

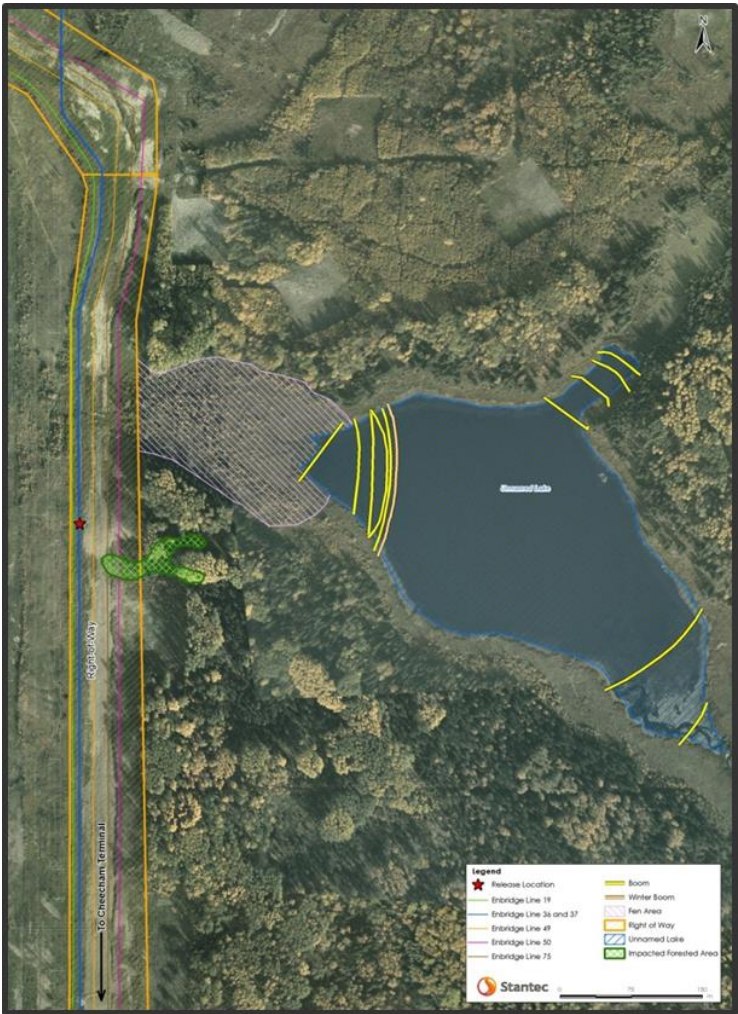
# Risk-Based Spill Closure Utilizing Ecological Function Assessments

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# Incident Overview and Response Summary



# Contaminants of Concern

- CoCs identified by analysis of raw product, recovered product, soil, groundwater, surface water, and sediment analysis
- CoCs: BTEX, PHC F1 to F4, and PAHs
- Metals were not present in the analytical results and were not considered in additional sampling



# Initial Oil Distribution

## Shoreline Cleanup Assessment Technique (SCAT)



# Remediation Objectives

- Remove free product
- Reduce concentrations of CoCs in applicable media to levels protective of human and ecological health
- Minimize additional impacts to fen and lake habitats



## Initial Remediation

- Product removal from the lake
- Sediment excavation
- Fen flushing



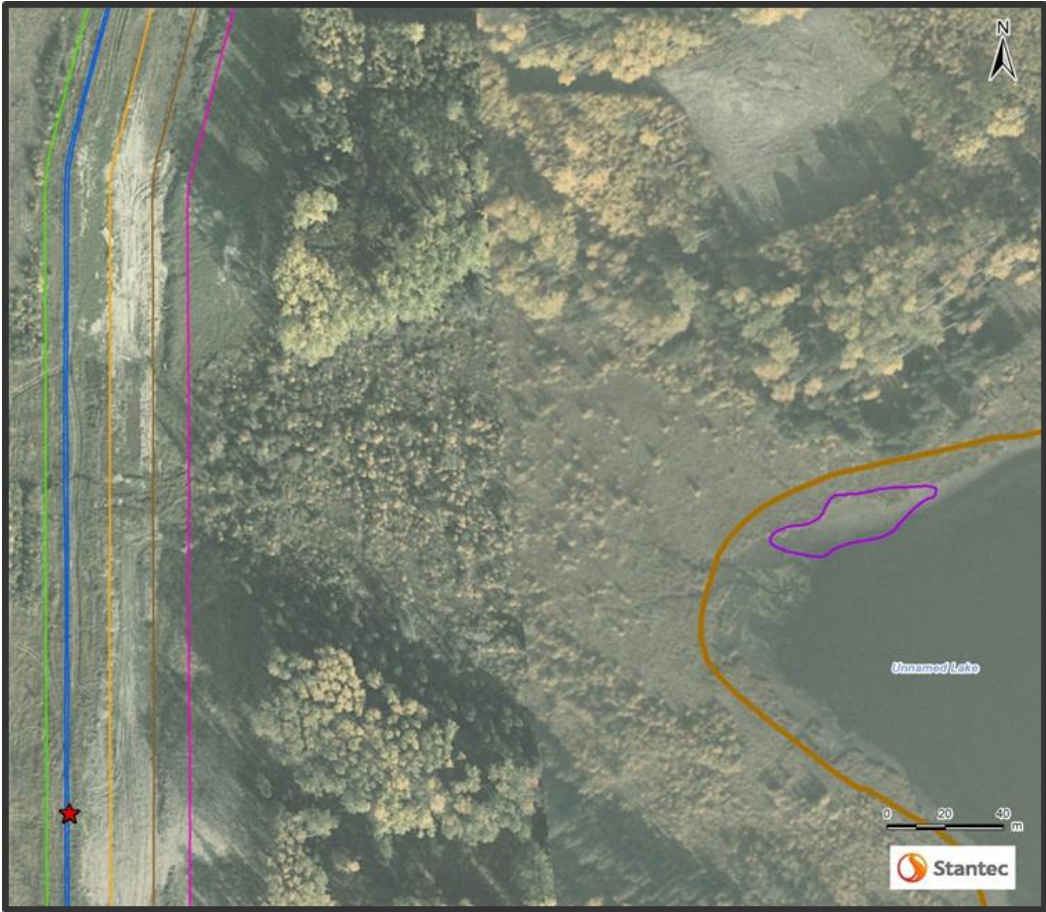


# Product Removal From Lake



# Sediment Excavation

## Product Recovery Operations Area at the Lake

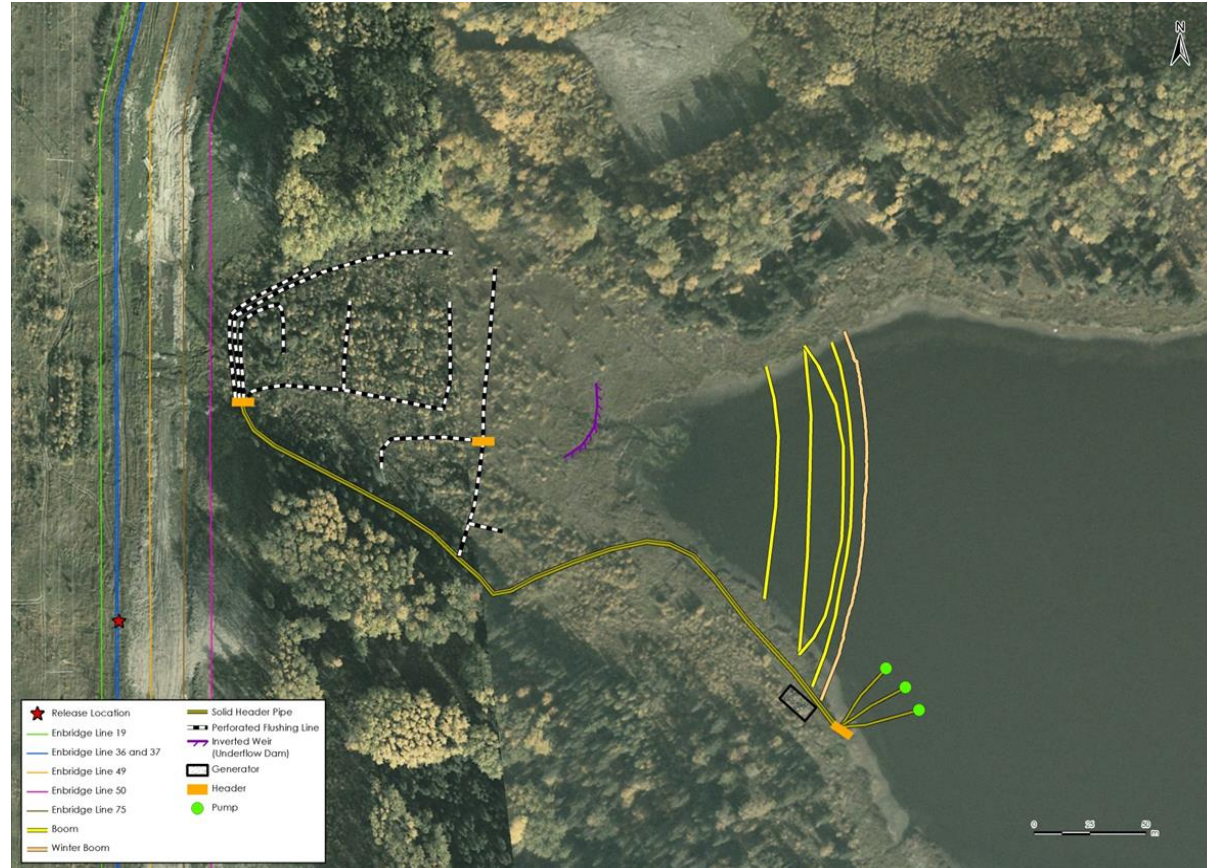




# Fen Flushing

## Targeted and Broad Flushing

- Broad flushing
  - Mobilize product
  - Maintain high water level in fen
- Targeted flushing
  - Wash affected vegetation
  - Mobilize trapped product to collection areas



# Fen Flushing

## Pumping and Headers





# Fen Flushing

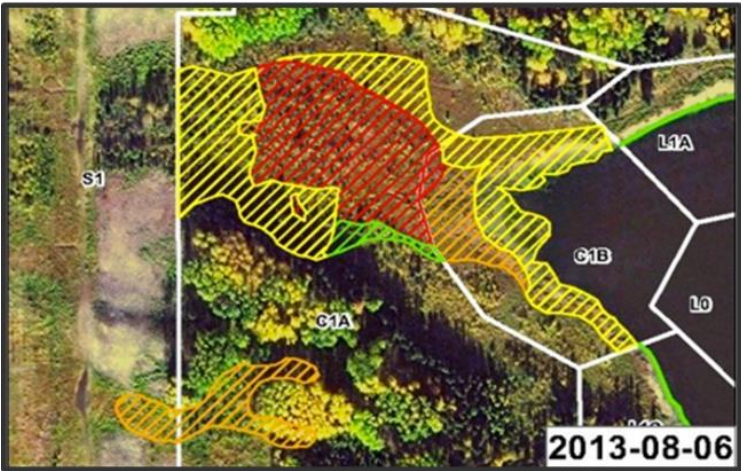
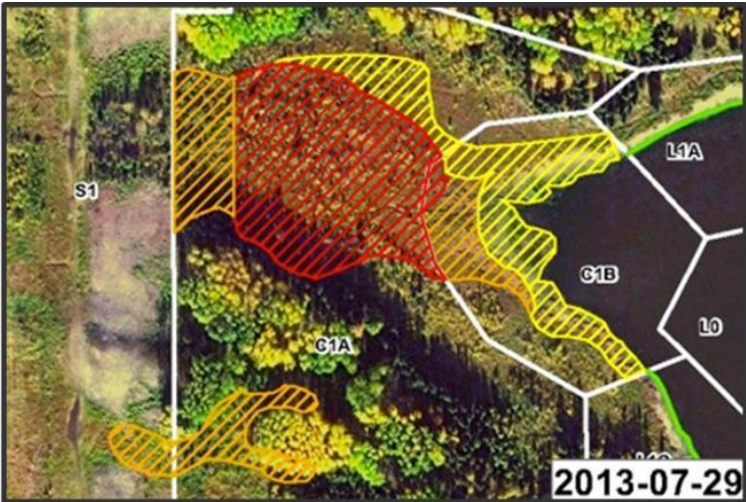
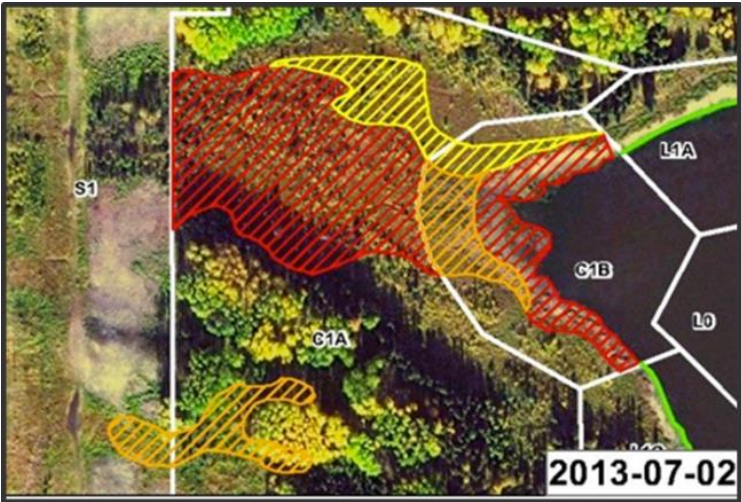
## Flushing and Inverted Weir





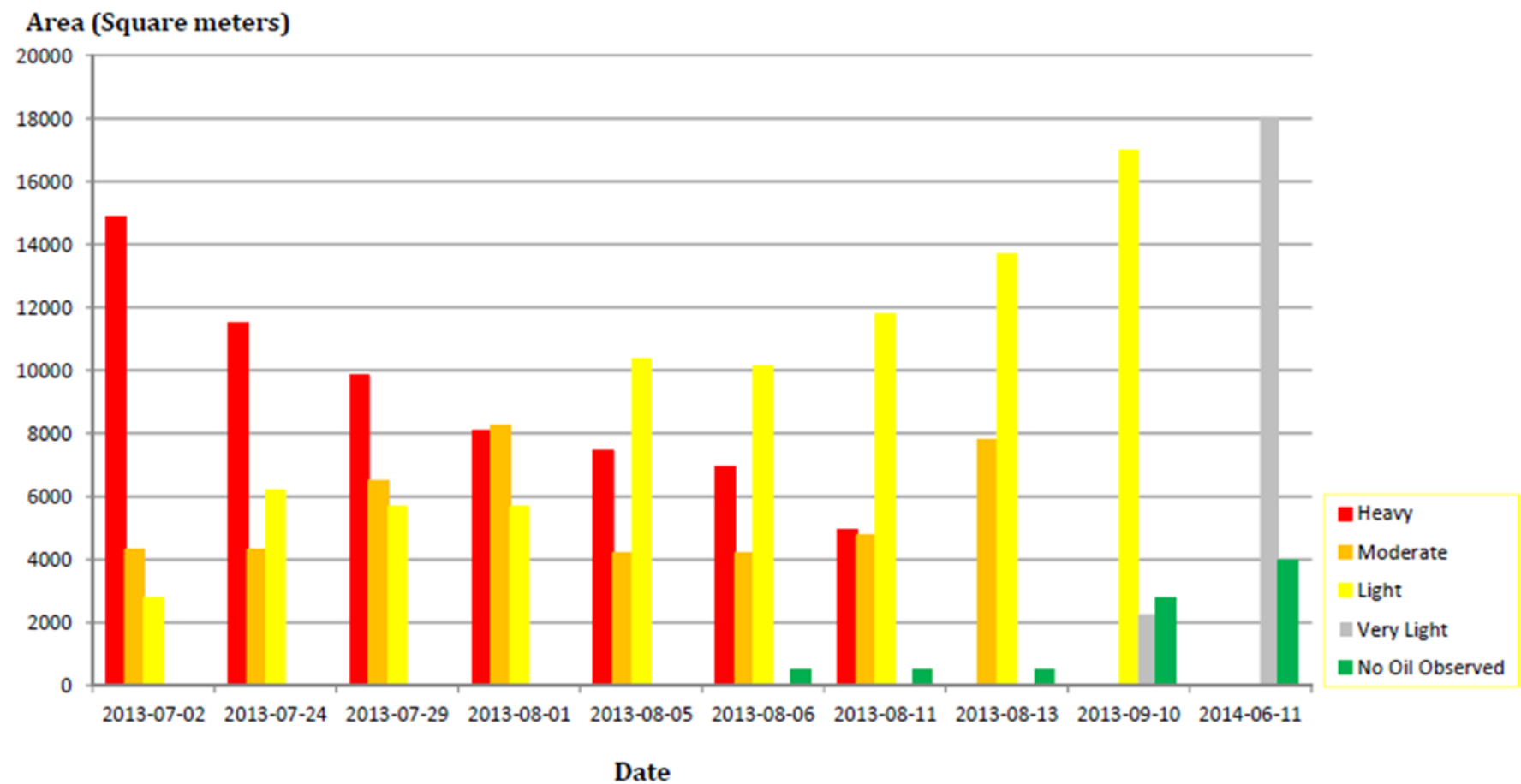
# Fen Remediation Progress

## Oiling Distribution Through Time



# Fen Remediation Progress

## Evolution of Oiling Conditions





# Evolution of Oiling Conditions

## South Area of Fen





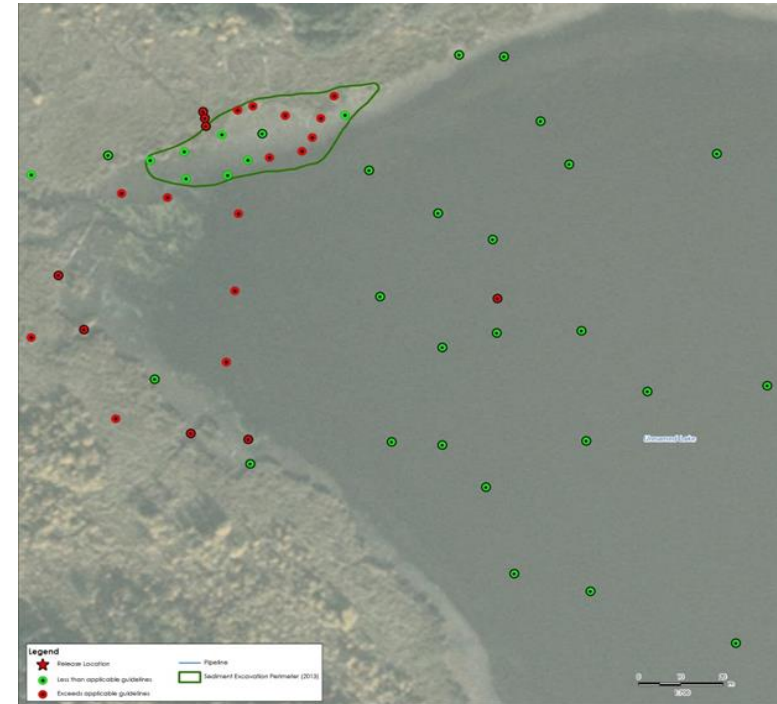
# Evolution of Oiling Conditions

## West Shore of Lake



# Characterization of Residual Impacts

- Soil in the fen
  - Residual PHC impacts were heterogeneous
  - More than 1000 soil samples
  - Statistical analysis showed soil monitoring was ineffective to demonstrate impacts were stable or decreasing
- Lake Sediments
  - Residual PHC impacts along west shore
  - Disturbed area from sediment excavation
- Groundwater
  - Localized impact in fen
  - Suspected artifact due to well installation



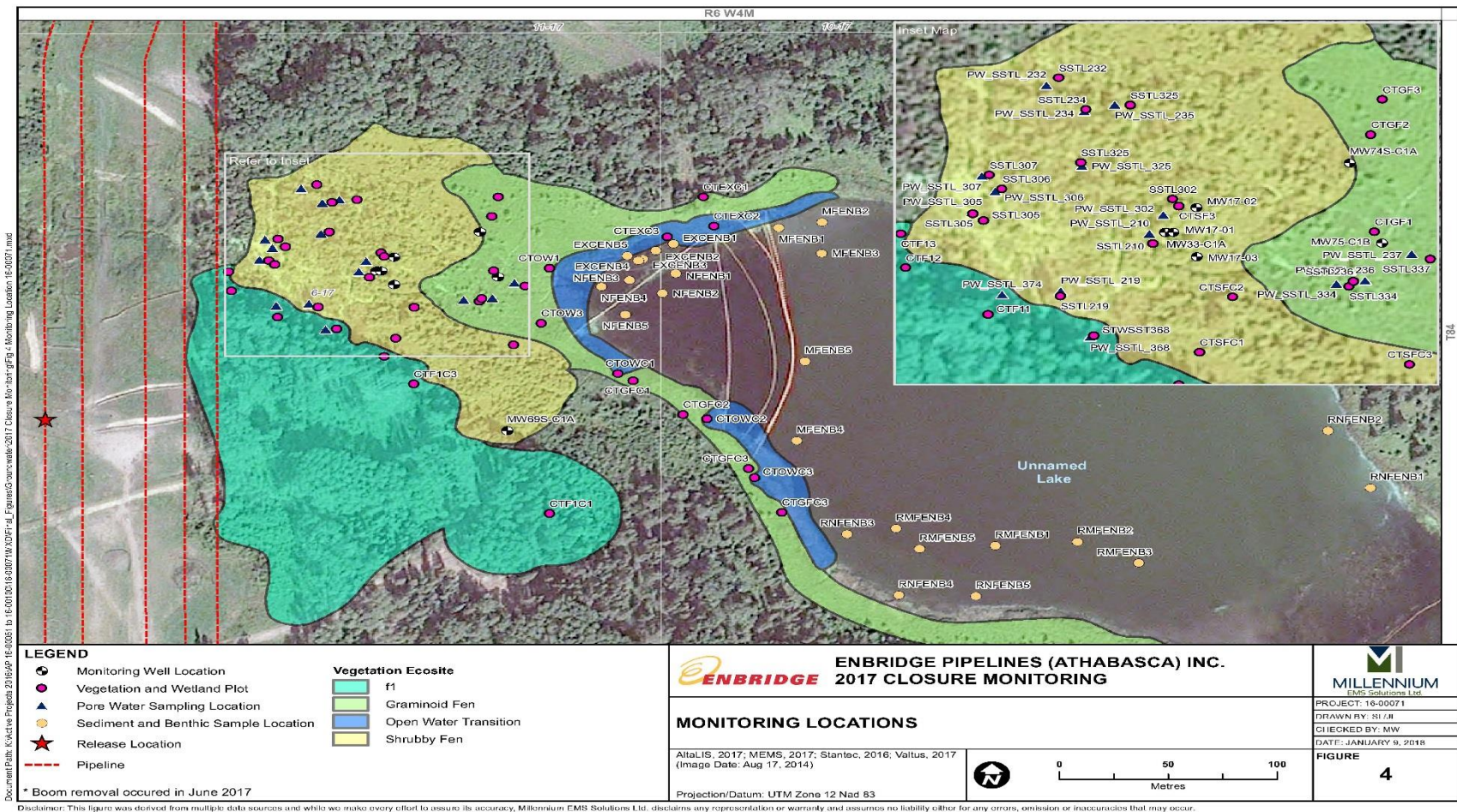
# Monitored Natural Attenuation End Points

## Utilizing Ecological Function Assessments

- Ecosystem health and function assessments
  - Demonstrate residual impacts in fen and lake are not causing an adverse environmental effect
  - Equivalent vegetation health and function in the fen and un-impacted reference locations
  - Equivalent benthic invertebrate community from lake sediments
- Stable/decreasing CoCs in fen and sediment
  - Demonstrate COCs are not acting as a source to surface water or groundwater pathways
  - Sediment CoCs stable or decreasing
  - Groundwater CoCs below guidelines for three consecutive events



# Ecological Function – Fen Vegetation





## Ecological Function – Fen Vegetation

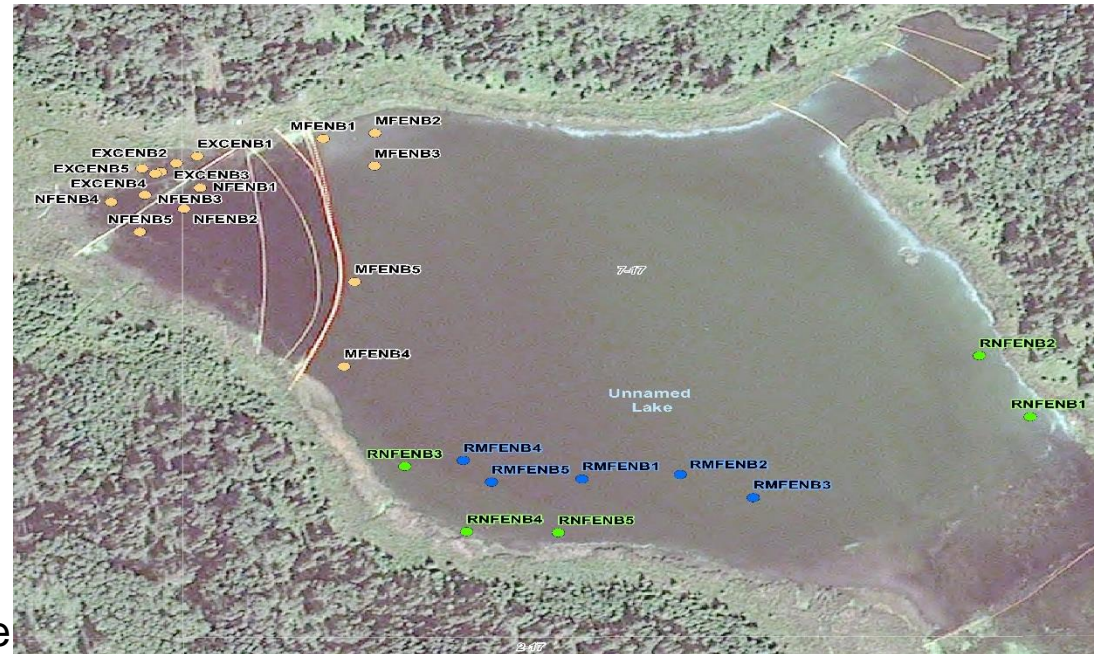
- No reduction in wetland function due to loss or shift in wetland community composition has been observed

### Graminoid Fen



# Ecological Function – Benthic Invertebrates

- Mid-field
  - Benthic community equivalent in all but one location
- Near-field
  - Benthic community recovering, equivalent or better than near-field reference area
- Excavated area
  - Lower total organisms and number of taxa
  - Appears to correlate more strongly with physical disturbance characteristics than hydrocarbon impact





## Stable/Decreasing CoCs

- Pore water monitoring in fen
  - CoC concentrations were below applied guidelines
  - Residual soil impacts bound to organic fen soil
  - No pathway to surface water or groundwater
- Sediment hydrocarbon monitoring in lake
  - Sediment concentrations appear stable in the nearfield samples
  - Sediment concentrations appear within guidelines in the midfield samples
  - Excavation area results varied year over year
- Groundwater
  - Localized groundwater impact – verified to be well installation artifact
  - Groundwater monitoring results are within applied guidelines
  - Discontinue groundwater monitoring in 2018

# Risk-Based End Point Summary

## Low Impact Oil Recovery and Ecological Function Assessments were Effective

- Low disturbance approach to initial remediation reduced CoCs and preserved ecological function
- No observable effect on fen vegetation community
- Residual organic soil impacts not a risk to surface water or groundwater
- Benthic community in unexcavated areas were equivalent or better compared to reference locations with one exception
- Lower benthic community indices in excavated areas
- Sediment CoC concentrations are stable in nearfield locations
- Groundwater CoC concentrations meet guidelines

## Risk-Based Monitoring – Next Steps

- Annual site inspection
- Vegetation and benthic monitoring on a reduced schedule
- Decommission groundwater monitoring wells in 2018





# Questions

