



# Monitoring with the CABIN Wadeable Streams Protocol in the Oil Sands Regions of Alberta

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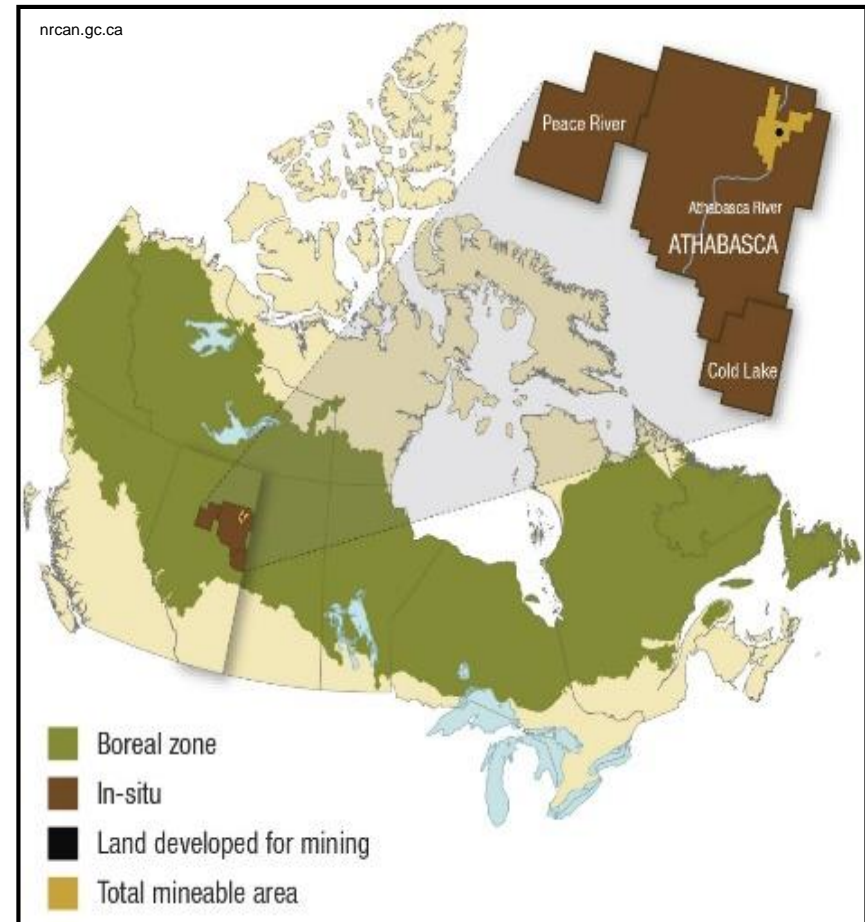
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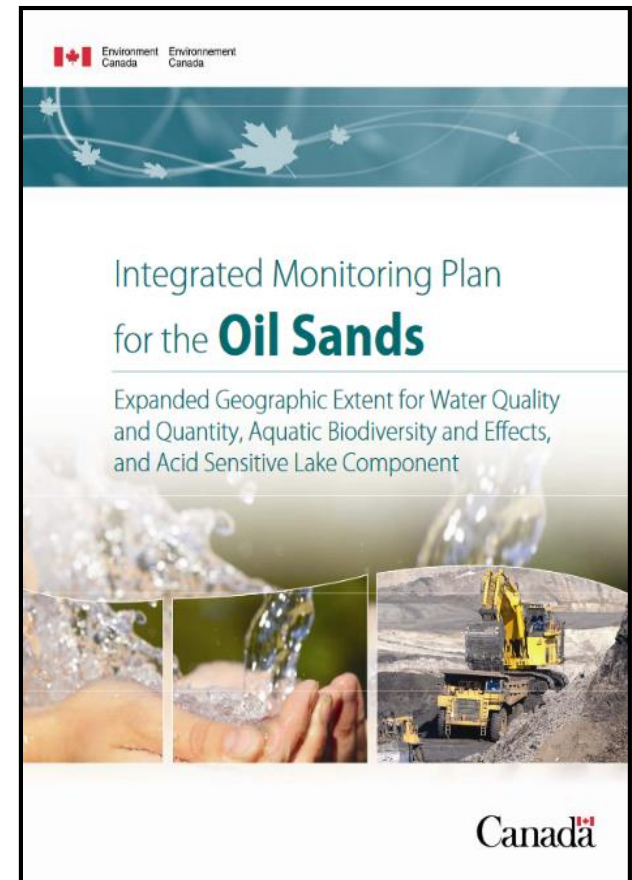
# Overview

- History and objectives of the Canada-Alberta oil sands monitoring program
- Study design in the major tributaries of the Lower Athabasca River
- Site selection and limitations
- Challenges in the field
- Data assessments
- Decision framework
- Summary



# Oil Sands Monitoring (OSM) Program

- Developed in 2011 by the governments of Canada and Alberta
- Includes monitoring of water quality and quantity, air quality, groundwater quality, benthic invertebrates and fish
- Based on recommendations from the Federal Oil Sands Advisory Panel and other reports that identified key shortcomings of historic monitoring efforts



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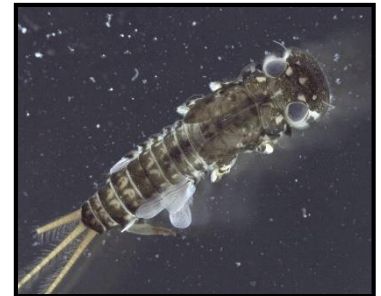
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# Benthic Program Objectives

Using standardized protocols (CABIN) and clearly defined habitat (erosional):

1. Characterize the natural range in assemblage structure in reference areas (inside and outside the natural bitumen deposit)
2. Determine whether assemblages from areas of increasing oil sands development differ from those in reference areas
3. Develop predictive relationships that link environmental drivers to benthic assemblage responses





# Scope in the Athabasca Tributaries

- Focus on major tributaries of the Lower Athabasca River north of Fort McMurray
  - Steepbank River
  - Ells River
  - Mackay River
  - Firebag River
- Data collected annually in the fall from 2011 (pilot year) to 2019
- Large spatial coverage (120+ sites sampled)
- Core sites sampled annually with rotational sampling of other sites



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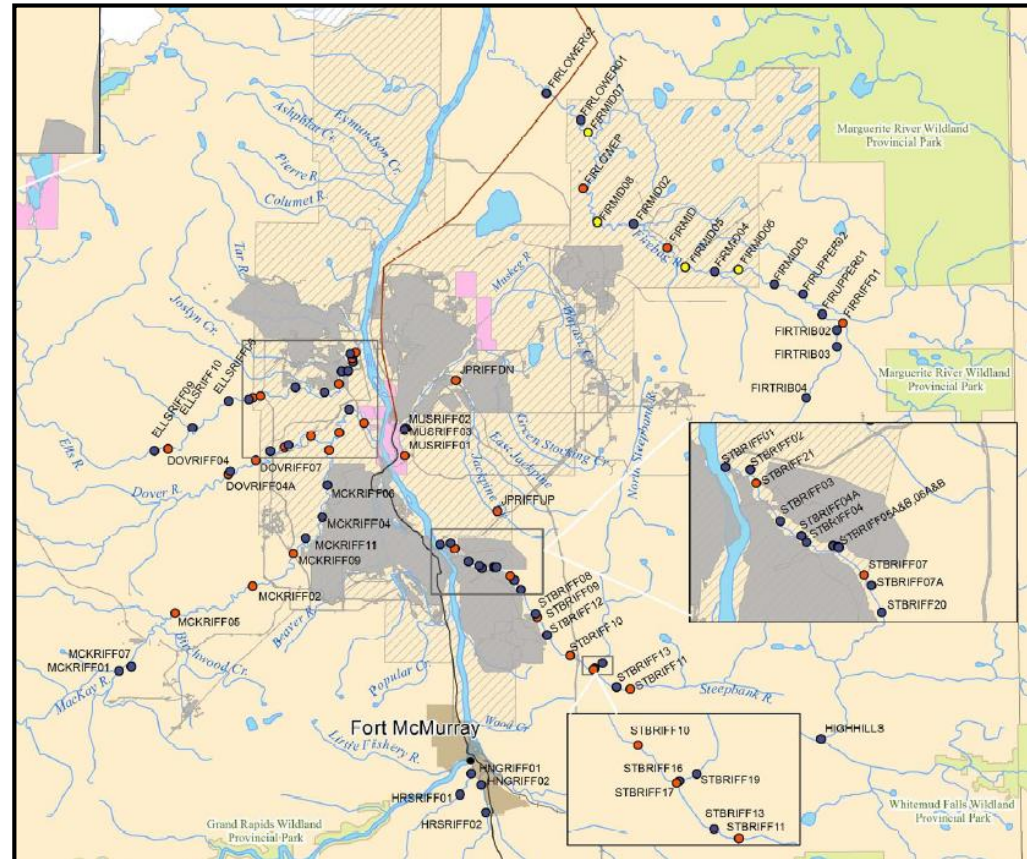
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# Study Design

- Intensive gradient design
- Reference sites
  - Outside bitumen deposit (no bitumen observed at site or upstream)
  - Inside bitumen deposit (bitumen observed and confirmed at site or upstream)
- Test sites
  - > 10% active lease and > 1% land disturbance in the upstream catchment
  - Further subdivided into groups based on level of disturbance in upstream catchment



# Study Design Considerations

Natural co-occurring gradients:

- Slope
- Groundwater inputs
- Nutrients (bogs/fens in upper catchment)
- Natural bitumen seepage and presence in substrate



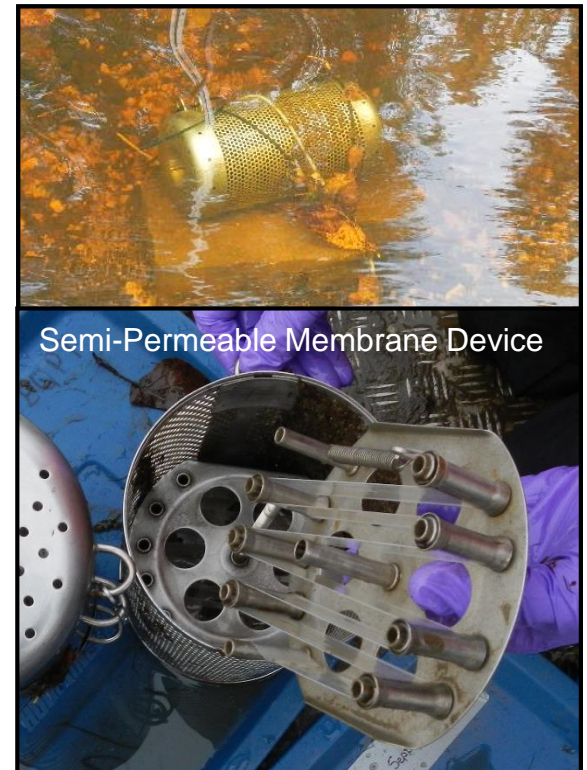
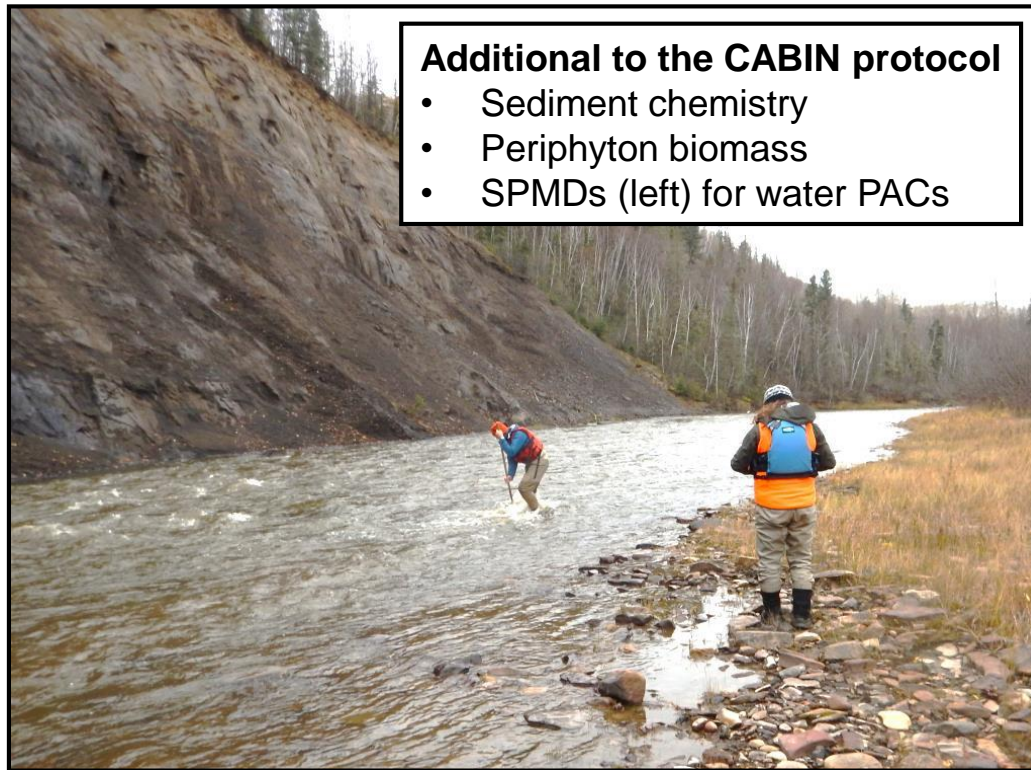
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# Sampling Methods

CABIN protocol for wadeable streams with additional measurements for habitat/chemistry data





# Site Selection and Limitations

- Desktop and aerial reconnaissance to find suitable erosional habitat and landing areas
- All sites are accessed by helicopter due to the scale (50+ sites per year over hundreds of km) and remoteness of sampling locations
- Helicopter access can be limited during high water years



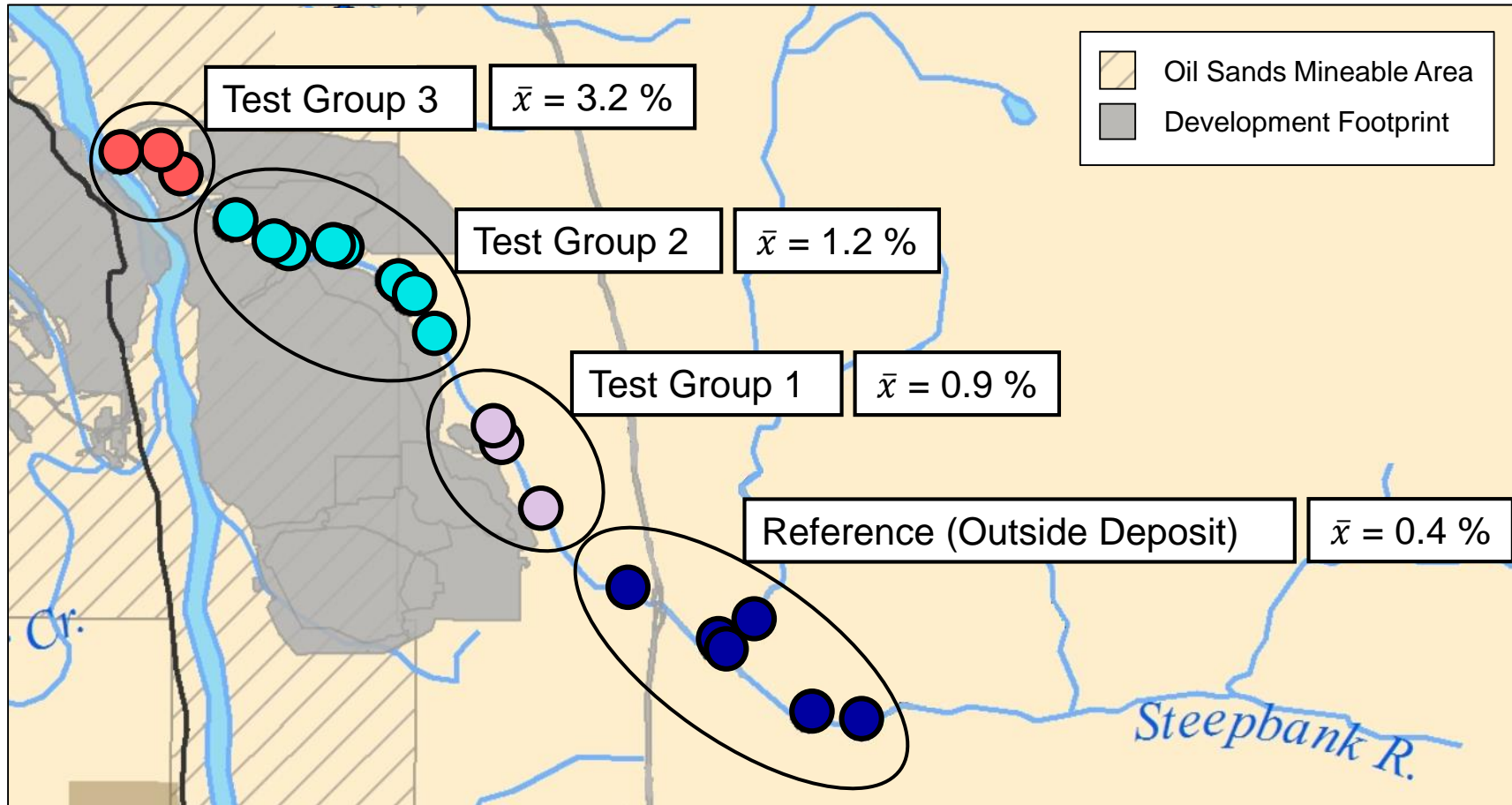
# Challenges in the Field

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- Intensive field logistics and budget
  - Multiple crews (some years 12+ staff)
  - Multiple helicopters
  - Multiple sets of sampling gear
  - Shipping water samples to labs daily
- High (swift) water years
  - Difficulty accessing sites
  - Difficulty completing the benthic kick and other measurements
- Weather delays common in the fall (snow, fog)
- Beaver dams
- Keeping samples cool (water and sediment) or frozen (SPMDs)

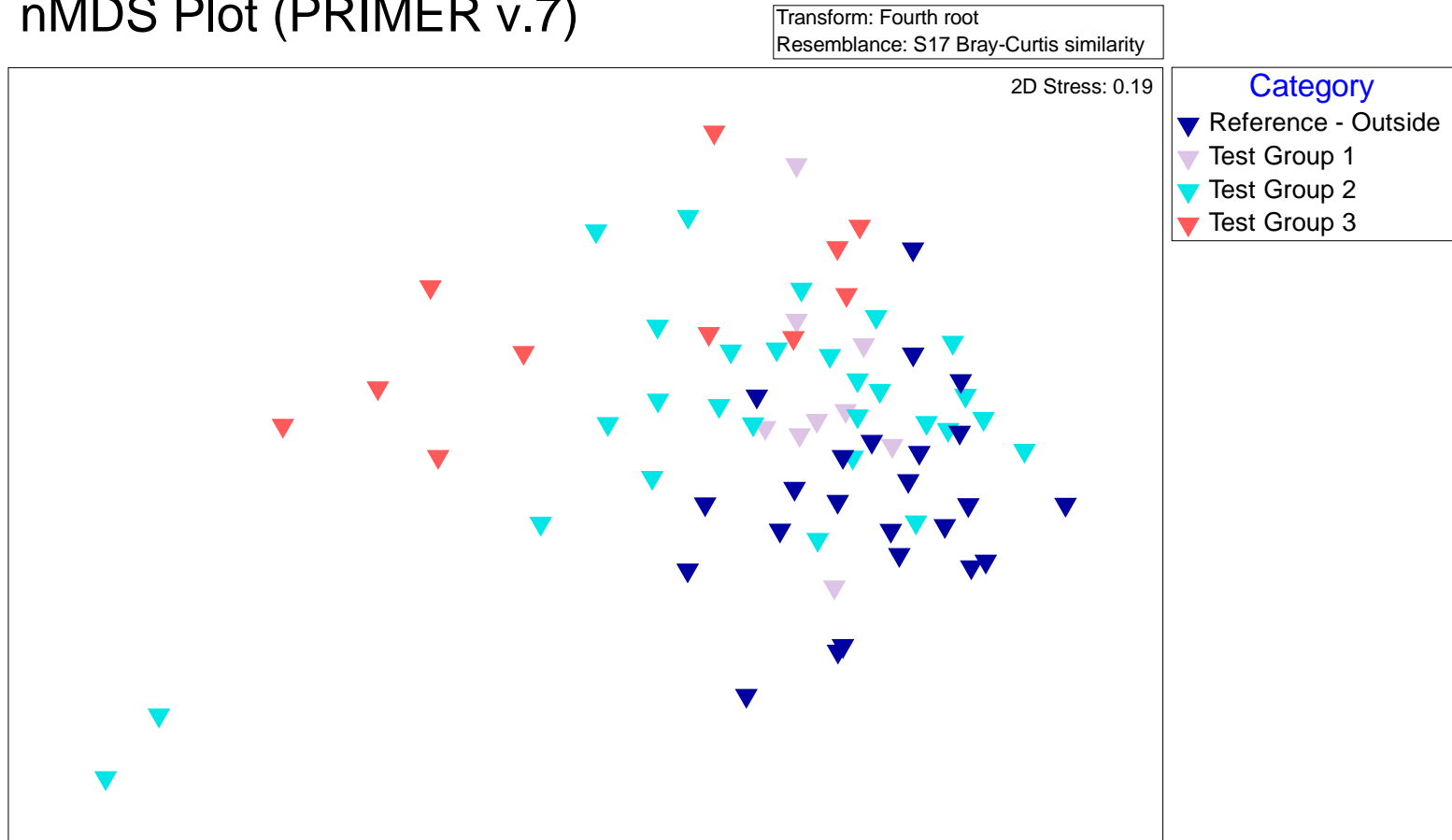


# Steepbank River Gradient



# Steepbank River Invertebrates

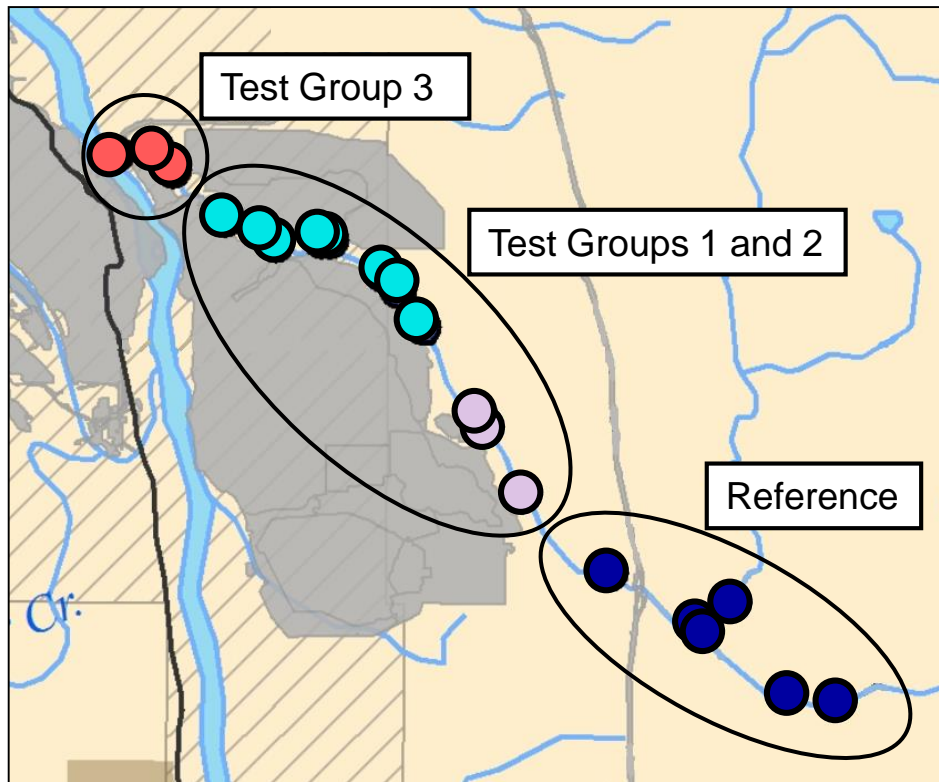
nMDS Plot (PRIMER v.7)





# Steepbank River Invertebrates

PERMANOVA (Permutational MANOVA; PRIMER v.7)

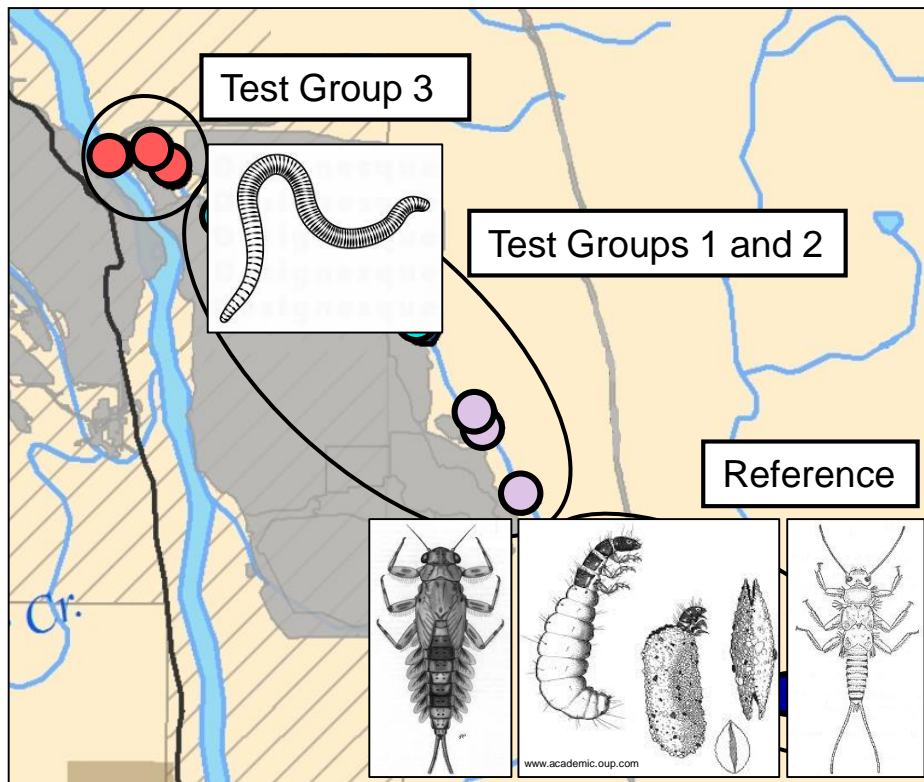


p values				
	<i>Ref</i>	<i>Test 1</i>	<i>Test 2</i>	<i>Test 3</i>
<i>Ref</i>		0.0031*	0.0002*	0.0001*
<i>Test 1</i>			0.2863	0.0004*
<i>Test 2</i>				0.0104*
<i>Test 3</i>				



# Steepbank River Invertebrates

SIMPER (Similarity Percentages; PRIMER v.7)

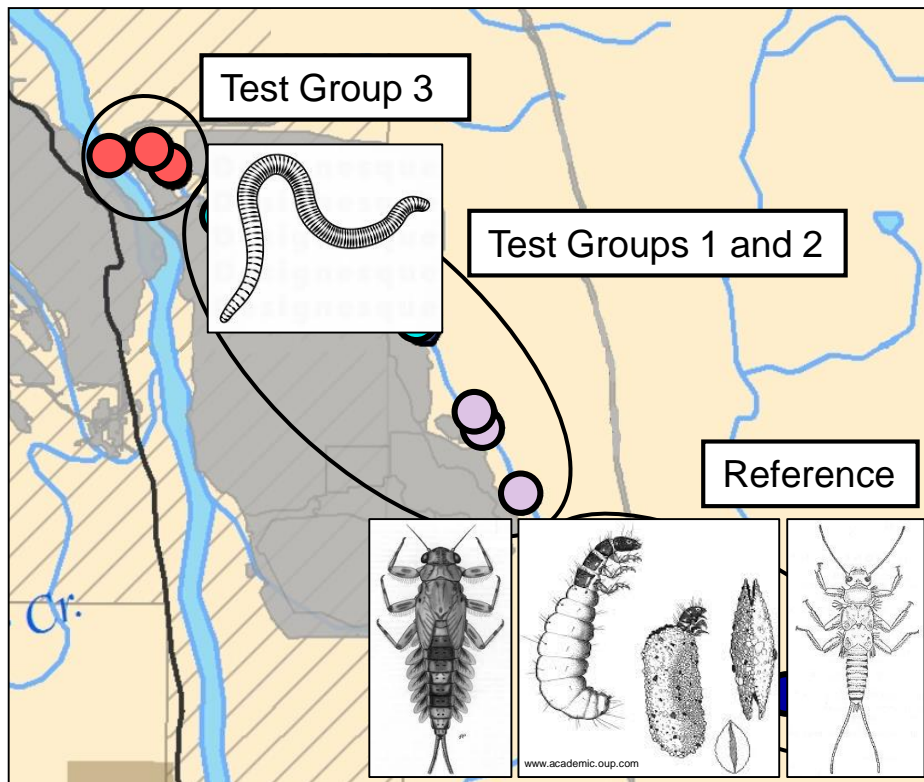


## Reference vs. Test Groups

Plecoptera	Nemouridae	↑ Ref
	Brachycentridae	↑ Ref
Trichoptera	Hydropsychidae	↑ Ref
	Lepidostomatidae	↑ Ref
Annelida	Naididae	↑ Test

# Steepbank River Invertebrates

SIMPER (Similarity Percentages; PRIMER v.7)



## Reference vs. Test Groups

Plecoptera	Nemouridae	↑ Ref
	Brachycentridae	↑ Ref
Trichoptera	Hydropsychidae	↑ Ref
	Lepidostomatidae	↑ Ref
Annelida	Naididae	↑ Test

## Test Groups 1 and 2 vs. Group 3

Ephemeroptera	Baetidae	↓ Test 3
	Lepidostomatidae	↓ Test 3
Trichoptera	Hydropsychidae	↓ Test 3
	Glossosomatidae	↓ Test 3
	Brachycentridae	↓ Test 3

# Decision Framework

Level	Trigger	Magnitude
1	Effect detected	Statistical change
2	Confirmation of effect	Statistical change in same direction
3	Exceeds critical effect size	Under development
Action Level	Exceeds critical effect size and is getting worse	Prolonged exceedance of critical effect size

Integrated Monitoring Plan for the Oil Sands (ECCC 2011)





# Summary

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- OSM benthic program in Lower Athabasca River tributaries uses standardized CABIN protocols to assess invertebrate assemblages along a longitudinal gradient of increased oil sands mining development
- There are statistical differences in benthic assemblages from upstream reference areas and downstream test groups (in all major tributaries)
- A large portion of the dissimilarity between groups was explained by the abundances of several EPT (Ephemeroptera Plecoptera Trichoptera) families which are in higher abundance in reference areas and upstream test groups
- A critical effects size is being developed to assess the ecological importance of these changes and an investigation of potential environmental drivers is underway





# CABIN Biomonitoring in the In Situ Oil Sands Regions of Alberta

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Introduction to the Canadian Aquatic Biomonitoring Network

Environment and Climate Change Canada and Alberta Environment and Parks

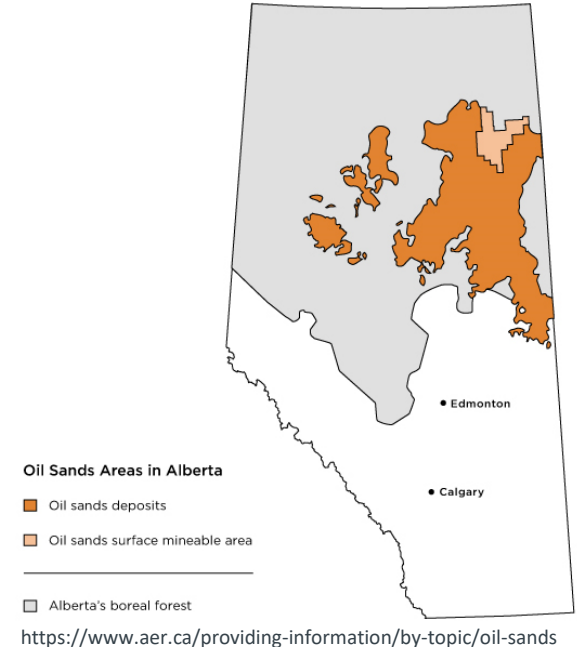
February 24, 2021

Alberta



# CABIN Monitoring in In Situ Regions

- Bitumen extraction in the in situ regions of Alberta often occurs in a complex landscape of multiple stressors, including agriculture and urban development
- How can a monitoring program be designed that teases potential oil sands impacts from other stressors?



# CABIN Monitoring in In Situ Regions

## Roadmap for talk:

- 1) Choosing sample sites in a complex landscape using GIS analysis
- 2) Using desktop resources to identify erosional habitat in areas targeted for sampling



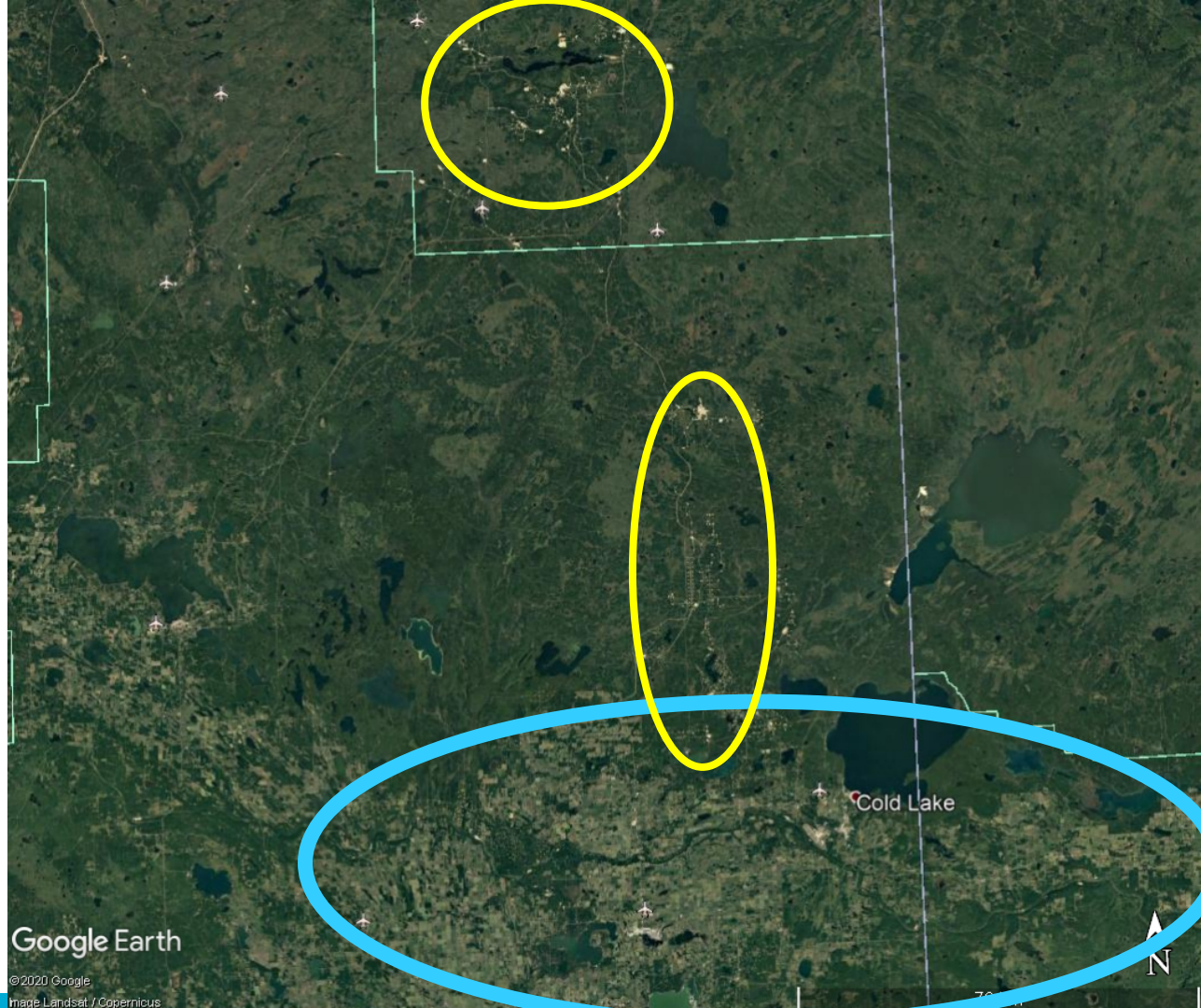


# In Situ: Cold Lake OSR

In situ facilities exist in agricultural/urban context

- Agriculture/Urban
- In situ facilities

Some facilities are closer to agriculture and urban areas than others

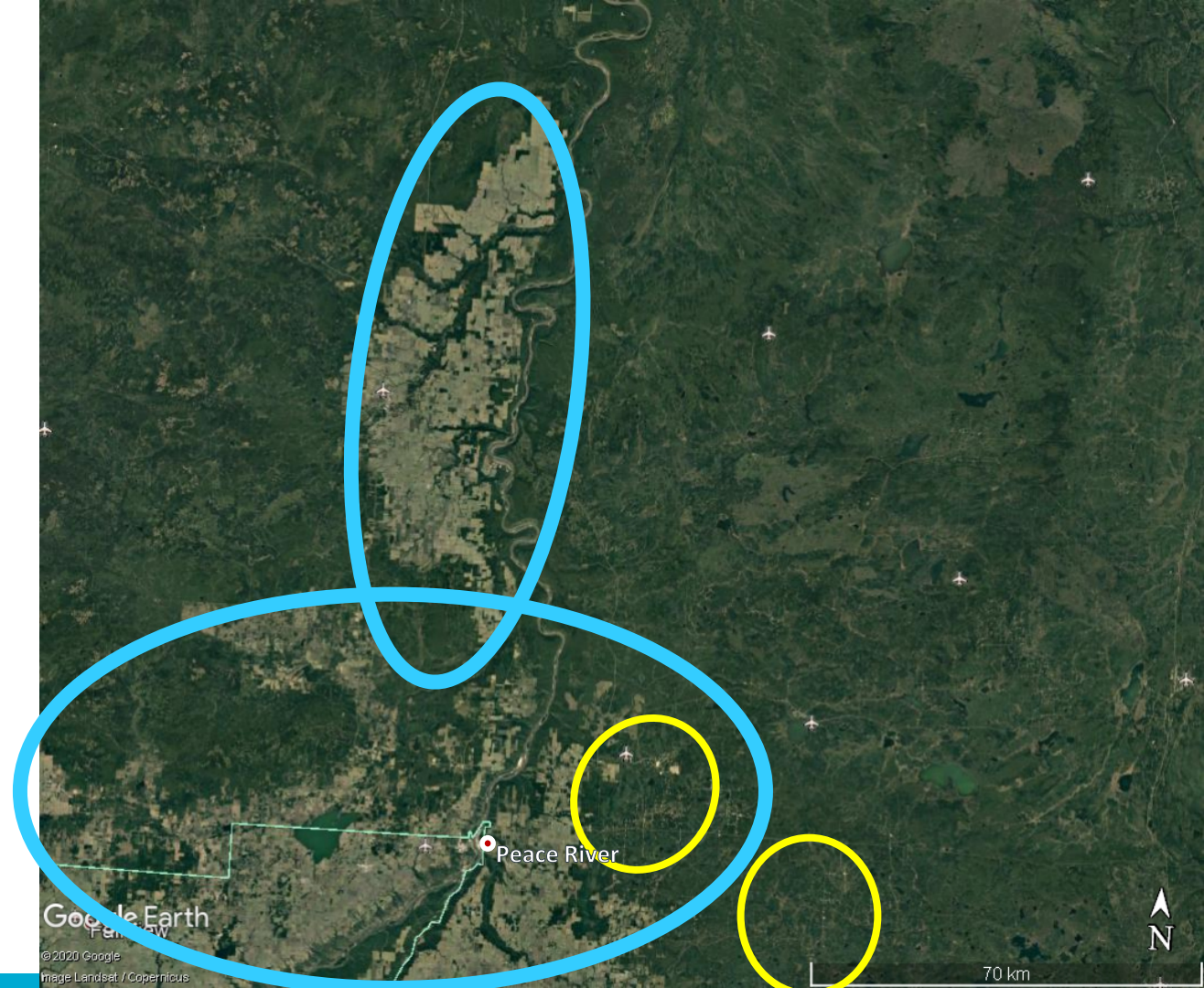


# In Situ: Peace River OSR

In situ facilities exist in agricultural/urban context

- Agriculture/Urban
- In situ facilities

Some facilities are closer to agriculture and urban areas than others



# In Situ Regions: CABIN in complex landscapes

- Study design and sampling are ongoing in the in situ regions of the province, and effort is focused on using GIS to define types and intensities of human activities on the landscape. This allows us to:
- Choose test sites in areas likely to have potential oil sands impacts.
- Choose reference sites in areas unlikely to have potential oil sands impacts.

**What about other potential anthropogenic impacts– urban development?  
Agriculture?**



# Using GIS to identify potential sample sites

- Geospatial programs (GIS) can be used to extract data for many types of human stressors in sub-watersheds and determine what the primary source(s) of potential impacts are
- There are many publically-available data layers, including the Alberta Biodiversity Monitoring Institute's Human Footprint Inventory (2016)

## Wall-to-Wall Human Footprint Inventory

A comprehensive digital representation of anthropogenic disturbances (e.g., agriculture, forestry, energy) on the Alberta land-base, digitized manually, as seen from SPOT6 satellite imagery, this includes the linear features section.





# Using GIS to identify potential sample sites

For the in situ regions of oil sands extraction, we work with a GIS specialist to:

- 1) Identify the spatial extent of our study areas including potential test and reference areas,
- 2) Identify the scale to extract stressor information (e.g., “microbasins,” or small watersheds at least 25 km<sup>2</sup>),
- 3) Identify all potential stressors of interest, including those related to oil sands extraction (e.g., facilities, pipeline crossings, etc.) and those related to other potential impacts (e.g., forestry, farming, and urban development).

# Using GIS to identify potential sample sites

4) Once values for stressors are extracted for all microbasins of interest, we can quantify the types and intensities of potential impacts across our defined study area to help determine test and reference areas.

**What do the results of these analyses look like?**



# Using GIS to identify potential sample sites

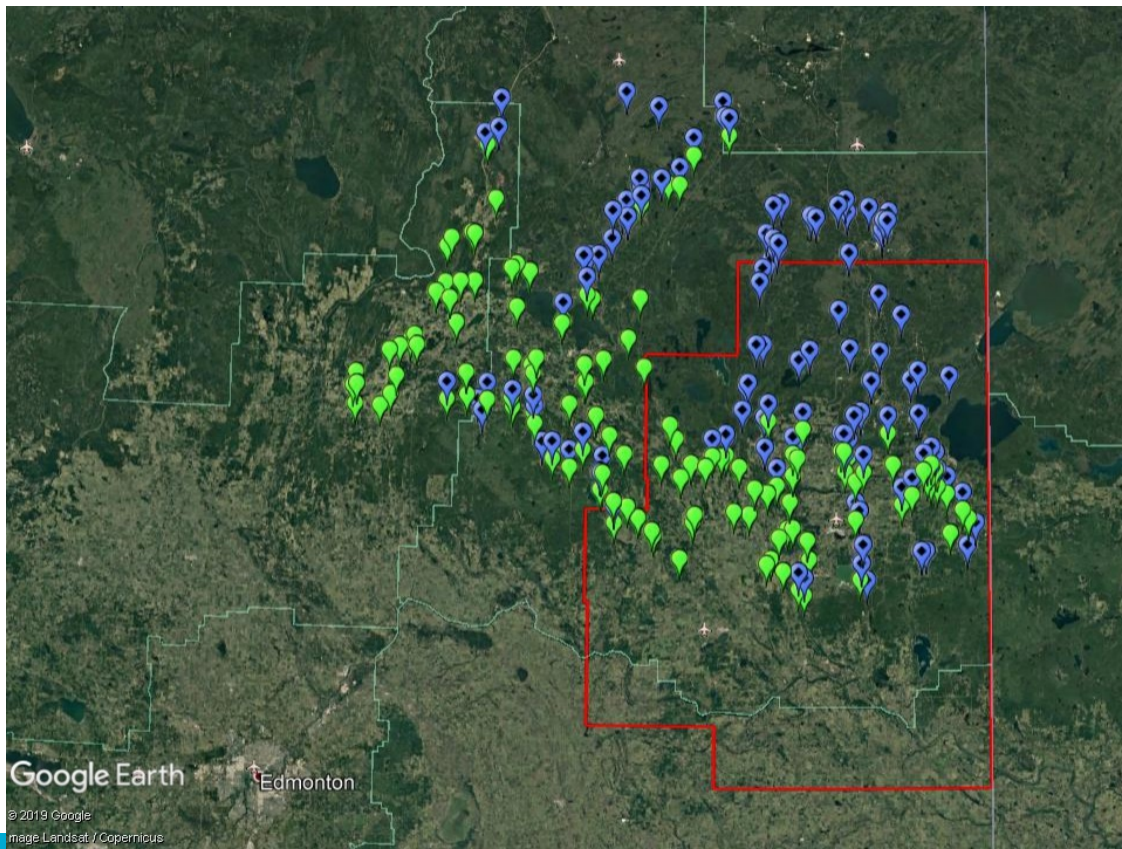
## In Situ: Cold Lake

Microbasins in **Green** have primarily agricultural and/or urban activities

Microbasins in **Blue** have primarily oil and gas-related activities

Microbasins in **Black** represent the top 25% of microbasins with highest measured oil and gas-related activities

Classification: Public



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Image Landsat / Copernicus



# Using GIS to identify potential sample sites

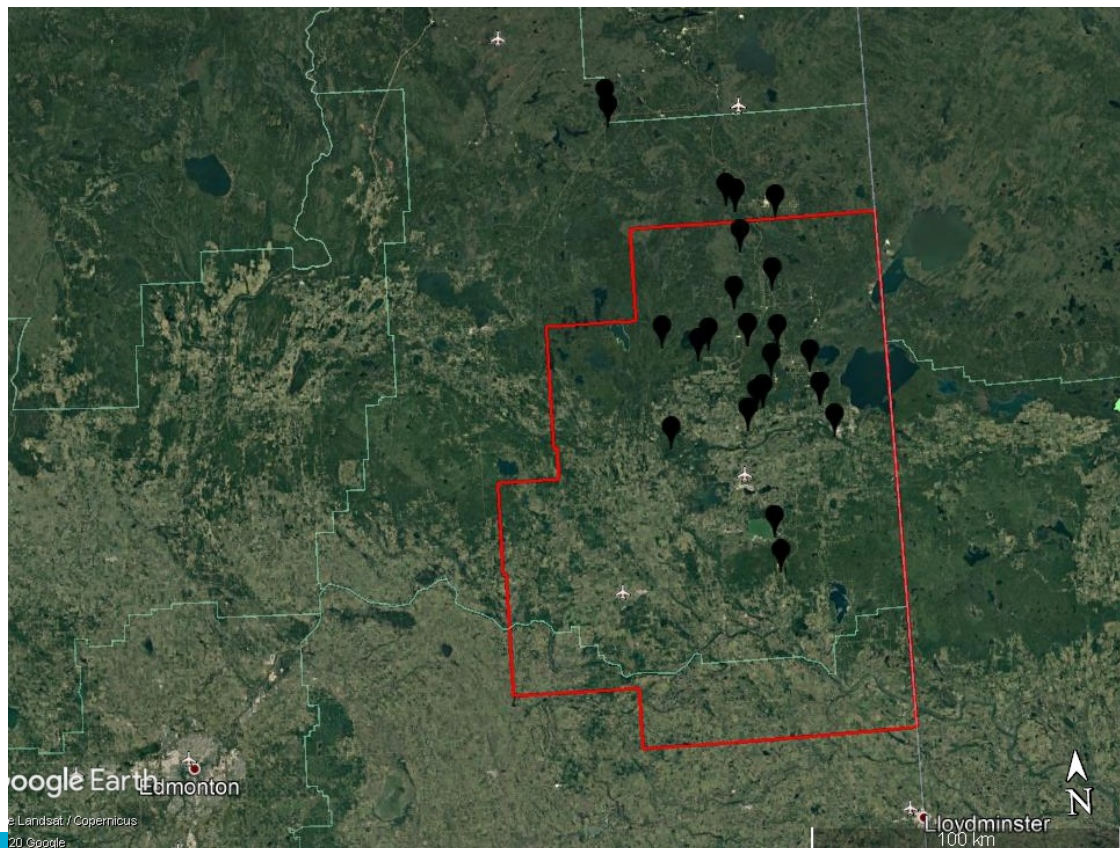
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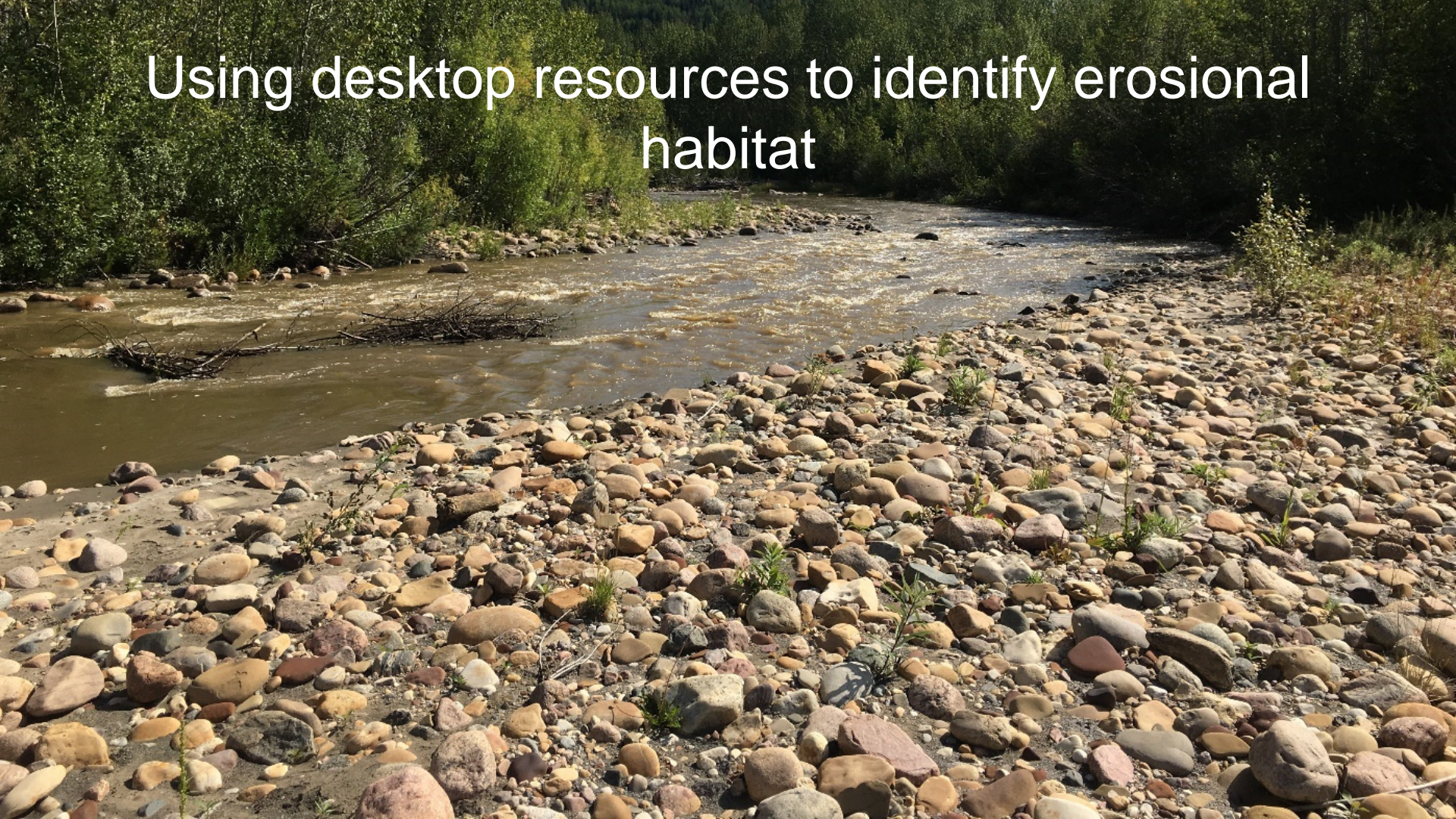
Microbasins in **Black** represent the top 25% of microbasins with highest measured oil and gas-related activities

Classification: Public





# Using desktop resources to identify erosional habitat





# Using desktop resources to identify erosional habitat

- Finding erosional sites appropriate for CABIN sampling can be a challenge in some regions
  - E.g., low gradient areas with slow-moving streams.
- Field reconnaissance is essential, but some tools do exist to help guide effective “desktop” searches for erosional habitat.
- Alberta’s Fisheries and Wildlife Internet Mapping Tool (FWMIT) can be used to locate potential erosional habitat.

# FWMIT Landing Page

Everyone who applies to conduct a fish and fish habitat assessment in Alberta must submit the results of their assessments to AEP

Results are publically available via the Fish and Wildlife Internet Mapping Tool

Most people use the tool to query fish records, but **habitat** records are also available

Classification: Public

maps.alberta.ca/FWIMT\_Pub/Viewer/?TermsOfUseRequired=true&Viewer=FWIMT\_Pub

Environment and Parks

## Fish and Wildlife Internet Mapping Tool - Public

Sign in

Getting Around | Go to Location | Tasks | Analysis | Tool Labels

Layer List | Pan | Zoom In | Zoom Out | Full Extent | Previous Extent | Next Extent | Bookmarks | Fish and Wildlife Report | Export Fish/Habitat Inventories | Point | Aquatic Invasive Species Information | Fish Sustainability Index Information | Whirling Disease in Alberta Information

Map Layers | Navigation Tools | Identify | Location Inf... | Fish & Wildlife Topics

### Home

I want to...

#### Introduction

Welcome to the Fish and Wildlife Internet Mapping Tool. This map-based site enables users to spatially access fisheries and wildlife inventory data from the Alberta Fish and Wildlife Management Information System (FWMIS). FWMIS provides a centralized repository for which government, industry, and the public can store and access extensive and reliable fish and wildlife inventory data to support the conservation and management of Alberta's fish and wildlife.

#### Getting Started

There are two ways to view Fish and Wildlife data:

- The Layer List**  
Click on the "Map Layers" icon then click on the Species Inventory layer to view all of the fish and wildlife locations. You must zoom into an area to a minimum scale of 1:433,342 in order to enable the layer to appear.
- The Fish and Wildlife Report**  
This will display a report of all fisheries and wildlife species presence information as currently stored in FWMIS.

**Report Display Note:** You must allow pop-ups from this site to view the report Report tool results and enable other functionality.  
**Note:** Only fisheries data is displayed as a point locations. Wildlife species observations are not displayed as point locations within the map window, but are displayed in reports generated by the "Fish and Wildlife Report".

#### Contacts Information

##### Fisheries and Wildlife Management Information System (FWMIS)

For more information regarding submitting or

Home | Layers

0 100 200km

Base Data provided by Spatial Data Warehouse Ltd. \n Alberta Road Netw...



# Export Fish/Habitat Inventories

Results of fish and habitat surveys are available via a button at the top of the page

The screenshot shows the 'Fish and Wildlife Internet Mapping Tool - Public' interface. At the top, there is a navigation bar with 'Getting Around', 'Go to Location', 'Tasks', and 'Analysis'. Below this is a toolbar with icons for 'Layer List', 'Pan', 'Zoom In', 'Zoom Out', 'Full Extent', 'Previous Extent', 'Next Extent', 'Bookmarks', 'Fish and Wildlife Report', 'Export Fish/Habitat Inventories' (circled in black), and 'Point'. To the right of the toolbar are three tabs: 'Aquatic Invasive Species Information', 'Fish Sustainability Index Information', and 'Whirling Disease in Alberta Information'. Below the toolbar is a 'Map Layers' section with a 'I want to...' dropdown menu. The main map area displays a map of Alberta with various lakes and rivers. A large purple area is highlighted in the northeast, labeled 'AIR WEAPONS RANGE'. Several red areas are highlighted in the south, labeled 'BUFFALO LAKE METIS SETTLEMENT', 'AIRIND METIS 30 SETTLEMENT', and 'MURIEL LAKE METIS SETTLEMENT'. A scale bar at the bottom left shows 0, 15, and 30 km. The URL in the browser address bar is 'maps.alberta.ca/FWIMT\_Pub/MapsOfUseRequired=true&Viewer=FWIMT\_Pub'.

# Export Fish/Habitat Inventories

Results of fish and habitat surveys are available via a button at the top of the page

All surveys can be queried within a HUC 8

maps.alberta.ca/FWIMT\_Pub/Viewer/?TermsOfUseRequired=true&Viewer=FWIMT\_Pub

Alberta Environment and Parks

Fish and Wildlife Internet Mapping Tool - Public

Getting Around Go to Location Tasks Analysis

Layer List Pan Zoom In Zoom Out Full Extent Previous Extent Next Extent Bookmarks Fish and Wildlife Report Export Fish/Habitat Inventories Point

Map Layers Navigation Tools Identify Location Inf... Aquatic Invasive Species Information Fish Sustainability Index Information Whirling Disease Information

Export Fish Inventories

I want to...

Choose the Area of Interest - Hydrologic Unit Coded (HUC) 8 Watershed

- Click on the map to select the HUC8 area of interest
- Select the HUC8 area of interest by Name and Code

Next

Home Layers Fish a... Export...

Base Data provided by Spatial Data Warehouse Ltd.\nAlberta Road Netw...

# Export Fish/Habitat Inventories

Results of fish and habitat surveys are available via a button at the top of the page

All surveys can be queried within a HUC 8

Aquatic habitat results can be exported to CSV after the desired HUC 8 is chosen on the map

Classification: Public

maps.alberta.ca/FWIMT\_Pub/Viewer/?TermsOfUseRequired=true&View=FWIMT\_Pub

Alberta Environment and Parks

Fish and Wildlife Internet Mapping Tool - Public

Sign in

Getting Around Go to Location Tasks Analysis

Layer List Pan Zoom In Zoom Out Full Extent Previous Extent Next Extent Bookmarks Fish and Wildlife Report Export Fish/Habitat Inventories Point

Map Layers Navigation Tools Identify Location Inf... Fish & Wildlife Topics

Tool Labels X

Export Fish Inventories

Choose Layer(s) to export:

- Fish Survey
- Aquatic Habitat
- Fish Culture Stocking

Choose Output Format(s):

- SHP File(s)
- CSV File(s)

Back Export

I want to...

Home Layers Fish a... Expor...

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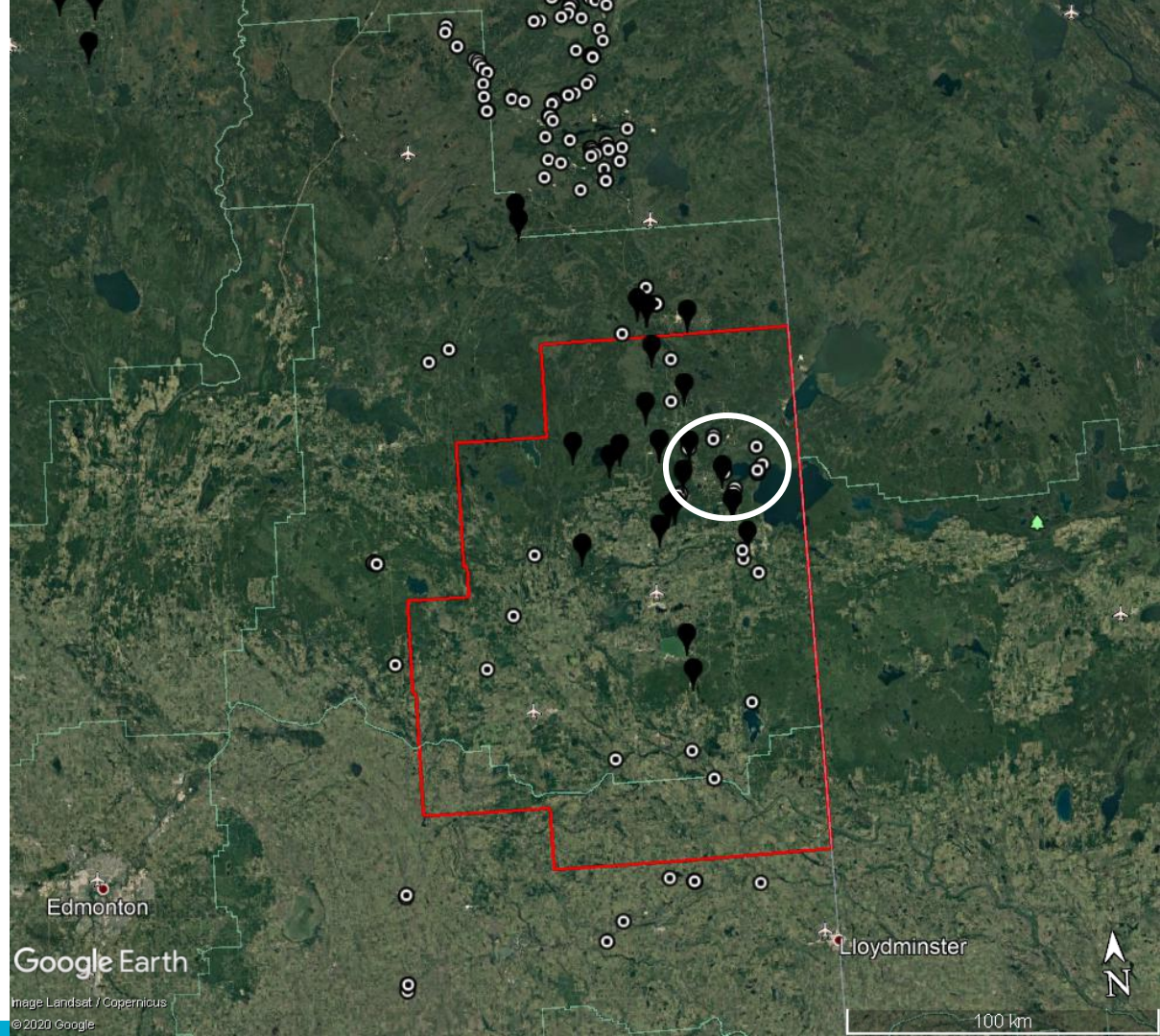
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2	55.989581	-110.95317	7.5	0	0	0	0	100	0	0	0	0	0	FRM ENVII	2554	1139178
3	55.456126	-110.96999	3	4.5	5	0	0	80	0	5	0	100	0	GOLDER A	16348	2330274
4	55.456126	-110.96999	4.4	4.8	0	10	0	80	0	10	0	0	100	GOLDER A	16348	2330274
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24	55.671775	-111.09905	20	0	14	18	0	60	0	8	0	0	0	FRM ENVII	2554	1139173
25	55.671775	-111.09905	28.9	0	14	18	0	60	0	8	0	0	0	FRM ENVII	2554	1139173
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27	55.671775	-111.09905	20.2	0	14	18	0	60	0	8	0	0	0	FRM ENVII	2554	1139173

# Combining GIS and desktop site reconnaissance

We overlaid sites with > 80 % non-fine substrate with microbasins having the highest calculated oil and gas activities

Conducted fly-over recon in an area with both documented erosional habitat *and* microbasins with potential O&G impact

Located several sites for sampling in a region we were concerned wouldn't be suitable for CABIN



# Conclusions

- Process presented here is “screening-level” desktop exercise to identify potential test and reference areas and specific sampling locations.
- FWMIT database is very helpful where lots of previous assessments have occurred (e.g., areas of exploration and development) but less so where exploration/development haven’t occurred.
- Geospatial analyses will be combined with measurements of water and sediment quality at each site to better quantify potential gradients of impacts.



# Acknowledgments

- Funding: Canada-Alberta Oil Sands Monitoring Program
- ECCC and AEP scientific and technical staff
- National Laboratory for Environmental Testing
- Reports: <https://www.canada.ca/en/environment-climate-change/services/oil-sands-monitoring/documents-reports.html>





Questions?

