EVALUATION OF RECLAMATION PRACTICES ON FORESTED AND PEATLAND WELLSITES

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Outline

- Project Background
- Stage 1 Findings
- Stage 2 Outputs
  - Preparing Variance Justifications for Reclamation Certification of Wellsites and Associated Facilities on Forested Lands
  - Certification of Mineral Soil Pads in the Boreal Region - Decision Framework and Support Tools (DSTs)
- Stage 3 Research Program: Mapping Padded Wellsites, Field Pilot & Full Research Program

What's the problem?

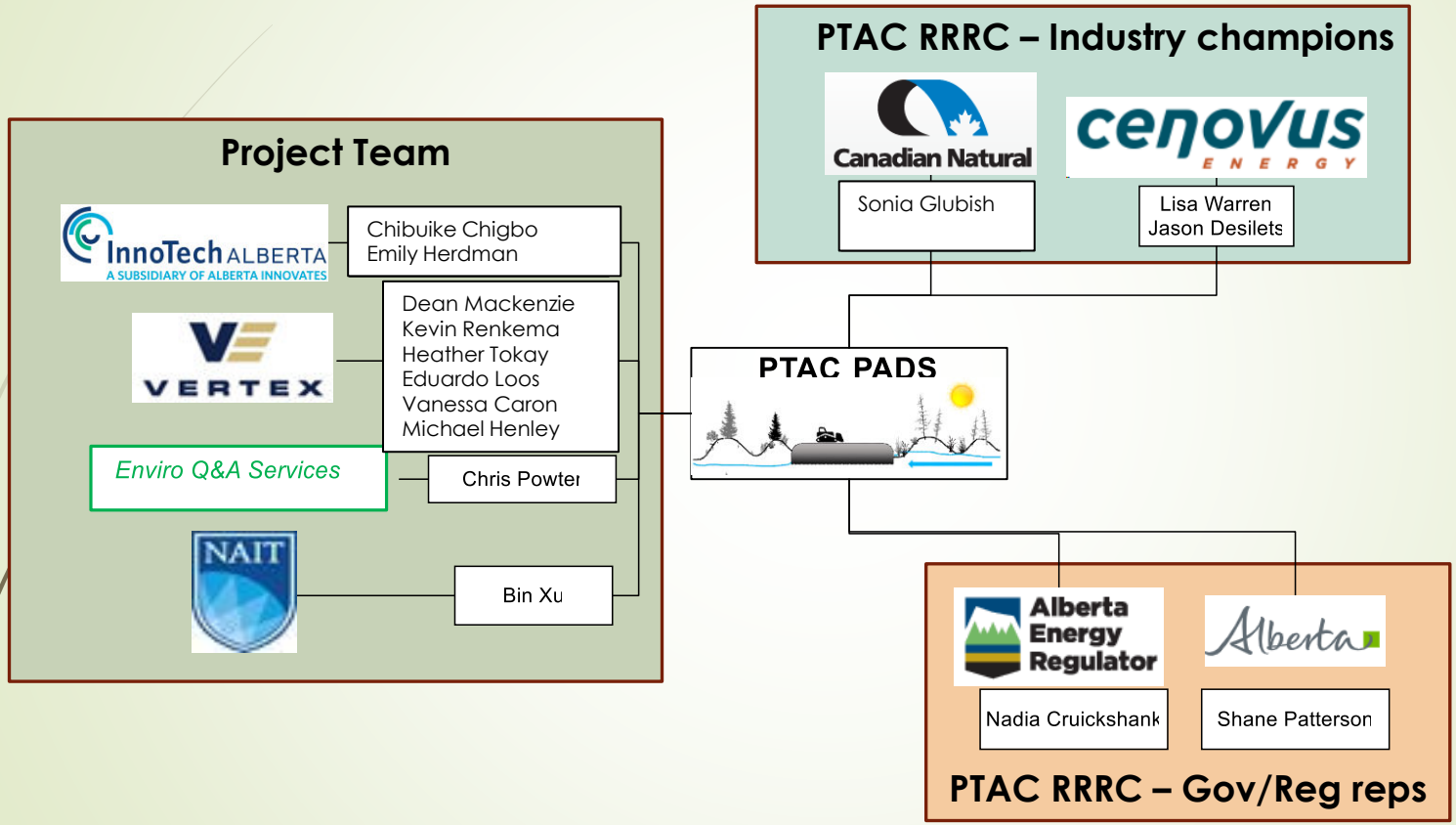
- Historically, industry and regulators have agreed **that in certain site-specific circumstances**, **legacy forested sites** that have natural vegetation establishment can be certified without removing existing vegetation and re-starting the reclamation process
- Similarly, sites with mineral pads in peatlands have been certified without pad removal or with partial pad removal.
- However, practitioners were often unclear on processes to follow and recommended data to include in applications for variance(s) and change in end-land use.

Objectives

- Document basis for current industry practices and regulatory decisions for legacy upland and padded peatland sites
- Provide practitioners with streamlined processes to follow and recommended supporting data to include in variances and change in end land use applications

The goal is to ensure that sites are on a trajectory towards functioning ecosystems with an appropriate level of activity

Project Team



Project Overview

3 Stage Project

- **Stage 1 – Desktop review (2018 to 2019)**
  - Literature and regulatory review
  - Outreach program
- **Stage 2 – Site specific reviews (2020 to 2022)**
  - Guidance documents/decision support tools for Upland and Padded Sites
  - Verification
- **Stage 3 – Research to address knowledge gaps for padded sites (on-going)**
  - Inventory of padded sites (2021-2022)
  - Pilot Study (2021-2022)
  - *Site Selection, Re-evaluation of Objectives and Sampling Methodology*
  - *Field data collection and preliminary observations*

Stage 1 – Literature Review and Outreach

- Regulatory review of applicable legislation, authorizations, guidelines and policies with emphasis on:
  - Factors affecting ecosystem function for naturally revegetated upland forested sites
  - Factors affecting functional peatland ecosystems
- Reviewed assessment methods outside oil and gas
- Surveyed practitioners, industry & regulators/government

Tokay, H., C.B. Powter, B. Xu, B. Drozdowski, D. MacKenzie and S. Levy, 2019. Evaluation of Reclamation Practices on Upland and Peatland Wellsites. Prepared for the Petroleum Technology Alliance of Canada, Calgary, Alberta. 227 pp.

Drozdowski, B., C.B. Powter, H. Tokay, D. Mackenzie and B. Xu, 2020. Certification of Mineral Pads in the Boreal Region – A Path Forward. Working Session Summary. Prepared for the Petroleum Technology Alliance of Canada, Calgary, Alberta. Report 19-RRC-09_3. 47 pp.

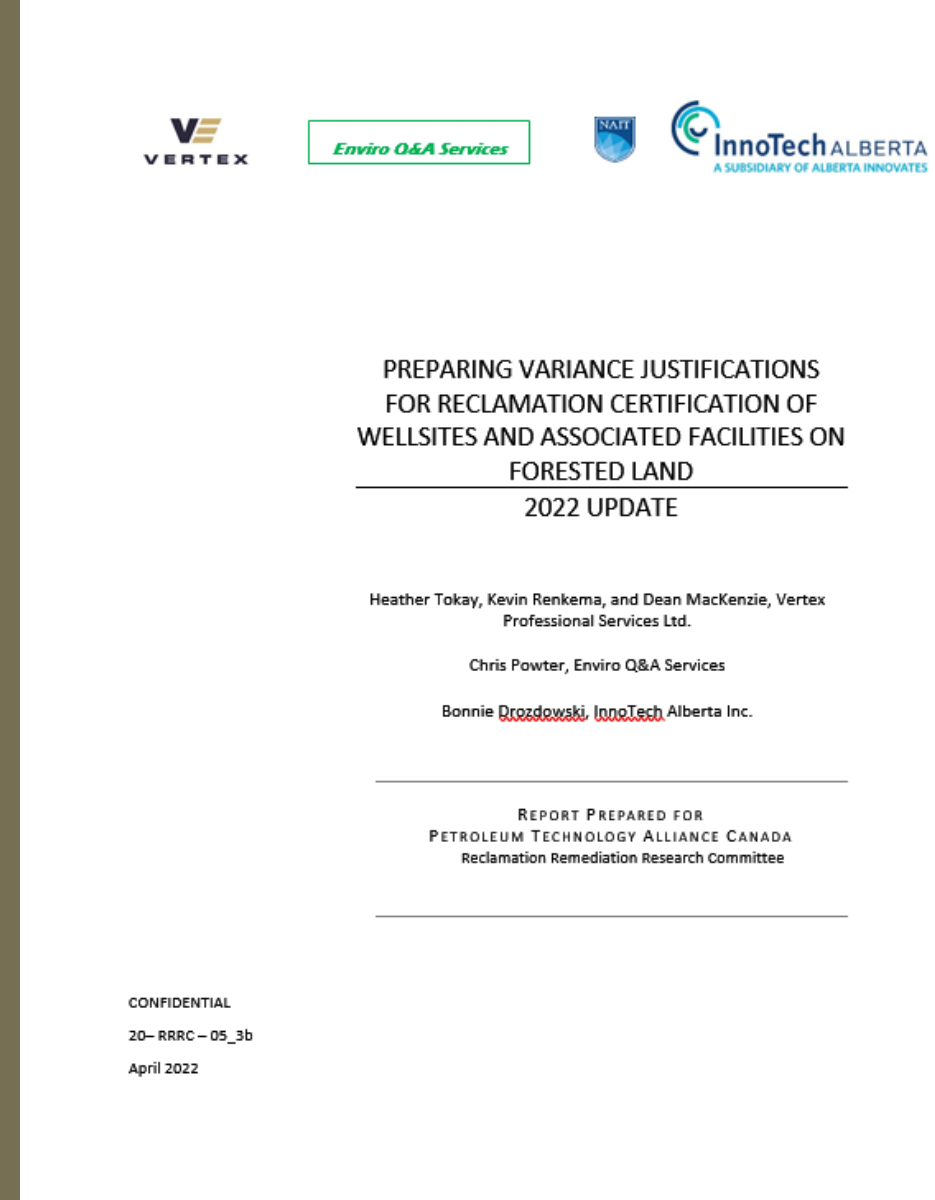
Stage 2: Support Documents

Forested Legacy Upland Sites

- Guidance to prepare complete and comprehensive variance requests to streamline for rec cert applications under **Forested Criteria**
- Emphasis on achieving best possible ecological outcomes (net environmental benefits)
- Detailed information for common variances (Landscape, woody debris; Soils; Vegetation)

Forested Pad within a Peatland

- Decision support tool(s) outlining
  - Process for practitioners to follow to guide decisions on whether an application should be made to leave a pad in place, and
  - to provide supporting information for the request to AEP for a Change in Land use



Document for Preparing Justifications

- Second version of the document
- Revised based on stakeholder feedback from 2021 and 2022
- Key changes include:
  - New Title
  - List of Caveats (Section 1.2)
  - Section 3.0 to emphasize achieving best possible ecological outcome (net environmental benefit)
  - Justification form to reduce redundancy and focus on key information to include

Decision Framework and Support Tools

- Second version of the document
- Revised based on stakeholder feedback from 2021 and 2022
- Key changes include:
  - List of Caveats
  - Added detailed description(terminology and explanation) to decision framework and support tools
  - Updated tables and support tools to improve clarity and use
  - Added section on back up documentation required

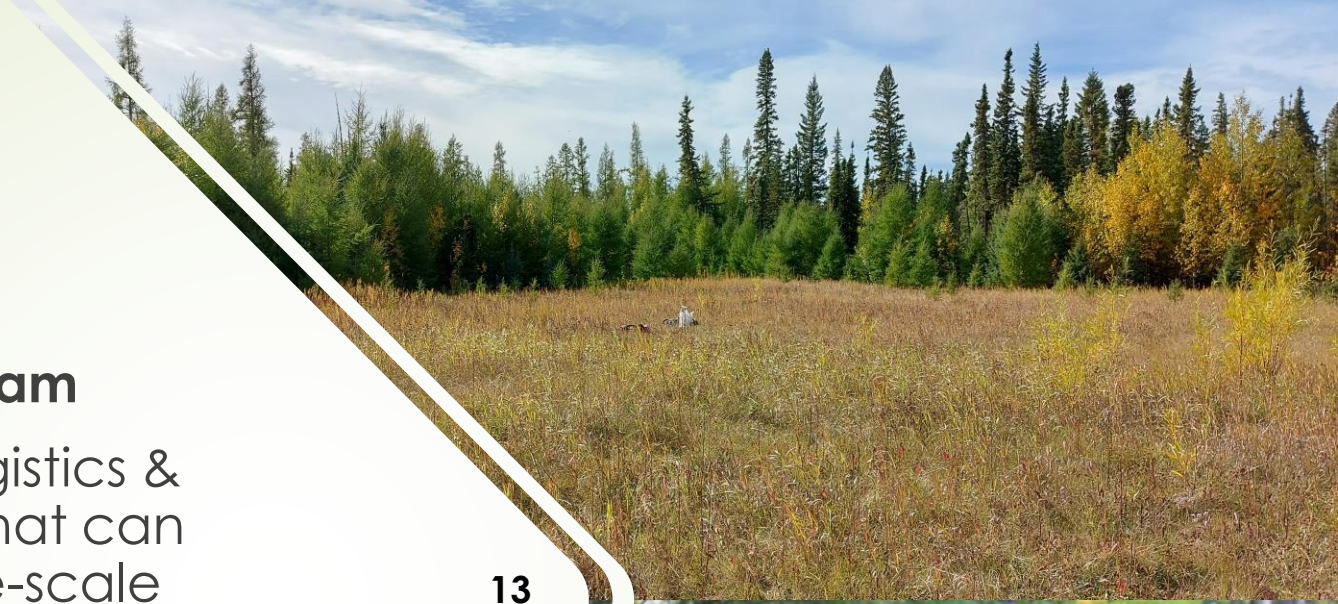
Stage 3 Research Program Goals

- Address knowledge gaps for sites that were constructed using mineral soils in peatlands, and
- Refine the decision framework and support tools, where required.

Research Objectives

1) Which pad characteristics result in a vegetation composition and tree growth performance that meet expected thresholds for a forest ecosystem
2) Develop a mechanism for detecting and evaluating the effects of pads off-site
3) Determine factors that result in padded sites having impacts to their surrounding peatland ecosystems in the long term and affect the extent and severity of these impacts
4) Evaluate the effectiveness of partial reclamation activities for alleviating off-site impacts resulting from pads left in place in peatlands

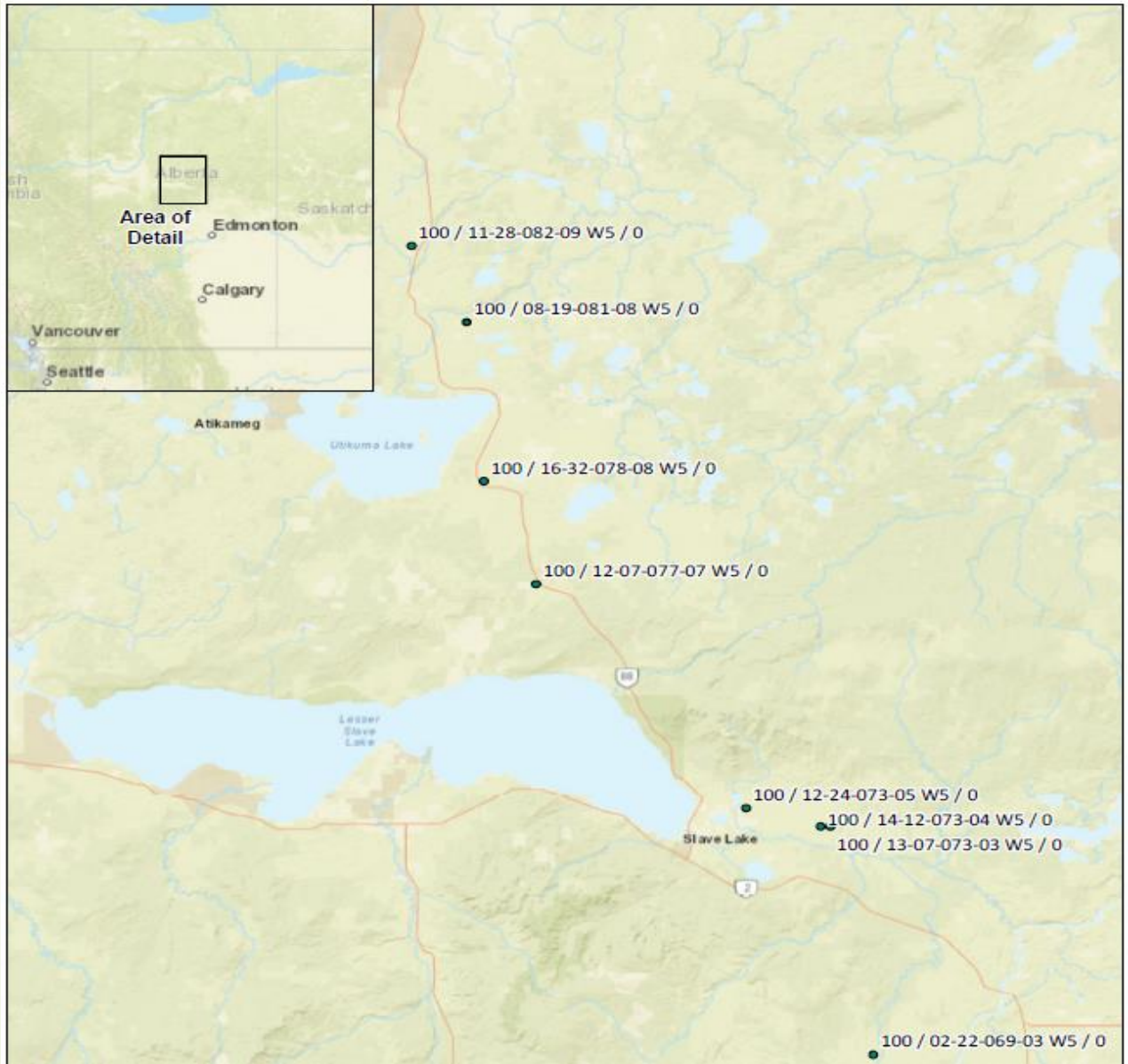
Pilot Study



- **De-risk the larger program**
  - Better understand logistics & identify efficiencies that can be applied to a large-scale study
  - Test field sampling protocol and adapt
  - Provide preliminary results to inform the program
- **Focus on Objective 1**

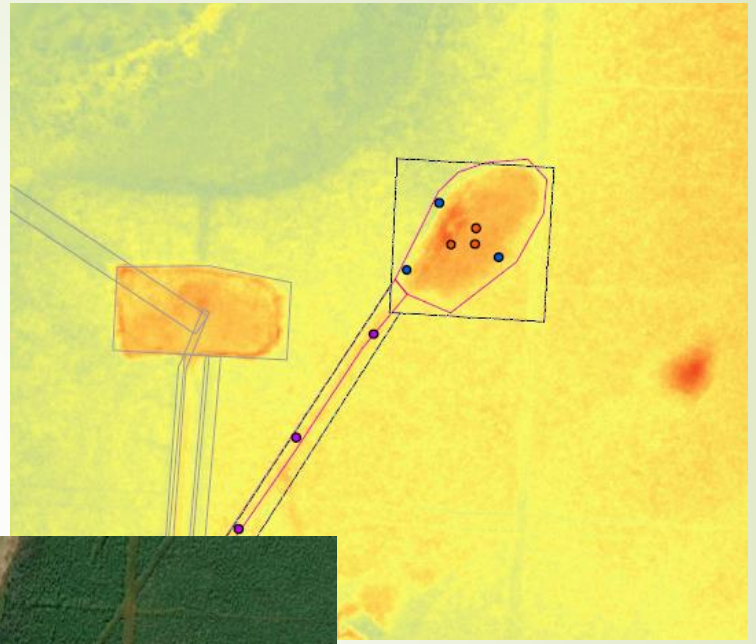
Site Selection

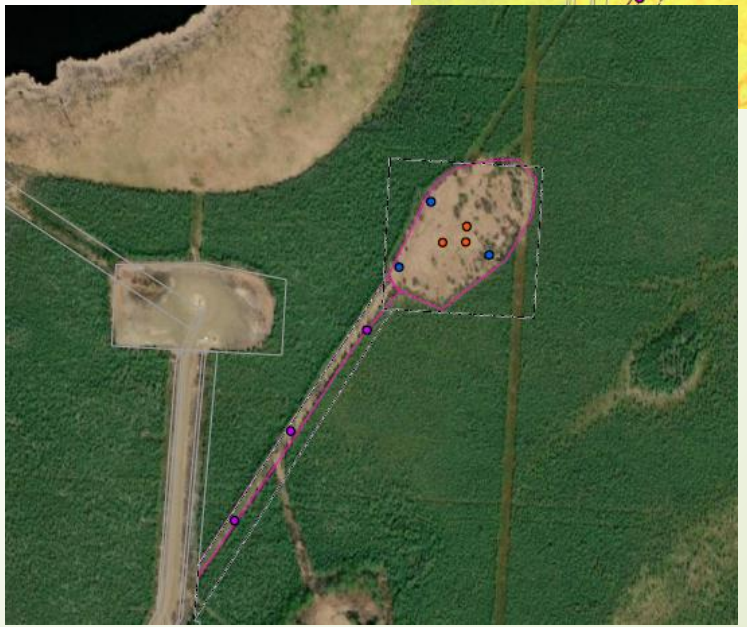
- Planned for 13 sites
- Measured 8 sites
  - Late in season
  - Difficult access



Sample Design

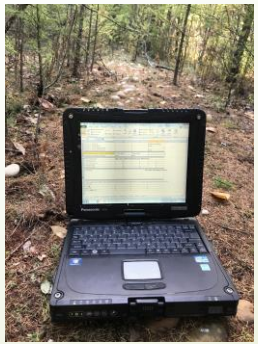
- Stratified into zones
  - Pad centre, pad periphery and access road
  - Three sample areas per zone

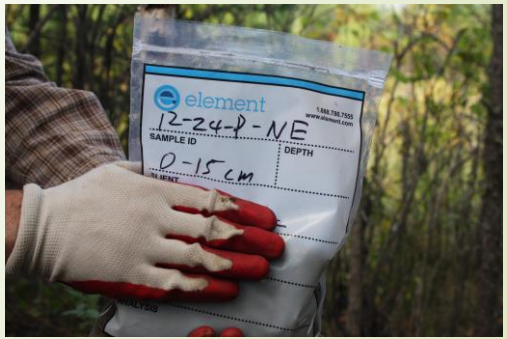




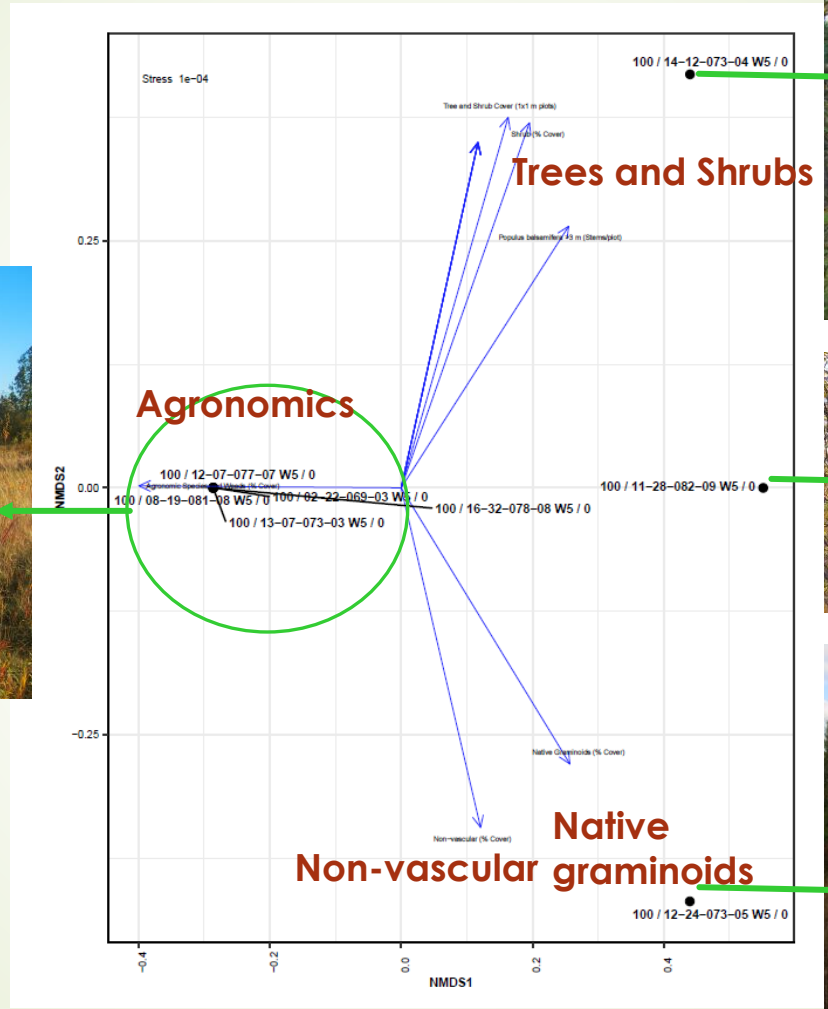
Data Collected

- **Predictive Variables**
  - Pad thickness, depth to water table, various physical and chemical properties of the pad material
  - Pad size, elevation, proximity to uplands, surrounding wetland type, time since construction/abandonment, construction and abandonment practices
- **Response Variables**
  - Cover by strata and species in 2 – 1 x 1 m plots
  - Tree density, height, DBH and age in 1 – 10 m^2 plot





Results


Stress 1e-04
100 / 14-12-073-04 W5 / 0
Trees and Shrubs
Agronomics
100 / 12-07-077-07 W5 / 0
100 / 08-19-081-08 W5 / 0
100 / 02-22-069-03 W5 / 0
100 / 13-07-073-03 W5 / 0
100 / 16-32-078-08 W5 / 0
100 / 11-28-082-09 W5 / 0
Native
Non-vascular graminoids
100 / 12-24-073-05 W5 / 0
NMDS1
NMDS2
0.25
0.00
-0.25
-0.4
-0.2
0.0
0.2
0.4

Site & Pad Characteristics

- **High variability between sites**
  - Pad thickness: 0.8 to 1.8 m
  - Elevation: 0.3 to 0.8 m above surrounding peatland
  - Texture: sand to clay and organic material mixed with mineral
  - Moisture: dry to saturated
  - Surrounding wetland types were bogs and fens
  - % Upland in surrounding area: 0 to >30%
  - Material at all sites generally had a neutral pH, non-saline and non-sodic
  - Slight variability in cations present (Ca, K, Mg, Na)

Results

Influence of Pad Characteristics on Vegetation

- Predictive factors
  - **Moisture characteristics**
  - Cation concentrations
  - Pad dimensions and elevation
  - Distance to upland areas
  - Bulk density / compaction

Dry

Moist

Wet

Pilot Study Conclusions

- **Pilot study validated the research objective and research questions**
  - Forest vegetation establishes on pads
  - There is variability in pad characteristics that influence the vegetation outcomes and can be used as predictors

There is rationale for a large-scale study

2023 Research Program

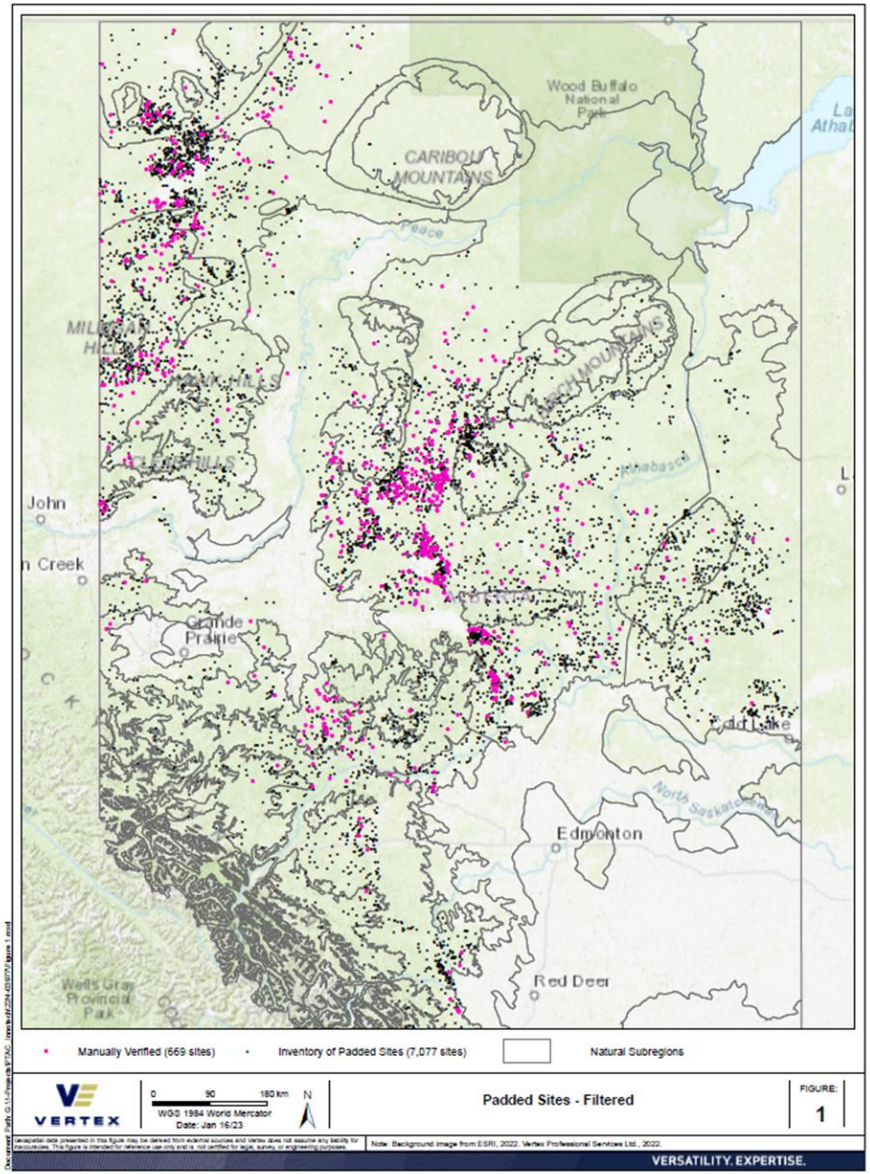
- **Spring 2023**
  - Site selection/scouting
- **Summer 2023**
  - Program execution
- **Fall 2023/Winter 2024**
  - Data analysis and reporting

Site Selection

- Select 40 sites + 20 backup sites that can be used to answer research objectives
  - Ideally multiple research objectives at each site

Site Selection

Site Selection



Site Selection

- Stratification of Pads
  - On-Site Vegetation Cover
  - Wetland Type
  - Off-Site Impacts

Site Selection – On-Site Vegetation Cover

>50% Tree/Shrub Cover – 222 Sites (out of the 669 Sites)

25 to 50% Tree/Shrub Cover – 307 Sites

<25% Tree/Shrub Cover – 140 Sites

Site Selection – Wetland Type

Wetland Type	Number of Sites
Bog	34
Bog-poor fen	85
Bog-poor fen-transitional	35
Bog-rich fen	20
Bog-rich fen-transitional	11
Bog-transitional	43
Peatland complex	31
Peatland complex-transitional	10
Poor fen	32
Poor fen-transitional	60
Poor-rich fen	97
Poor-rich fen-transitional	68
Rich fen	81
Rich fen-transitional	62

Site Selection – Off-Site Impacts

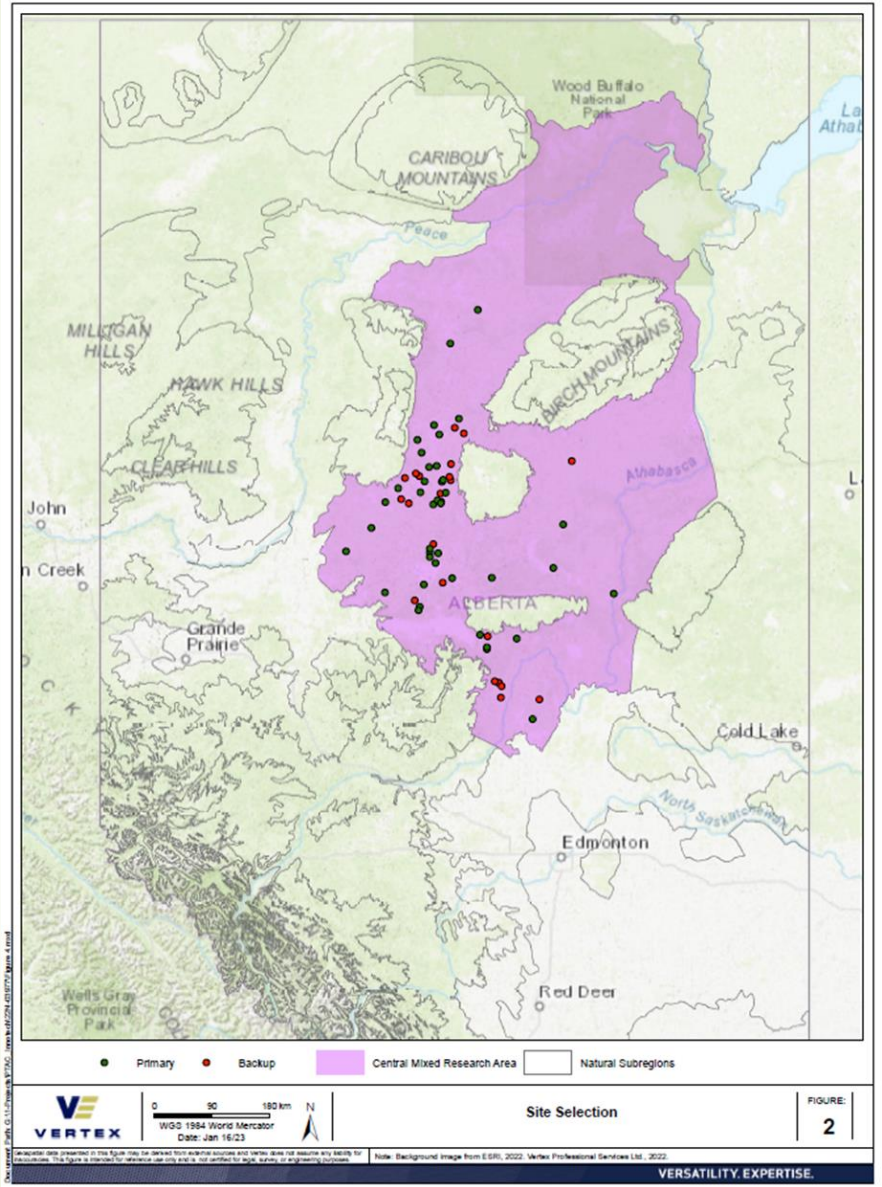
Impact– 104 Sites (out of the 669 Sites)

Slight or Uncertain– 196 Sites

No Impact– 369 Sites

Site Selection - Final

On-Site Vegetation	Off-Site Impact	Wetland Type						Grand Total
		Bog-Poor Fen	Bog-Poor Fen-Transitional	Peatland Complex	Peatland Complex-Transitional	Poor-Rich Fen	Poor-Rich Fen-Transitional	
<25% tree/shrub	None	1				1		2
	Slight	1	1	1		1	2	6
	Impact		1			2	2	5
Total		2	2	1		4	4	13
25 to 50% tree/shrub	None	1	1			2	1	5
	Slight	3					1	4
	Impact	2				1	2	5
Total		6	1			3	4	14
>50% tree/shrub	None	1	2		1		2	6
	Slight		1			2		3
	Impact	1	1	1	1			4
Total		2	4	1	2	2	2	13
Grand Total		10	7	2	2	9	10	40



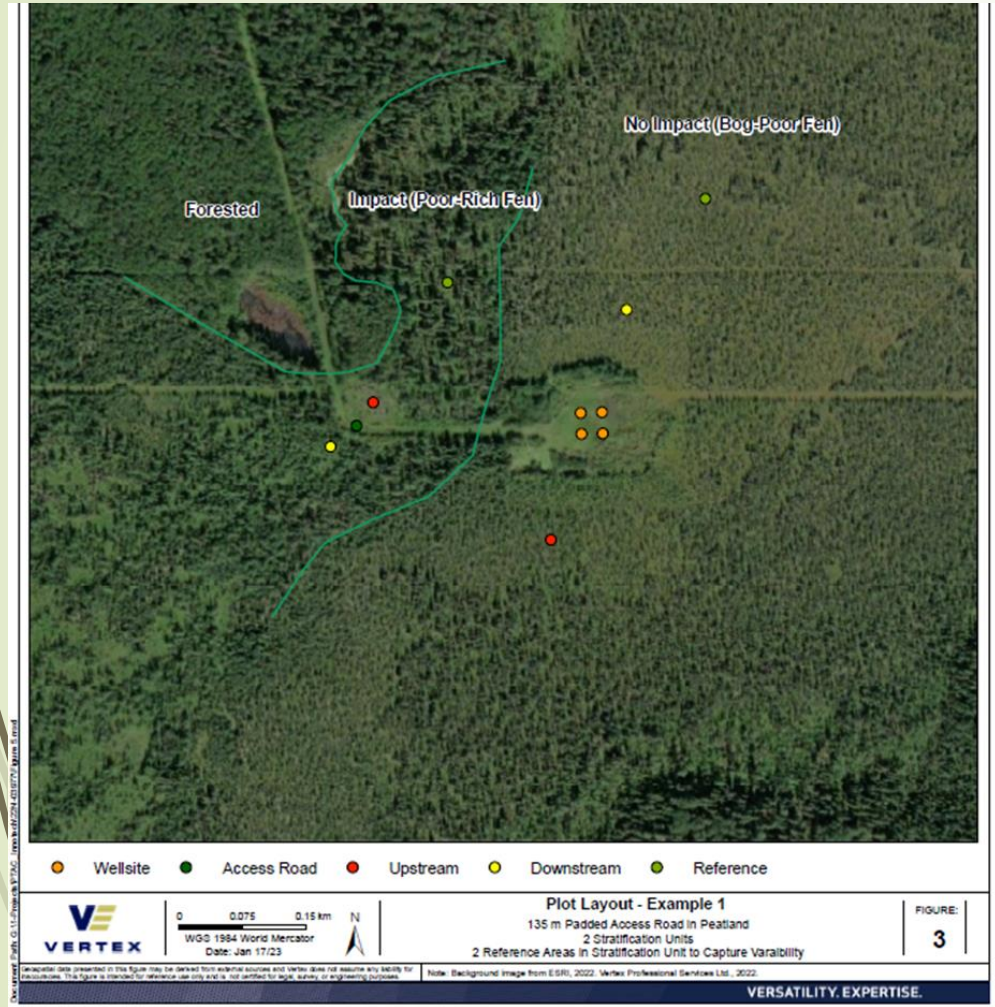
Sampling Methodology

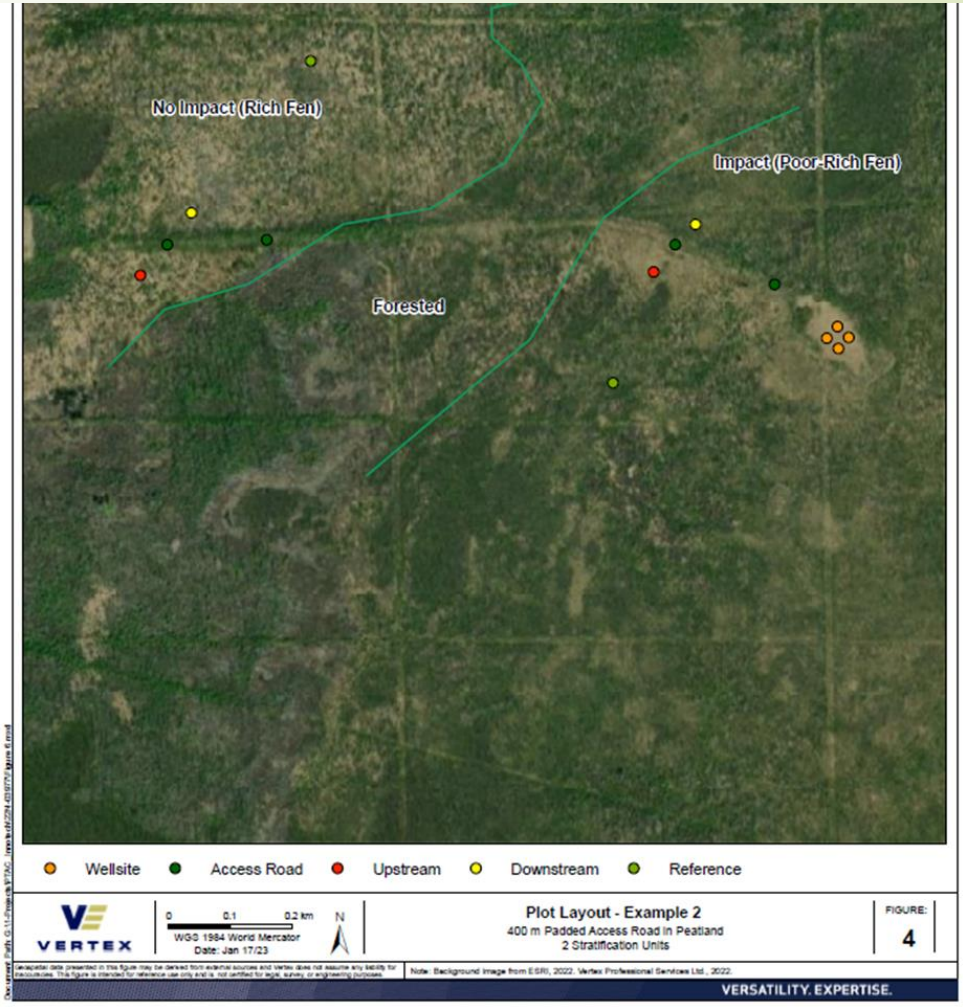
- Ground Verification of Site Characteristics (based on stratification completed)
- Plot Layout
- Measurements

Plot Layout

- On-Site for Objectives 1 and 3
  - Wellsite
  - Padded Portions of Access Road
- Offsite for Objective 3
  - Stratified by Wetland Type and Visual Impact
  - Upstream, Downstream and Reference Plots in Each Stratified Area

Plot Layout


No Impact (Bog-Poor Fen)
Forested
Impact (Poor-Rich Fen)
Wellsite
Access Road
Upstream
Downstream
Reference
VERTEX
0 0.075 0.15 km
WGS 1984 World Mercator
Date: Jan 17/23
N
Plot Layout - Example 1
135 m Padded Access Road in Peatland
2 Stratification Units
2 Reference Areas in Stratification Unit to Capture Variability
FIGURE:
3
Note: Background image from ESRI, 2022. Vertex Professional Services Ltd., 2022.
VERSATILITY. EXPERTISE.


No Impact (Rich Fen)
Impact (Poor-Rich Fen)
Forested
Wellsite
Access Road
Upstream
Downstream
Reference
VERTEX
0 0.1 0.2 km
WGS 1984 World Mercator
Date: Jan 17/23
N
Plot Layout - Example 2
400 m Padded Access Road in Peatland
2 Stratification Units
FIGURE:
4
Note: Background image from ESRI, 2022. Vertex Professional Services Ltd., 2022.
VERSATILITY. EXPERTISE.

Measurements

- On-Site
  - Characterization of the Pad (thickness, moisture regime, physical and chemical characteristics)
  - Vegetation (composition, cover, and tree density and growth)
- Off-Site
  - Vegetation (composition, cover, and tree density, health and growth)
  - Characteristics of the Soil/Peat (thickness, degree of decomposition)
  - Hydrology (depth to water, water chemistry – one time measurements)

2023 Preliminary Observations – Objective 1

- Wide range of outcomes
- Differences are partially due to age since reclamation
- Pad thickness and compaction influence soil moisture and vegetation community
  - Thicker and highly compacted pads tend to have drier moisture regime and are grass dominated
  - Thinner and less compacted tends to have wetter moisture regimes and have are tree and/or shrub dominated

2023 Preliminary Observations – Objective 3

- Impacts were typically present but severity ranged from obvious shifts in wetland types and vegetation composition to nearly imperceptible changes
- Similar to objective 1, pad thickness was a key contributing factor to severity of impact
  - Greater the pad thickness, the greater its impact on water movement below (or through) the pad
- Pad Size/Access Road Length/Orientation were also contributed to severity of impact
  - Right angles in roads tended to increase the severity of impact

Contact

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    – Emily Herdman
    – Field Crew