detailed site assessment (DSA) side of things it's 85%
- Soil chemistry – EC, pH, salinity
- In monocultures it's easier to compare on site (similar vegetation) compared to off (variance in vegetation). In native grasslands, it's tougher. 85% threshold.
- Rec Certificate in place of field data via site-access (not accessible)
- Remote sensing data criteria. Seems a DSA that would fail under a 85% veg. threshold. 15% to allow for variability.
- For variable sites in Alberta, you need to sample more (16 on and off) if high variance vs. uniform vegetation types.
- Height or density or cover.
- Tame pasture or cultivated land works better because of uniform vegetation. Forested area is more difficult.
- Tree mortality assessment could be set up randomly.
- In oilsands, attempts with drones which were used to replace field assessments. Windy conditions hindered approach.
- In Alberta, head weights, height, density, and pasture is cover.

- Multiple years would be better to perform the assessment. Different crops function/respond differently with changes in the environment. The actual crop would change the assessment.
- You need government to oversee the data integrity even when it comes to calibrating the devices and developing measures for compliance tools. Flexibility for innovation, with compliance to develop standardization piece.
- GoA directive must be tied to the regulation/code.
- Eventually there will be a remote sensing tool to assess soil.
- Should not: Still limitations in using ReDCAT tools for analyzing species composition.
- Cannot: Unable to use ReDCAT tools to determine soil chemistry, subsoil information (groundwater).
- Landscape (subsidence) and soils (tilth and compaction) cannot have criteria developed. Application dependent and have to consider limitations. Redefining the landscape, change in species and density.
- Plant community composition (e.g., native grassland), may be achievable in the future
- Farmers may argue that their instruments for measuring crop yield give different data than ReDCAT tools. In this case, whichever approach is most accurate and feasible for the entire site should be used.
- In the case of parameters like soil quality, further research and development of these criteria are required.
- Soil texture and chemistry cannot be determined remotely. Subsurface data is also not detectable using imagery or LiDAR. As well, some experts may believe that species composition determination requires field "touch-and-see" and distrust AI image classification.
- I don't think so, except perhaps some of the soil assessment criteria. When looking at the vegetation and landform criteria, there are already established methods in other industries that are measuring the same thing using ReDCAT. And there are new technologies being developed all the time.
- there will always be value in asking the landowner for their opinions on productivity or drainage after a disturbance has been reclaimed.
- Some criteria, such as soil profiling, soil compaction or rare plant species identification/native species identification, cannot be currently reliably assessed remotely and require field sampling. Other preferences are often a matter of regulatory comfort, not technical feasibility.
- Probably
- ReDCAT is one tool, it should never be considered the only tool. When/where it is used depends on the suite of tools being applied to the task.

S2/Q1b. What are the costs or degree of effort needed to develop ReDCAT criteria using current technologies and practices?

- Cost comparison is necessary to determine if ReDCAT criteria is more affordable than field work. Drones are becoming increasingly affordable, but may not be more affordable at easily accessible sites currently.
- Costs can be significant, there are different frameworks for supporting innovation costs
- NRCan research is publicly funded
- Forestry company research funded through contributions to FRIAA
- COSIA is a great example of a group of companies that carry out research – the research benefits everyone, therefore it's best to share the cost
  - Initially high, especially while validating remote data – ground truthing to slow down and increase costs
  - AER – AI reviewing applications? 65% of applications don't get reviewed already. 30-day period is still required due to stakeholders.
  - Adapting government and educational technologies for our use. A lot of effort is being put from separate companies, it's too niche focused, should broaden and have collected effort to develop. This would minimize overall costs. Results may be different from companies working each on their own.

- Previous years had funding to develop these technologies. A lot of it has been developed but it may not have been aggregated in a format to give to others. Lost in translation.

- Hyperspectral imagery applications: high cost/high value
- Stereo satellite imagery/photogrammetry: in absence of LiDAR what options are available
- It depends on the criteria. Some sensors can detect trace elements like nitrogen so measuring soil quality in relation to nitrogen content would require less research and development than detecting something a sensor has not been able to detect yet.
- Most of these require only pilot-level funding and trained analysts — ideal for <2 year demonstration projects. Species composition/community typing needs model development.
- I'm assuming costs and effort would be quite high as it would require a complete overhaul to the currently used criteria.
- Review of current usage of technologies, research on how these might translate into assessments, establishment of criteria to be used for each type of landcover.
- This is tough because it is taking Government of Alberta a long time to catch up to the technology – staff are keen to use, but may not have accessible platforms or current legislative tools/guidance documents
- Costs are moderate for established indices like NDVI or DSM, but higher for advanced metrics (e.g., species identification via ML). Criteria that rely on new ML models or advanced spectral techniques will need further research and validation.
- No, there is enough information and studies existing that show the benefits of the tech, the issue would be getting an agreement from Government, as to the standards and implementation.
- With continual ReDCAT technological advances, continue HQP development is required. An understanding of the information uncertainties are also required to best determine applicability to the application being reported.
- LiDAR data available 2-3 years, more convenient. Instead of waiting 30 years for a reclamation certificate with a detailed assessment.
- Cost-effective (rent on private land is high) to lean towards LiDAR/remote
- Helicopter operators charge every time they start the rotors.

S2/Q-1b. Which ReDCAT criteria would require additional R&D?

- Soils – topsoil depth, structure (using plant colour for soil fertility)
- Species identification – weeds, native prairie composition (plant colour for plant identification).
- Should there be similar certification as wetland classification for this type of REDCAT assessment?

<u>Additional Statements from Table Notes:</u>

- Standards are different between forestry and oil & gas.
- There is a need for policy/regulators to take the lead on creating these opportunities to share data
- ODAA
- Need to look at the limitations (trees, dead or alive, weeds, etc.). Training sites and sharing data sets for that purpose.
- Need to see if remote sensing IS the tool you need to use for the sites.
- Regulator pushed the developers to publish a public ID. Works in the EU.
- Risks of entering sensitive habitat via field work. Remote sensing better in that circumstance.

S2/Q-2. For the evaluation of ReDCATs or ReDCAT criteria is there a need:
2a(i). To compare ReDCAT assessments/criteria to traditional field-level assessments /criteria? If not, why?

- Yes, for cost and accuracy.
- If more data is available (since it is being collected remotely instead of manually in the field) more data may become required.
- At the start yes – to create baseline data and make sure ReDCATs are operating the way they need to be. With AI progressing that may become a no.
- Conduct testing – earth observation and physical assessments on several sites to prove up the model
- Building trust – how do we get landowners/ stakeholders/ regulators to trust in the earth observation assessments
- Education & policy gap needs to be addressed
- Paradigm shift needed – no established methodology to allow earth observation
- Is there a proxy from another jurisdiction where earth observation has been used? Looked at other jurisdictions in Canada and Australia haven't adopted earth observation yet.
- Use of AER Pilot directive to enable change (e.g., GPS technology in surveying)
- Mistrust of change... Change is hard.
- Some might be easier to compare than others (i.e., canopy). However, seed pod and length measures would not be able to be done. Should overall look at the function and how it's measured to determine if it would work.
- Remote sensing is not 100%, more about 80%. To refine that, must use field data and tools from other assessments to work on the assessment in question.
- Need to identify the clear connection between remote sensing data and the field data.
- With pipelines there are monitoring costs associated with abandoned pipeline, unless it's completely removed from the ground.
- Abandoned pipes may cost millions of dollars to remove.
- Ground truth 10% of the sites?
- Use a machine to figure out which sites would pass/fail. Now you can get a probability value of pass/fail associated with the decision (so you can decide when to go in or not)
- Some consultants have said you will never have remote sensing alone, you always need a human element... but if a site is 90% probability of failing, would a human be necessary?
- Are we thinking 'can we get rid of professionals and replace them with drones?' We need professionals to analyze the data, but robots will be smarter and better at it than us
- Yes, as machines make mistakes, you need a human to verify on the ground what you see in the data
- No – need to step back from the traditional parameters to look at things from a wider perspective and rethink the goal – equivalent land capability.
- Yes, at least initially until confidence in outcomes is achieved.
- Not sure
- Probably
- Yes, in terms of both accuracy and economic feasibility.
- Yes, most likely. For example: DSAs for agricultural cereal crops require weight and length of the heads and a stem count. ReDCAT could be used to assess vegetation health, but not the weight and length of the heads and the stem count; therefore, the criteria would need to be updated.

- When using ReDCAT assessments that have already been proven in other industries (i.e., agriculture, forestry), then I don't believe there is a need to compare them to traditional field-level assessments. This is because ReDCAT is using different methods to do the assessment so it is not an apples-to-apples comparison. In addition, ReDCAT allows for the evaluation of an entire site, rather than a small number of sample locations. This removes any bias in selecting the sample locations. Finally, ReDCAT results are typically a number, such as a pixel reflectance value. Statistical analysis on these datasets once again produces an unbiased result.
- The criteria to use with ReDCAT needs to be determined and tested.
- Is it necessary, No; however, to increase buy-in. Comparison and replication of passes or fails between RoO and ReDCAT should bs demonstrated.
- Yes and No. It really depends on data quality and resolution used to obtain the data.
- Doing this could increase acceptance of ReDCAT data.
- First Nations are not likely to accept ReDCAT as the final or definitive assessment.
- I think the assumption is that all field assessments are the gold standard, and that the info collected from drones, etc. is secondary in quality.
- Yes, direct comparison is essential to build trust, and understand how best to use ReDCAT with traditional assessments/criteria. Or update how the field work / ground truthing is done to fill in ReDCAT gaps.
- Yes - this is a feedback loop if done well. ReDCAT informs field-level, who acquires more detail which informs advances in ReDCAT which allows for improved assessments which better informs field-level, etc. Requires targeted HQP development and open data / metadata availability between levels.
- Yes, there should be, with expectations set and mapped such as a Technical Requirements Document that spells out what ReDCAT assessments would be meant to achieve.
- Absolutely. This is a critical step to making remotely sensed data relevant in an assessment/regulatory environment.
- Element of human trust cannot be replaced!
- Rigour between them is because of accessibility issues
- Also personal preferences of owner: do you want to know everything (extensive analysis) or the absolute minimums (quick-over)
- Yes – comparing to EM survey – can use these tools to guide us, but not to make final decision.
- Use statistics to compare buffer, site, and off-site. You can really influence what is pass/fail based on what statistics you run.
- Discussion over data captured and the need for the human QC component; questions of reliability
- Initially high, especially while validating remote data – ground truthing to slow down and increase costs
- Human bias could be at play when data is entered by people
- Financial incentives at play when selecting location of plots in oil & gas (this doesn't apply as much in forestry as they have a standardized process and georeferenced plot locations)

S2/Q-2a(ii). How would a "pass" vs. "fail" decision be made using ReDCAT criteria?

- Begin by remotely assessing certified sites to determine if the field data and the remote data both pass or fail
- Low veg cover, time-series isn't showing an increase in veg cover and health.
- Degree of similarity
- Similar thresholds to existing criteria could be applied to a ReDCAT derived indices.

- Use of earth observation will increase the number of "points/grids" assessed onsite allowing for initial statistical comparisons or rough estimates of variability, these could be used to determine – point is flagged +/- 2 standard deviations from the range of variability within the control area.
- Spatial scales: will result in an increase in the number of points assessed – for example 120 x 120 m lease ~9 grid points for visual assessment (40 x 40 m grid); satellite imagery 36 grids (20 x 20 m grid); satellite imagery ~ 144 grids (10 x 10 m grid); satellite imagery ~ 3,600 grids (3 x 3 m grid)
- Levels would need to be set for ReDCAT criteria. If comparing a Site to ELC, maybe a certain percentage of deviation is allowed between on-Site and off-Site data for each criterion being measured.
- Comparison to offsite
- The same as the current standard, % of offsite.
- Pass fail could be determined using vegetation coverage, plant health, weed percentage when compared to offsite controls.
- Speaking to vegetation assessments using ReDCAT criteria, Pass/Fail of a site can be determined by running a series of tests on sample populations of NDVI (or other veg indices) data from the onsite and offsite areas to determine if there is a statistical significance in the means (Z-Test) or the variance (F-Test). A simple comparison of the minimum values can also be evaluated. GetiSOrd Gi* analysis can also be performed to determine if the onsite area has a statistically significant greater number of clusters of low values than the offsite area.
- Depends on activity, depends on current accepted criteria/legislation/guidance documentation/level of comfort by statutory decision maker
- Cultivated Veg 85% comparable overall, with calculation/variance for slope aspect, professional judgement where percentage of comparable slope locations are not present.
- There is a great opportunity for ReDCAT pass/fail to be done based on local (rest of field or adjacent land) natural variability. The less variability in the adjacent land, the less variability is allowed in the pass/fail threshold.
- It could be used by the assessor as a preliminary step before applying for certification.
- If site conditions meet approval requirements. For example, sand and gravel pits have sloping requirements, and we measure those for rec certs
- If ReDCAT detects no change outside of expected change (increased vegetation density for example) then okay. If a change is detected, trigger field-level. If a field-level change is detected that is not seen by ReDCAT, then trigger/drive improved application and technology development. A "pass" or "fail" based on one tool alone is a poor system.

S2/Q2a(iii). How might these be influenced by land cover type?

- Cultivated – based on yield metric
- Cultivated – one field visit for soil, weeds
- Native prairie – not clear how we can apply REDCATs yet.
- Can use drones for photography to identify plant species – satellite imagery isn't there yet.
- Forested – it's been demonstrated that enough woody stem growth and no weeds, then that is sufficient
- Forested – from safety perspective – high priority for adopting this. However – evidence that grass encroachment can be a big concern for forested sites so can't ignore weeks
- Forested – field visit to check for weeds, then do remote to watch for desired species returning
- Limitations in peatlands – bryophyte cover – potentially multiple flights, water held sites would leave huge data gaps but in drought conditions. Groundtruthed data would be necessary
- Each land cover type is different.
- May be easier to assess bare ground in agricultural land verses forested land.

- Automated stuff (sign-offs, imagery, etc.) is easier on crown land
- As land cover type complexity increases, resolution of imagery needed to different species will also increase.
- If there is a species that a landowner prefers over surrounding area; should it have to have the same as surrounding species, should it be aligned with landowners wishes, do you need to match the bare area with that?
- Responses are variable when vegetation is younger/smaller
- The type of criteria will differ with land cover type. As well, the allowed variance between on-Site and off-Site may differ if there are significant differences between off-site and on-site landcover, for example, a large change in elevation.
- Same as current
- Land cover type shouldn't be an issue as the site in question would be compared to offsite controls adjacent to the lease boundaries.
- Different vegetation indices might be used depending on the type of crop being grown, or the type of land cover. For example, if it is a grassland area that is very patchy, then the Soil Adjusted Vegetation index should be used instead of a standard NDVI to evaluate the health of the vegetation. If the crop cover is canola, then the Normalized Difference Yellow Index is used during the flowering stage.
- Shouldn't make a difference, the assessment and data used needs to be defensible and repeatable/reliable
- Natural variability is easier to measure in monocrop / annual crops. It gets more complicated in mixed crops, perennial crops or forestry.
- Probably easiest to use on cropland, or forests managed for wood production.
- Not likely to be applicable for landscapes managed for traditional land uses, where diversity of plants is important.
- Bare earth for landscape assessments or LiDAR for vegetated.
- Land cover type can significantly impact the accuracy of remote sensing analysis.

<u>Additional Statements from Table Notes:</u>

- Hard to monitor
- Automating a process to get a bulk number for multiple sites; but once you apply that algorithm to one site how do you do that?
    - Example: using a central system where people can prioritize strategically
    - Multiple examples shared – Firesmart treatment blocks, clearcuts, restoration areas
    - Discussion over the need to mitigate against weeds. This will no longer be a requirement, as per recent news (weeds out-compete anyway)
- Consultants, producers, governments, need to compile data. Without remote sensing it's difficult.
- Canada Energy Regulator (CER) relies on companies to report on their activities. CER dependent on third-party data providers (shape files). Remote sensing derived data should help
- CER – Regulate pipelines that cross provincial and international borders.
- Damage prevention – unauthorized
- GDM pipeline data.
- AltaLIS acquires data.
- Can we chip away at it
- We see companies building IP on those capabilities – making them less likely to share
- How do we deal with this fragmentation and the competitive advantages that companies have

S2/Q-2b. To establish methodology to compare data collected from different platforms or at different spatial resolution? For example, data acquired by RPAS versus data acquired from satellites?

- Yes, some standardization and consistency is needed across the board
- Discussion over how NRCan uses drones to support satellite; heights may be accurate
- Field to drone to satellite
- Discussion over whether we need height data for cultivated area?
- Generally not, but any height difference can flag problem areas
- Precision A data provides height, but not always available
- What information would height data provide (crop context)
- Satellites lose accuracy, remote sensing seems to be the most appropriate
- Some sensor data is comparable to others while others are not.
- Try to get apples to apples comparison within the framework.
- Not too restrictive to smother new innovations and technology.
- Technology advances so quickly it's hard to make sure the framework can adapt.
- Yes, some standardization and consistency is needed across the board
- Try to come up with a standard resolution (able to integration datasets).
- They feed on one another and improve each other. The 100 m feeds the drone data for a general area (different products).
- Ideally would need both. Acceptance from clients would be very different if there was only one source mode.
- Need to understand differences in platform types and assumptions being made when using different platforms (e.g., noise increases as resolution gets smaller)
- Yes, the bands a sensor is able to pick up, the spatial and temporal resolution should all be considered. The accuracy of different indices may not allow for a fair comparison of data.
- Absolutely. As has already been indicated, both RPAS and satellite data can be problematic. Methodologies for using the different types of data have to be established, tried and tested.
- Yes, RPAS data is more detailed where satellite imagery is less detailed and should require some level of field verification until such time as resolution improves.
- Consistent methodologies are needed for comparing datasets across platforms or resolutions, such as upscaling or downscaling and using common calibration targets.
- Yes, RPAS should have a standard minimum criterion for data acquisition.
- Must be open to all levels of evaluation and open to advances in applications and technologies.
- Yes. Significant trade-offs between platforms, not all platforms may be suitable for all uses.

S2/Q-2c(i). For dedicated areas to support: testing, evaluation, calibration, validation of existing or new ReDCATs?

- Yes
- Yes, data will be required for validating ReDCAT criteria.
- That would certainly simplify the process
- All the above
- Standard auditing would work, wouldn't it?

- Supporting HQP development is a must. Having known sites where ReDCATs must demonstrate data products a good practice. Peace River is one such site (https://lpvs.gsfc.nasa.gov/LPV_Supersites/LPVsites.html) but sites managed by Alberta for Alberta needs would be appropriate.
- Several areas of different strata should be considered (e.g. ecosite, disturbance history, disturbance type, etc.).

S2/Q-2c(ii). If so, would the Open Data Areas Alberta (ODAA) initiative fill this gap? If not, what is missing?

- Some field validation is still required, at least initially until these approaches have been validated. But ODAA could help support and reduce the amount of field validation needed.
- Need to expand the open data access to larger areas
- Lots of research sites universities have, and supersites to validate remote sensing
- Their whole goal is data sharing and validation
- Maybe need more federal support
- Blue sky version – what are we going to do with this in 10-20 years
- How critical are they, how do we work requirements into remote version
- Would be valuable trying to train AI to identify weed species for example.
- Should you require that if you're doing work in the test areas that all the data should be open source?
- Remains a need for open sharing of data – especially for data related to production.
- Discussion over whether to start with the relatively straightforward versus more challenging cases – i.e., agriculture versus forestry
- Stakeholder consultation takes time, resources and often a specific skillset/training
- Yes – Cost saving potential
- Discussion over whose responsibility it would be to evaluate?
- One perspective – anyone can do it so long as it's validated
- Tree AI box on GitHub, plug-in for cloud compare – NRCan tree point tool
- Funding a key consideration – consultants won't do it unless there is a financial advantage; federal government is an option however that comes out of our taxes...who benefits?
- Discussion over the quality of Planet Data, flown daily
- Land cover-based calibration – what is accepted in a peatland vs uplands vs. native prairie vs. cropland
- Sharing data to build accuracy criteria and resolution standards
- Could add area near Foremost to align with UAV test range to allow / compare vertical integrations of datasets from different platform types.
- Area near Beaverhills (east of Edmonton) could be increased to cover Edmonton's industrial Heartland area
- It may largely fill the gap, but some additional data might also be needed. For example, as conditions continue to change in certain areas additional sampling will be required for field validation.
- It's a start. But there is higher quality and more up to date data available now. For example, some of the satellite data is already more than 10 years old. Higher resolutions of satellite data are now available. New datasets, such as hyperspectral imagery, are going to make it possible to come up with new ways of analyzing and evaluating sites.

S2/Q3a(i). What would an "ReDCAT Detailed Site Assessment and Reclamation Certificate Application" consist of?

- Would need supplemental information to support it
- Imagery tech would be a part of it
- This question is difficult to answer even without this tech
- What changes would need to be made to the reclamation certification criteria?
  - Enhanced assessment built in; standard assessment + 4 years multispectral assessment
  - Not sure what they are looking for
  - Continual monitoring does not seem overly effective
- Extrapolating growth trajectory
  - DSM + DTM (surface vs. terrain); will calculate the median/base elevation without the veg. Not clean, not overly accurate, just gives an idea of what's going on
  - LiDAR is king, will go through dense canopy but still doesn't get to the level we want
  - Everything is mixed in the forest, very difficult to pick out and analyze specific species
- LiDAR is great, but you can do approximately the same thing as photogrammetry
- Would need highly detailed drone imagery (painting the area with different angles of imagery)
- Sometimes simple imagery will give you the same info as high-res imagery (i.e., RGB vs photogrammetry); start with the simplest and move up as you need it
- Now there is a problem with data consistency if you are using different imagery resources depending on the situation
- How will data be compiled from this?
- Need a technical committee/ guidance report to set the technical parameters – Needs to be tri-party in nature: regulator, industry, practitioners / SME
- Easy:
  - contour, erosion, surface water flow, veg health, veg height
  - temporal aspect: evolution of
  - wetland species: peat forming species (high-res drone data).
  - drone data super powerful for wetland species
  - terrain stability: can build to 10m resolution on demand
- How do we address the things we can't address:
  - Do an earth observation for program, then support with physical monitoring for a statistically significant number
  - Operational efficiency to manage this way
- Wetlands:
  - Temporal is key, recovery is slow so need to have multiple monitoring events
  - Need to have landcover assessment to support certification
- Metadata: type of imagery used, acquisition date, etc.
- Derived data: tabular and visual representation of the data collected or produced during the assessment
- Information: narrative on how data (or trends) demonstrates that site is on a trajectory towards achieving ELC or has achieve ELC
- A comparison of ReDCAT indices on-site to ReDCAT indices off-site to determine whether ELC is met.
- Similar framework but with a different dataset, resolution standard will need to be established and confirmation of remote observations with on-site observations (spot check) should be implemented.

- The ReDCAT data being used (imagery, data value spreadsheets, etc.), test results (i.e. F-Test conclusion), summary observations on the site, justifications for passing if some tests fail.
- Same information as in current guidance
- Similar information currently required.
- Vector data used for the assessment (lease boundary, background, sub areas etc.) and rationale for why and how the zones were made.
- Multiple years of:
  - UAV orthomosaics, DSM, and NDVI raster data.
  - Zonal Statistics and interpretation.
- If lease fails to meet background statistics, justification of why it should still pass (i.e. topographic or natural field variability data).

S2/Q-3a(ii). What is necessary to inform a decision that a reclaimed site is on a trajectory to achieve ELC?

- Satellite/drone data can be used to detect bare soil and compare veg cover and health onsite vs. offsite.
- These analyses would need to be conducted over multiple growing seasons, and during different seasons. Ensure spring, summer, and fall data is consistent and valid.
- Multiple years
- Whatever we decide to go with (drone, satellite etc.) need more than one piece of information to determine
- Pre disturbance? – no using surrounding forest as a reference
- Pre disturbance would be helpful but maybe not necessary
- Professional designation approval of set criteria based on land use
- Ground truthing. Can mix field work for a few hours and the remaining using ReDCAT. Would allow for confirmation and see if its accurate.

S2/Q-3b(i). What ReDCAT data (e.g., raw imagery, processed imagery, interpreted imagery, derived data) would need to be included in the application?

- Raw and processed imagery may need to be provided to demonstrate which processing has occurred and whether it is valid.
- Soil would be least developed
- Could get vegetation, tree height, species diversity
- Plant typing classification (improves with multiple bands)
- Remotely sense water bodies and their criteria
- Classification, hydroperiod, optical depth, turbidity, total dissolved solids
- All land types are suitable, certain may be easier than others
- At a high level
- How similar is your site to a nearby reference site, the less similar, the more data that would need to be done
- The bigger the spread – the more data collection needed (aerial, field etc.)
- If they look similar – use more money for higher res identification to confirm that they look the same
- Multi resolution approach
- Would require removing soil requirements?

- Remote sensing for soils – organic content, moisture
- Going to need field visits as a basis for soil and weeds, but REDCATs could be used for follow-up visits and longer-term data (stubble counts, forested vegetation).
- Decision tree – an obvious pass (all REDCAT tech indicates passing), unsure bucket – might need more work, clear that it doesn't pass – must return to the traditional assessment.
- Initially requires finalized interpreted results, then depending on risk level or issues Raw data would need to be included
- Agriculture would most likely need ground truthing no matter what
- Raw and processed would be required. There needs to be a certain level of processing that people can get a certain level of meaningful information. Not fully processed but not at the final piece.
- Data & Interpretation: that demonstrates a site is within the natural range of variability
- Time series data would likely be necessary.
- The positive progress of vegetation health.
- Soil replacement depths, ability to compare to pre-disturbance soil depths, vegetation establishment, drainage pre and post activity. Potentially: landowner observations
- Similar data that demonstrates reclamation outcomes have been achieved.
- Multi-year ReDCAT data showing stable or improving indicators (vegetation cover, productivity, bare soil) along with supporting field data.
- That needs to be defined per site, but would require an understanding of an unexpected or unwanted change in the ReDCAT imagery.

S2/Q-3b(ii). How is this influenced by land cover type?

- Forested:
  - Raw imagery – processing steps, any statistical analysis used to come to conclusion.
  - Growth trends + proof of current status
- Cultivated:
  - Need a field visit
  - Follow up just imagery for vegetation
- Native:
  - Not possible yet
- Generally report with statistics should be sufficient

3c. Are there barriers, such as data licensing, that might prevent certain data from being provided in an application?

- IP and data sharing issues for original / raw imagery - likely can't share
- Ground truthing/field validation of problem sites (landowner concern) or sites flagged through remote sensing.
- Planet imagery – what would you be allowed to share in rec cert application
- The freer the imagery – the more caveats
- Licensing per organization – private
- Share it within orgs, or people using it for the organization

- Licenses – hard to police them
- Is the data uploaded going to be publicly available? Providers may have issues with this.
- Proprietary file formats?
- Sensitive data – DND?
- Data licensing example of Planet data. If you have to pay for your data, likely can't import it into a public source
- Confidentiality considerations
- IP and data sharing issues for most commercial data
- Data collected on behalf of the client would have to be shared with the regulator
- Regulator could create public dataset but would have to be anonymous to be accessed – work with Abadata
- Private land ownership would have to agree to soil data being shared – would it just be vegetation data shared?
- Maybe should be answered that there's a range and the threshold falls inside the range. NDVI values will differ based on sensors.
- Variability in the technology.
- Data licensing; type of platform used
- If satellite imagery is not open-source there could be issues with sharing the data publicly. I think it would be able to be in an application, like how aerial photos are purchased now for inclusion in reports but there is a copyright on them.
- There are significant barriers around licensing.
- Data licensing for sure is a barrier, compatibility with reviewers' platforms.
- Yes, commercial satellite or software licenses can restrict sharing. Preference should be given to open data and transparent workflows wherever possible.
- As a regulator I do not have access to all the different programs that might be necessary to review the raw data.
- As there is no standard in reporting, analysis, or delivery of ReDCAT data, barriers are everywhere. It is difficult to respond to or interpret results when there is no standard to delivery of information.

3d. What changes to existing reclamation criteria may be necessary to support the ReDCAT application?

- Landowner concerns there may still be specific landowner concerns that will need to be addressed. Landowner sign-off may be necessary before ReDCAT analysis is done. Landowners already have some authority to retain access roads, etc.
- Data and methods
- Do we want to meet changes, or meet the current framework, or change existing framework?
- Keeping up with the technology
- Do the rules need to be changed to meet the technology
- What's missing, and how essential are those things
- Remote sensing is still a supplementary tool, used to inform other things
- Supplement with remote sensing to fill in the gaps
- REDCATs can make a more detailed fulsome picture of the health of a site. More than the point based traditional assessment.
- Removes a lot of field bias in selectively assessing areas.
- Oil & Gas Sites are not georeferenced which is a limitation, sites are selected based on human choice...opportunity for bias

- Makes it challenging for monitoring change/growth over time
- Company is unable to disagree with audit results, nobody knows where points taken
- Common theme around – How do we get to a point where we can share this data we all are separately collecting?
- ODAA came up again
- What components of existing criteria
- Growth curves drive assessment methods
- Proximal controls are more important for cultivated and grasslands, however peatland and forested it needs to be ecologically relevant (vs. adjacent)
- Could defining background be the responsibility of the regulator? Understand the background condition could be done at a macro level?
- Have EO signature for different vegetation types build the growth curves needed
- EO will be very effective for Progressive Reclamation planning for the mines
- Need to acknowledge the difference between local controls and regional reference sites
- Habitat suitability (veg structure, flora & fauna, biodiversity measures) can be measured easily and effectively through EO and can be a part of reclamation assessment for forested/ peatlands
- Soil data collection at time of reclamation instead of time or DSA
- Weeds in forested areas – using predictive models to anticipate competition between woody stems and weeds, inform which sites to do intervention on vs. which sites will out compete the weeds
- Changes to the RoO to allow ReDCAT data to be submitted
- Equivalent rankings for ReDCAT derived criteria
- The amount of data required in applications could need to be increased depending on the accuracy of the data as well as more detailed information on methodologies used in data collection.
- Permission through policy to indicate a new set of reclamation criteria that complement or potentially supersede existing criteria would need to be broadly accepted for each of the different land cover types.
- We won't necessarily need to change the criteria. Once AER is comfortable with the approach / methodologies, AER will start approving these applications as variances.
- GOA needs to publish something newer than 2010 Wellsite Criteria.
- Allow for ReDCAT data to influence the locations of field level / ground truthing assessments.
- My organisation uses CCME criteria and our use of provincial reclamation criteria is discretionary.
- My organisation's requirement to have a site inspection would need to be changed. That is not likely.
- Development of test demonstration sites for applications, and of HQP.

S2/Q-4. Can ReDCAT produce other supporting evidence of impacts that may influence decisions on the "success" or "failure" with respect to ELC? If so, what are they? For example, human use, third-party, climate change.

- Third party impacts: grazing or other activities.
- Climate change potentially through time-series data (veg health, wetland size).
- What you get from the top down is the interconnectivity (there not hard lines) – GIS based approach
- You can tell from remote sensing what's affecting a site that you maybe can't see from the individual site
- Huge benefit is the hydrology part

- Creates a larger control data set to utilize
- Climate change
- Sites won't re-establish due to abiotic factors that are stifling reclamation, but without years of satellite imagery it makes it much harder to know
- Can look at temperature with the sensing – can see nighttime lows creeping up
- Helpful for the sites up in the arctic
- Time series imagery, anything long term would be helpful to track climate
- People want to see a minimum of 40 years of data
- It can, but not necessarily for the listed examples
- Can ReDCAT be used for monitoring? Yes, but it extends liability for the operation (similar problems as before, doesn't actually get the certificate out while we wait for problems to come up overtime)
- Easier to compare on site vs offsite
- Landscape, soil, vegetatation for rec cert (ReDCAT excellent, okay, and decent for these things, respectively) (i.e. contouring, depth of soils, textures (ground penetrating radar cannot detect these last 2 things, but radar CAN detect stuff like contouring — the technology may require more disturbance to use it like a probe being put in the ground))
- Climate change is so dynamic; it is difficult to pinpoint specific factors (what is the cycle on the landscape?)
- Specific to areas (Nunavut vs Southern AB)
- Want to quantify amount of GHG being emitted from oil and gas assets (i.e., tailings ponds); once again open to interpretation right now
- Need to weigh benefits vs. risk (helicopter flights, cutting down trees to access restored site, etc.)
- Stratified growth of seismic lines? How do we assess it?
  - Need to be creative using the tools to tell a story
  - Look at growth patterns, walking trails of predators
  - If it's so thick where you cannot access it, we should prioritize elsewhere
  - There are not enough criteria to define what is meeting 'equivalent land capability'
  - Minimum size grid spacing for rec cert = 40 x 40 — sourced from arbitrary data
- Want to remove grid system to create transect system; more holistic
- Defined within an area, i.e. 1/2 a section requires the use of 40 x 40, whereas a well site requires 5 points of reference
- Too prescriptive; again, no nuance (one bad weed does not mean the whole area isn't ready for rec cert!)
- Historical analysis using LandSat data; plotting recovery
  - Prior to disturbance, we can see the values; can see the drop when disturbance happened
  - Can then slowly see the gradient returning to baseline
  - Another situation where it can be used as a tool
  - Can then use a 20-year time series to analyze recovery
  - BUT would need to make sure you can be confident enough to verify that
- There is no silver bullet: we need to use it as a tool, no one tool will give us everything
- ReDCAT can show a lot of human use and third-party use.
- Maybe ReDCAT can show long-term trends in vegetation/soil changes – climate change to be used a justification.
- Can we use earth observation for regional risk assessment to support reclamation success?
- Slope stability risk assessment

- Trend data & growth curves (earth observation signatures & number of sites). Will build confidence in end land use
- Potential to gather multiple visits within each growing season
- Comparison of offsite crops to onsite cover year after year
- More representative imagery – especially offsite – no personal interpretation
- Wildlife data – bear dens, migratory birds, caribou
- Soil moisture, temperature
- Tailings ponds, sulfur dust, wildlife could be incorporated. Watershed assessment before water use applications. The raw data can be utilized.
- Excavation areas on contaminated sites.
- Radar used to detect hydrocarbons on water bodies.
- Wildlife cameras.
- eDNA could also be used for remote sensing information.
- Thermal imaging could be used for biomass.
- Green LiDAR runs from top of the trees to bottom of the lake. Operates on a different wavelength. 50 to 100 m.
- Fishermen use Live-view to "cheat" while fishing.
- Stunted crop growth could be detected using canopy cover.
- Photogrammetry is both affordable and helpful even without LiDAR.
- Hyperspectral
- Institutional, historical, and traditional input equally important to detect nuance/sequencing of data.
- Regulator needs to certify that a methodology works.
- Yes, all of the above.
- ReDCAT may also provide evidence over time that a site fails (e.g., forested wellsite 5 to 10 years post-certification, site planted to trees which pass initially but die off later)
- Third-party/ human use could definitely be detected using remote sensing.
- ReDCAT can show trends from drought or excessive rainfall, track disturbances like vehicle trails or grazing
- It could be used to show if the subject site is significantly different from adjacent or nearby sites.

S2/Supplemental Information:

The following supplemental information was provided to the table leads to help drive conversation, if needed:

Existing vs. ReDCAT Criteria:

- The existing criteria (and indicators) used for assessing reclamation outcomes allow for these to be replaced, or supplemented by, ReDCAT criteria such as the examples below. Are there others that could be considered? What key criteria (or indicators) might be missing?
  - Topography: field level assessment of macro-/meso- contour vs. ReDCAT criteria – DEM derived from LiDAR;
  - Topography: field level assessment of drainage vs. ReDCAT criteria – soil moisture conditions derived from Synthetic Aperture Radar (SAR) or persistence of surface water in optical satellite imagery
  - Vegetation (and soil): plant growth stage / productivity (or bare ground) vs. ReDCAT criteria – vegetation (or soil) indices derived from satellite imagery.

- Which criteria (or indicators) would still need to be assessed in-field?
    - Existing criteria (or indicators) used currently for assessing reclamation outcomes have been developed over time based on the expertise of many qualified professionals with decades of experience. As new ReDCAT criteria are developed how should these be evaluated?
    - Is there an opportunity to adopt the use of select ReDCATs or ReDCAT criteria based on their commonly accepted use in other sectors such as agriculture or forestry? For example, the use of LiDAR is well known to provide topographic information such as digital elevation models (DEMs) and vegetation information (e.g., plant canopy structure) in forested areas. Could LiDAR be adopted for use in conservation and reclamation without additional research?
    - What are the key considerations that must be included in decisions to incorporate the use of ReDCAT criteria into policy? E.g., do these need to be science-based? Do ReDCAT criteria need to have a field-level equivalent? What about accessibility of the data – is it publicly accessible or does it need to be purchased?
    - At what point might a ReDCAT criteria be considered adequate for use?
    - Are dedicated areas needed to support evaluation of new ReDCATs or ReDCAT criteria?
- ReDCAT Criteria & Reclamation Certificate Applications:
    - In a scenario where select soil information (e.g., topsoil depth, texture) and landscape (e.g., contour) information has been collected once reclamation has been completed and the site has been revegetated (e.g., seeded, planted, or left for natural recovery), if the site isn't visited again before a reclamation certificate application is made and submitted to a regulator:
    - What information is necessary to support a decision that a site is on a trajectory to achieve equivalent land capability? How does this change based on land cover type?
    - What ReDCAT data would need to be included in the application? Are there barriers, such as data licencing, that even though data is accessible, it might restrict the raw data from being submitted to a regulator. For example, satellite imagery acquired through a license that limits the ability to provide the data to a 3rd party such as a regulator?

11. Appendix 5: Session 3 – Project Concept Forms

The form used for the collection of information from participants on their project proposal concepts discussed in Section 4.4 is presented below.

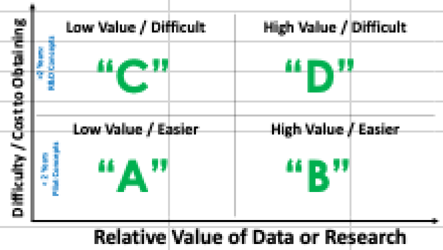
Project Concepts:						
Project Type (based on figure below):			"A"	"B"	"C"	"D"
Purpose						
	Based on the group table discussions so far, identify project concepts to address the knowledge gaps that were identified Project concepts may consist of one or more demonstration (i.e., up to 2 years) or research and development (i.e., 2+ years).					
1)	**Title**					
2)	**Objective**					
3)	**Landcover Type:**	Cultivated / Agricultural	Forested	Native Grassland	Peatland	Mineral Wetland
4)	**Data Needs:**					
5)	**Funding Sources:**					
6)	**Partners:**					

Figure 1. Form used for the collection of project concept information.

12. Appendix 6: Online Questionnaire: General Questions

The following questions were asked only in the online survey to provide a general understanding of the experience with ReDCAT that the workshop participants have. The responses are provided below.

General/Q-1a: Describe how you are using Remote Data Collection and Assessment Tools (ReDCAT) operationally, or for research purposes.

- We are not currently using ReDCAT data tools. As a space-based hyperspectral data provider, we are interested to determine how space-based hyperspectral would help improve ReDCAT tools or improve efficiency.
- Remote data collection – field maps is used during groundwater monitoring to collect data, it is used to link data to GPS coordinates. Aerial photography is used in Phase 1's and other reports. Some remote data collection is also used for air monitoring.
- Assessment – data is sometimes analyzed using AI such as Microsoft Copilot.
- We use ReDCAT for delineating waterbodies and for wetland classification. Water outlines is underway for all our mining areas. Wetlands is partially completed and will be revisited for an expansion phase.
- Operationally, we are using remote sensing and assessment to complete a census of conifer stocking on disturbed features in the boreal. On a research basis, in conjunction with the BERA project, we are also completing a comparison of remote sensing methods between helicopter-based (visual), RPAS and aerial methods. Establishment surveys are completed. Further research is also underway. Cold Lake region.
- I started with RPAS operations in 2013 and have continued to use drones and mapping software for use in the energy industry. Environmental monitoring reclamation progress tracking, asset management and HSE compliance and risk management. Daily use of drones on active and reclaimed industrial sites continues.
- We studied the use of remote sensing and earth observation and how it can support reclamation certification in Alberta. Project Title: Evaluating Technology-Based Assessments for Use in Reclamation Certification of Anthropogenic Footprints. Completed.
- We are currently using remote monitoring stations to collect environmental data for various project. GIS and other technologies are used to model this data.
- We are regularly using drones for imagery in difficult to access areas and to cover larger areas.
- We are currently transitioning to mostly digital field data collection across a wide range of work types.
- We use remote monitoring equipment tied to web-based analytics platform for air and water monitoring.
- We are at early stages of using AI/ML for data analysis and streamlined reporting.
- We engineered a sophisticated geospatial inference system using ML and six band high resolution satellite imagery, and available regulatory information to reconstruct BC's complete pipeline network. Final stages.
- Performing weed assessments on upstream oil and gas site and pre-assessments to determine if reclaimed sites on agricultural lands are DSA ready. Proposed, throughout Alberta
- The objective of the research project was to determine how RS/EO and GIS technologies could be used to perform vegetation assessments on cultivated sites as part of the reclamation certification process. RPAS and satellite multispectral imagery was used to create onsite and offsite datasets. GIS technology was used to perform geostatistical analysis and R was used to run statistical tests on the datasets, comparing onsite to offsite. The research project is completed. The research was conducted on multiple cultivated well sites around central Alberta in the summers of 2023 and 2024.
- Environmental impact assessments and post-construction monitoring to determine the accuracy of conclusions of the assessment and the effectiveness of the mitigation measures. Federally and provincially regulated pipeline projects that have been proposed, underway and completed in Canada with a current focus on Alberta and Saskatchewan.
- Fund research projects, for example, to map land cover and support long-term grizzly bear habitat conservation.

- Not currently using; position includes reviewing EPEA applications for land disturbances on private land, as well as reviewing submissions for reclamation certificates.
- LiDAR for operational Construction projects
- We use ReDCAT operationally through the Converge platform (https://www.converge.io/) to support pipeline integrity and regulatory compliance, with a particular focus on pipeline water crossings and consequence risk assessment.
- Our software integrates GIS, remote sensing, and ML to analyze and monitor pipeline crossings with a suite of tools that enable:
  - Inspection and assessment of pipeline water crossings, including analytics for erosion rate calculations based on historical inspection project future depth of cover.
  - Spatial overlays that identify high-risk geotechnical zones, wildfire activity, land cover classification, population density, and indigenous lands to assist in consequence risk prioritization.
  - Access to real-time water gauge data for river and stream levels across Western Canada, integrated via live map services to contextualize inspection timing and flood risk.
  - These tools are used by pipeline operators to make informed decisions about inspection frequencies, mitigation timelines, and compliance reporting. While not currently part of a formal research initiative, our analytics are continually evolving based on operator feedback and validation data.
- Drones to assess closure on pipelines. Underway on cultivated lands.
- We utilize RPAS to collect RGB and multispectral data which is combined with digital elevation surface models. Data is utilized to inform vegetation status and topographical influences, both on and off site. These projects are underway throughout SW Manitoba and SE Saskatchewan. Flights typically occur annually; initial data collected in 2021.
- In this workshop, we serve as developers of GIS and project management software, and our feedback in the survey will primarily reflect our observations of our users – predominantly environmental consultants and energy producers. We've discovered that the primary applications involve managing location-based projects and monitoring field surveying and inspection sites. Our users employ Matidor for a range of purposes, including reclamation and remediation project management, construction, vegetation management, pipeline integrity, park maintenance, and various environmental studies. The Matidor software is completed and commercialized. New improvements have been added on a regular basis to enhance the user's data collection and assessment efficiency and experience. Since it's a software there is no restriction on location.
- Our research study, titled ‘Advancing the application of remote sensing technologies in land reclamation monitoring’ aims to develop an automation framework to convert remote sensing data collected from UAV to tree-wise inventory variables. Major contributions from this project include the development of a 3D transformer-based deep learning model for vegetation filtering, an innovative offset-based deep learning model for crown delineation, and a fusion process integrating multi-spectral imagery with lidar data. This project is underway at several reclaimed wellsites and OSE sites in northern AB.
- Aerial photographs / satellite images are used as part of applications. Underway. Ontario.
- There is a legacy well identification program that has an aspect of LiDAR and RPAS to find wells established and abandoned over 80 years ago.
- For current surveys, rec certs applications, approvals. Ongoing.
- Not currently using ReDCAT (is this a software?) in any assessments but I'm interested to learn more about it. As a remote sensing data vendor we currently work with AEPA, AB MoF, AB MoAg, AER, and industry with our site monitoring data. Projects with AER using Planet high resolution time series for site reclamation status are underway (species detection and site compliance checks). We have also completed 2 years of evaluation with Olds College and industry partners in Alberta that have demonstrated significant cost and time savings for cultivated land rec cert program using our satellite data services for vegetation analysis
- We use RGB and multispectral RPAS data, combined with digital surface models and ground data to do vegetation assessments, account for topography, and background vegetation conditions. Operational since 2021, with annual flights. Located in southeast Saskatchewan and southwest Manitoba
- Not currently involved or doing this.

- Not yet used, interested
- High resolution hyperspectral has not been available from a satellite-based platform. Previous versions were either very coarse (100 km+) or were on airborne platforms which were very expensive and limited in footprint. Our objective is to explore the utility of high-resolution (5 m) hyperspectral data in the ReDCAT space. We are leveraging experience with multi-level sampling (field to drone, drone to satellite) from prior infrastructure projects in both the wildlife and reclamation space. 1.Wildlife - Underway, across 1.6 million hectares in northern Ontario. 2.Reclamation - Proposed, in northern Alberta.
- With GIS and remote sensing background, I am working on the submitted reclamation data from the oil sand facilities. I am working on the quality-controlled data submitted via RIS. I am interested in how the data is collected. Oil Sand facilities, submit annually
- I research applications related to mapping distribution of dust and tailings from mining related activities (active or abandoned) into regional environments, and where appropriate the impacts on the environment. Project Name: EO4CE: Site Monitoring and Remediation. Underway, presently active in Nunavut and Nova Scotia. Have looked at sites in BC, AB, and ON.
- I am the manager of a remote sensing research organization, the Canada Centre for Remote Sensing, in Natural Resources Canada and am thus involved in numerous ReDCAT research activities. One of our focal areas is to develop remote sensing technologies to support impact assessment and environmental monitoring. Continuous – focused on the development of national scale EO-derived data products to support impact assessment and environmental monitoring as well as regional applications for specific priority areas.
- I recently completed a research project that assessed the use of PlanetScope Classic satellites to determine vegetation regrowth on seismic lines and well pads in the boreal forest. This work was completed as part of my MSc research at the University of Calgary under Dr. McDermid's Boreal Ecosystem Restoration and Assessment project. Publication in preparation. NE Alberta
- Our SaaS solution "ESdat" is an environmental data management system (EDMS) and is commonly used as a single source of truth for environmental data storage, including lab analytical data, field observations, logger/sensor data, spatial data, and regulatory standards. Built -in reports allow generation of tables, charts, maps and trends. Data can also be accessed directly via OData or API for use in other tools such as GIS, AI, and other interpretive tools/software. Commercial of the shelf available software. Canadian head office is in Vancouver, but we are a global organization.
- Remote sensing for cultivated land DSAs, as well as reclamation and vegetation assessments. Phase 1 is completed and waiting on AER/AEPA feedback.

General/Q-1b: Type/name of sensor (e.g., hyperspectral, multispectral, panchromatic, LiDAR, SAR), platform (e.g., ground-based, RPAS, aerial, satellite) used for remote data collection.

- Light Detection and Ranging (LiDAR)
- Synthetic Aperture Radar (SAR)
- Panchromatic, RGB, and Multispectral imagery
- Photogrammetry; Photogrammetric DSM
- Aerial, satellite, remotely piloted aircraft systems (RPAS) data.
- RPAS: senseFly Duet M & MicaSense RedEdge-MX Dual multispectral sensors.
- Satellite: multispectral bands.
- It depends on the type of data being collected: environmental assessments, vegetation health monitoring, land cover classification, base mapping, forest canopy, topographic mapping
- Proprietary
- LiDAR (DJI L1 and L2) and Multispectral (Micasense RedEdge)
- Planetscope Fusion (daily cloud free multispectral monitoring at 3m pixels)

- Dragonette 1 and 2, also will leverage single-photon LiDAR (30+ hits per m2)
- Landsat for temporal archive, Sentinel-2 and EnMAP for ongoing. Have also used EO-1 Hyperion and CHRISon-Proba

General/Q-2a(i). Description of how AI/ML is used

- Hyperspectral imagery pairs well with AI/ML models for scene classification
- Used to analyze data and support report writing
- We are in the early stages of building ML models for feature extraction
- Used to identify and enumerate conifer trees.
- AI is integrated into the drones and software.
- Project reports, methods and results have not been made public yet (under review) and hence we cannot comment on this.
- AI is mainly used for project brainstorming by the regulatory team. On our digital solutions, AI is a useful tool for modelling and development.
- In my research project on cultivated sites, I did not use AI/ML. However, it can be used in other circumstances. For example, it can be used to train models to identify plant species, or land types.
- One company is doing some interesting work with this on their post-construction monitoring.
- Not required to formulate an interpretation on equivalent land capability.
- We are exploring the use of AI/ML to organize data into areas for statistical analysis of multispectral data. This allows for comparison of on-site/off-site data in meaningful groupings.
- Under development: summarization and pattern recognition.
- This work uses a 3D transformer-based deep learning model for vegetation filtering and an innovative offset-based deep learning model for crown delineation. Machine learning is also used for species classification into deciduous, coniferous, and shrub.
- Visual recognition and estimates
- ML (DL) driven data fusion and cloud masking is used to create cloud free surface reflectance time series data to measure vegetation growth and site condition
- ML is also used in the generation of LiDAR-like vegetation structure datasets derived from satellite imagery trained on LiDAR to obtain very low-cost global canopy height and biomass data
- Exploring using AI/ML to assist the creation of zones, depending on the complexity of the site, the amount and types of data layers to be included in the assessment and the goals of the assessment.
- Kmeans Clustering or Random Forests
- AI/ML models will be used in 2 stages, the first will be from field to drone, and the second will be from done to satellite.
- Not presently used. I am aiming to inform AI, not be informed by AI.
- Various AI/ML techniques used both in model development, but also in QA/QC.
- Data source for ML tools.
- Different projects. AI/ML for well file reviews for phase 1 ESAs and liability assessments for acquisitions.
- It is used in several analytics to map field boundaries, identify crop types and land use, time series analysis, and various other applications.

- We use AI/ML technologies within Converge in two key areas:
  - Risk Methodology Enhancement: Our pipeline risk models to improve the accuracy of likelihood scoring, this includes: Automatically deriving operational attributes such as flow regime, velocity, and corrosion rates where operational data is available; using historical failure data to improve internal corrosivity estimates for steel pipelines; and, supporting the classification of infrastructure conditions and contributing to dynamic risk recalculations as new data becomes available.
  - Unstructured Document Intelligence (in progress): We are actively expanding our use of AI/ML to extract and structure critical data from a repository of over 1 million regulatory and operational documents tied to pipeline, facility, and well assets. These include: risk assessments; inspection reports; engineering drawings; and, licensing documents. Our goal is to make this information searchable, filterable, and actionable within Converge to improve workflows related to integrity planning, compliance, and asset management.

General/Q-2a(ii). What are the advantages (or limitations) of using artificial intelligence (AI) and machine learning (ML) in ReDCAT assessments?

Table 36. General – Online Questionnaire: Advantages and limitations of AI/ML.

Advantages	**Limitations**
• Handles large datasets	• Requires training data; only as good as training data provided
• Analytics	• The limitations are mostly practical....
• Adaptable	• High-quality, labelled training data are still scarce for rare ecosystems or early-successional vegetation communities, so model performance depends on carefully curated ground truth
• Less bias	• The sheer dimensionality of hyperspectral cubes can lead to overfitting unless you apply feature-selection or physics-based priors
• Can process imagery from hundreds or even thousands of sites in a single workflow, enforcing consistent scoring criteria while eliminating most truck rolls and the associated HSE exposure	• Mixed-sensor archives (Cloud-covered Sentinel, RADARSAT, UAV imagery, etc.) also need radiometric harmonisation; otherwise the model interprets sensor artefacts as ecological change
• Modern ML algorithms can exploit the full spectral depth of hyperspectral data – hundreds of narrow bands – so they pick up faint vegetation-stress or hydrocarbon signatures that simple RGB or NDVI composites routinely miss	• Regulators remain wary of “black-box” predictions, so explainability layers—e.g., Shapley values or counter-factual examples—should accompany any automated decision score
• Time-series models can flag regressions early and even forecast when a site is likely to cross regulatory thresholds, improving capital-planning and closure-cost estimates.	• Using AI requires protection of client data. Our company has Enterprise Data Protection through Microsoft co-pilot
• The ability to rapidly assess and census conifer stocking	• ML models are hard to build in a robust way when using high spatial resolution and/or very high spatial resolution data. They vary in their effectiveness over larger geographies. Medium resolution public imagery has more broad geographical application.

Advantages	**Limitations**
• Ability to batch process and analyze hundreds of sites under the same criteria (analysis pipeline/algorithm)	• Depending on the information, this often requires good field validation so that classification tasks are highly accurate.
• Once the analysis pipeline is built and validated it's a very fast process	• AI/neural networks can be a black box and difficult to understand, however at the same time, if predictions are accurate, this isn't necessarily a problem
• Ability to train a classifier to detect cover classes (grasses, shrubs, seedlings, trees etc.)	• Building models and algorithms requires expert knowledge in a fast-paced technical environment.
• Count features on the landscape	• Our current limitation of using AI is ensuring that our client's data is protected.
• Its ability to analyze data on a large scale, exponentially faster than a human could	• Needs a sufficient training data set
• Speed and accuracy of data collection	• It is only as good as it is trained to be. Errors can happen and humans need to be able to know when and where to spot them.
• Ability to incorporate data into multiple forms	• At this time AI and ML would not be used in these scenarios due to the high variability of each site
• Scalability and Speed: AI/ML allows us to analyze large datasets such as historical inspection records, operational data, and spatial imagery quickly and consistently, making it feasible to support assessments across thousands of assets.	• While I'm not working with the data directly, but applying the outputs of the data to meet regulatory requirements, from a compliance perspective, I would say what's lacking is "what's the best QA/QC process?". How can you bring quality management to these processes? The limitation is you need to know how to navigate where to go.
• AI/ML can be used to train models and recognize different land uses, crop types, plant species (at a high resolution), presence of weeds. These can then be used for initial assessments of sites.	• Due to the high variability of situations on the ground (for example, wheat field in drought versus healthy wheat field), ground verification is still required to continually improve the model.
• Improved Accuracy and Objectivity: By training models on historical failure data and operational conditions, we can generate likelihood scores (e.g., for internal corrosion) that are more precise and reproducible than subjective or default-based approaches.	• Questions on accuracy AI vs. human data collection
• Continuous Learning: ML models can evolve over time by incorporating new inspection data, enabling risk scores and recommendations to improve with ongoing use.	• May be new to clients/trust issues

Advantages	**Limitations**
• Unlocking Unstructured Data: AI is essential for extracting insight from over a million regulatory and operational documents – information that would otherwise remain siloed and inaccessible for decision-making	• Data Dependency: AI/ML performance is heavily influenced by the quality and completeness of the underlying data, which is the primary competency of our company (data quality).
• Handles large data sets, and complex data better than manual interpretation.	• Transparency: For integrity use, outputs must be explainable. Black-box models may struggle to meet this requirement unless supported by clear logic and confidence scoring.
• Artificial Intelligence (AI) is no longer a distant vision of the future – it has become a strategic imperative for the oil and gas industry today. As the sector navigates growing pressures to improve efficiency, reduce costs, and meet environmental, social, and governance (ESG) expectations, AI stands out as a powerful enabler of transformation. From predictive maintenance and real-time analytics to emissions monitoring and carbon footprint reduction, AI-driven solutions are already demonstrating their value across the energy value chain.	• Accuracy, data quality and perceptions
• Embracing AI not only enhances operational performance but also supports the industry's transition toward a more sustainable, low-carbon future. It enables companies to make data-driven decisions, reduce environmental impact, and ensure compliance with evolving regulations – all while remaining competitive in an increasingly decarbonized global economy.	• Complex to get started and needs checks and balances to ensure accurate outputs
• Realizing the full potential of AI requires more than just technological investment. It calls for robust collaboration among technology providers, policymakers, regulators, and industry leaders. By fostering cross-sector partnerships, encouraging responsible data practices, and aligning on shared goals, the oil and gas industry can scale AI innovations in a way that drives both economic and environmental progress.	• Large training datasets are required, and AI can sometimes make errors such as species with large crowns being counted as multiple stems, or species close together being counted as one stem.
• The ability to automate the process of individual tree detection and quickly extract important metrics such as heights and densities.	• Not there yet, keeps evolving too fast
• High volume data processing	• Errors
• Capable of picking up nuanced patterns or signals that we might not be able to deduce	• Can't be used directly as a substitute for human-level experience.
• Automation	• Misclassification due to limited or lower quality input data.

Advantages	**Limitations**
• (Potentially) faster data processing	• Blind trust
• Possibilities for pattern recognition,	• Training Data and inference accuracy
• Scalability	• Technological limitations
• Potential use as an early warning system	• Policy limitations for RPAS
• Potential more frequent assessments across larger areas, or areas more difficult to access	• Resistance to change
	• Missing ties to current assessment criteria
	• Low confidence in AI at the moment
	• Minimal dedicated environmental based software
	• Ground truthing required
	• Training data required to tune and validate the model

General/Q-3: Are there ReDCATs (including data derivatives) that should be accepted as "fit-for-purpose" based on their accepted use in other sectors (e.g., municipal, surveyors, transportation, forestry, agriculture) in Alberta, Canada, or other jurisdictions? If so, what are they? For what purpose is the data collected? How would those uses be applicable to conservation and reclamation? For example: Forestry: LiDAR returns ~ digital surface/elevation models, topography; tree/canopy height; Agriculture: Spectral data ~ vegetation indices, such as NDVI – vegetation productivity/stress.

- LiDAR: forestry use (tree height; canopy structure) - similar applications in reclamation although data has limited application for recently established seedlings (i.e., <50 cm) or seedlings grown from seed;
- Landscape: production of DEM – digital elevation models
- Vegetation: Vegetation – vegetation indices from multispectral imagery (e.g., plant heath, biomass);
- Soil: presence of bare soil; standing water;
- Landscape – drainage and soil moisture/saturated soil conditions (e.g., synthetic Aperture radar)
- Hyperspectral is especially useful for plant stress, nutrient content, and species identification. Not all of these require new research, and some of them have established workflows.
- Agriculture: researchers at Olds College's provincially funded Smart Farm ingest 30- to 500-band hyperspectral cubes (e.g., DESIS scenes from the ISS) to diagnose nutrient stress and disease before they are visible in RGB or multispectral imagery. These agricultural indices could be applied to reclamation work.
- Water-quality management: hyperspectral sensors can create risk maps on water quality – algae in particular.
- Forestry: hyperspectral can create moisture-stress indices for detecting early mountain-pine-beetle attack, showing statistically significant correlations between spectral water-absorption features and beetle damage levels. Provincial forest-health programs cite that work in their aerial-survey standards, effectively endorsing hyperspectral red-edge and water-stress metrics as credible evidence of vegetation decline. The same indices translate to early warning of invasive weeds or drought stress on reclaimed well pads
- I think that the tools used in agriculture are developed and accurate enough to be used in vegetation assessments.
- NDVI and other indices are used to measure crop cover and health.

- Yes
- Detailed Site Assessments – those should be automated
- Crop health and veg height compared to offsite
- Yes, from chat GPT: In Alberta, the integration of remote data capture systems into reclamation certification processes is gaining momentum. Notably, Imperial Oil received the first reclamation certificates based on remote sensing technologies in 2021, utilizing satellite imagery and LiDAR to assess vegetation cover and landscape features without extensive ground-based assessments . This approach has been particularly beneficial for remote sites, reducing safety risks and inspection times. (https://thenarwhal.ca/remote-sensing-reclamation/?utm_source=chatgpt.com)
- With satellite imagery data now spanning back decades, we may be able to pre disturbance vegetation data even if a site was not assessed on-ground at the time of pre-construction.
- Drones can collect data for interpretation against landscape and 95% of vegetation closure criteria.
- Multispectral and high-resolution digital surface models (DSM) are used in precision agriculture to create management zones; this would be similar use in reclamation areas, albeit on a smaller scale. Vegetation health is correlated with topography, soil type and conductivity, which can be evaluated in part through NDVI statistical analysis and reference to a DSM.
- LiDAR data is widely used across industries for mapping and surveying. In the forestry industry, LiDAR data is used in forest inventories to capture tree mensuration data.
- The ability of LiDAR to capture the terrain beneath vegetation allows for the creation of digital elevation model (DEM) maps. These could be used to answer questions regarding reclaimed landscapes and comparing them to the landscape of the adjacent forest.
- In the forestry industry, LiDAR is used to accurately capture information such as heights, densities, crown area and canopy cover to aid in forest management. These metrics are also important to the assessment of reclamation sites.
- For finding disturbances, metallic artifacts, yes.
- Not certain about detailed vegetation assessment for our purposes.
- Yes, our unique satellite monitoring data products are used by regulatory agencies in many other jurisdictions for compliance and enforcement purposes, including Environment and Climate Change Canada.
- Our high cadence multispectral time series data is unique among remote sensing capabilities due to the high resolution and high revisit which enables analysts to obtain high confidence indicators and metrics compare to single point-in-time observations which can be confounded by multiple sources of uncertainty. It's a big difference between looking once at something complicated, vs looking at it over and over to understand the system. This data provides quantitative metrics on ecological function and structure to determine ELC remotely
- Tree heights could be fit for purpose (CHMs) and could be valuable to assess the level of regrowth in conjunction with canopy closure estimates.
- That would have to be on a per-case basis, but would definitely rely on a well maintained and defined metadata source of each ReDCAT
- Physically-based modelling (as opposed to empirically-based interpretation) would support use outside of direct application data collection was for.
- Some types of vegetation assessments, some types of terrain assessments.
- Leaf Area Index (LAI) and Fraction of Vegetation Cover (FCOVER) are key indicators of vegetation density and canopy structure. They are sensitive to changes in plant growth and biomass, making them effective for tracking the success of land reclamation efforts. Increases in LAI and FCOVER over time signal healthy vegetation recovery and improved ecosystem function.
- Radar data, especially from Synthetic Aperture Radar (SAR), is ideal for assessing terrain stability because it can detect ground movement with millimetre precision using techniques like InSAR (Interferometric SAR). It works day or night and

penetrates cloud cover, making it highly reliable for monitoring landslides, subsidence, and slope deformation in all weather conditions.

- Vegetation indices, time series analytics, vegetation models.

General/Q-4: Are there examples of, or opportunities for, demonstration of multi-functionality of a platform or sensor? For example, RPAS for interim monitoring site assessments (vegetation) and use for habitat assessments (bird/nest sweeps).

- RPAS optical/MS cameras for monitoring veg/weed surveys could also be used for nest sweeps or wildlife surveys.
- A single 5-metre–resolution hyperspectral satellite scene already checks more than one regulatory box. The visible and red-edge bands give you species level vegetation classification, letting you prove “equivalent land capability,” while the short-wave-infrared channels in the same cube reveal soil chemistry cues – hydrocarbon staining, salinity crusts, even acid-generating sulphides on tailings berms. Because both outputs are derived from the same calibrated dataset and timestamp, one downlink can satisfy the vegetation-recovery and residual-contamination portions of Alberta’s Reclamation Certificate without separate field campaigns.
- At the drone scale, mounting a lightweight push-broom hyperspectral imager on a multirotor – alongside a gimbal-stabilised RGB camera – creates a true multi-function platform for interim site inspections. During a single flight you can (i) map centimetre-scale vegetation as well as some soil parameters.
- Satellite imagery has many potential uses such as disturbance detection, vegetation recovery detection.
- I'm not aware of examples, although there are certainly many potential applications.
- From chat GPT: Yes, there are practical examples and growing opportunities for using remotely piloted aircraft systems (RPAS), or drones, as multifunctional platforms in Alberta and other jurisdictions. These platforms can support both interim vegetation monitoring and wildlife habitat assessments, including bird nest sweeps. (https://arxiv.org/abs/2310.11257?utm_source=chatgpt.com)
- could be used for calculating financial security; ability to quickly assess onsite stockpiles/liability
- vegetation assessments for reclamation certificates
- assessing soil depths for even distribution over larger sites (pre-site surveys as well as end of life rec cert applications)
- wetland delineation
- accurate measuring/comparison of site boundaries
- yes
- We typically collect RGB, multispectral and DSM data in a single flight. The operator can also collect oblique imagery at a lower altitude to evaluate the presence of weeds, or to further assess vegetation health.
- RPAS can collect RGB, Multispectral and DSM data in one pass.
- Oblique imagery can be used to differentiate weed patches, or veg stress, signs of erosion, etc. after the mapping mission if the operator is knowledgeable.

General/Q5: For data and/or reporting tools – are there:
5a. Existing cost-sharing models to support one or more of the following: acquiring, developing, updating, maintaining, distributing, or ownership of reporting tools or, non-regulatory data e.g., Alberta Data Partnerships (ADP, P3)?

- Alberta Data Partnerships; Saskatchewan Geospatial Imagery Cooperative (https://www.cubewerx.com/case-study-the-saskatchewan-geospatial-imagery-collaborative/)
- Some offices in Regulatory Assurance in Environment and Protected Areas have access to drones, but not all offices have capability or software programs to easily incorporate that info into other things

- We value and actively seek out authoritative datasets to ensure the quality, consistency, and defensibility of the information presented in our Converge platform.
- For national-scale data needs, our primary source is the Government of Canada, including Natural Resources Canada and Environment and Climate Change Canada. For provincial and local datasets, we work with sources such as Altalis (Alberta) and Information Services Corporation (ISC) (Saskatchewan). These sources enable us to maintain accurate and up-to-date geospatial data layers, which are foundational to the integrity and operational utility of our reporting tools.
- Unsure
- Not to my knowledge
- We are not currently part of an existing cost-sharing model but are open to coordinating with others who wish to create these types of partnerships.
- Yes, data licensing can be multi-entity across any number of organizations to share the costs
- That would have to be on a per-case basis, but would definitely rely on a well maintained and defined metadata source of each ReDCAT. Would also require well defined open science / open data model that demonstrates referenceable ownership and was required to be used by all participants in a robust fashion.

General/Q5b. Data assets that are currently available but could be made more accessible, at risk of being lost, duplicated, or underutilized if not properly managed or funded?

- GoA's Air photo library
- ADP
- Olds College Smartfarm
- I find there are a lot of useful government of Alberta datasets, but sometimes it is not the most straightforward to be able to access these or they are only available in certain formats (i.e., shapefile vs KMZ)
- Disturbance and regeneration data should likely be stored in a safe and accessible manner, so that ecological outcomes on public land are available for researchers and public.
- We believe that many publicly available datasets hold significant value and need to be properly managed. Our approach is to enhance and add value to open datasets to better align with specific industry needs. For example, we have taken the national hydrology dataset and applied additional logic to network water features and assign Strahler stream order, enabling more advanced risk assessments for pipeline water crossings. In our view, data providers should focus on delivering authoritative, well-maintained, and accessible base data that industry and research users can expand upon. This ensures the longevity and usability of critical data assets while reducing duplication of effort across the sector.
- Unsure
- Years of soil and vegetation assessments have been completed and are sitting in pdf files. This data could be used for bench marking or data validation in certain land uses.
- If satellite imagery were available at high-resolution, we may consider referring to it when we cannot fly a site at optimum timing.
- Our CloudCompare plugin, TreeAIBox is a free plugin that uses AI to detect and record individual trees from a point cloud.
- Would also require well defined open science / open data model that is properly maintained and that demonstrates referenceable ownership and was required to be used by all participants in a robust fashion.
- Will introduce a significant number of data products in session, many can be found here: https://geo.ca/initiatives/understanding-canadaSland-from-space
- Currently available public LiDAR data is sometimes only available in raster format.

General/Q5c. Advantages (or limitations) of Environmental Data Centres or Co-operatives? For example, provincial imagery (or LiDAR) Co-op?

Table 37. General – Online Questionnaire: Advantages and limitations data centres / data co-operatives.

Advantages	Limitations
• Lower cost, potential cost savings for imagery acquisition	• Needs central coordination
• Central repository for locations of where LiDAR/Aerial/Satellite imagery has been acquired	• Companies may have different specs for data requirements
• Openly available data that can be used for many purposes without replication of resources.	• Our company is very keen to contribute to these important initiatives, however, it is difficult to determine key AOIs we could image and how to get our imagery into the hands of these organization
• Allows users who may not have the means to generate their own data to still complete meaningful evaluations on the data.	• Data privacy could at times be an issue with publicly available data.
• Such data sharing might be beneficial.	• Not all information could be available publicly depending on where it's at in review/approval process (some information may be proprietary) also could be sensitive depending on whether an appeal is underway
• We hear that high-resolution LiDAR is being rolled out across Canada; this would be very useful data	
• If more data were publicly available, it would allow for faster development and scale-up between data types (i.e. LiDAR and satellite imagery) because less time and money would need to be spent collecting data.	
• Broad coverage, high res (1m) LiDar is being rolled out across Canada, the completion and publication of that data would be very valuable. Also need to have the collection date available.	

13. Appendix 7: Reflection on Notetaking and Role of Artificial Intelligence

13.1. In-Person Note Takers, MeetGeek and Microsoft CoPilot

The irony of writing a report on the use of AI (amongst other things) with the support of AI was not lost on the authors. Given the significant amount of written feedback to compile, using an AI tool such as Microsoft CoPilot made sense. A summary of the advantages and limitations of these options are presented in Table 38. After all information was collected from the three sources: table notes, MeetGeek notes recorded at each table, and the online questionnaire, a decision was made regarding how each source was to be used for the report.

While MeetGeek and Microsoft CoPilot were chosen for this particular workshop for various reasons, the organizers of any future workshop or event should consider the pros and cons of all free and paid options available at that time. Given the speed at which these technologies are improving, the challenge will be keeping up with the pace of change in this space.

13.1.1. Online Survey

As a part of the workshop planning, we knew the value in having participants also complete an online questionnaire prepared using Survey Monkey. Although potentially redundant, this would ensure that any feedback that individuals wanted to get across would definitely be captured for the report. It was possible that all desired input may not be brought up within the table discussions, so this provided another level of backup. It further ensured that a direct response could be provided to each question asked, versus the somewhat muddled conversations that sometimes came from the table notes.

13.1.2. Workshop: In-Person Note Takers and MeetGeek

This workshop marked the first experience for both the authors and supporting organizations in using a virtual note taker - and overall, it was a positive one. The experience highlighted both the advantages and limitations of these tools compared to traditional methods of documenting discussions during workshops and breakout sessions. Additionally, the resulting transcripts and summaries offered a valuable starting point for preparing follow-up workshop reports.

In planning the workshop, we decided to use MeetGeek to record the conversations at each table, with a note taker as a backup. We used ANKER Ultra Clear portable conference speakerphones at each table to ensure the software could pick up the conversations effectively (versus using cell phone or laptop microphones which wouldn't have the same capacity to record clear conversations around a table of 10 people). The backup note taker was important and paid off, as the speaker/MeetGeek did not record at one table.

Separate Microsoft Teams meetings were set up for each session and for each table, allowing MeetGeek to consider each session an independent entity. For each session, MeetGeek provided a summary of the conservations at each table, which was used to develop the compiled summary/introduction for each session presented in Section 5 of this report. The MeetGeek summary was based on the entire recording for the session – it did not differentiate between the questions discussed throughout the conversation.

Due to the format of the sessions with tables starting on different questions, it would have taken significant effort to manually go through the MeetGeek recordings and transcription to determine which questions were being discussed, and to sort the questions and answers accordingly. Therefore, the MeetGeek recordings and transcriptions and generated topic highlights were not used in the Microsoft CoPilot summaries.

The 9 MeetGeek summaries from each session were copied into Microsoft CoPilot, which provided one collated summary for each session. Only the summaries of each table conversation for each session generated by MeetGeek were summarized using Microsoft CoPilot and included in this report. If there is a desire for a MeetGeek summary to be available for each question, the workshop would need to be set up in advance so that each question was its own MeetGeek meeting.

13.1.3. Report Development: In-Person Notes, Online Survey, and Microsoft CoPilot

Once the workshop was completed and the online survey closed, the answers for each question captured through the in-person notes taken by the note takers were combined with the responses to the same questions from the online questionnaire; a compilation of responses are found in Appendix 3: Session #1 – Lifecycle (Temporal) Considerations & Reporting, Appendix 4: Session #2 – Remote Data Collection and Assessment Tools, and Appendix 5: Session 3 – Project Concept Forms.

Microsoft CoPilot was then used to collate and summarize the results which were presented in Section 5 of this report. Using both the table notes and the online questionnaire ensured that all feedback provided was incorporated into the report. However, since the online questionnaire provided very explicit responses to the questions asked, if it weren't for the online questionnaire, the value of this approach using only the handwritten notes would be lessened. Of course, relying on both a workshop and an online questionnaire to provide information in support of the final report has its pros and cons too, as noted in Table 38.

13.1.4. Learnings

Each group in the workshop was presented with the same set of questions; however, their discussions varied significantly due to the diverse mix of participants representing different sectors, educational backgrounds, and professional experiences. As a result, many conversations included specialized terminology and acronyms that may not be widely recognized outside of those groups. While the summaries generated for each table were not reviewed during the session itself, groups considering the exclusive use of a virtual note taker in future workshops should consider allocating dedicated time for participants to review and refine their summaries to ensure accuracy. The revised versions should then be shared with the workshop organizers.

Based on the results of the workshop, there were clear learnings regarding the way the questions were set up for each session. While there was value in linking the session questions to the online questionnaire for the purpose of report writing, it seemed there was too much detail, and too many sub questions provided to the table participants to respond to. If the desire is to capture specific answers to specific questions, the questions should be made more concise and the note takers at each table should be provided direction to document the results of the conversation accordingly. Extra details and sub questions could be provided only as extra context, allowing the conversation to flow in response to the main question, instead of being chopped up by sub questions.

Recommendations for using AI such as MeetGeek to record workshop, panel, or meeting conversations:

- Ensure people are aware that the conversations will be recorded. Confirm and communicate that names will not be used in the documentation. Allow people to decline participation if they're not comfortable.
- Set up the recording sessions based on your needs (e.g., based on individual questions or for an entire session; the summary provided by AI will be based on the full recording, so choose wisely).
- Consider using multiple AI platforms and/or use different prompts for summarizing the information collected. As experience is gained in this space, it may be possible to refine the approach for recording and summarizing the technical conversations.

Recommendations for developing questions for discussion:

- If you want specific answers to specific questions, direct the participants and note takers to compartmentalize the conversation and notes accordingly.
- If you are okay with free-flowing conversation regarding a higher-level question, know that the notes will be harder to collate (manually or with AI) and the results will be harder to connect to any online questionnaire.
- Ensure questions are clear and concise, minimize duplication. Provide context.

We found that setting up a technical workshop like this required thoughtful placement of participants at the tables to ensure balanced conversations took place. In other words, if people were left to sit where they wanted, the tables could have been very imbalanced with experience. By assigning people to tables, we were able to ensure each table had representatives from: regulatory/policy, industry, consulting, and data/service providers (as best as possible).

Table 38. Advantages and limitations of the approaches used for collecting, summarizing, and/or collating data for the workshop.

	IN-PERSON	SURVEY MONKEY	MEETGEEK	MICROSOFT COPILOT
Role:	**COLLECTION**	**COLLECTION (ONLINE QUESTIONNAIRE)**	**COLLECTION & SUMMARY**	**COLLATION & SUMMARY**
Advantages				
	- Can associate comments to people if desired - May understand nuances in terminology and acronyms better than AI - Can determine what is important versus not important to document - Allows for genuine conversations to take place; people can feed off each other, ask questions, build upon stories - Learnings take place at the workshop, versus the need to set aside time to read a report at a later date	- Allows for a clear question and answer approach which makes for a cleaner report and makes for easier collation (whether manually or using AI) - Ensures that all feedback that participants want to provide is received	- Free and subscription pricing options - Records and transcribes conversations nearly verbatim ▪ Still requires review for accuracy ▪ Comments typically anonymous, depending on number of speakers ▪ Allows for re-analyses of discussion in the future using different templates - Provides a summary of the entire conversation, which is good for an overarching summary - Identifies how many people participated in the conversation and provides 'AI Insights' related to participation and conversation flow - Recordings of the conversation can be used later for reference, or validation, of transcriptions - User can define acronyms and create a dictionary for MeetGeek to draw upon	- Available in MS 365 or online (free and paid subscriptions) - Can learn acronyms and nuances over time based on previous inputs
Limitations				

	- A junior person or person with little to no experience with the topic will not necessarily be able to capture all points
	- Writing can be hard to read
	- Some note takers have their own short-hand style
	- Requires interpretation, typing (if notes taken my hand), collation, etc.
	- Conversations are fluid. It can be hard to determine what question the conversation was intended to address
		- Value is limited if people do not respond
		- Input is based on one individual; limited collaboration
		- Unless written into a report, and the report is read, the feedback is not heard by others and cannot be learned from
		- Questions need to be carefully worded or they could be mis-interpreted.
			- Different pricing packages
			  ▪ Mitigation: baseline option is free, but fewer options
			- Spelling mistakes for acronyms and technical words
			  ▪ Mitigation: allows development/use of customized terminology (e.g., dictionaries, acronyms) to improve transcription
			- Provides a summary of the entire conversation, not a summary for each question. If a summary for each question is desired, the recording would need to stop/start for each question
			- People have concerns about being recorded, even though their contributions are not attributed to them in the recording
			- Conversations are fluid. It can be hard to determine what question the conversation was intended to address
				▪ Different pricing packages
				▪ Mitigation: baseline option is free, but fewer options
				▪ Not everyone uses Microsoft

14. Appendix 8: Relevant Reference Materials

The following are a list of relevant references that may be of interest. Links were functional as of the date of release for this report.

TYPE	NAME	LINK
Criteria / Standards / Directives	Government of Alberta (GoA): Grassland Vegetation Inventory (GVI) Specifications	https://www.albertapcf.org/rsu_docs/grassland-vegetation-inventory-specificationS5th-edition--june-29-2010-revised---november-9-2011.pdf
	Criteria and Indicators Framework for Oil Sands Mine Reclamation Certification - Final Report (2012)	Criteria and indicators framework for oil sands mine reclamation certification - Open Government
	Coal and Oil Sands Exploration Reclamation Requirements (2015)	Conservation and reclamation directive for renewable energy operations - Open Government
	Reclamation Criteria for Wellsites and Associated Facilities for:	
	Cultivated Lands (2013)	2010 reclamation criteria for wellsites and associated facilities for cultivated lands - Open Government
	Forested Lands (2013)	2010 reclamation criteria for wellsites and associated facilities for forested lands - Open Government
	Native Grassland (2013)	2010 reclamation criteria for wellsites and associated facilities for native grasslands - Open Government
	Peatland (2017)	Reclamation criteria for wellsites and associated facilities for peatlands [2017] - Open Government
	Government of Alberta: General Specifications for Acquiring Aerial Photography (March 2014)	General specifications for acquiring aerial photography - Open Government
	Conservation Assessments in Native Grasslands: strategic siting and pre-disturbance site assessment methodology for industrial activities in native grasslands (2018)	Conservation assessments in native grasslands - Open Government
	Conservation and Reclamation Directive for Renewable Energy Operations (2018)	Conservation and reclamation directive for renewable energy operations - Open Government
	Reclamation Practices and Criteria for Powerlines (2020)	Reclamation practices and criteria for powerlines - Open Government
	Alberta Wetland Mapping Standards and Guidelines: Mapping Wetlands at an Inventory Scale (Version 1.0)	https://open.alberta.ca/publications/alberta-wetland-mapping-standardSguidelineSmapping-wetlandSinventory-scale-version1

TYPE	NAME	LINK
	Alberta Environment and Parks, 2022. *Guidelines for End Land Use Planning for Reclaiming Borrow Pits Supporting Energy Activities on Public Lands*. Alberta Environment and Parks, Lands Policy and Programs Branch, Edmonton, Alberta. AEP Land Policy 2022 No. 1. 8 pp.	https://open.alberta.ca/publications/guidelineSend-land-use-planning-for-reclaiming-borrow- pitssupporting-energy-activities
	SED001: Direction for Conservation and Reclamation Submissions Under an Environmental Protection and Enhancement Act Approval for Enhanced Recovery In Situ Oil Sands and Heavy Oil Processing Plants and Oil Production Sites (Feb 2016)	https://static.aer.ca/prd/documents/manuals/Direction_001.pdf
	SED002: Application Submission Requirements and Guidance for Reclamation Certificates for Well Sites and Associated Facilities (March 2024)	https://static.aer.ca/prd/documents/manuals/Direction_002.pdf
	SED003: Direction for Conservation and Reclamation Submissions Under an Environmental Protection and Enhancement Act Approval for Mineable Oil Sands Sites (December 2018)	https://static.aer.ca/prd/documents/manuals/Direction_003.pdf
	Government of Alberta (GoA): Alberta Vegetation Inventory Standards (Version 2.1.5)	https://open.alberta.ca/publications/alberta-vegetation-inventory-standards
	Government of Alberta: Reforestation Standard of Alberta (May 2024)	Reforestation standard of Alberta - Open Government
Supporting References	Remote Sensing of Soils (2014)	(PDF) Remote Sensing of Soils
	Anne M. Smith, Michael J. Hill & Yongqin Zhang (2015). *Estimating Ground Cover in the Mixed Prairie Grassland of Southern Alberta Using Vegetation Indices Related to Physiological Function*. Canadian Journal of Remote Sensing: Journal canadien de télédétection, 41:1, 51-66	Estimating Ground Cover in the Mixed Prairie Grassland of Southern Alberta Using Vegetation Indices Related to Physiological Function: Canadian Journal of Remote Sensing: Vol 41 , No 1 - Get Access
	Powter, C.B., M. McKenzie and C.C. Small, 2018. *Inventory of Native Species Seed Mixes in Alberta: December 2018 Update*. InnoTech Alberta, Edmonton, Alberta. 207 pp.	https://www.cclmportal.ca/resource/inventory-native-specieSseed-mixeSalberta-december- 2018-update

TYPE	NAME	LINK
Knowledge Sharing	Alberta Centre for Reclamation and Restoration Ecology and Oil Sands Research and Information Network, 2014. *Creating a Knowledge Platform for the Reclamation and Restoration Ecology Community: Expanding the OSRIN Model Beyond the Oil Sands*. Oil Sands Research and Information Network, University of Alberta, School of Energy and the Environment, Edmonton, Alberta. OSRIN Report No. TR-65. 19 pp.	https://doi.org/10.7939/R3R49G91S
	Alberta Innovates – Technology Futures, 2012. *Investigating a Knowledge Exchange Network for the Reclamation Community*. Oil Sands Research and Information Network, University of Alberta, School of Energy and the Environment, Edmonton, Alberta. OSRIN Report No. TR-26. 42 pp.	https://doi.org/10.7939/R36T0GW1X
	Hornung, J, C. Wytrykush, G. Haekel, T. Charette and M. Trites, 2011. *Knowledge Transfer Process – Wetland Reclamation Research in the Alberta Oil Sands*. IN: A.B. Fourie, M. Tibbett and A. Beersing (editors), Mine Closure 2011: Proceedings of the Sixth International Conference on Mine Closure. Australian Centre for Geomechanics, Perth, Australia. pp. 573-580.	https://www.cclmportal.ca/resource/knowledge-transfer-procesSwetland-reclamation-research- alberta-oil-sands
Research Programs	Alberta - Boreal Ecosystem Recovery and Assessment (BERA)	http://beraproject.org/
	Canada – Assessment of Wood Attributes from Remote Sensing (AWARE)	https://awareproject.ca/
Workshops / Conferences	Oil Sands Research and Information Network, 2011. *Equivalent Land Capability Workshop Summary Notes*. Oil Sands Research and Information Network, University of Alberta, School of Energy and the Environment, Edmonton, Alberta. OSRIN Report No. TR-13. 83 pp.	https://www.cclmportal.ca/resource/equivalent-land-capability-workshop-summary-notes
	De Abreu, R., S. Patterson, T. Shipman and C. Powter, 2015. *Earth Observation for Improved Regulatory Decision Making in Alberta – Workshop Report*. Geomatics Canada, Open File 18. 178 p.	https://publications.gc.ca/collections/collection_2017/rncan-nrcan/M103-3/M103-3-18- 2015-eng.pdf
	Powter, C.B., B. Scorfield, B. Lakeman and S. Patterson, 2016. *Commercializing Remote Sensing Technology for Environmental Management: Moving From Data to Decision*. Prepared for Alberta Innovates – Technology Futures, Edmonton, Alberta. 202 pp.	https://www.cclmportal.ca/resource/commercializing-remote-sensing-technology-environmental- management-moving-data-decision

TYPE	NAME	LINK
	InnoTech Alberta, 2018. *Workshop Summary Report: Harnessing the Innovation System to Support Efficient Upstream Oil and Gas Wellsite Assessment, Remediation and Reclamation*. Prepared by Simone Levy, Marian Weber and Sarah Laughton. October 10, 2018. 55 pp.	https://www.cclmportal.ca/resource/harnessing-innovation-system-support-efficient-upstream- oil-and-gaSwellsite-assessment
	Drozdowski, B., C. Aumann and C.B. Powter, 2019. *Predictive Soil Mapping Seminar: Summary Report*. InnoTech Alberta, Edmonton, Alberta. 188 pp.	https://www.cclmportal.ca/sites/default/files/2021-11/PSM%20Seminar%20Report%20-%202019%2003%2018%20reduced_2.pdf
	Powter, C.B., T. Richens, A. Etmanski, A. Schoonmaker and D. MacKenzie, 2023. *Towards a Shared Foundation for Innovation and Evolution*. Presentation at the 2023 Alberta Chapter/Canadian Land Reclamation Association Annual Meeting, Edmonton, Alberta.	https://www.cclmportal.ca/resource/towardSshared-foundation-innovation-and-evolution
Technology: Alberta Projects	Approaches for Monitoring Landscape Composition and Pattern Using Remote Sensing (2001)	Approaches for Monitoring Landscape Composition and Pattern Using Remote Sensing
	Group on Earth Observations and its Global Agricultural Monitoring Rangeland and Pasture Productivity (GEOGLAM RAPP)	GEOGLAM RAPP | Rangeland and Pasture Productivity
	GEOGLAM RAPP: Pilot Site - Alberta, Canada	Canada | GEOGLAM RAPP
	Tan, T. and S. Nielson, 2014. *Testing UAV-based Remote Sensing for Monitoring Well Pad Recovery: UAV Field Performance 2014 Summary Report*. Prepared for the Alberta Biodiversity Monitoring Institute. 27 pp.	https://www.cclmportal.ca/resource/testing-uav-based-remote- sensing-monitoring-well-pad-recovery
	Rochdi, N., J. Zhang, K. Staenz, X. Yang, D. Rolfson, J. Banting, C. King and R. Doherty, 2014. *Monitoring Procedures for Wellsite, In-Situ Oil Sands and Coal Mine Reclamation in Alberta (MOPRA) – December 2014 Update*. Oil Sands Research and Information Network, University of Alberta, School of Energy and the Environment, Edmonton, Alberta. OSRIN Report No. TR-47. 167 pp.	https://www.cclmportal.ca/resource/monitoring-procedureSwellsite-situ-oil-sandS and-coal-mine-reclamation-alberta-december
	Assessing the Quality and Stability of Photogrammetric Point Clouds Derived from Stereo UAV Imagery (2015)	Assessing the Quality and Stability of Photogrammetric Point Clouds Derived from Stereo UAV Imagery
	A Report on the Comparison of Unmanned Aerial Vehicle Data with Field Data over Reclaimed Wellsites in the Boreal Forest (2015)	A Report on the Comparison of Unmanned Aerial Vehicle Data with Field Data over Reclaimed Wellsites in the Boreal Forest
	Predictive Ecosite Mapping Project (2016): Final Report	Predictive EcoSite Mapping Project Final Report

TYPE	NAME	LINK
	Predictive Ecosite Mapping Project (2016): Creating and Commercializing a Predictive Ecosite Classification Platform for Alberta	Creating and Commercializing a Predictive Ecosite Classification Platform for Alberta
	Predictive Ecosite Mapping Project (2017): Predictive Soil Mapping Pilot in NE Alberta	Predictive Soil Mapping Pilot in NE Alberta
	Ecological Recovery Monitoring Program (ERMP) for Certified Reclaimed Sites in Alberta: Specialized Monitoring Protocols	Ecological Recovery Monitoring Program (ERMP) for Certified Reclaimed Sites in Alberta: Specialized Monitoring Protocols
	Use of Unmanned Aerial Vehicles for Monitoring Recovery of Forest Vegetation on Petroleum Well Sites (2017)	Use of Unmanned Aerial Vehicles for Monitoring Recovery of Forest Vegetation on Petroleum Well Sites
	Ecological Recovery Monitoring of Certified Reclaimed Wellsites in Alberta: Crop Harvest Mapping on Reclaimed Agricultural Sites (2017)	Ecological Recovery Monitoring of Certified Reclaimed Wellsites in Alberta: Crop Harvest Mapping on Reclaimed Agricultural Sites - Supplemental Information
	State of the Prairie: Technical Report – Chapter 8.0 The Time Scan data sets: source, processing and results (2019)	State of the Prairie
	Development of Remote Sensing Technologies for Regional Reclamation Monitoring of Peatlands (2017)	https://ptac.org/technicallibrary/development-of-remote-sensing-techniqueSfor-regional-reclamation-monitoring-of-peatlandsin-alberta/
	Assessment of Remote Sensing Technologies for Regional Reclamation Monitoring in Alberta (2019)	https://ptac.org/technicallibrary/assessment-of-remote-sensing-technologieSfor-regional-reclamation-monitoring-in-alberta/
	Algar Habitat Restoration Project: Studying the Outcomes of an Alternative Treatment Trial – Phase 1 & 2 (2019)	https://ptac.org/technicallibrary/algar-habitat-restoration-project-studying-the-outcomeSof-an-alternative-treatment-trial-phase-1-2/
	Wetland Assessment and Monitoring using Multi EO Data and Advanced Analytics (2021)	https://hatfieldgroup.com/projects/wetland-assessment-and-monitoring-using-multi-eo-data-and-advanced-analytics/
	Registered Interests on Titled Land (RITL): Pilot Project (2021)	https://mncl.ca/services/consulting/2021-registered-interestSon-titled-land-ritl-pilot-project/
	Registered Interests on Titled Land (RITL): AER Data Integration Report	https://mncl.ca/services/consulting/2022-registered-interestSon-titled-land-ritl-aer-data-integration-report/
	Identification and Characterization of Abandoned Padded Wellsites Using Remote Sensing (2022)	Identification and Characterization of Abandoned Padded Wellsites Using Remote Sensing « PTAC

TYPE	NAME	LINK
	PTAC Webinar – Everything you wanted to ask about how Drone Surveillance can affect your asset and sustainability initiatives – but didn't know to ask!	https://ptac.org/ptac-webinar-everything-you-wanted-to-ask-about-how-drone-surveillance-can-affect-your-asset-and-sustainability-initiatives-but-didnt-know-to-ask/

Technology – Tools/Geospatial Datasets

TYPE	AGENCY	LINK
Alberta	Alberta Biodiversity Monitoring Institute (ABMI)	Open Data Portal
	Abadata	Website
	Alberta Data Partnerships (ADP)	Homepage - Alberta Data Partnerships
	ADP – Open Data Areas	Open Data Areas – Open Data Distribution for Alberta
	Alberta Electric Systems Operator (AESO)	Connection Project Reporting » AESO
	Alberta Energy Regulator (AER)	Spatial Data
	AER – OneStop Query Tool	*OneStop Query Tool*
	Alberta Utilities Commission (AUC)	What is renewable power generation? - AUC
	Altalis	Altalis - Home
	Government of Alberta (GoA): Alberta Human Footprint Monitoring Program (AHFMP)	Website
	GoA: Environmental Site Assessment Repository (ESAR)	Website
	GoA: Geodiscover Alberta	GeoDiscover Alberta
	GoA: Open Government	opendata - Open Government
	GoA: Provincial Geospatial Centre (PGC)	Air photos | Alberta.ca
Canada	Canadian Conservation and Land Management: Knowledge Network	https://www.cclmportal.ca/
	Canadian Space Agency (CSA): smartEarth	https://www.asc-csa.gc.ca/
	Canadian Space Agency (CSA): Radarsat Constellation Mission (RCM)	Access to RCM data | Canadian Space Agency
	Government of Canada (GoC): Geospatial Data, tools, and services	Website

	Natural Resources Canada (NRCan)	Satellite imagery, elevation data, and air photos
	NRCan – Canda Center for Mapping and Earth Observation (CCMEO) Data Cube Platform	https://datacube.services.geo.ca/en/index.html
International	Committee on Earth Observation Satellites (CEOS)	Website
	CEOS: Visualization Environment (COVE)	CEOS Acquisition Forecaster
	Earth Observation for Oil and Gas (EO4OG)	https://earsc-portal.eu/display/EO4/EO4OG+Home
	EO4OG: Onshore Products	https://earsc-portal.eu/display/EO4/EO4OG+Products+On-shore
	European Space Agency (ESA)	European Space Agency
	ESA – Copernicus Space Data Ecosystem	Copernicus Data Space Ecosystem | Europe's eyes on Earth
	Group on Earth Observations (GEO)	Group on Earth Observations | GEO
	Google Earth Engine Apps, LandTrendr	LT-GEE Pixel Time Series
	Google Earth Engine Apps, Change Mapper	LT-GEE Change Mapper
	United States Geological Survey (USGS)	EarthExplorer
Commercial Data	Airborne Imaging	Airborne Imaging Inc.
	Airbus	Satellite imagery | Earth observation satellites
	EarthDaily	EarthDaily
	Planet	Planet Labs
	Maxar Technologies	Maxar Intelligence & Maxar Space Systems
	Tarin Resource Services	Tarin Resource Services

15. Appendix 9: Presentations

CLRA | ACRSD ALBERTA CHAPTER

ALBERTA INNOVATES

TOWARDS A SHARED FOUNDATION: DATA/INNOVATION – FROM THE GROUND UP… WAY UP

June 16, 2025 - Calgary, Alberta

WELCOME

Land Acknowledgement

We acknowledge the many First Nations, Métis and Inuit who have lived in and cared for these lands for generations. Alberta Innovates and the Canadian Land Reclamation Association respectfully acknowledges that we are situated on traditional territory of the First Nations; home to Métis Settlements and the Métis Nation of Alberta. We make this acknowledgement as an act of reconciliation and gratitude to those whose territory we reside on or are visiting.

AGENDA:

TIME	WHAT	WHO	LINKS TO OBJECTIVES
8:00 to 9:00	Registration & Coffee	All	
9:00 to 9:05	Land Acknowledgement	CLRA	
9:05 to 9:30 (25 min)	Setting the Stage (Presentation)	Alberta Innovates	#1: AB C&R Policy & Reg Framework
9:30 to 10:30 (60 min)	State of RS/EO Technology (Presentation)	Canada Centre for Mapping and Earth Observation	#2: To review the current and emerging capabilities and uses of **Re**mote **D**ata **C**ollection and **A**ssessment **T**ools (ReDCAT)
10:30 to 10:50 (20 min)	Coffee Break		
10:50 to 12:10 (80 min)	Session #1: Lifecycle (Temporal) Considerations and Reporting	Table Discussion	#1: Specific to using ReDCATs, what is the role of time and how should it be considered in the determination of Equivalent Land Capability?
12:10 to 12:50 (40 min)	Lunch		
12:50 to 14:20 (90 min)	Session #2: **Re**mote **D**ata **C**ollection and **A**ssessment **T**ools (ReDCAT)	Table Discussion	#2 & 3a: To identify the existing and proven ReDCAT technologies that can meet the desired data and information requirements within the next 1-2 years where pilots or demonstrations are needed.
14:20 to 14:40 (20 min)	Coffee Break		
14:40 to 16:00 (80 min)	Session #3: Project Concepts: Pilot/Demonstration Projects (<2 yrs) and Research Projects (+2 yrs)	Table Discussion	#3b: To identify the gaps in information where research and field testing is needed to identify future use of ReDCAT. #4: To fill these gaps, where possible, by developing concepts for: 4a – pilot/demonstration projects; and 4b – research projects
16:00 to 16:15	Next Steps	CLRA & AB Innovates	

OUR ROLE AT ALBERTA INNOVATES

CONVENOR & CONNECTOR

PARTNER & COLLABORATOR

FUNDER & SERVICE PROVIDER

2 Subsidiaries
InnoTech Alberta Inc.
C-FER Technologies (1999) Inc.

Land Management Solutions Program

Advancing knowledge & technologies:

Monitoring – Footprint reduction – Remediation / Reclamation – Contaminants

Improved Technologies / Policy / Practices

- Reclamation / restoration
- Environmental monitoring / modeling
- Footprint reduction
- Biodiversity & Species at Risk (SAR)

Footprint reduction

Monitoring, modelling

Biodiversity

Contiguous Intake Program, must demonstrate:

- Match funding (at least 50%)
- End-user / problem owner interest
- Potential for scale and spread of knowledge / solution
- Innovative or de-risking elements

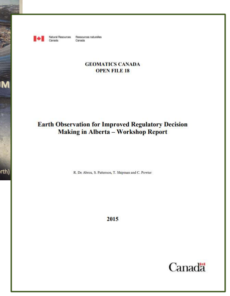
How to apply:

1. Contact a project advisor
2. Alberta Innovates website https://albertainnovates.ca/funding/agriculture-environment-program/

SETTING THE STAGE

INITIATIVES IN ALBERTA: REMOTE SENSING & EARTH OBSERVATION

- 2010 to Present: University led initiatives
  - U of Calgary (ongoing): Boreal Ecosystem Recovery and Assessment (BERA)
  - U of Lethbridge (completed): Monitoring Procedures for Reclaimed Areas in Alberta
- 2011 to 2016 Workshops
  - 2011: Earth Observation Monitoring of the Oil Sands in Alberta (Workshop Report), Workshop involving Government, Regulators, Researchers
  - 2013: Remote Sensing Technology Action Plan (RSTAP), LOOKNorth & PTAC
  - 2015: Earth Observation for Improved Regulatory Decision Making in Alberta – Workshop Report
  - 2016: Commercializing Remote Sensing Technology for Environmental Management: Moving from Data to Decision


GEOMATICS CANADA
OPEN FILE 18

Earth Observation for Improved Regulatory Decision Making in Alberta – Workshop Report

2015

Canada

CLRA ALBERTA: RECLAMATION WORKSHOP & PRACTITIONER VIEWS REPORT

- 2024: CLRA Alberta - Reclamation Workshop: *Towards a Shared Foundation for Innovation and Evolution*
- 2025: Practitioner Views on the Drivers of Change in Alberta Reclamation Practices: Past and Future in 2025
- Topics discussed included what new technologies can be used to help reclamation programs, such as:
  - Drones and remote sensing
  - Data management
  - Artificial intelligence
- Themes: Communication; Shared Responsibility; Maximizing Data Value; Education and Training; and Change


Reclamation Workshop: Towards a Shared Foundation for Innovation and Evolution

Enviro Q&A Services


Practitioner Views on the Drivers of Change in Alberta Reclamation Practices: Past and Future

Enviro Q&A Services

CANADA'S STRATEGY FOR SATELLITE EARTH OBSERVATION

- Canada's Strategy for Satellite Earth Observation – Resourceful Resilient Ready

- **End-to-end Integration and Innovation (pg 10)**: *data collected by satellites and turned into information to support decisions can be visualized as a value chain (figure left).*

- **Foster domestic and international partnerships (pg 13)**:
  - **Partnerships** - European Copernicus program; membership in the Group on Earth Observations (GEO) … to increase opportunities for Canadian companies; examples:
    - Water & Land Sustainability: Earth Observations for Multi-Scale Monitoring of Mining Impacts (GEOMIN)
    - Ecosystems, Biodiversity, and Carbon Management: GEO Biodiversity Observation Network (GEOBON)

- **Measuring key environmental and health indicators (pg 14)**: Satellite EO is also being used to make regulatory compliance and standards certification easier, more cost-effective, and safer through rapid satellite observations

USE OF REMOTE DATA COLLECTION AND ASSESSMENT TOOLS (REDCATS) IN RECLAMATION

- For the purposes of this workshop, **Re**mote **D**ata **C**ollection and **A**ssessment **T**ools (ReDCATs) collectively refer to the following:
  - Geographic Information Systems (GIS)
  - Remote Sensing (RS): Active and passive sensor types
  - Earth Observation (EO): Ground-based; Remotely Piloted Aircraft Systems (RPAS), Fixed or Rotary Wing Aircraft, Satellites
  - Artificial Intelligence & Machine Learning (AI/ML)

IN-SCOPE

- ReDCAT technologies, methodologies, or criteria that can or may be used to:
  - identify,
  - monitor,
  - assess, and/or
  - report on

  changes to infrastructure, landscape, soil, and vegetation at a given point in time or to show trends over time.

- Lands that have been reclaimed but not certified or are undergoing reclamation activities where the term "lands" refers to the following land cover types: cultivated land; forested land; native grassland; and peatlands & mineral wetlands

- Activities in Alberta with conservation and reclamation obligations, referred to as specified land, regardless of whether they require an approval or registration

OUT-OF-SCOPE

- ReDCAT technology, methodologies, or criteria for assessing spills and/or soil/water contamination/remediation

- Determining who is qualified to collect/interpret data acquired through ReDCAT

- Changes to previous decisions for lands where a reclamation certificate has been issued

- Recommendations for specific changes not related to the use of ReDCAT, including but not limited to:
  - Data governance frameworks;
  - Electronic submission platforms (e.g., Digital Regulatory Assurance System - DRAS, OneStop); and,
  - Liability management frameworks.

- Please keep marketing or sales-related discussions for the break

RULES

WE HAVE TWO EARS AND ONE MOUTH SO THAT WE CAN LISTEN TWICE AS MUCH AS WE SPEAK!
EPICTETUS, A GREEK PHILOSOPHER

- Allow everyone a chance to participate. We want to hear from you so if you have more to say, use the Post-it Notes. All information will be collected, collated, and included in the post-workshop report.
- Remember not everyone has your expertise or experience, or works in the same sector, so take the opportunity to teach (not preach) as well as to learn.
- Be respectful. Focus on the idea, not the person or their affiliation.
- In the final report, we won't attribute comments to a person, organization, or sector, so feel free to express personal as well as corporate views.

Classification: Protected A

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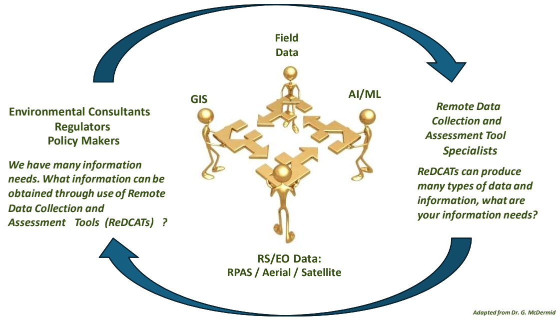
THINK OUTSIDE THE BOX

FOR GOOD IDEAS AND TRUE INNOVATION, YOU NEED HUMAN INTERACTION, CONFLICT, ARGUMENT, DEBATE
MARGARET HEFFERNAN, CEO & KEYNOTE SPEAKER

- Today is about considering alternatives and new ways of doing things
- Focus on the big picture, not issues with an individual site, application, or result
- So, have an open mind, be ready to challenge each other and be prepared to "**think outside the box**"



Classification: Protected A

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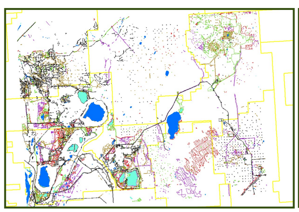
THINK OUTSIDE THE BOX…

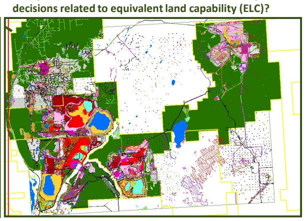
(1) What data is needed for detecting and monitoring footprint?

(2) How can this data be reported – can it be integrated with existing reporting tools (are they adequate or are changes needed? How can it be used for informing decisions related to equivalent land capability (ELC)?

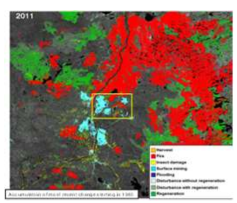
(3) How can artificial intelligence (AI) and machine learning (ML) be used to inform decision making?



Footprint Boundaries
e.g., 2007-2011 change detection using satellite imagery



Footprint Classification
e.g., 2010 Reclamation Information System (RIS) Submissions



Acknowledge: (1) Ying Zhang, Bert Guindon, Nicholas Lantz, Todd Shipman, Dennis Cho, Don Raymond, Peter White, Lixin Sun; (2) Brett Purdy, Caroline Bampfylde, Hannah McKenzie, Don Page, Geniene Sabila, Moses Bitew, Brian Brassard; (3) Rasim Latifovic; Darren Pouliout; *Sorry to those that were missed…*

Classification: Protected A

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WORKSHOP OBJECTIVES

1. To better understand regulatory requirements for conservation and reclamation, and the demonstration of the return of equivalent land capability (ELC) for reclamation certification in terms amenable to the use of ReDCAT.
2. To review the examples of current and emerging capabilities and uses of ReDCAT as they relate to these requirements.
3. To identify the:
   - Existing and proven ReDCAT technologies that can meet the desired information requirements within the next 1 to 2 years where pilots or demonstrations are needed; or,
   - Gaps in information where research and field testing is needed to expand the future use of ReDCAT.
4. To fill these gaps, where possible, by developing concepts for:
   - Pilot/demonstration projects (<2 years to complete); and/or
   - Research projects (2+ years to complete).

Classification: Protected A

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STATE OF TECHNOLOGY

Presentation:
Natural Resources Canada,
Canada Centre for Mapping and Earth Observation

17

INSERT CCMEO PRESENTATION HERE

18

BREAK

Classification: Protected A

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SESSION #1:
LIFECYCLE (TEMPORAL) CONSIDERATIONS AND REPORTING

20

SURVEY QUESTION SUBMISSIONS

- **Sensors & Use:** Mainly RPAS; some aerial & satellite (optical) imagery
  - **Sensors:** LiDAR & multispectral ➔ Used for topography (digital surface model); Vegetation assessments
  - **AI/ML**: Data organization; fusion/integration of different data; model development
- **Artificial Intelligence / Machine Learning:**
  - **Advantages:** handles large datasets; pattern recognition
  - **Limitation:** lack of training data & model validation; shouldn't replace human-level experience
- **Updating Reporting Tools:**
  - **Advantages:** allows integration of other datasets; provides additional training data
  - **Limitation:** Need for QA/QC; different reporting requirements across sectors
- **Updating Other Layers:**
  - **Advantages:** allows for trend analyses;
  - **Limitation:** Needs to be respectful of FN/Metis concerns;

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SESSION #1:

- **Current Requirement:** Under the Conservation and Reclamation Regulation, the objective of conservation and reclamation is the return of equivalent land capability (ELC).
- **Purpose:** Discussion on ReDCAT assessments (and criteria) and the **influence of time in the decision-making** process related to whether equivalent land capability (ELC) has been met.
- Examples:
  - **Single "point-in-time" assessment**: one assessment completed in a growing season.
  - **Multiple "point-in-time" assessments**: two or more assessments completed within a single growing season or across multiple growing seasons; multi-temporal datasets used. May be used to show trends over time.
    - ➢ **Enhanced**: used to support reduced sampling intensity at a field-level; or
    - ➢ **Hot Spot/Area of Concern**: like the **Enhanced approach**; but used to identify areas of concern where site-specific interventions may be required.
    - ➢ **Retrospective**: used to assess older reclaimed sites that differ for one or more reasons (e.g., historical policy; construction/reclamation practices), regardless of whether the surface reclamation liability period has expired.

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RECLAMATION & EQUIVALENT LAND CAPABILITY

- **Criteria:** numeric limits or narrative statements intended as a general guidance for the protection, maintenance, and improvement of specific uses of soil, water, and land.
- **Indicator**: An attribute which can be measured or described and used to evaluate if a criterion has been met.
- **Land Capability:** "… the ability of land to support a given land use, based on an evaluation of the physical, chemical and biological characteristics of the land, including topography, drainage, hydrology, soils and vegetation" (Conservation and Reclamation Regulation).
- **Equivalent Land Capability:** *"… the ability of the land to support various land uses after conservation and reclamation is similar to the ability that existed prior to an activity being conducted on the land, but that the individual land uses will not necessarily be identical*" (Conservation and Reclamation Regulation).

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CRITERIA AND INDICATORS

RDCAT: Considerations

- **Temporal**: data can be collected more frequently - daily, weekly, or monthly.
- **Spatial Coverage**: of the data can be collected at various scales ranging from site to (sub-)regional areas.
- **Spatial Resolution**: resolution on the ground can range from cm's to 10's of meters.
- **Spectral/Radiometric Resolution**: existing & new radar, spectral and thermal sensors enable a range of datasets to be derived.
- **Indices**: data from sensors can be combined as indices and used to quantify soil or vegetation properties
- **Data Analytics**: artificial intelligence/machine learning allows larger datasets to be processed and analyzed quicker and more efficiently.

Evaluation Criteria

- **Science Based:** needs to be testable and reproducible with a linkage to ecosystem or land management functions at a site or landscape level;
- **Workable:** offer alternatives to standard practices that promote efficiency while also recognizing any constraints associated with their use (i.e., what they cannot do);
- **Repeatable and Reliable**: data used to support decision making needs to be repeatable and reliable.
- **Transparent:** process for how data was derived should be transparent with clear supporting rationale.
- **Relevant and Enforceable**: data being required needs to be relevant with clear connection back to regulatory requirements.
- **Equitable and Accessible**: all stakeholders should have an equal opportunity to access available data (i.e., public or commercial) or equivalent dataset.

Assessment Criteria: Criteria below were pulled from various policy and guidance documents including the 2010 Reclamation Criteria along with the Criteria and Indicators Framework.

Footprint Boundary
- Lifecycle Stage: Construction / Operation / Reclamation
  - Pre-Disturbance / Construction / Operation / Reclamation
    - Evidence of Disturbance
    - Adverse Impacts Offsite
  - State of Reclamation
    - Encroachment by vegetation
    - 3rd Party Impacts
  - Determine Land Use Changes
    - Industrial Use Boundary
    - Land Use Changes
- Liability Management
  - Prioritizing inspections / audits
  - Assessing liabilities

Landscape
- Drainage
  - Surface water flow
    - Onsite
    - Offsite
  - Ponding
- Erosion
  - Wind
  - Water
- Soil Stability
  - Slumping
  - Subsidence
- Operability
  - Bare Areas
  - Slope
  - Changes in Topography
    - Due to Construction or Reclamation Practices
    - Surface heave
    - Surface deformation
  - Contour
    - Microcontour: <10 m width scale
    - Mesocontour: 10-30 m width scale
    - Macrocontour: 30-100 m width scale

Vegetation / Plant Community:
- Ecological Measures
  - Site Type
  - Ecosite / Ecological Site
  - Ecosite Phase / Ecological Range Site
- Comparisons (vs. Control)
  - Comparable to control
  - Not comparable to control
- Plant Community Composition
  - Plant Community Structure or Layers
  - Species Identification:
    - Trees
    - Shrubs
    - Forbs
    - Grasses
    - Wetland Species
    - Mosses / Lichen
    - Desirable Speces
    - Undesirable Species
    - Species Diversity
    - Species Richness
    - Species Abundance
  - Weeds
    - Prohibited Noxious
    - Noxious

Soil:
- Cultivated land - Crop Management Practice
- Bare Ground
- Color
- Moisture

Water Body / Wetland:
- Bank/Shore Stability
- Classification
  - End Pit Lake
  - Wetland - bogs, fens, marshes
  - Riparian or Wet Transitional Zones
- Physical Characteristics
  - Depth
  - Width
  - Surface Area
- Water Quantity
  - Water Flow
  - Hydroperiod
  - Water Level Variability
- Littoral Area
  - % Area
  - Littoral Slope
  - Littoral Zone - reclamation materials

Vegetation / Plant Community:
- Productivity:
  - Plant Height
  - % Survival
  - Plant Health
    - Biomass / Yield
    - Leaf Area
    - Litter
      - Quantity
      - Quality
  - 3rd party impacts
    - Anthropogenic / Human Caused
    - Animal - Browsing
    - Climate - Drought
  - Recovery Trajectories
    - % Cover
    - Site Indices
    - Other - Successional / Reclamation Trajectory Criteria
- Habitat
  - Connectivity
  - Coarse Woody Material (CWM)

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AUTHORIZATION AND REGULATED ACTIVITY TYPES UNDER EPEA

No Authorization

- Wellsites
  - Petroleum & Natural Gas
  - Geothermal
  - Brine-Hosted Minerals
- Exploration Operations
  - Coal
  - Oil Sands
  - Minerals
- Pipelines (Class 2)
  - Private and Crown Land
- Transmission Lines
- Highways / Railways

Registration, Under EPEA

- Pits (Sand & Gravel)
- Renewable Energy Operations (REOs)
  - Solar
  - Wind

Approval, Under EPEA

- Mines
  - Coal
  - Oil Sands
- Quarries (or, Mineral Mines)
- Oil Production Sites
- Pipelines (Class 1)
  - Private Land Only
- Plants Sites
  - In Situ Facilities
  - Thermal Power Plants (> 1MW)

EXISTING REPORTING TOOLS IN ALBERTA

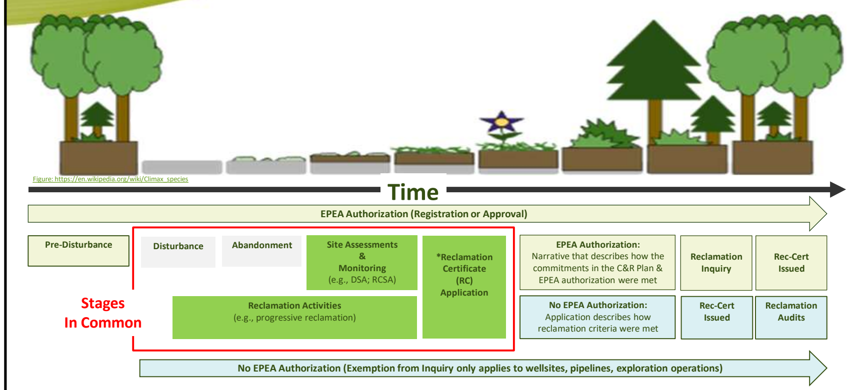
Record of Observation (RoO)

- Standard template for reporting data collected during a detailed site assessment for upstream oil and gas wellsites & exploration operations
  - Could be expanded to include geothermal & brine-hosted minerals
- Land Uses
  - Cultivated
  - Forested
  - Native Grassland
- MS Excel Format
  - Tabs – Landscape; Soils, Vegetation Data

Reclamation Information System (RIS)

- A standard template for geospatial data submission of oil sands disturbance and reclamation data (geodatabase)
- Develop capacity to receive data describing:
  - Annual C&R report
  - Reclamation & closure planning
- Provide access to historical, current and future oil sands industrial features to the public, internal staff and other stakeholders
  - Tracking of disturbance & reclamation activities
  - Progressive & final reclamation
  - Analysis of trends
  - Spatial (local, activity-specific, regional) & temporal scales
  - Project boundaries and regional integration
  - Cumulative effects & regional planning

EPEA REGULATED ACTIVITIES: RECLAMATION CERTIFICATION PROCESS



**Process for submitting applications are dependent on the applicable Regulator*

SESSION #1: QUESTIONS

1) What are the advantages (or limitations) of updating existing reporting tools such as the Record of Observation (RoO) or the Reclamation Information System (RIS) for use across other sectors?
2) Could data submitted as a regulatory requirement subsequently be used for: comparisons to other similar disturbance types; or, to update publicly available geospatial or land cover datasets?
3) What are the advantages (or limitations) of using ReDCATs for assessments compared to field-level assessments for detecting differences in landscape, soils or vegetation?
4) Provide a list of possible secondary issues (or unintended consequences) that may arise from the use of ReDCATs.

LUNCH BREAK

Classification: Protected A

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SUPPORTERS:

PTAC PETROLEUM TECHNOLOGY ALLIANCE CANADA

cosia with Pathways Alliance

30

SESSION #2:
REMOTE DATA COLLECTION AND ASSESSMENT TOOLS

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SURVEY QUESTION SUBMISSIONS

- **Fit-for-Purpose**
  - Agriculture: uses multispectral imagery & high-res DSM – nutrient management zones;
  - Forestry: LiDAR – mapping, forest surveys, canopy height models
- **ReDCAT Criteria**
  - ReDCAT: Veg health/productivity; topography; drainage/erosion
  - Field Assessment: Species composition (maybe option in future); soils assessment
- **ReDCAT**
  - **Advantages:** "site level" perspective; provides supplemental info;
  - **Limitations:** lacks detailed ground-level data (e.g., species composition)
- **Secondary Issues Arising from ReDCAT Use**
  - Acceptance by FN/Metis ~ still require field assessment; may miss important field-level info

Classification: Protected A

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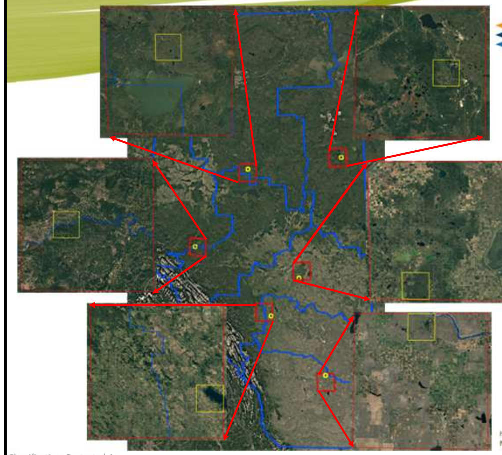
SESSION #2

- **Current requirement**: Provincial reclamation policy has developed several criteria and indicators used in field level reclamation assessments to inform decisions on whether ELC has been met. These assessments have traditionally relied upon visual, physical, biological, or chemical measurements; for example, visual assessment of plant health.
- **Purpose**: Where possible, match the appropriate technology with current and/or future criteria. Consider the current requirements related to field-level assessments and identify if appropriate ReDCAT criteria (for example, NDVI) can be used instead.



OPEN DATA AREAS
ALBERTA

Coverage

- 6 Areas:
  - Red ~2,500 km^2
  - Yellow ~100 km^2
- 7 Land-use Framework Regions (Blue)
- Sectors: Agriculture, Forestry, Energy

Data

- Open government license, no cost
- Aerial Photos (Tarin)
- LiDAR (Airborne Imaging)
- Satellite Imagery (Maxar)
- Hyperspectral/Ortho/LiDAR (NRCan-CCRS)
- Ecological Data; Soils Data; Land Titles; Dispositions; Utilities

Website: www.opendataareas.ca

https://abdatapartnerships.ca/wp-content/uploads/2021/12/ADP-Stakeholder-Session-November-16-2021.pdf

SESSION #2: QUESTIONS

1) For the existing criteria – Are there equivalent “ReDCAT criteria”?
2) For the evaluation of ReDCATs or ReDCAT criteria is there a need to compare against traditional field-level assessments? If not, why?
3) What would a “ReDCAT Detailed Site Assessment and Reclamation Certificate Application” consist of?
4) Can ReDCAT produce other supporting evidence of impacts that may influence decisions on the “success” or “failure” with respect to ELC? If so, what are they?

BREAK

SESSION #3:
PROJECT CONCEPTS: PILOTS (<2 YRS) AND R&D (+2 YRS)

37

SESSION #3: QUESTIONS

To fill knowledge gaps, where possible:

1. What pilot/demonstration projects (< 2 yrs) are needed?

2. What research & development (> 2 yrs) projects are needed?

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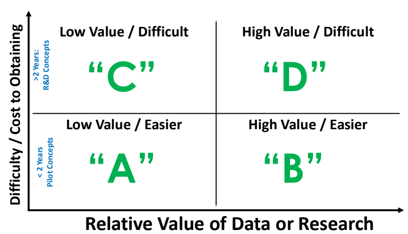
Project Concepts

- What kind of project?
  - Figure to right, quadrant: A / B / C / D
- Proposed title
- Objective or Goal
- Landcover Type
  - Cultivated/Agricultural; Forested; Native Grassland; Peatland; Mineral Wetland;
- Who should be involved:
  - Industry (sector); academia; GoA; AER; consultants;
- Data needs & specifications (if known); and,
- Potential funding sources.

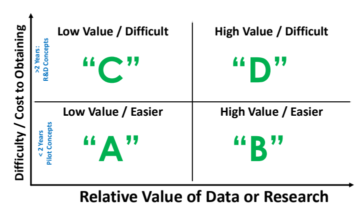


39

SESSION #3: QUESTIONS & CONCEPTS

Questions:

1. What pilot/demonstration projects (< 2 yrs) are needed?
2. What research & development (> 2 yrs) projects are needed?



Project Concepts

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40

BEFORE WE GET TO THE NEXT STEPS…

WE NEED TO ACKNOWLEDGE SOME FOLKS…

41

TABLE LEADS:

Alana DeBusschere (AER), Colin Peters (AER), James Agate (CNRL), Jason Desilets (Cenovus), Tyrel Helmsley (EPA), Kirsten Horne (AER), Tannis Such (PTAC), Katie Howes (CNRL), Erin High (Ember); Dean MacKenzie (Vertex),

NOTETAKERS:

Britney Hammerlindl (Millenium EMS); Cara Kalancha (SLR), Elizabeth Russell (), Avery Braaten (North Shore), Alexandar Gauvin (Earth Master), Harikrishna Umat (GCL), Isabella Bagni (CNRL), Bridget Fecteau (CNRL), Sarah Khan (EPA), Libby Price (Silvacom)

42

CANADIAN LAND RECLAMATION ASSOCIATION: ALBERTA CHAPTER (STEWARDSHIP & EO WORKSHOP SUB-COMMITTEES)

Amber Flammand (Earth Master); Diana Dunn (CNRL); Chris Powter (Enviro Q&A), James Agate (CNRL), Dean MacKenzie (Vertex) Tanya Richens (TCR Environmental), Shane Patterson (Alberta Innovates), Tamara Hudson (Managewise); Kelly Howard & Jacqueline Rade (AGAT)

NATURAL RESOURCES CANADA – CANADA CENTER FOR MAPPING AND EARTH OBSERVATION

Darren Janzen, H. Peter White, and Richard Fernandes and the rest of the CCMEO team (hopefully we can get them out again…)

43

SUPPORTERS:

PTAC PETROLEUM TECHNOLOGY ALLIANCE CANADA

cosia® with Pathways Alliance

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REMINDER…. BY JUNE 20TH

1) Additional comments or ideas
2) Survey

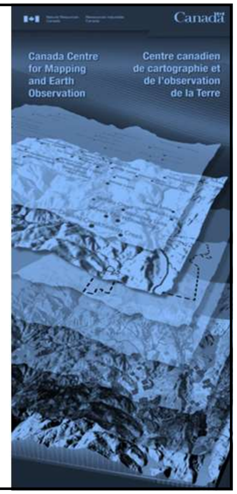
	2015 Workshop: Recommendation #4		2025 Workshop (Next Steps)
1)	Future activities should be supported by multi-sector teams from the beginning to ensure good business focus is being combined with the best science and the road to implementation is understood and ready.		**White Paper**: outcomes be used to identify areas of opportunity to address operational knowledge gaps related to using ReDCATs for conservation and reclamation through demonstration or R&D.
2)	This will require unique integrated funding frameworks that allow resources to move easily between government, academia and commercial project partners		**Partnerships – Funding & Data**: Continue exploring opportunities with provincial, federal, and commercial partners for funding & data to support project concepts.
3)	Putting EO technology on the value chain and moving it down to operational implementation and use requires a wide variety of skills and competencies, none of which exclusively exist in one sector, be it government, academia or commercial.		**Innovation & Knowledge Sharing**: CLRA Alberta (and other chapters across Canada) provides the opportunity to bring sectors together to continue discussions, exchange ideas, and present results at Lunch & Learns or the annual conference.

THANK-YOU!

EO Overview

Darren Janzen
darren.janzen@nrcan-rncan.gc.ca
Deputy Director – Science and Technology

Canada Centre for Mapping and Earth Observation
Natural Resources Canada



1

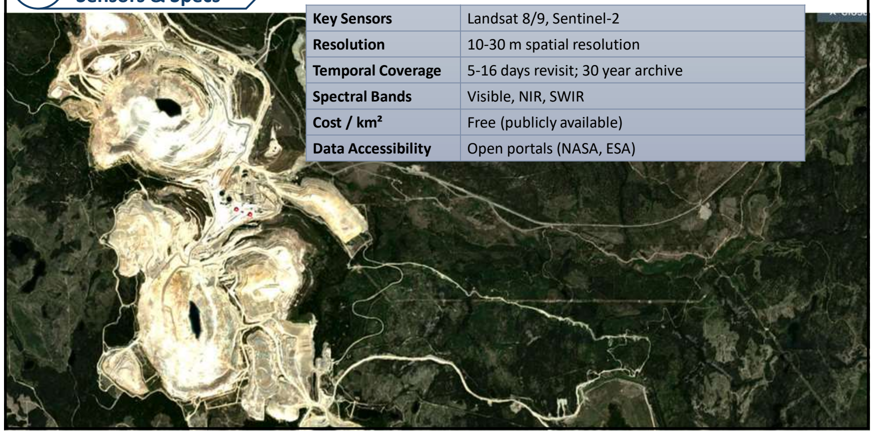
EO Overview

- Medium Resolution Optical Sensors
- High Resolution Optical Sensors
- Hyperspectral Sensors
- Radar Sensors (SAR – Synthetic Aperture Radar)
- Lidar Sensors (Light Detection and Ranging)
- Unmanned Aerial Vehicles (UAVs / Drones)

2

Medium Resolution Optical Sensors
Sensors & Specs

Key Sensors	Landsat 8/9, Sentinel-2
Resolution	10-30 m spatial resolution
Temporal Coverage	5-16 days revisit; 30 year archive
Spectral Bands	Visible, NIR, SWIR
Cost / km²	Free (publicly available)
Data Accessibility	Open portals (NASA, ESA)

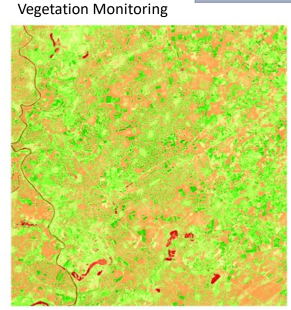


3

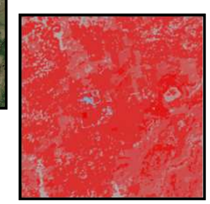
Medium Resolution Optical Sensors
Applications

Vegetation monitoring	Assess regrowth and abundance
Land cover classification	Map disturbance and recovery
Site Use	Monitor site changes over time
Water, Snow, Ice	Monitor water bodies, snow/ice dynamics

Vegetation Monitoring



Snow Cover – End Date



4

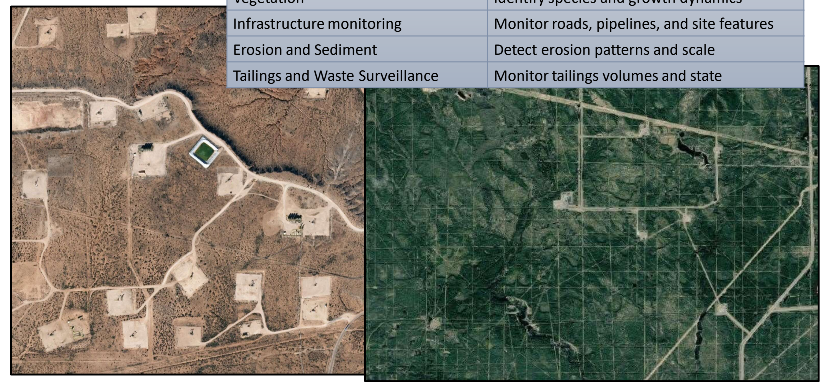
High Resolution Optical Sensors
Sensors & Specs

Key Sensors	WorldView-3/4, Pleiades, GeoEye
Resolution	0.3 – 2.0 m spatial resolution
Temporal Coverage	1-5 days revisit, taskable acquisitions
Spectral Bands	Visible, NIR, SWIR
Cost / km²	Commercial: ~$10-50 per km² (varies)
Data Accessibility	Commercial portals/providers

5

High Resolution Optical Sensors
Applications

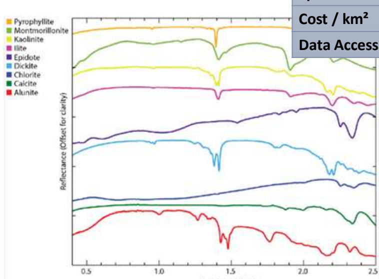
Vegetation	Identify species and growth dynamics
Infrastructure monitoring	Monitor roads, pipelines, and site features
Erosion and Sediment	Detect erosion patterns and scale
Tailings and Waste Surveillance	Monitor tailings volumes and state

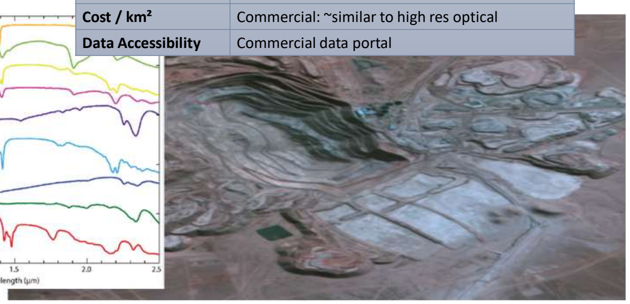


6

Hyperspectral Sensors
Sensors & Specs

Key Sensors	Wyvern; legacy-AVIRIS, PRISM
Resolution	5-30 m spatial resolution
Temporal Coverage	1-5 days revisit, taskable acquisitions
Spectral Bands	Many narrow bands (Visible, NIR, SWIR)
Cost / km²	Commercial: ~similar to high res optical
Data Accessibility	Commercial data portal

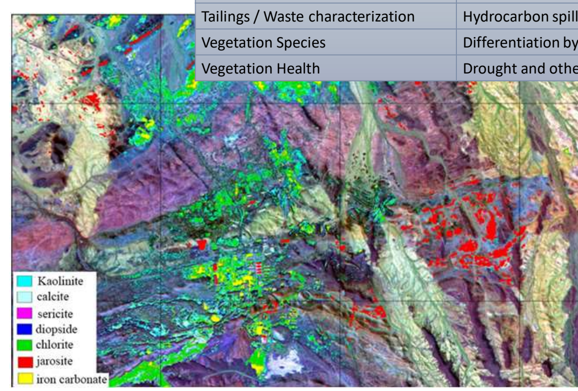




7

Hyperspectral Sensors
Applications

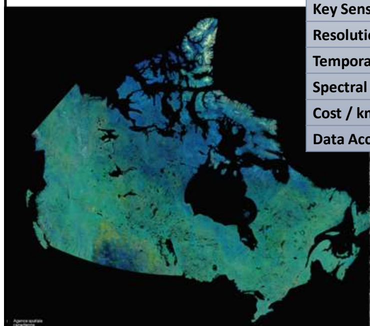
Exposed soil/rock mapping	Mineral detection, contamination detection
Tailings / Waste characterization	Hydrocarbon spills, heavy metals
Vegetation Species	Differentiation by spectral signature
Vegetation Health	Drought and other forms of stress

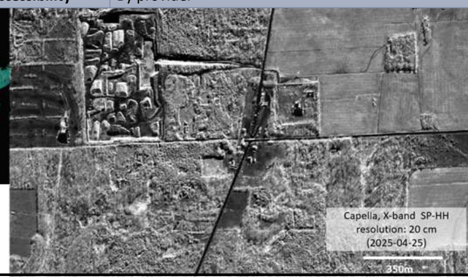


8

Radar Sensors (SAR – Synthetic Aperture Radar)
Sensors & Specs

Key Sensors	RADARSAT-2, RCM, Sentinel-1
Resolution	3-100 m spatial resolution (High res ~ 20cm – 1m)
Temporal Coverage	1-3 days revisit, all weather
Spectral Bands	C-band, X-band, L-band
Cost / km²	Free (S1), commercial pricing varies
Data Accessibility	By provider

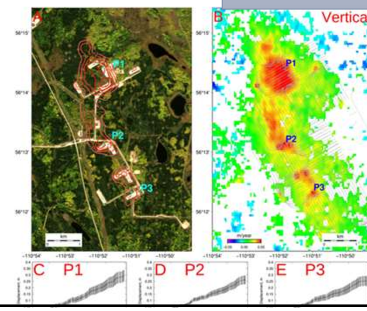


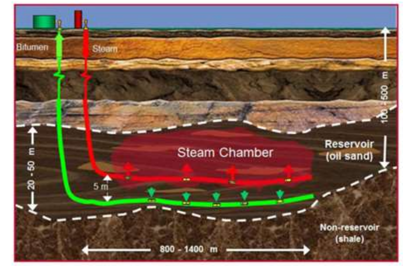


9

Radar Sensors (SAR – Synthetic Aperture Radar)
Applications

Surface deformation	Subsidence/uplift
Wetland characterization	Water changes, wetland types
Soil moisture	Assess soil conditions
Infrastructure Health	Monitor roads, dams, and tailing pond stability

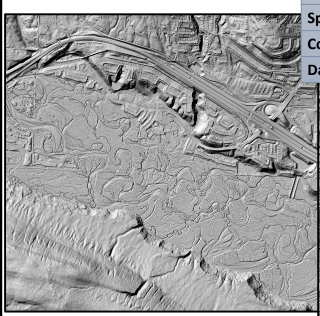


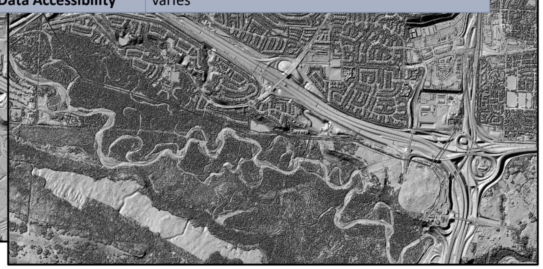


10

Lidar Sensors (Light Detection and Ranging)
Sensors & Specs

Key Sensors	Airborne Lidar (e.g., Terrapoint, Leica, Riegl)
Resolution	<1 m spatial resolution, cm vertical accuracy
Temporal Coverage	Airborne campaigns
Spectral Bands	N.A. Point Clouds describing physical features
Cost / km²	$100 per km2, sponsored coverages
Data Accessibility	varies

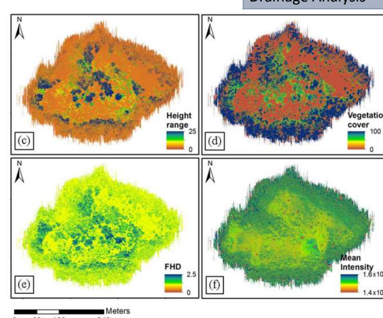


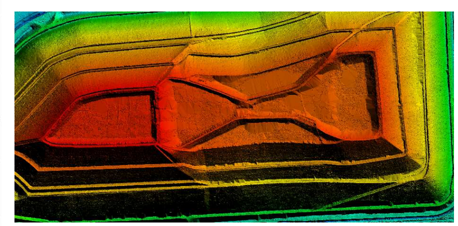


11

Lidar Sensors (Light Detection and Ranging)
Applications

Topographic mapping	Detailed DEMs (Digital Elevation Models)
Vegetation Structure Analysis	Canopy Surface Models, Tree Height
Tailings Pond Monitoring	Monitor volumetric changes
Drainage Analysis	Surface runoff and erosion pathways

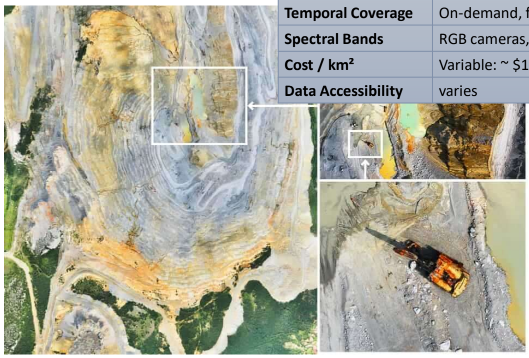




12

Unmanned Aerial Vehicles (UAVs / Drones)
Sensors & Specs

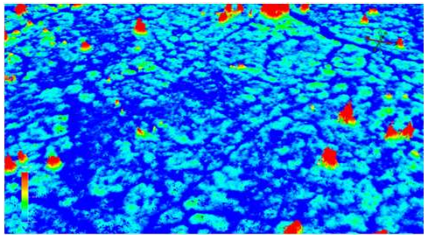
Key Sensors	DJI Phantom, Mavic, SenseFly, custom UAVs
Resolution	Sub-cm to cm spatial resolution
Temporal Coverage	On-demand, frequent flights possible
Spectral Bands	RGB cameras, multispectral, thermal, Lidar
Cost / km²	Variable: ~ $100 to $1000 km2
Data Accessibility	varies



13

Unmanned Aerial Vehicles (UAVs / Drones)
Applications

Site Mapping	Very high resolution site mapping
Thermal Monitoring	Detect leaks, groundwater seepage, anomalies
Infrastructure inspection	Inspect pipelines, roads, and equipment
Microtopography	Drainage patterns, ponding



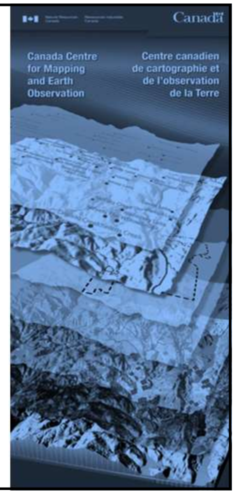
14

Integrating Earth Observation Data into Impact Assessment Frameworks

"If some countries have too much history, Canada has too much geography"
William Lyon Mackenzie King, 1936

Darren Janzen
darren.janzen@nrcan-rncan.gc.ca
Deputy Director – Science and Technology

Canada Centre for Mapping and Earth Observation
Natural Resources Canada



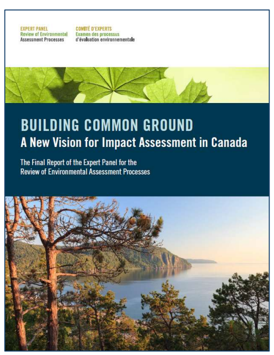
1

Integrating Earth Observation Data into Impact Assessment Frameworks

- Impact Assessment Framework in Canada
- Earth Observation for Cumulative Effects (EO4CE)
- The Future of EO and Impact Assessment

2

Impact Assessment Framework in Canada
Federal Update of Impact Assessment Legislation (2016 - 2019)



The Panel recommends that IA legislation require that all phases of IA use and integrate the best available scientific information and methods.

The Panel recommends that IA legislation require the development of a central, consolidated, and publicly available federal government database to house all baseline and monitoring data collected for IA purposes.

The Panel recommends that IA legislation require regional IAs where cumulative impacts may occur or already exist on federal lands or morine areas, or where there are potential consequential cumulative impacts to matters of federal interest.

2017 - https://www.canada.ca/en/services/environment/conservation/assessments/environmental-reviews/environmental-assessment-processes/building-common-ground.html

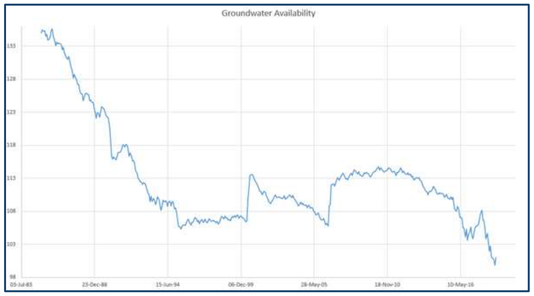
3

Impact Assessment Framework in Canada
Cumulative Impacts / Effects?

While several definitions exist, cumulative effects are defined by the Province of B.C. as "changes to environmental, social and economic values caused by the combined effect of past, present and potential future human activities and natural processes."

4

Impact Assessment Framework in Canada
Cumulative Impacts / Effects?



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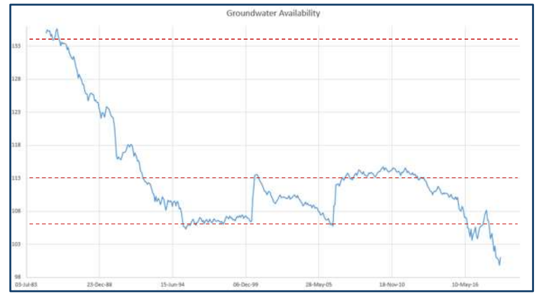
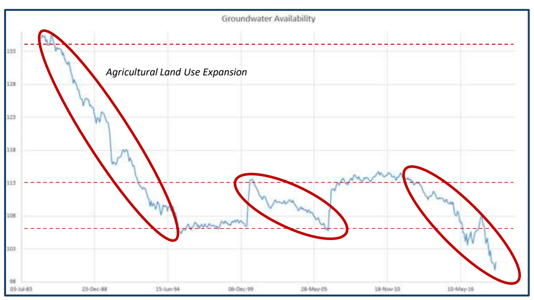
Impact Assessment Framework in Canada
Cumulative Impacts / Effects?



- How much groundwater has historically been available? ***(Baseline)***

6

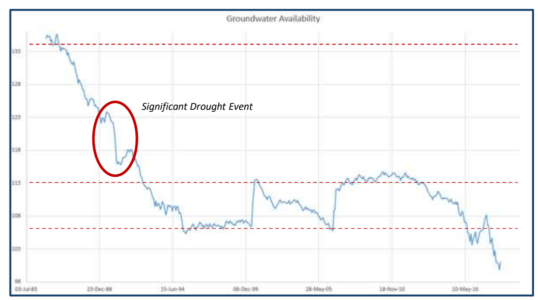
Impact Assessment Framework in Canada
Cumulative Impacts / Effects?



- How much groundwater has historically been available? ***(Baseline)***
- How does dev't and other events affect groundwater availability? ***(Impact)***

7

Impact Assessment Framework in Canada
Cumulative Impacts / Effects?



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8

Impact Assessment Framework in Canada
Cumulative Impacts / Effects?

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9

Impact Assessment Framework in Canada
Cumulative Impacts / Effects?

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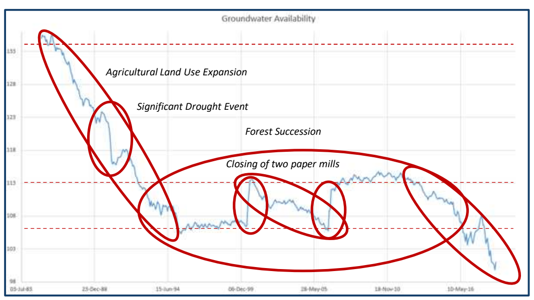
10

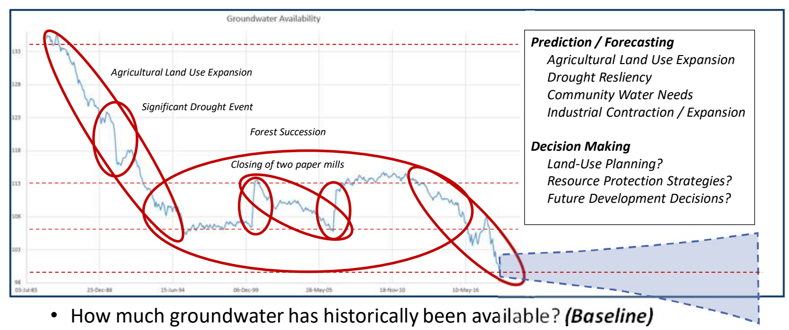
Impact Assessment Framework in Canada
Cumulative Impacts / Effects?



- How much groundwater has historically been available? ***(Baseline)***
- How does dev't and other events affect groundwater availability? ***(Impact)***
- How much groundwater withdrawal is sustainable? ***(Threshold)***

11

Impact Assessment Framework in Canada
Cumulative Impacts / Effects?



- How much groundwater has historically been available? ***(Baseline)***
- How does dev't and other events affect groundwater availability? ***(Impact)***
- How much groundwater withdrawal is sustainable? ***(Threshold)***
- *What kinds and how much development can be supported?* ***(Decision-Making)***

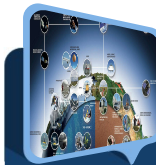
12

CCRS Assessment in 2016/17:

- Coordinated use of Earth Observation (EO) in Impact Assessment lacking in Canada; limited throughout the world

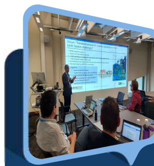
How can we accelerate the use of EO in Impact Assessment to improve Canada's IA processes?

How can we accelerate the use of EO in Impact Assessment to improve Canada's IA processes?



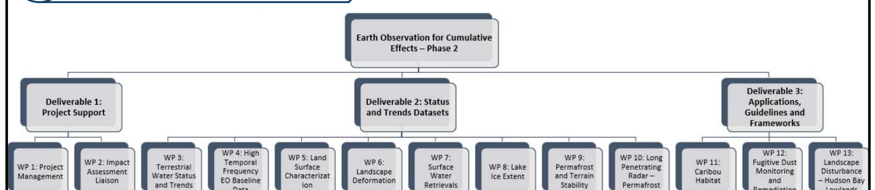
Data Availability

Technological Solutions and Associated Awareness



Analytics Expertise & Capacity

Earth Observation for Cumulative Effects (EO4CE)



- *Supporting R&D for EO data products*
  - *Adoption of new sensors*
  - *Expansion of EO data products*
- *Demonstrating application of EO in regional assessments*
- *Operationalizing data production frameworks*
- *Conducting targeted outreach of earth observation*

Earth Observation for Cumulative Effects (EO4CE)
High Temporal Frequency Baseline Data

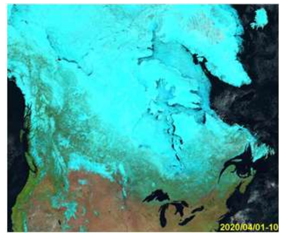
Alexander Trishchenko, Calin Ungureanu, Shaheen Ghayourmanesh

25 Year Records (MODIS/VIIRS)

Single Granule

10-day Composite

Seasonal Dynamics



- ***Changes across Canada's Arctic***
- ***Multi-Year Coastal Ice Trends***
- ***Summer Minimum Snow/Ice (MSI)***
- ***Water Body Fraction Map of Canada***

https://open.canada.ca/data/en/dataset/236680e0-0014-4edc-904b-2e1b9f4061ff

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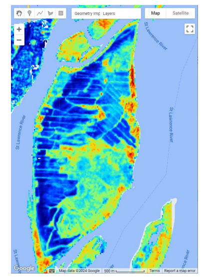
Earth Observation for Cumulative Effects (EO4CE)
Vegetation Parameters

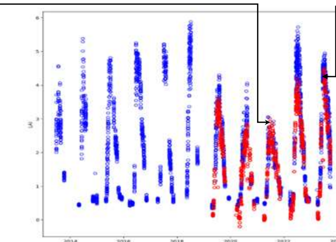
Richard Fernandes, Lixin Sun, Gang Hong

National Coverage – 2019 – Present; derived from Sentinel-2

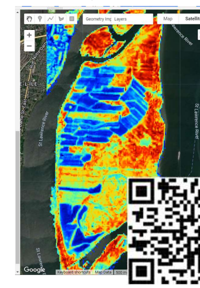
reforestation of St Therese Island

LAI July 4, 2020





LAI July 4, 2023



Medium resolution (20m-30m) Satellite Maps and time series using CCMEO LEAF-Toolbox ***(https://github.com/rfernand387/LEAF-Toolbox/wiki)***

https://doi.org/10.4095/pmrkmpbtuy

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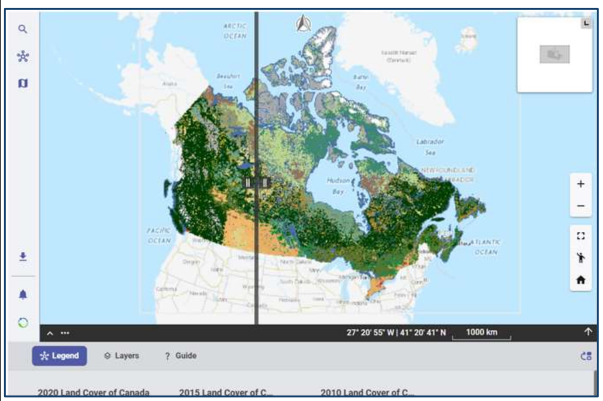
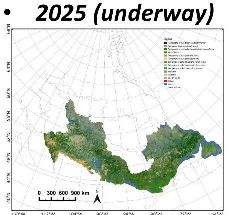
Earth Observation for Cumulative Effects (EO4CE)
Land Cover

Fariba Mohammadiminesh, Rasim Latifovic, Morgan McFarlane-Winchester



Land Cover Products:

- ***2010, 2015, 2020***
- ***2025 (underway)***



https://geo.ca/imagery/land-cover-canada/

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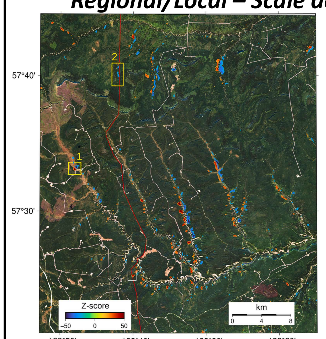
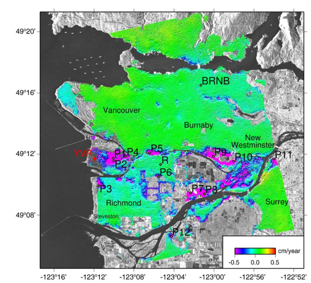
Earth Observation for Cumulative Effects (EO4CE)
National Landscape Deformation

Sergey Samsonov, Meisam Amani

National Coverage – Deformation (~50m)

Regional/Local – Scale dependent on data & time





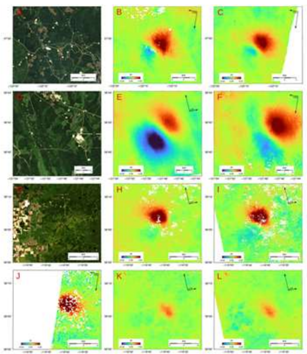
(Left) Regional Scale – slow-moving landslides (red and blue) near pipelines (white) in Northern BC

(Right) Subsidence in Greater Vancouver, particularly prevalent in Richmond & YVR

Federal Access Only; Access for others requires data sharing agreement

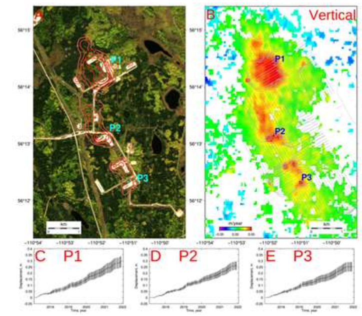
https://gcgeo.gc.ca/geonetwork/metadata/eng/1da588c1-0dc6-45e4-9e63-9acf2fdc353a

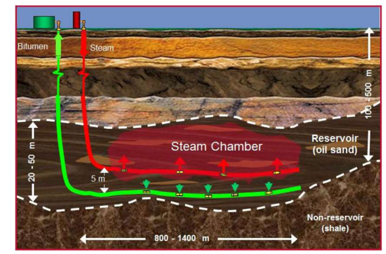
20



- 1st row: 2015 earthquake and slow-slip event induced by fracking (BC)
- 2nd row: 2017/18 slow slip events induced by fracking (BC)
- 3rd and 4th rows: 2022/23 earthquakes induced by wastewater injection (AB)

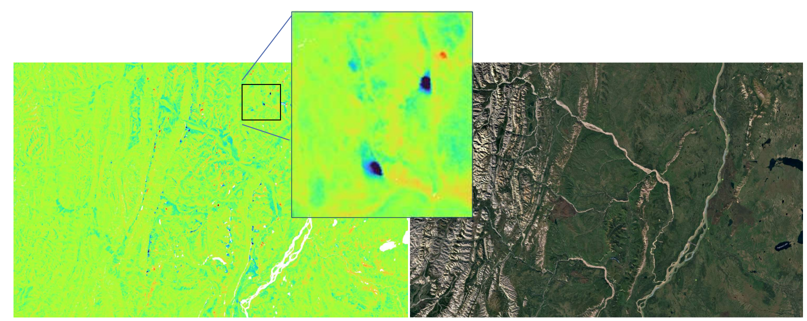
Steam-Assisted Gravity Drainage (AB)





Final Results

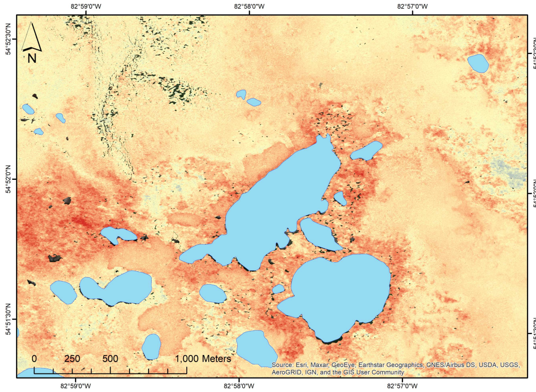
- 2017-2024 average deformation rate (measured in m/year) computed from data acquired on ascending and descending orbits
- 40 m spatial resolution
- Available for download from here
- Restricted to GC users**
- Zoom-in to see active deformation processes
- Recommended blue-green-red scale in a range ±0.1 m/year



Earth Observation for Cumulative Effects (EO4CE)

Terrain Stability

Naomi Short, Francois Charbonneau

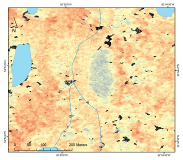


Vertical displacement (cm)

8 (uplift)

0 (stable)

-8 (subsidence)



Monitor individual landforms

No InSAR data

Waterbody

Watercourse

Hudson Bay Lowlands, summer 2023. RADARSAT-2 Spotlight (1m)

Earth Observation for Cumulative Effects (EO4CE)

Terrain Stability

Naomi Short, Francois Charbonneau

Data requirements – Site Specific DInSAR

- Commercial purchase (RCM/R2) –cost ~$4 - 5k per scene depending on resolution (10m to 1m)
- Sentinel-1 – reliable and free but resolution ~20 m (horizontal); (~1 cm vertical)
- Need at least two acquisitions over a short observation period for a single event ($10k), at least five for an event that evolves over several months or single season ($25k), many more if looking for long slow trends over a year or more, such as mining subsidence 12+ ($60k+)
- Processing costs – in house experts or contract a consulting company

Earth Observation for Cumulative Effects (EO4CE)

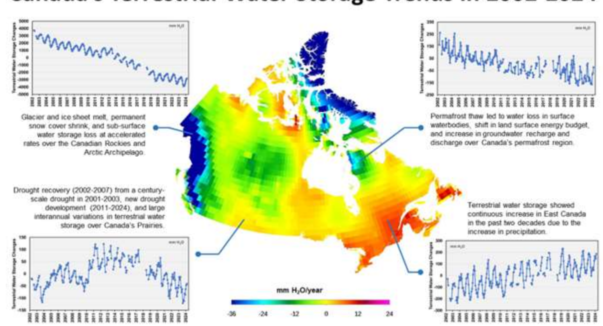
Terrestrial Water Storage

Shusen Wang, Junhua Li, Liming He

Terrestrial Water Data Products:

- ***Terrestrial Water Storage***
- ***Groundwater Recharge***
- ***Land Surface Evapotranspiration***
- ***Water Surface Evaporation***

Canada's Terrestrial Water Storage Trends in 2002-2024

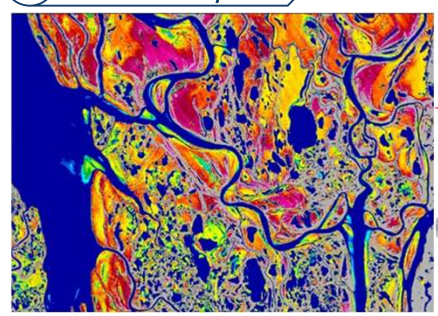


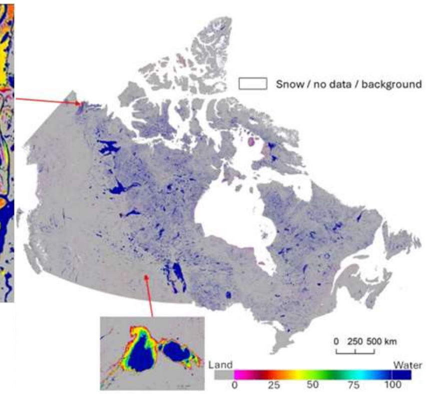
https://geo.ca/imagery/canadas-evapotranspiration-and-evaporation/

Earth Observation for Cumulative Effects (EO4CE)

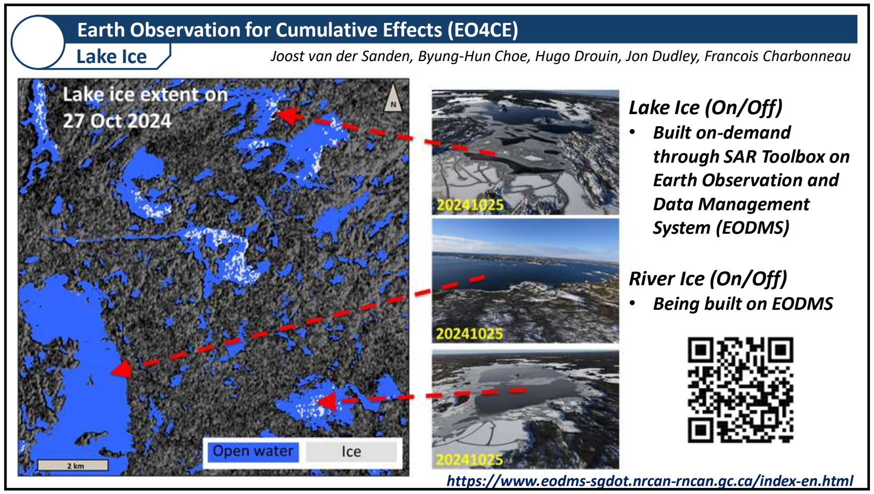
Surface Water Dynamics

Junhua Li, Shusen Wang, Liming He, Lixin Sun

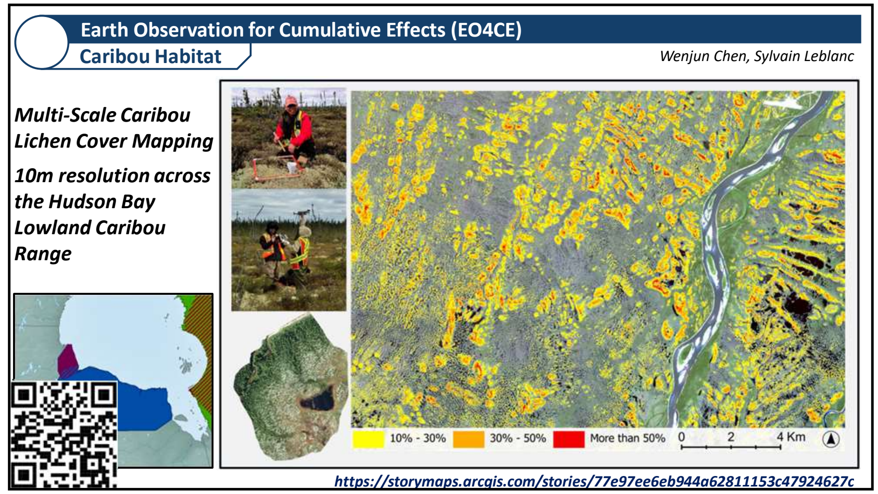




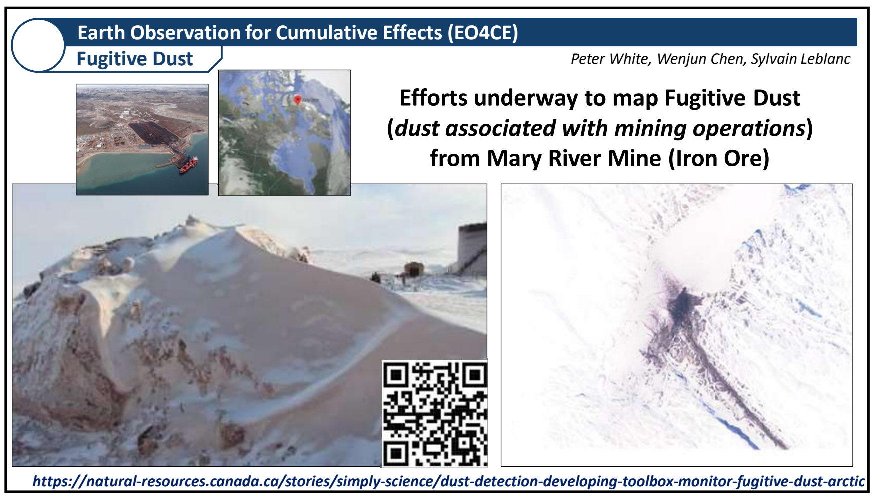
https://open.canada.ca/data/en/dataset/2b76d117-d940-4ebb-bf26-91f768081c5f


Earth Observation for Cumulative Effects (EO4CE)
Lake Ice
Joost van der Sanden, Byung-Hun Choe, Hugo Drouin, Jon Dudley, Francois Charbonneau
Lake ice extent on
27 Oct 2024
Open water
Ice
2 km
20241025
20241025
20241025
Lake Ice (On/Off)
• Built on-demand through SAR Toolbox on Earth Observation and Data Management System (EODMS)
River Ice (On/Off)
• Being built on EODMS
https://www.eodms-sgdot.nrcan-rncan.gc.ca/index-en.html

29


Earth Observation for Cumulative Effects (EO4CE)
Caribou Habitat
Wenjun Chen, Sylvain Leblanc
Multi-Scale Caribou Lichen Cover Mapping
10m resolution across the Hudson Bay Lowland Caribou Range
10% - 30%
30% - 50%
More than 50%
0
2
4 Km
https://storymaps.arcgis.com/stories/77e97ee6eb944a62811153c47924627c

30


Earth Observation for Cumulative Effects (EO4CE)
Fugitive Dust
Peter White, Wenjun Chen, Sylvain Leblanc
Efforts underway to map Fugitive Dust
(dust associated with mining operations)
from Mary River Mine (Iron Ore)
https://natural-resources.canada.ca/stories/simply-science/dust-detection-developing-toolbox-monitor-fugitive-dust-arctic

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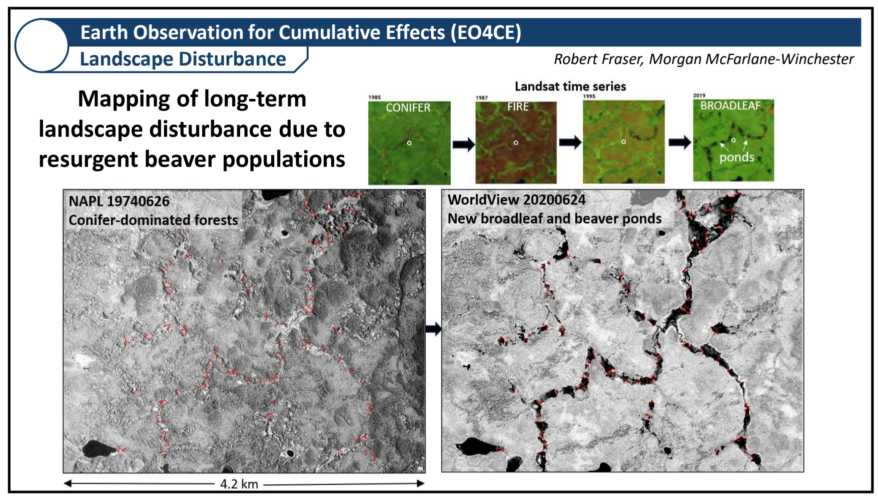

Earth Observation for Cumulative Effects (EO4CE)
Landscape Disturbance
Robert Fraser, Morgan McFarlane-Winchester
Mapping of long-term landscape disturbance due to resurgent beaver populations
Landsat time series
1985
CONIFER
1987
FIRE
1995
2019
BROADLEAF
ponds
NAPL 19740626
Conifer-dominated forests
WorldView 20200624
New broadleaf and beaver ponds
4.2 km

32

Earth Observation for Cumulative Effects (EO4CE)
Understanding Canada from Space

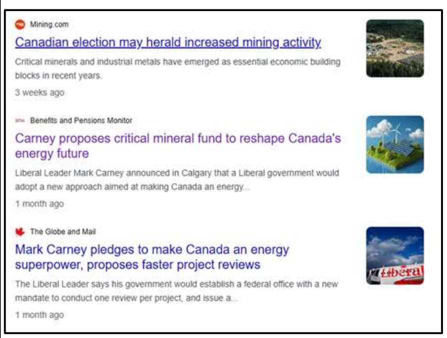
https://geo.ca/initiatives/understanding-canadas-land-from-space/

33

The Future of EO and Impact Assessment

34

The Future of EO and Impact Assessment
New Government & New Priorities



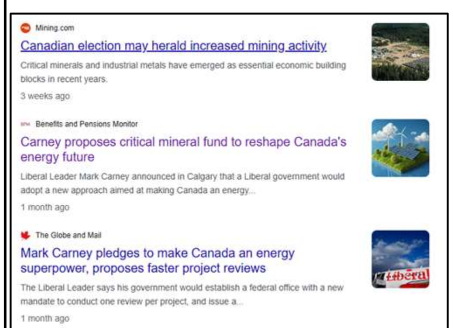
Mining.com
Canadian election may herald increased mining activity
Critical minerals and industrial metals have emerged as essential economic building blocks in recent years.
3 weeks ago

Benefits and Pensions Monitor
Carney proposes critical mineral fund to reshape Canada's energy future
Liberal Leader Mark Carney announced in Calgary that a Liberal government would adopt a new approach aimed at making Canada an energy...
1 month ago

The Globe and Mail
Mark Carney pledges to make Canada an energy superpower, proposes faster project reviews
The Liberal Leader says his government would establish a federal office with a new mandate to conduct one review per project, and issue a...
1 month ago

35

The Future of EO and Impact Assessment
New Government & New Priorities



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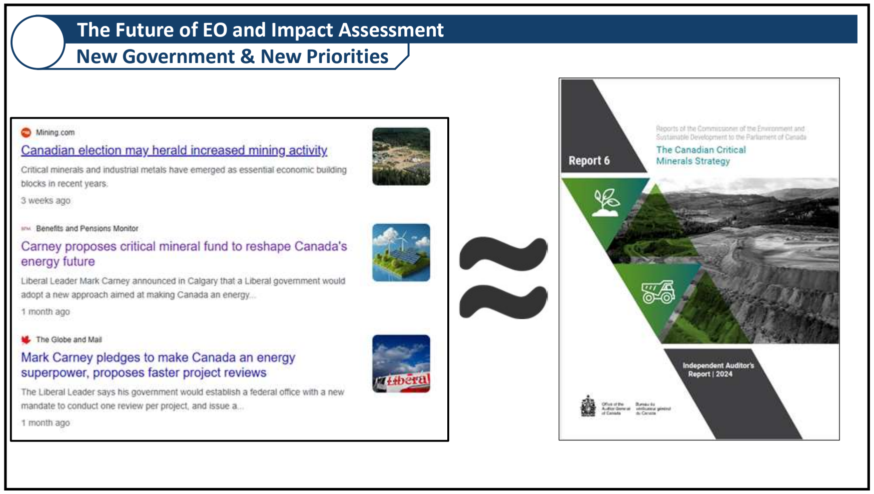
In *Yahey v. British Columbia*, the B.C. Supreme Court (BCSC) ruled that the rights of Blueberry River First Nations (BRFN) under Treaty 8 had been infringed by the cumulative impacts of decades of industrial development within BRFN's traditional territory in northeast B.C. This precedent-setting decision represents the first time a Canadian court has found an infringement of Indigenous treaty rights based on the cumulative impacts of policies and permitted development over decades, rather than based on a specific action or regulatory regime.

36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Report 6
The Canadian Critical Minerals Strategy
Independent Auditor's Report | 2024

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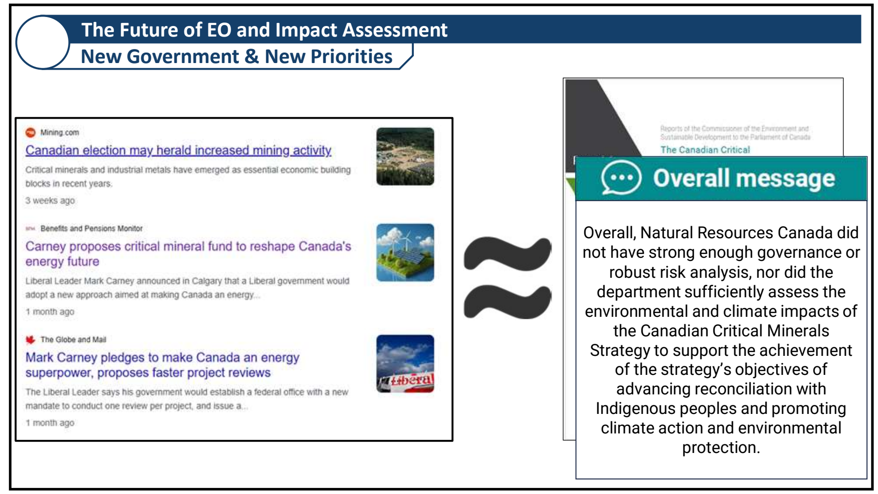
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Overall message
Overall, Natural Resources Canada did not have strong enough governance or robust risk analysis, nor did the department sufficiently assess the environmental and climate impacts of the Canadian Critical Minerals Strategy to support the achievement of the strategy's objectives of advancing reconciliation with Indigenous peoples and promoting climate action and environmental protection.

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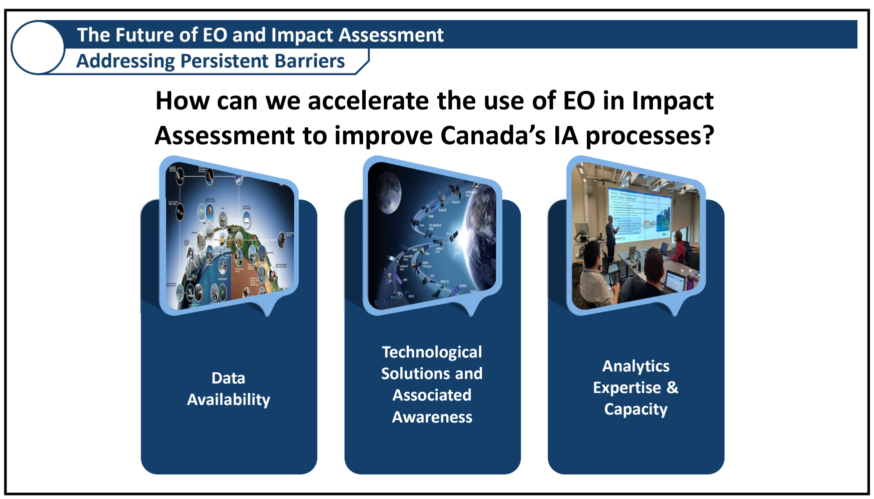
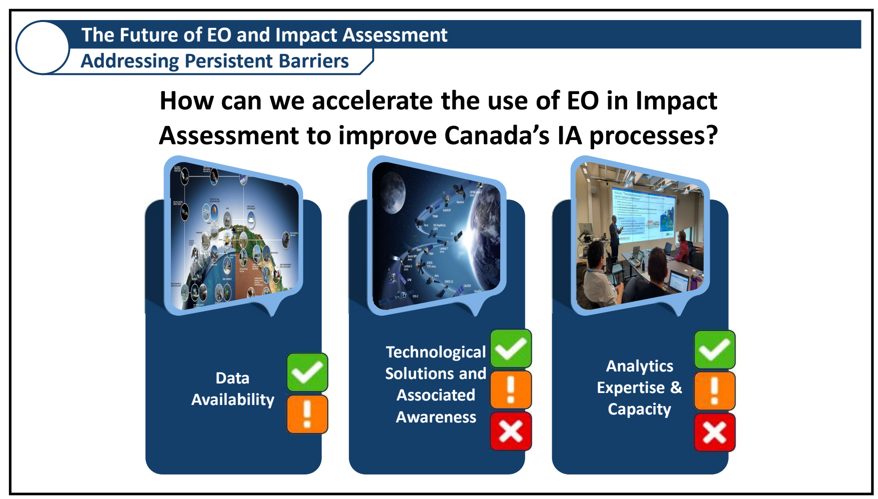

The Future of EO and Impact Assessment
Addressing Persistent Barriers
How can we accelerate the use of EO in Impact Assessment to improve Canada's IA processes?
Data Availability
Technological Solutions and Associated Awareness
Analytics Expertise & Capacity

39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The Future of EO and Impact Assessment
Addressing Persistent Barriers

How can we accelerate the use of EO in Impact Assessment to improve Canada's IA processes?

Data Availability

- Significant Data Holdings
- Long Temporal Coverage
- Datasets across Hydrosphere, Cryosphere, Biosphere

- Data Gaps (ex. High Resolution Change Products; Automated Disturbance/Anomaly Mapping)
- Challenges on Sustainable Production Frameworks

Technological Solutions and Associated Awareness

Analytics Expertise & Capacity

41

The Future of EO and Impact Assessment
Addressing Persistent Barriers

How can we accelerate the use of EO in Impact Assessment to improve Canada's IA processes?

Data Availability

Technological Solutions and Associated Awareness

- Data Access Systems (available and interactive)

- Multiple Data Access Points
- Lack of Analytics Platform

- Significant, Persistent Challenges in Cross-Domain Awareness

Analytics Expertise & Capacity

42

The Future of EO and Impact Assessment
Addressing Persistent Barriers

How can we accelerate the use of EO in Impact Assessment to improve Canada's IA processes?

Data Availability

Technological Solutions and Associated Awareness

Analytics Expertise & Capacity

- Dedicated EO Scientists
- Demonstrated Analytics

- Capacity Limitations with IA Experts & Monitoring

- Operationally Approved Regulations for EO-Based Assessment and Monitoring

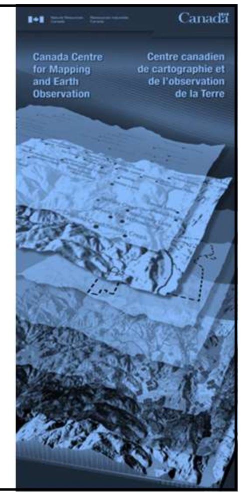
43

Integrating Earth Observation Data into Impact Assessment Frameworks

"If some countries have too much history, Canada has too much geography"
William Lyon Mackenzie King, 1936

Darren Janzen
darren.janzen@nrcan-rncan.gc.ca
Deputy Director – Science and Technology

Canada Centre for Mapping and Earth Observation
Natural Resources Canada



44

What might "EO for Reclamation" look like

Direct / Site Assessment

- Only EO approaches with high confidence & auditable evidence
  - Vegetation
  - Terrain Stability / Deformation
- Enables before-after comparisons, even retrospectively, using historical EO
- Spatial coverage of complex sites with varying degrees of reclamation

Portfolio Management

- Broader sources of EO information for situational awareness across diverse/expansive selection of sites
  - Vegetation
  - Terrain Stability / Deformation
  - Water, Land Cover, Dust, etc
- Rapid identification of anomalies or underperforming reclamation sites
- Enhances strategic planning for collection of commercial imagery or mobilizing site visits

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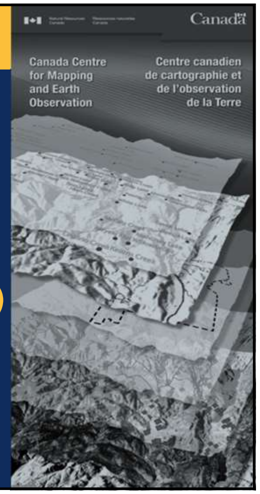
Centre canadien de cartographie et d'observation de la Terre



Case Studies in Earth Observation for Site Monitoring

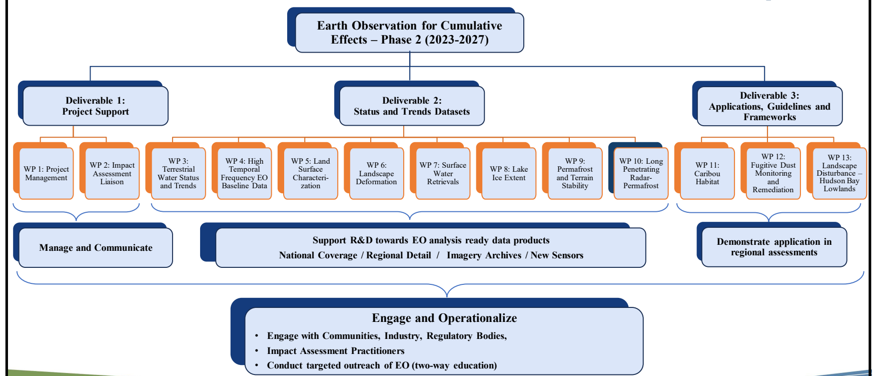
in Earth Observation for Cumulative Effects (#EO4CE)

H. Peter White, et al.

Canada

1

Earth Observation for Cumulative Effects (#EO4CE)



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2

Fugitive Dust

National Scale Issue – Regional Scale Challenge

- *Dust, Tailings, Waste Rock generated from mining operations – fugitive dust.*
- *Legacy of sites*
  *– over $200 billion in clean up and liability (*MiningWatch Canada)*
- *Environmental responsibility and Community relations – perspectives on fugitive dust often driving delays and denials of mining proposals*
- *Initiated an industry survey (2021). This highlighted:*
  - *gaps in regional cumulative effects monitoring and management practices*
  - *challenges regarding fugitive dust monitoring in diverse environmental conditions*
  - *"can't manage what you can't measure"*

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3

Geomatic tools are everywhere

Everywhere and growing

- *Tools like Google Earth Engine, QGIS, etc. provide a learning curve for non-geomatics users.*
- *Freedom of imagery. Satellite-based imagery and related data products are freely available.*
  - *30m spatial resolution*
  - *Targeted spectral bands*
  - *Increase overflight frequency.*
- *This will be leveraged, lets be prepared to guide it's use.*

Targets (red painted, 60x60 cm) are visible from space, as demonstrated by this Digital Globe image from Sept. 2016 (Mer Bleue Bog Peatland Observatory (MBPO) displayed by Google Earth).

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Jericho Mine site, from initiation to close-out (as displayed by Google Earth).

5

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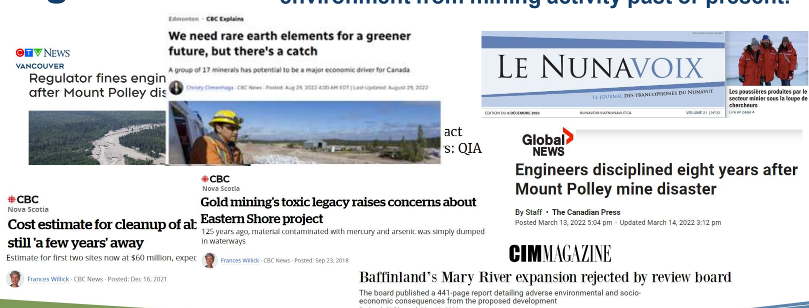
  - *Increase overflight frequency.*
- *This will be leveraged, lets be prepared to guide it's use.*

Mount Polley site, pre and post tailings dam breach (as displayed by Google Earth).

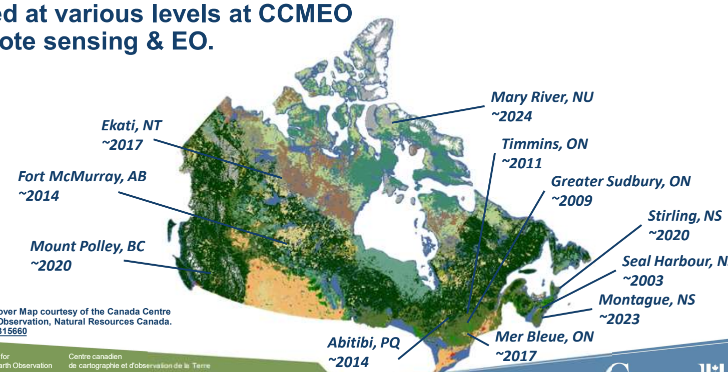
6

Fugitive Dust: Release of tailings and dust into the surrounding environment from mining activity past or present.



7

Explored at various levels at CCMEO via remote sensing & EO.



*2020 Canadian Land Cover Map courtesy of the Canada Centre for Mapping and Earth Observation, Natural Resources Canada. https://doi.org/10.4095/315660

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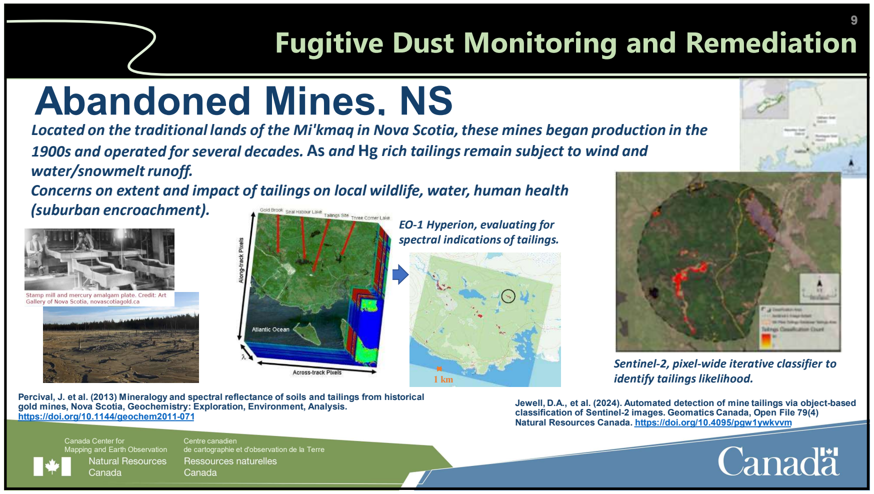
9
Fugitive Dust Monitoring and Remediation
Abandoned Mines, NS
Located on the traditional lands of the Mi'kmaq in Nova Scotia, these mines began production in the 1900s and operated for several decades. As and Hg rich tailings remain subject to wind and water/snowmelt runoff.
Concerns on extent and impact of tailings on local wildlife, water, human health (suburban encroachment).
Stamp mill and mercury amalgam plate. Credit: Art Gallery of Nova Scotia, novascotiagold.ca
Atlantic Ocean
Across-track Pixels
EO-1 Hyperion, evaluating for spectral indications of tailings.
1 km
Sentinel-2, pixel-wide iterative classifier to identify tailings likelihood.
Percival, J. et al. (2013) Mineralogy and spectral reflectance of soils and tailings from historical gold mines, Nova Scotia, Geochemistry: Exploration, Environment, Analysis. https://doi.org/10.1144/geochem2011-071
Jewell, D.A., et al. (2024). Automated detection of mine tailings via object-based classification of Sentinel-2 images. Geomatics Canada, Open File 79(4) Natural Resources Canada. https://doi.org/10.4095/pgw1ywkvvm
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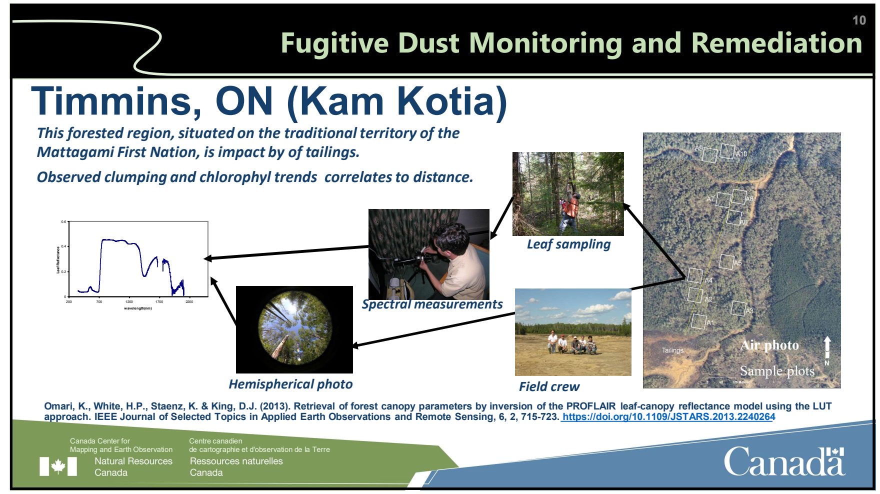
10
Fugitive Dust Monitoring and Remediation
Timmins, ON (Kam Kotia)
This forested region, situated on the traditional territory of the Mattagami First Nation, is impact by of tailings.
Observed clumping and chlorophyl trends correlates to distance.
Leaf sampling
Spectral measurements
Hemispherical photo
Field crew
Tailings
Air photo
Sample plots
N
Omari, K., White, H.P., Staenz, K. & King, D.J. (2013). Retrieval of forest canopy parameters by inversion of the PROFLAIR leaf-canopy reflectance model using the LUT approach. IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing, 6, 2, 715-723. https://doi.org/10.1109/JSTARS.2013.2240264
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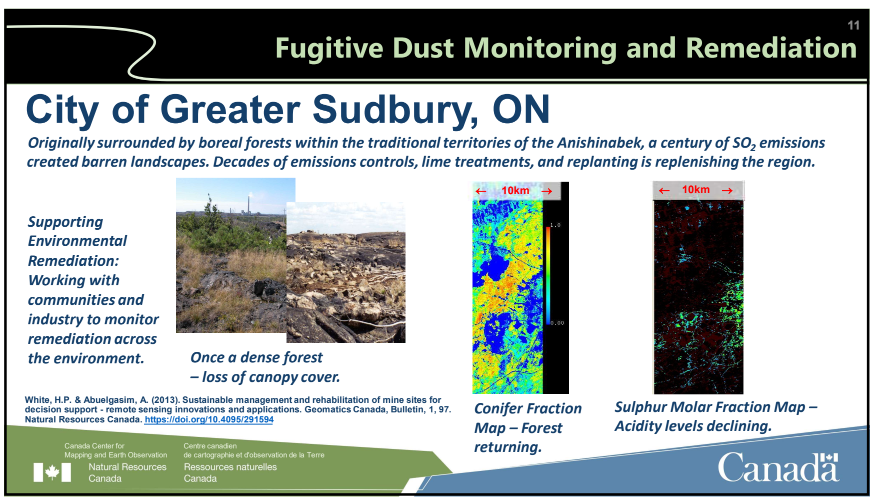
10


11
Fugitive Dust Monitoring and Remediation
City of Greater Sudbury, ON
Originally surrounded by boreal forests within the traditional territories of the Anishinabek, a century of SO_2 emissions created barren landscapes. Decades of emissions controls, lime treatments, and replanting is replenishing the region.
Supporting Environmental Remediation: Working with communities and industry to monitor remediation across the environment.
Once a dense forest – loss of canopy cover.
10km
Conifer Fraction Map – Forest returning.
10km
Sulphur Molar Fraction Map – Acidity levels declining.
White, H.P. & Abuelgasim, A. (2013). Sustainable management and rehabilitation of mine sites for decision support - remote sensing innovations and applications. Geomatics Canada, Bulletin, 1, 97. Natural Resources Canada. https://doi.org/10.4095/291594
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Centre canadien de cartographie et d'observation de la Terre
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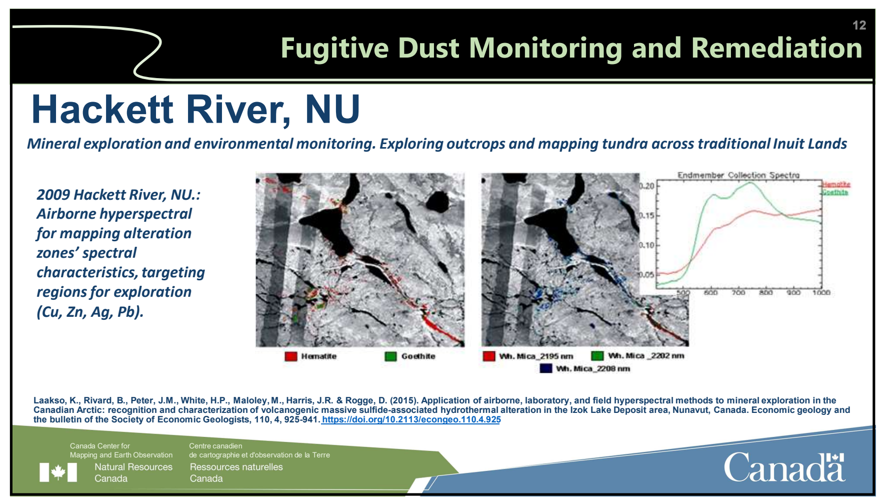
12
Fugitive Dust Monitoring and Remediation
Hackett River, NU
Mineral exploration and environmental monitoring. Exploring outcrops and mapping tundra across traditional Inuit Lands
2009 Hackett River, NU.: Airborne hyperspectral for mapping alteration zones' spectral characteristics, targeting regions for exploration (Cu, Zn, Ag, Pb).
Endmember Collection Spectra
Hematite
Goethite
Wh. Mica_2195 nm
Wh. Mica _2202 nm
Wh. Mica_2208 nm
Laakso, K., Rivard, B., Peter, J.M., White, H.P., Maloley, M., Harris, J.R. & Rogge, D. (2015). Application of airborne, laboratory, and field hyperspectral methods to mineral exploration in the Canadian Arctic: recognition and characterization of volcanogenic massive sulfide-associated hydrothermal alteration in the Izok Lake Deposit area, Nunavut, Canada. Economic geology and the bulletin of the Society of Economic Geologists, 110, 4, 925-941. https://doi.org/10.2113/econgeo.110.4.925
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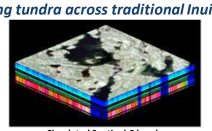
12

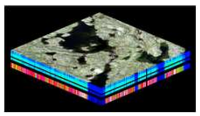
Izok Lake, NU

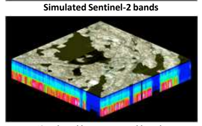
Mineral exploration and environmental monitoring. Exploring outcrops and mapping tundra across traditional Inuit Lands

2009 Izok Lake Region: Mapping surficial geochemistry spectral characteristics and tundra vegetation.

Simulating (ISDAS_v2) imagery for application analysis and development.


Simulated Sentinel-2 bands

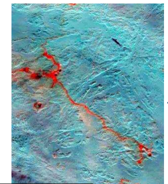

Simulated Landsat bands


Simulated hyperspectral bands

Laakso, K., Rivard, B., Peter, J. M., White, H. P. & Maloley, M. (2012). Hyperspectral remote sensing detection of hydrothermal alteration associated with the Izok Lake base-metal deposit, Nunavut, Canada. In 8th EARSeL (European Association of Remote Sensing Laboratories) SIG-Imaging Spectroscopy Workshop, abstracts, 67.

Ekati Diamond Mine, NT

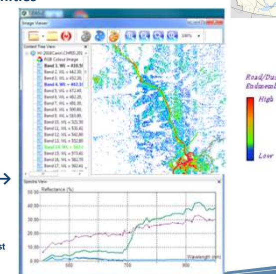
Just north of Lac du Gras, on traditional territories and homeland of the Dene and Inuit peoples, the site has been in operation since the 1990s. Located within the Bathurst Caribou range, communities have an interest in better understanding the influence mining activities.



Spectral indications of tailings dust are extracted along Misery Road.

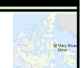
← Landsat (dust-on-snow)

CHRIS-on-Proba (dust-on-veg) →



White, H.P., Chen, W., Leblanc, S.G. (2022) Satellite Observations for Detection of Dust from Mining Activities in a Caribou Habitat, 2018 North American Caribou Workshop. https://doi.org/10.4095/330548

Mary River Mine, NU



Located midway between Pond Inlet (Mittimatalik) and Iglulik, on Inuit Owned Lands, the mine has been in operation since 2014 producing ~5Mt high-grade iron ore annually. Communities, industry, and government regulars have expressed a need for new tools towards qualitative understanding of fugitive dust distribution across the region.

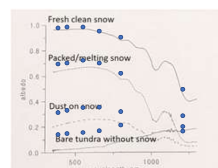

Image credits: CBC and Nunavut News media reports


Image credit: Justin Milton of Ikaarvik

In a joint project at NRCan, CanmetMINING's Climate Change Adaptation project and CCMEO's EO4CE: Fugitive Dust and Remediation project, engaged the Mittimatalik Hunters and Trappers Organization (MHTO), the Nunavut Government, and Baffinland Iron Mines Corp. (BIMC) to co-develop a study advancing new methods for fugitive dust monitoring.

Taking advantage of snow

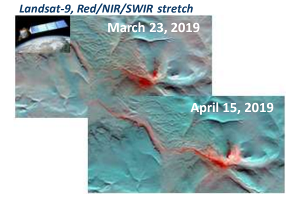
Study is ongoing – how to spectrally identify dust on snow.



Example spring spectral snow albedo, Brùggerhalvùya peninsula, Svalbard, Norway. (Gerland et al., 1999)

Is it dust?
or
Is it snow density?
Has the snow melted?
Is it ice mixture?
Is it cloud or shadow?
Is it exposed surface or slope?
When was the last snow/wind/rain/melt?
Is it something else?

Landsat-9, Red/NIR/SWIR stretch



EnMAP winter 2024 imagery overlaid on summer hi-res imagery

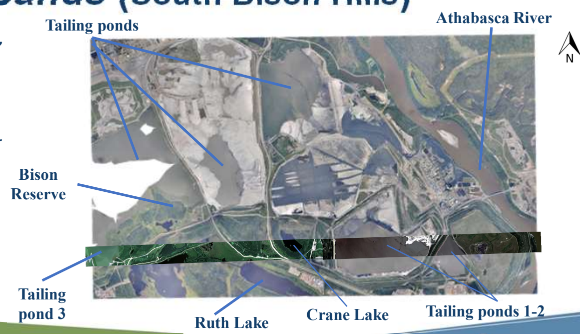
Chen, W., White, H.P., Leblanc, S.G (2024) Satellite-based method for mapping dust on snow indicators around a mine in the Canadian Arctic Archipelago., Pres 45th Canadian Symposium on Remote Sensing, Halifax.

Alberta Oil Sands (South Bison Hills)

In 2012/13 a multi-collaboration, multi-scale, multi-sensor campaign involving Governments, Universities and Industries was pursued.

Data/imagery was acquired over several sites around Fort McMurray and Cold Lake.

This is one example highlights the South Bison Hills area, part of the traditional territory of the Blackfoot Confederacy and the Maskwacis Cree.

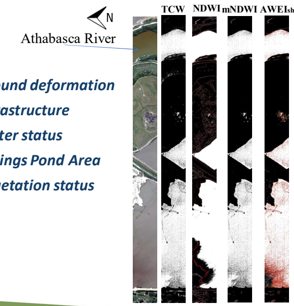


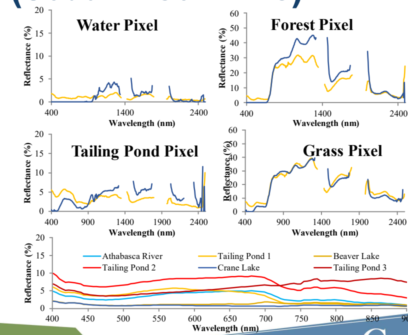
17

18
Fugitive Dust Monitoring and Remediation

Alberta Oil Sands (South Bison Hills)

Ground deformation
Infrastructure
Water status
Tailings Pond Area
Vegetation status





Canada Center for Mapping and Earth Observation
Centre canadien de cartographie et d'observation de la Terre
Natural Resources Canada
Ressources naturelles Canada
Canadä

18

19
Fugitive Dust Monitoring and Remediation

Thoughts, Comments or Questions?

We would welcome your thoughts on potential future studies.

HPeter.White@NRCan-RNCan.gc.ca

Canada Center for Mapping and Earth Observation
Centre canadien de cartographie et d'observation de la Terre
Natural Resources Canada
Ressources naturelles Canada
Canadä

19

COSIA Collaboration

James Agate Canadian Natural Resources Limited
Member, Land Environmental Priority Area

Pathways Alliance cosia with Pathways Alliance

1

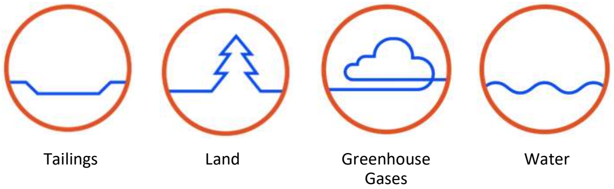
Pathways Alliance

- **Pathways Alliance** is a collaboration between Canadian Natural, Cenovus, ConocoPhillips Canada, Imperial, MEG Energy and Suncor representing six of Canada's largest oil sands producers.
- We're working together to provide energy the world needs while advancing environmental innovation.

2

Canada's Oil Sands Innovation Alliance

- In 2022, Canada's Oil Sands Innovation Alliance (COSIA) became part of Pathways Alliance.
- Formed in 2012, COSIA is focused on collaborative action and innovation in oil sands environmental technology in four key environmental priority areas (EPA):



3

Land Environmental Priority Area

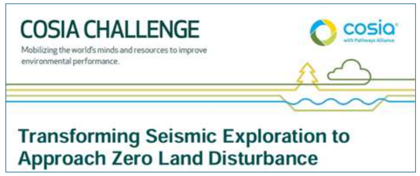
The Land EPA work falls into 3 main themes:

- Biodiversity
- Uplands, Soil, and Vegetation
- Wetlands

4

COSIA in Action

- Challenges
- Workshops
- Competitions
- Joint Industry Projects



5

Thank you

PathwaysAlliance.ca

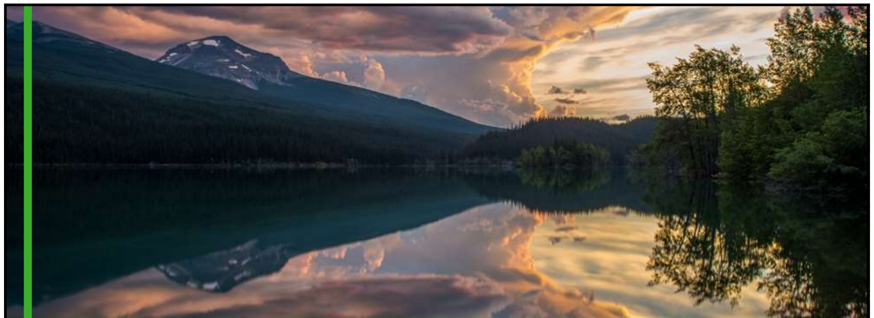
6

Advisory

Statements of future events or conditions included in the attached materials, including projections, targets, expectations, estimates, and business plans are forward-looking statements. Forward-looking statements can be identified by words such as achieve, aspiration, believe, anticipate, intend, propose, plan, goal, seek, project, predict, target, estimate, expect, forecast, vision, strategy, outlook, schedule, future, continue, likely, may, should, will and/or similar references to outcomes in future periods. Forward-looking statements in the attached materials include, but are not limited to, references to the viability, timing, impact of and the development of paths forward in support of a GHG emission-intensity reduced future and support for same from the Government of Alberta and the Government of Canada; the ability to enable reduced GHG emission-intensity from oil production and preserve economic contribution from the industry; the deployment of technologies to reduce GHG emission-intensity; the ability to create jobs, accelerate development of the clean tech sector, provide benefits for other sectors and help maintain Canadians' quality of life; and making economic investments and delivering long term value to shareholders.

Forward-looking statements are based on current expectations, estimates, projections and assumptions at the time the statements are made. Actual future results, including expectations and assumptions concerning: demand growth and energy source, supply and mix; amount and timing of emissions reductions; the adoption and impact of new facilities or technologies, including on reductions to GHG emission-intensity; project plans, timing, costs, technical evaluations and capacities, and the ability to effectively execute on these plans and operate assets; that any required support from the Government of Alberta and the Government of Canada will be provided; applicable laws and government policies, including climate change and restrictions in response to a pandemic; production rates, growth and mix; general market conditions; and capital and environmental expenditures, could differ materially depending on a number of factors. These factors include global, regional or local changes in supply and demand for oil, natural gas, and petroleum and petrochemical products and the resulting price, differential and margin impacts; political or regulatory events, including changes in law or government policy and actions in response to a pandemic; the receipt, in a timely manner, of regulatory and third-party approvals including for new technologies; lack of required support from the Government of Alberta and the Government of Canada; environmental risks inherent in oil and gas exploration and production activities; environmental regulation, including climate change and GHG regulation and changes to such regulation; availability and allocation of capital; availability and performance of third-party service providers; unanticipated technical or operational difficulties; project management and schedules and timely completion of projects; reservoir analysis and performance; unexpected technological developments; the results of research programs and new technologies, and ability to bring new technologies to commercial scale on a cost-competitive basis; operational hazards and risks; general economic conditions, including the occurrence and duration of economic recessions; and other factors referenced by the companies' in their most recent respective annual reports and management's discussion and analysis, as applicable. Forward-looking statements are not guarantees of future performance and involve a number of risks and uncertainties, some that are similar to other oil and gas companies and some that are unique to the Pathways Companies. Actual results may differ materially from those expressed or implied by forward-looking statements and readers are cautioned not to place undue reliance on them.

7



AUPRF 101

2025 - 2026

PTAC
Alberta Upstream Petroleum
Research Fund

PTAC
PETROLEUM TECHNOLOGY ALLIANCE CANADA

1

WHO WE ARE

PTAC – Petroleum Technology Alliance Canada is a **trusted**, **neutral**, **non-profit** association

- PTAC serves as the oil and gas industry's preferred facilitator for **collaborative research**, **technology development**, **demonstration**, and **deployment**
- PTAC Committees **reduce costs**, leverage government funding, and **deliver high-impact results** at a fraction of the cost producers would face independently

200+ Members – Oil & Gas Producers | Midstream & Transport | Service & Supply Companies | Government Agencies | SMEs | R&D Organizations | Academic Institutions

600+ Events – In 3 decades: Technology Information Sessions | Best Practices Workshops | Inform Smart Regulations & Policy Makers

250+ Experts – Across member companies driving projects on 10+ PTAC-led committees

1,000+ – Projects Launched & Facilitated to Date

94 – Active Projects including 63 New Projects in 2024

PTAC MLS – **Methane Leadership Summit** – Hosted by PTAC since 2018 | in Banff, AB | Sold out to 350 participants in 2025

Classification: Protected A

2

2

AUPRF

PTAC
Alberta Upstream Petroleum
Research Fund

- **Alberta Upstream Petroleum Research Fund (AUPRF)**, launched in 2006, is an industry-funded program that advances clean tech, emissions reduction, well closure, and land remediation
- **PTAC** acts as Alberta's oil and gas research arm, facilitating collaborative, industry-led innovation
- **Supported by CAPP and EPAC**, PTAC manages AUPRF to deliver practical, cost-effective solutions that advance environmental performance and operational efficiency.

Ecologists Gathering Samples for Canadian Toad Molecular Test Development

Classification: Protected A

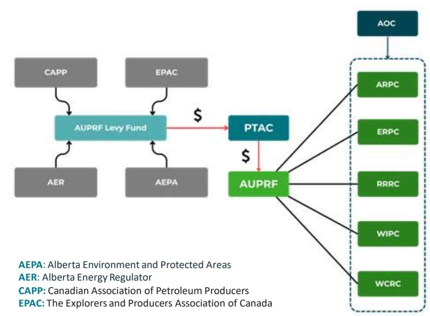
3

Governance

PTAC
Alberta Upstream Petroleum
Research Fund

AUPRF is guided by six committees

- Made up of industry, regulators, and government representatives
- Five technical and one oversight
  - AUPRF Oversight Committee (**AOC**)
  - Air Research Planning Committee (**ARPC**)
  - **Ecological Research Planning Committee (ERPC)**
  - **Remediation and Reclamation Research Committee (RRRC)**
  - Water Innovation Planning Committee (**WIPC**)
  - Well Closure Research Committee (**WCRC**)



Classification: Protected A

4

ERPC Focus Areas

PTAC
Alberta Upstream Petroleum Research Fund

- Projects focus on improving understanding of **how industrial activity and restoration efforts affect wildlife habitat, species behavior, and ecosystem recovery**.
- Ares of interest include the **development of advanced monitoring tools (eDNA, drones, WildTrax), species-specific habitat assessments, and integrating emerging technologies and biodiversity data** into regulatory and land management decision-making.

Testimonial

The AUPRF Ecological Research Planning Committee is committed to advancing science-based solutions that support responsible energy development while protecting Alberta's diverse ecosystems. Through strategic collaboration and targeted research, we aim to address key knowledge gaps and inform best practices across the industry.
– Mark Boulton, Suncor

RRRC Focus Areas

PTAC
Alberta Upstream Petroleum Research Fund

- Projects prioritize improving reclamation outcomes through **better assessment tools, updated guidelines, and innovative monitoring approaches.**
- Key areas of focus **include refining analytical and risk-based methodologies, evaluating weed management strategies, leveraging remote sensing opportunities, and advancing tools like the Tier 1 & 2 Guideline framework and Soil Salinity Tool (SST)** for more effective site closure.

Testimonial

As Chair of the RRRC, I'm proud to support the impactful projects currently underway. Our work focuses on advancing leading science and field practices to ensure remediation and reclamation efforts are carried out as cost-effectively and efficiently as possible. Many RRRC initiatives deliver practical tools, streamlined processes, and measurable cost savings—while also generating the data and evidence needed to inform sound regulatory and policy development that benefits both industry and regulators.
– Jason Desilets, Cenovus

PTAC

PTAC
Alberta Upstream Petroleum Research Fund

PETROLEUM
TECHNOLOGY
ALLIANCE
CANADA

THANK YOU!