Boat Harbour – Sludge Thickness Determination

Ben Sweet, M.Eng. – Technical Lead, SCG
Tim Bachiu, M.Sc., P. Geo – Project Manager, WSP

Boat Harbour Remediation Project

- Tidal Estuary converted to Stabilization Lagoon.
  - Received Industrial effluent since 1967, sealed 1972.
  - Project Goal – remediation - enable to “natural” conditions.

- Remediation Planning:
  - Planned Approach – dredging and removal of sediments for long-term storage and containment:
    - What is the total expected volume?
    - Where is the contaminated material distributed across the harbour?
    - What is the thickness/vertical profile (planned dredging specifications)?

Boat Harbour Characterization Challenge:

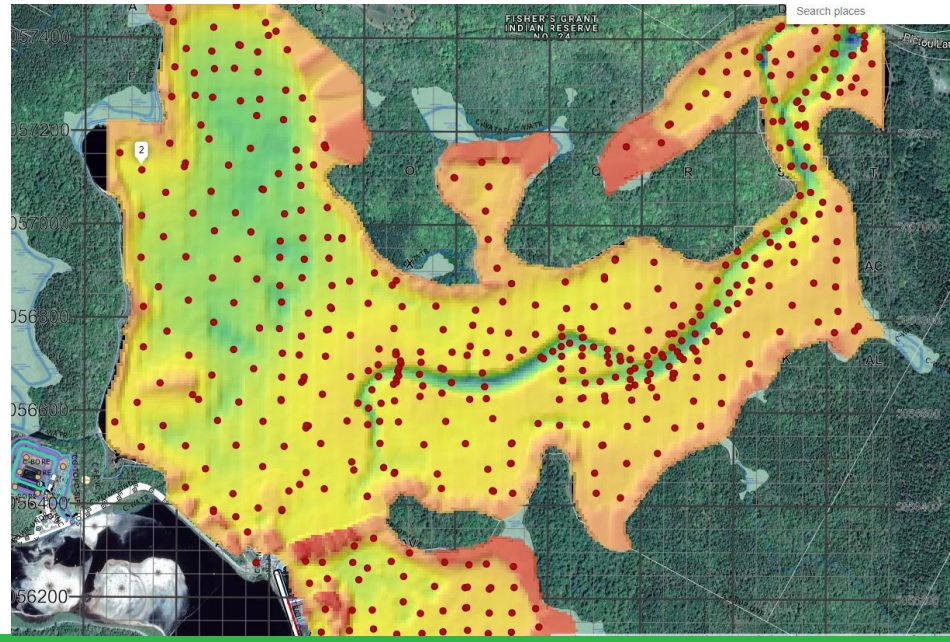
- Challenge - accurate estimation of contaminated sediment volume and distribution for effective remediation planning and delivery.
  - Sediment physical properties – inhibit data collection.
  - Significant area – 141 Hectares.
  - Significant heterogeneity related to complex sedimentation regimes and use history.

- Need to address:
  - Basin Morphology
  - Contaminated material distribution & vertical profile.

Boat Harbour Characterization Challenge:

- Morphology:
  - Sonar based approaches for high resolution bathymetric modeling
    - Single Beam Echo Sounder (SBES)
    - Multi Bean Echo Sounder (MBES)

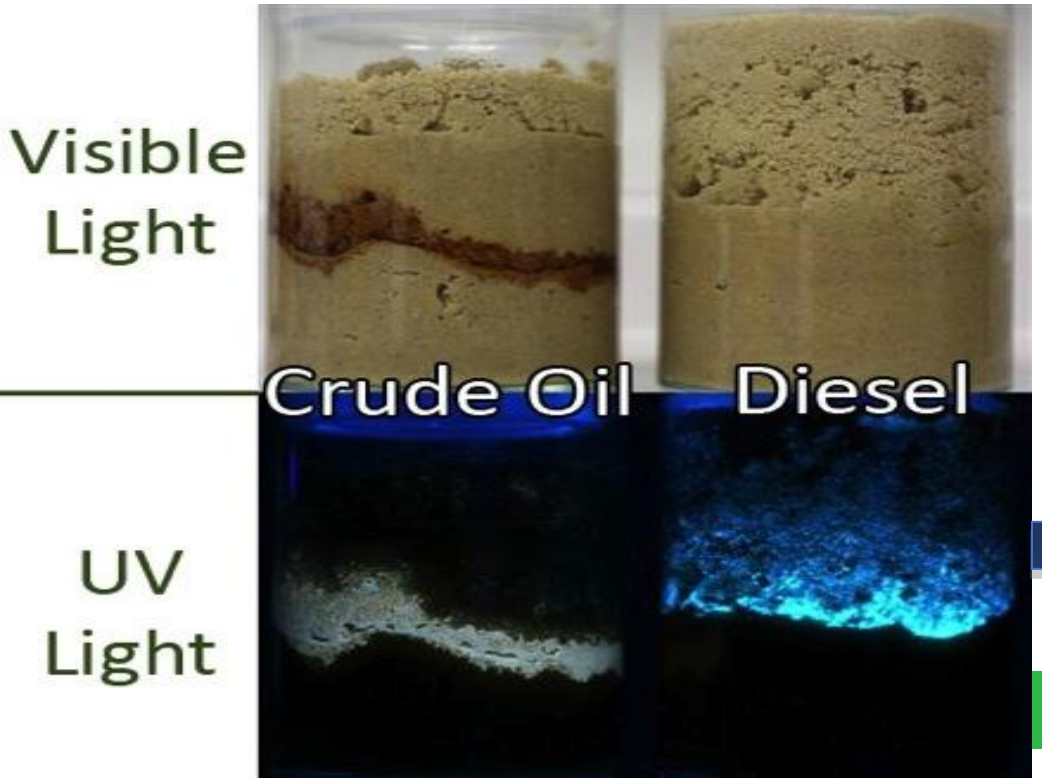
- Distribution and Thickness (volume).
  - Ex-situ Approaches based on sample collection:
    - XRF
    - UVF Spectroscopy
    - NIRS
    - Particle scatter
  - In-situ Approach:
    - **In-situ LIF and Electrical techniques??**

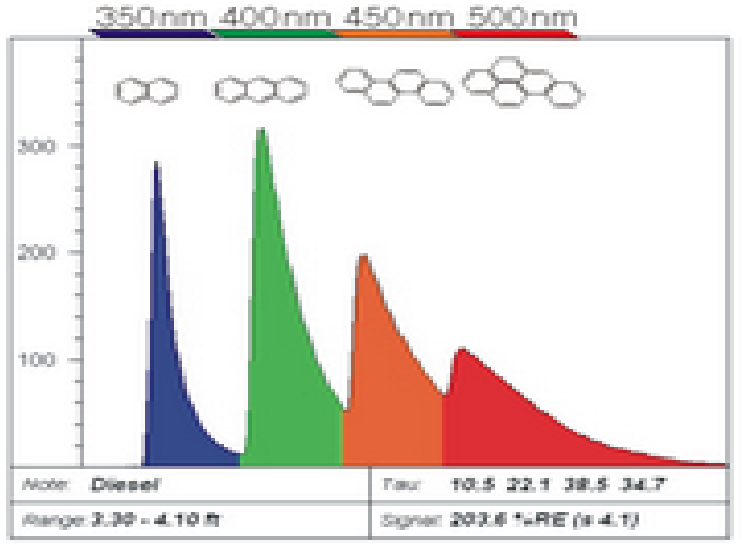


LIF – Laser Induced Fluorescence

- Utilizes in-situ fluorescence spectroscopy to locate Free Phase Petroleum Hydrocarbons.
- Dakota Technologies – UVOST & TarGOST.

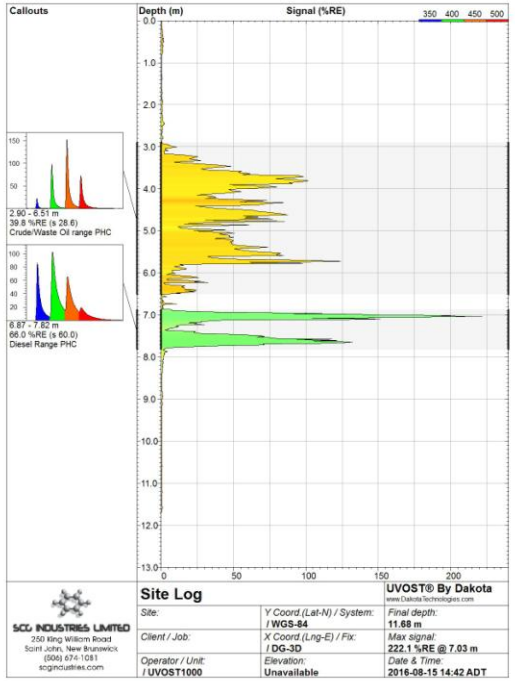
- Standard Practice - operation is based on two principles:
  - Fluorescence – PAHs
  - NAPL & PAH partitioning

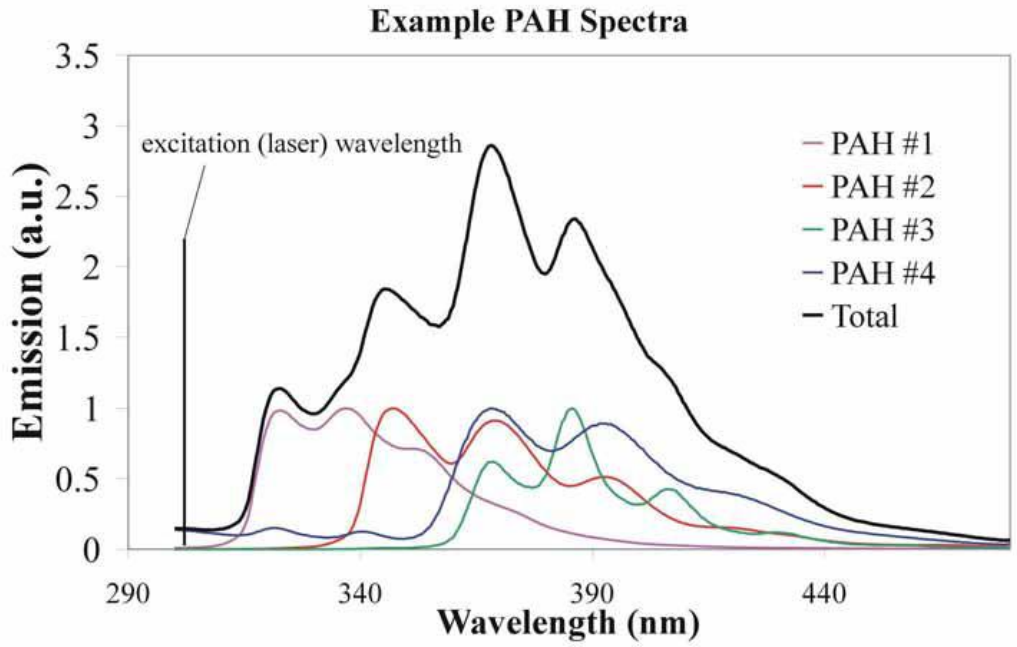


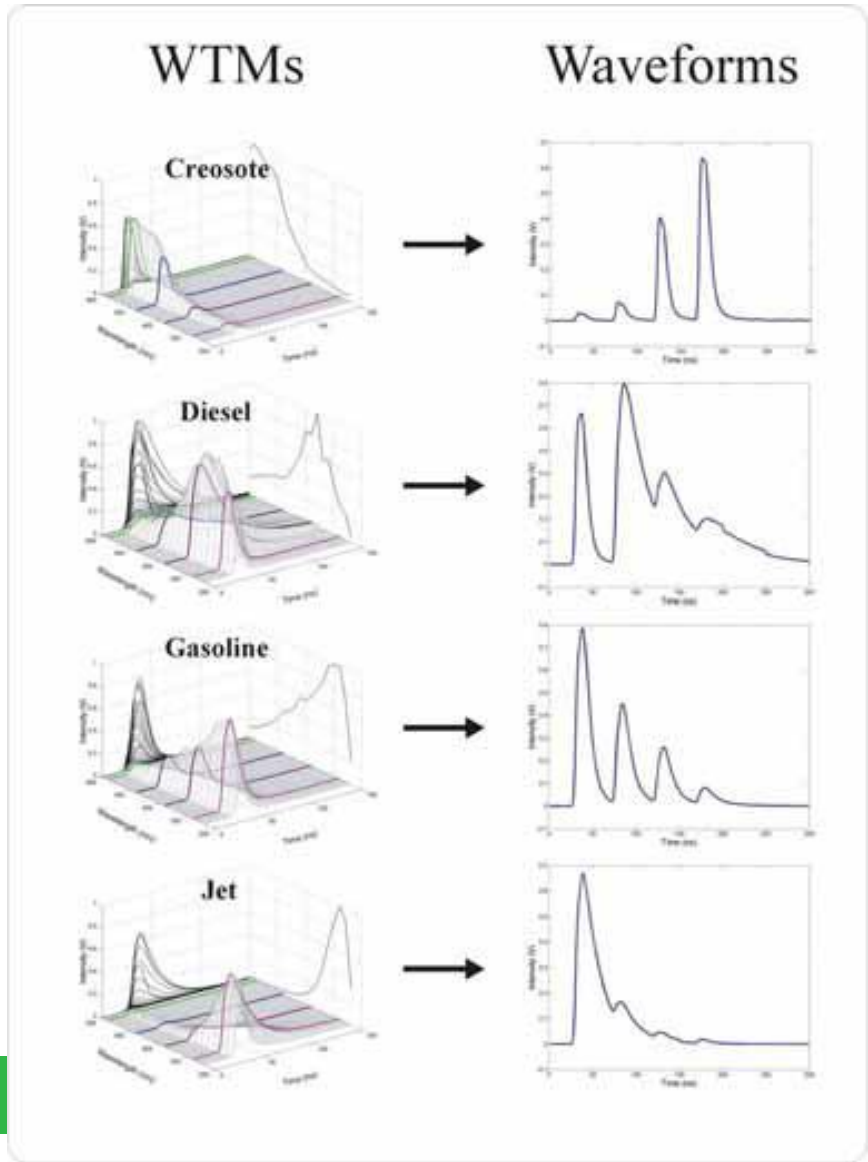


Can LIF do more?

- Standard processing and interpretation
  - Measure: Wavelength – Intensity – Tau (time decay)
  - Improves capacity to assess and interpret fluorescence signals related to NAPLs & PAHs
  - Other potential applications?

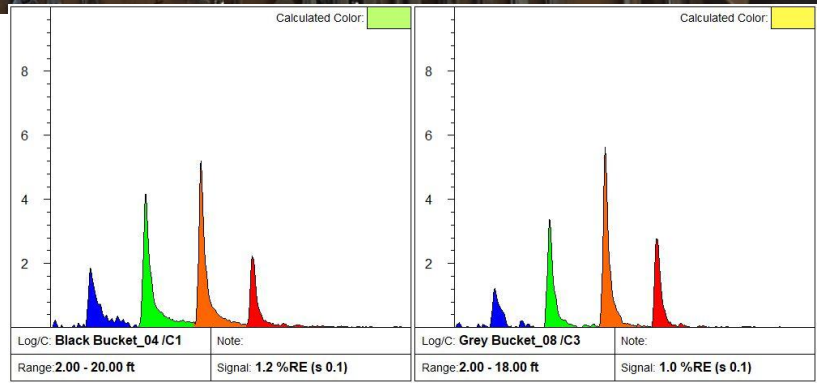






Tech. Development

- Approach:
  - Phase I – Bench Scale Assessment
  - Phase II – Field “Proof of Concept”
    - Comparative assessment
  - Phase III – Pilot Program
    - Assess technical and practical challenges to delivery and approach viability.
  - Phase IV – Full-scale Application
    - Cost and risk mitigation through staged R&D approach and project progression.



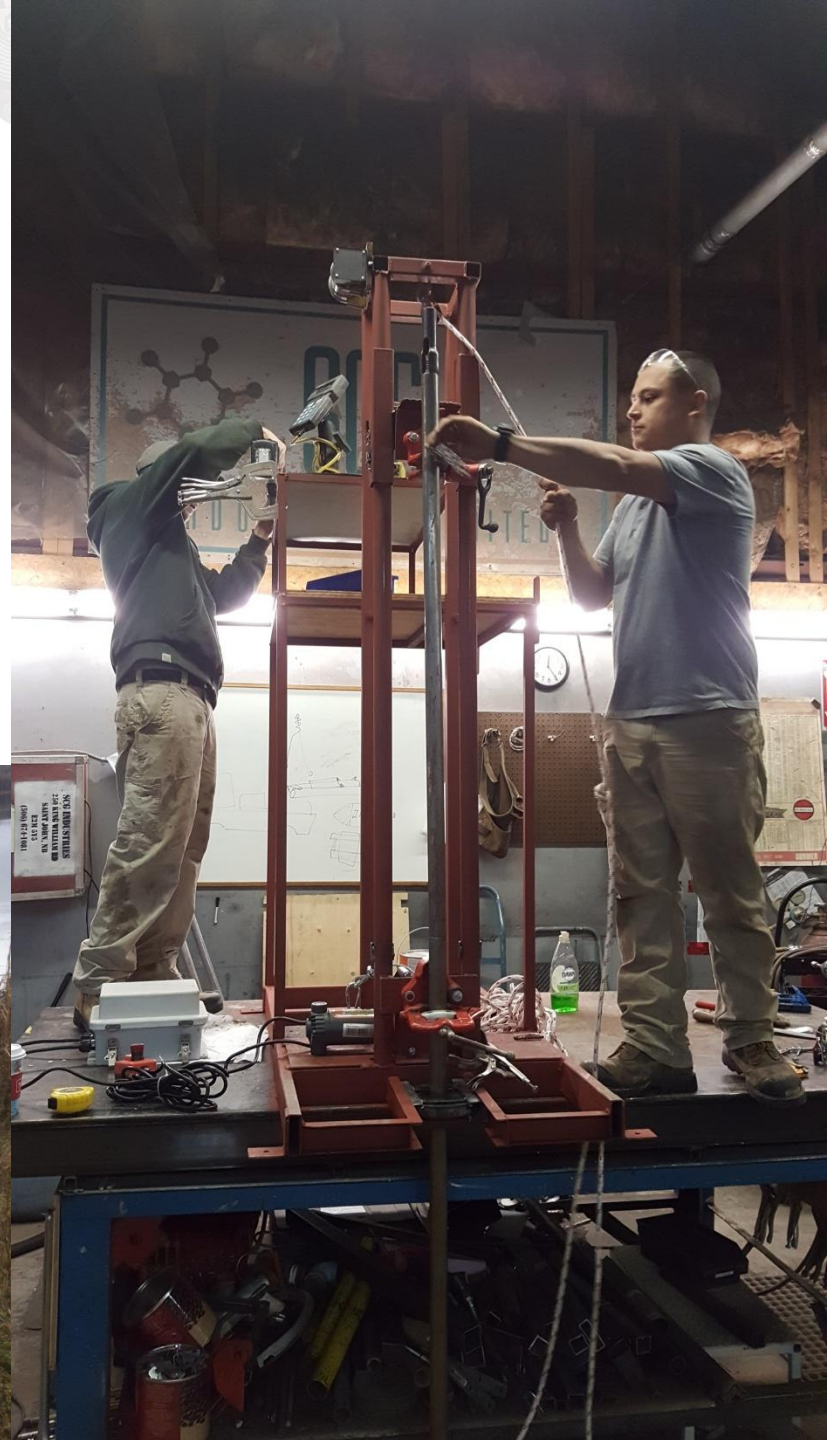
- Phase I – Bench Scale Assessment
  - Novel material and significant uncertainty in performance:
    - Organic Pulp Sludge.
    - Background Native Sediments.
    - Development of chemometric methods and assessment of LIF performance.
    - Initial results positive providing material resolving power through processing of LIF spectral data.

Phase II – Field Proof of Concept

- Project Challenges:
  - Technical:
    - Effective application of developed technique in-situ.
    - Compare to standard approach – grab and core sampling.
  - Logistical:
    - How to deliver cost-effectively?
    - Built and deployed a mobile system for UVOST delivery.


V1

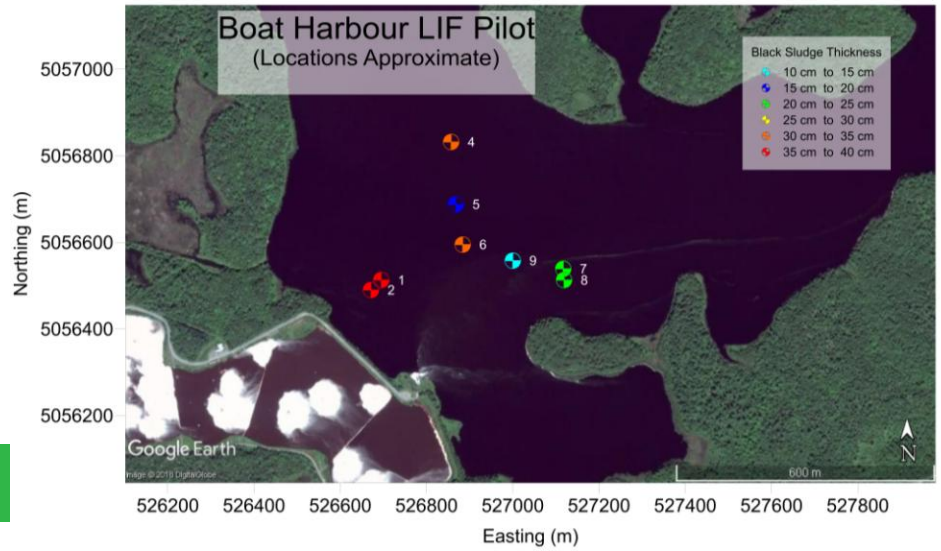

V2



Phase III – Pilot Program

- Phase II Results:
  - Uncertainty in practical delivery – overall safety & efficiency.
  - Technical performance – Identification of challenges to the process.
    - Both in data collection and data interpretation.

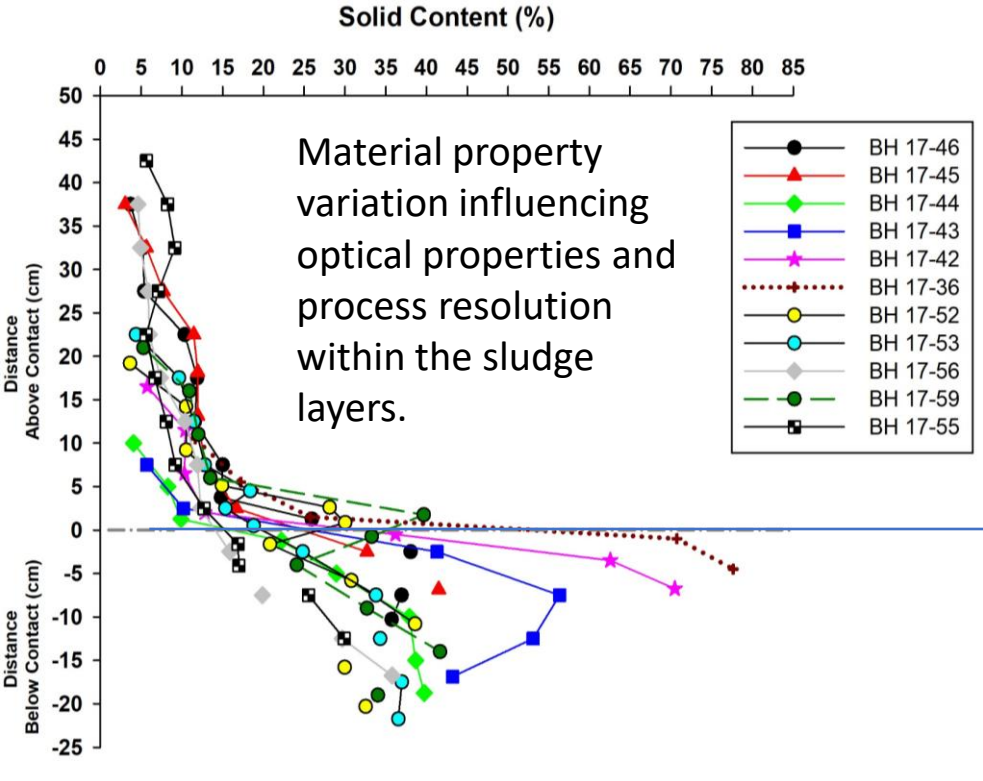
- Phase III – Pilot Program
  - Redevelopment of delivery system/operational platform
  - Optimization of data analysis and processing approach.
  - Goals:
    - Complete a robust comparative assessment.
    - Identify remaining logistical and technical challenges.



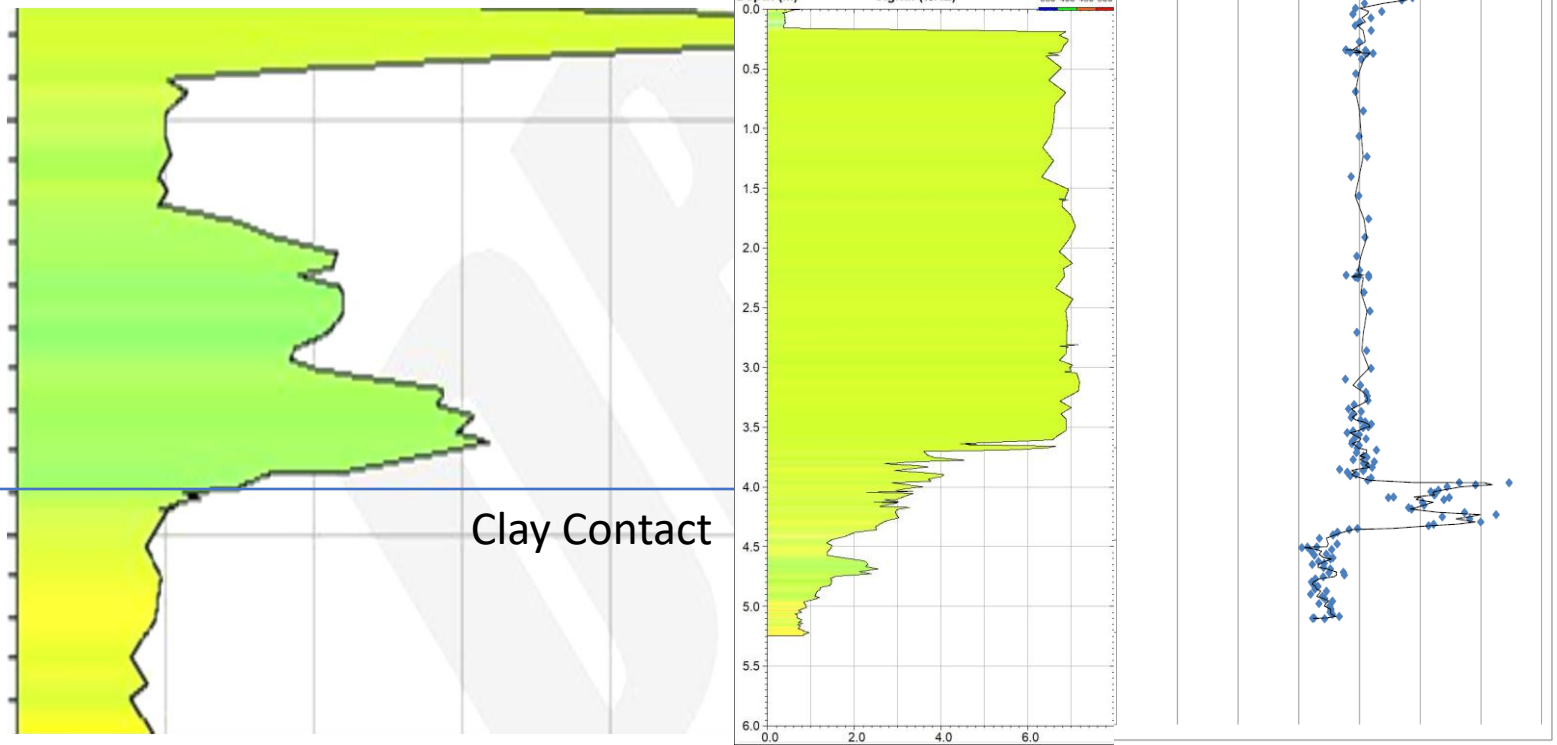
Phase II & III Results

- **What does LIF "see" vs. coring?**
  - Core recovers/logs only competent sludge layer.
  - Chemical, material, and structural differences detectable via LIF.

- Logs can be complex:
  - Mixing, Inter-bedding, variable background material and sludge properties.
  - Data processing critical to resolve complex signaling.



Raw vs. Processed data



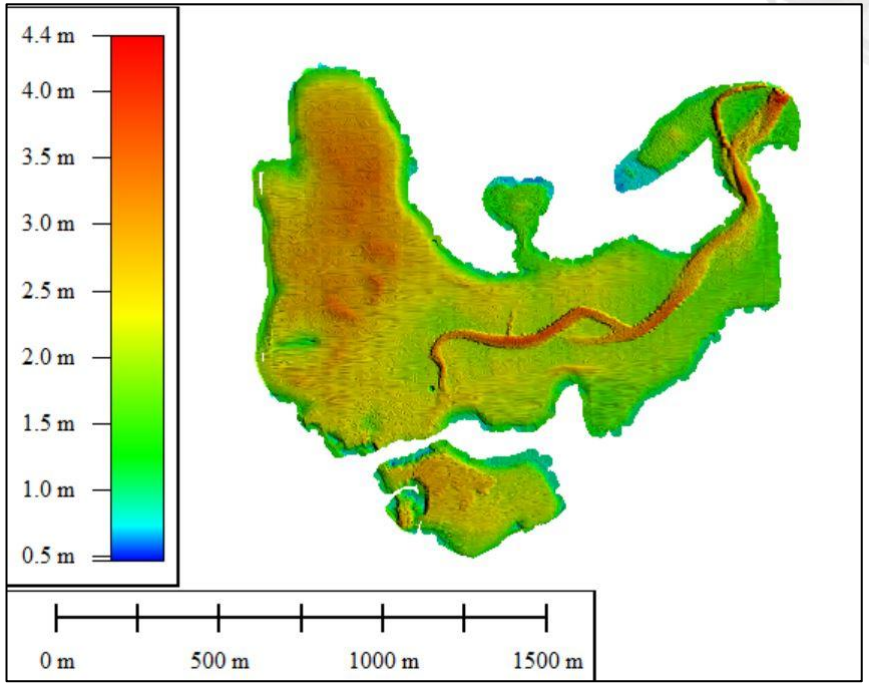
Full-Scale Application – Sludge Thickness Determination

Sludge Thickness Determination - SOW

- Conduct a bathymetric survey to map the top of the sludge across Boat Harbour.
- Investigate sludge profiles at 500 + locations to determine:
  - Sludge thickness profiles;
  - Elevation of the bottom of sludge.
- Combine the top of sludge map with the investigation points:
  - Sludge volume estimate to inform sludge containment design;
  - Map of the bottom of the sludge to be used for remedial design.

Bathymetry

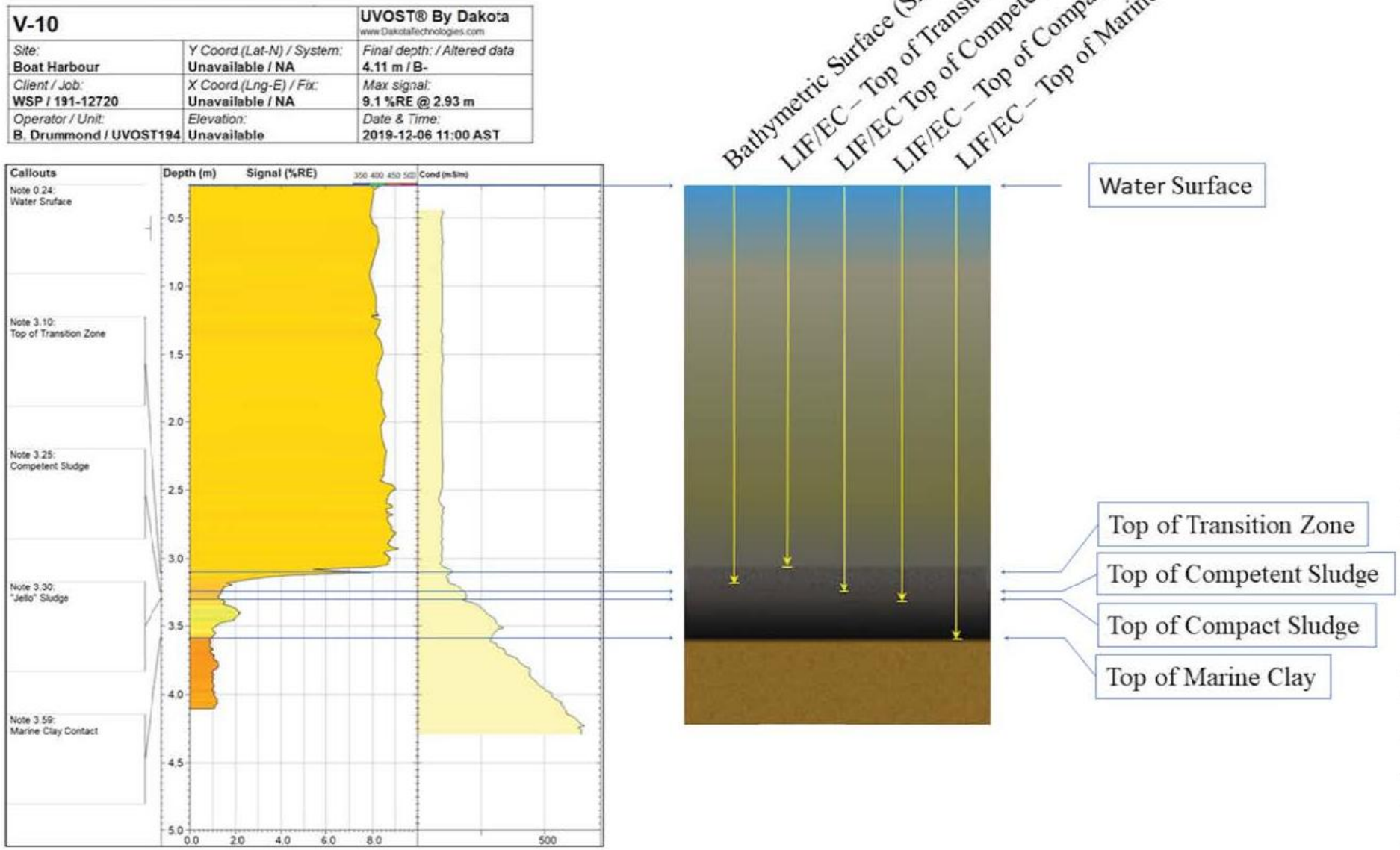
- Surveys to determine the depth of water.
- Single beam and multi-beam sonar.
- Connected to RTK survey equipment to provide elevations.
- Sonar depth measurements corrected to elevation.
- Used to produce a map of the bottom of the Harbour.



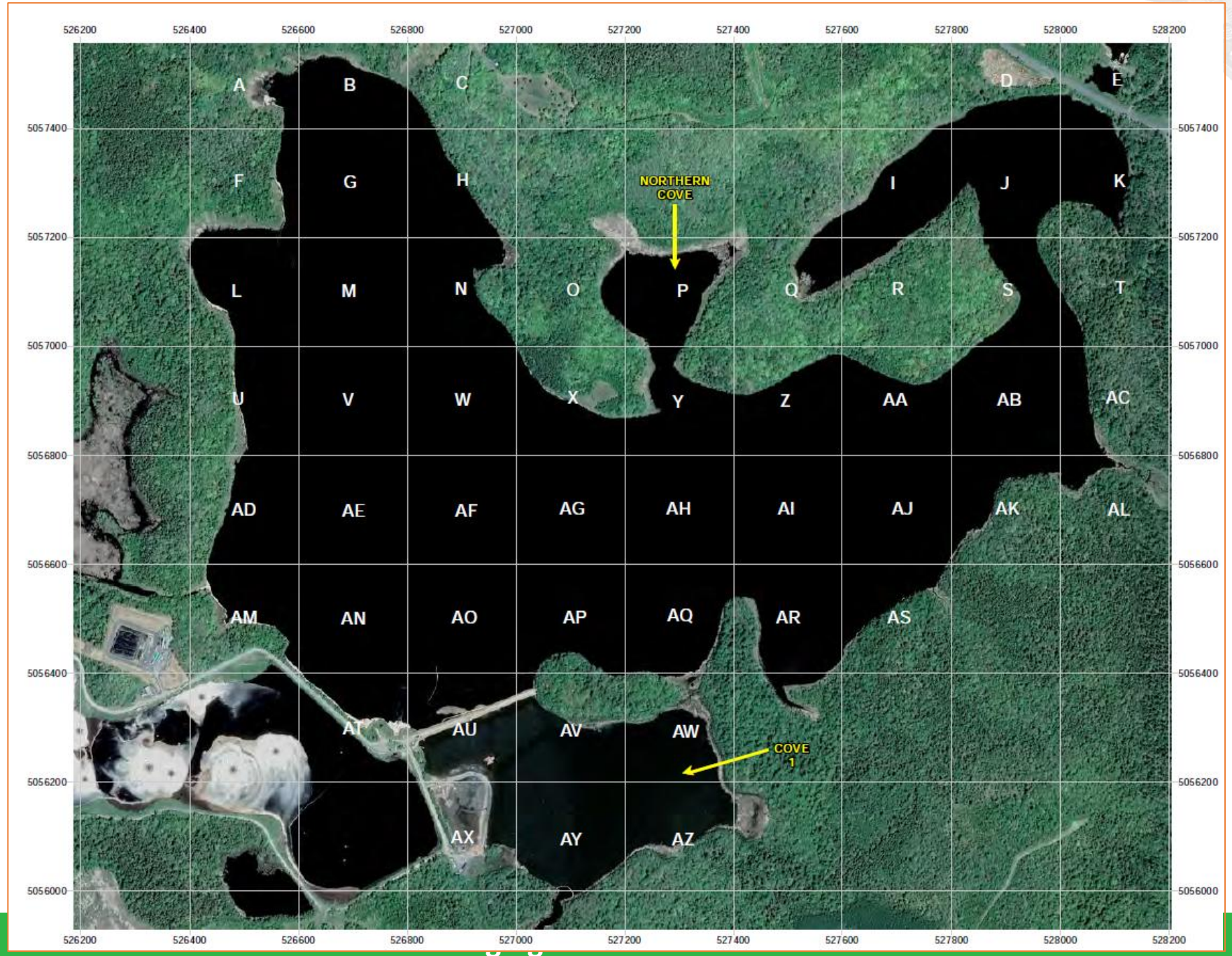
In-situ Data – Sludge Characterization

- Navigate to location;
- Secure the barge using pole anchors;
- Deploy LIF/EC;
- Survey benchmark on the barge;
- Verify data quality;
- Deploy secondary data methods (as needed);
- Enter data into database;
- Sync database to online tool.

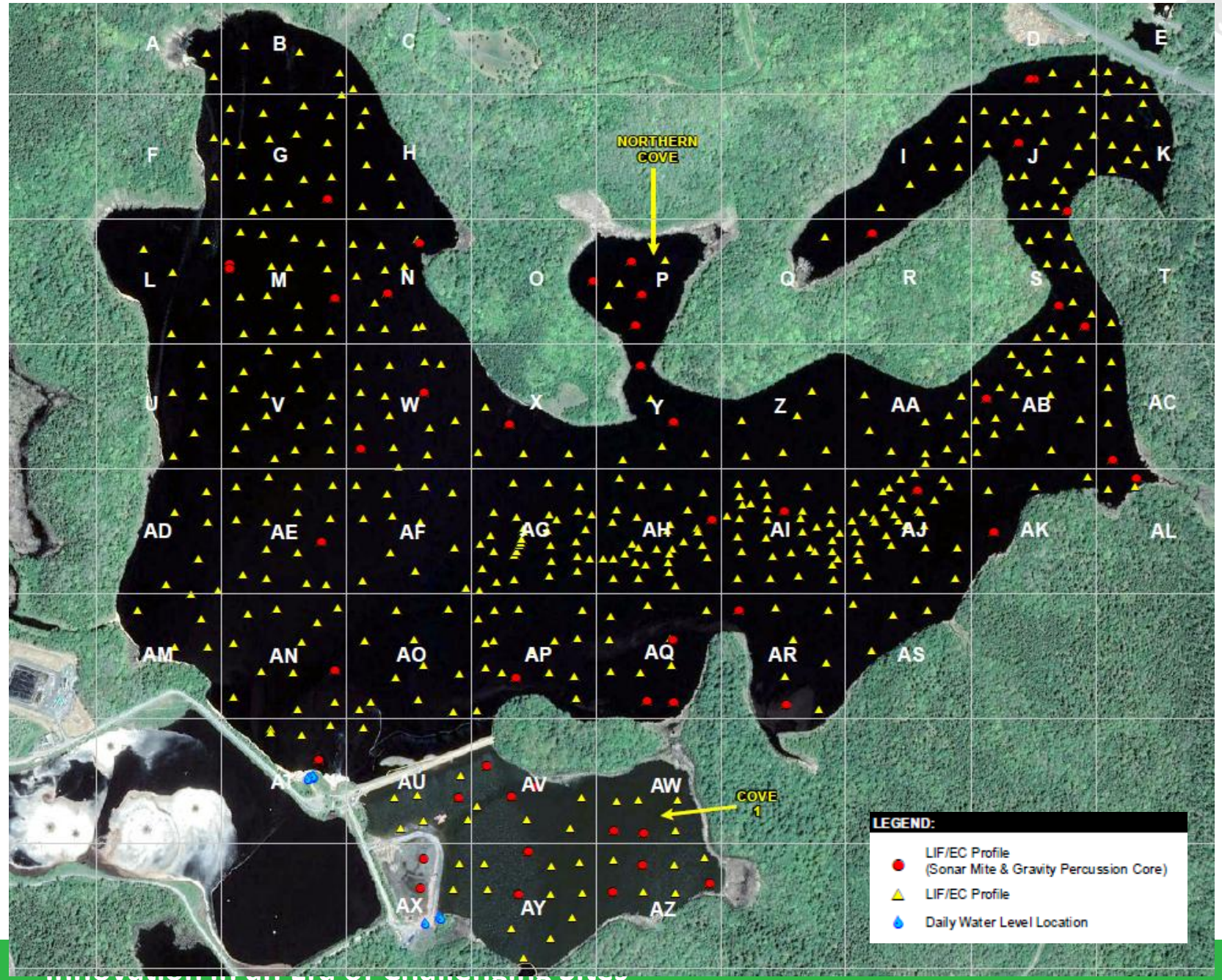
What does LIF and Sonar “see”?



ADAPTIVE MANAGEMENT



- The project area was subdivided into 200 x 200 m grids (A – AZ)



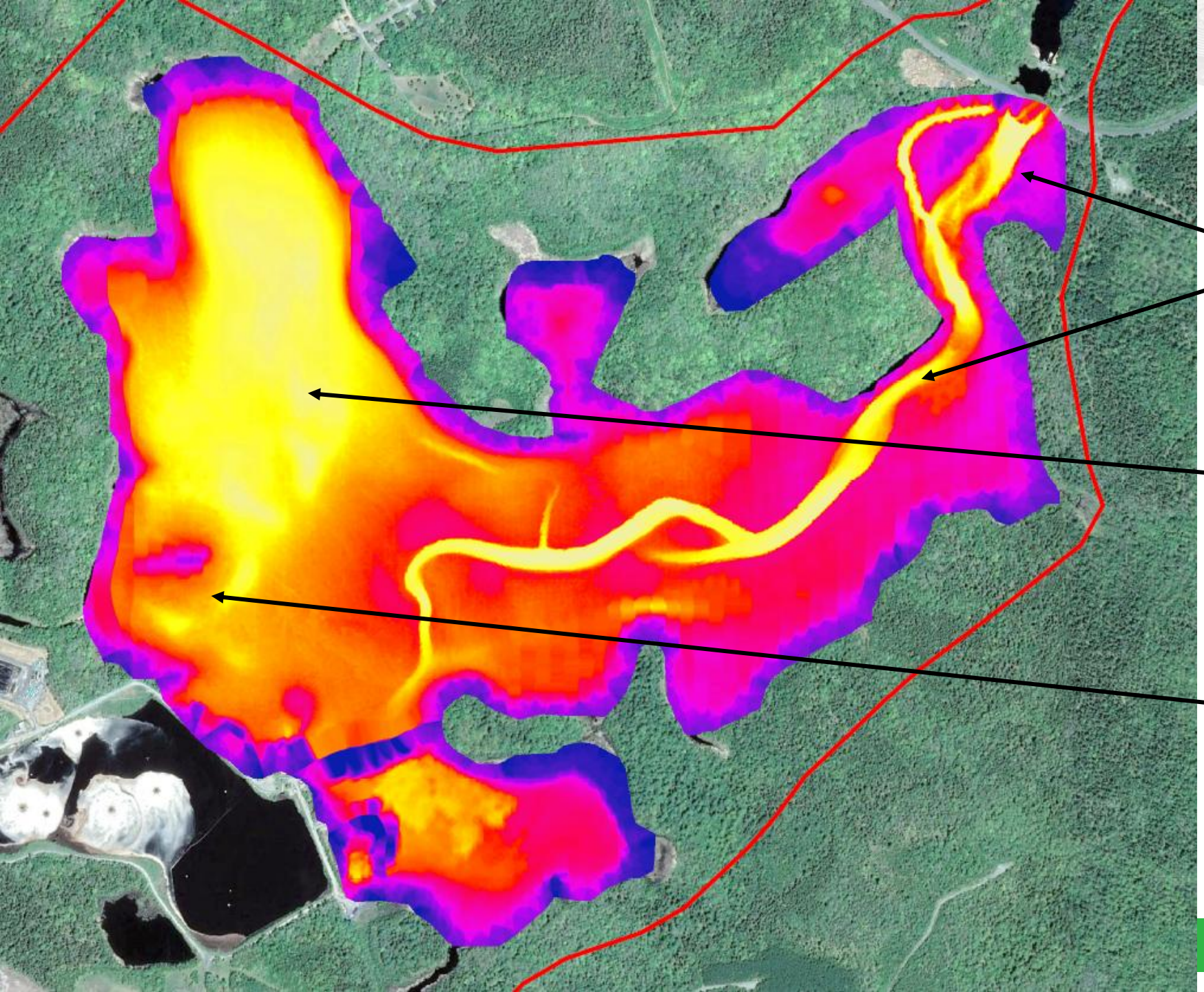
- Adaptive delivery approach to optimize data collection.
- 410 points placed initially
- 90 addition points were added during the program refine data understanding

Data QA/QC

- LIF/EC Data Control
  - Calibration checks
  - Real time profile monitoring
  - Duplicate profiles
  - Post Collection Processing
  - Core sampling
- Core Data Control
  - Repeat cores collected
  - Modified pulley system to reduce human error
  - Extrusion completed in short intervals
- Bathymetric Survey Data Control
  - Calibration checks
  - Testing of systemic errors
  - Post field processing

Results

Bathymetry

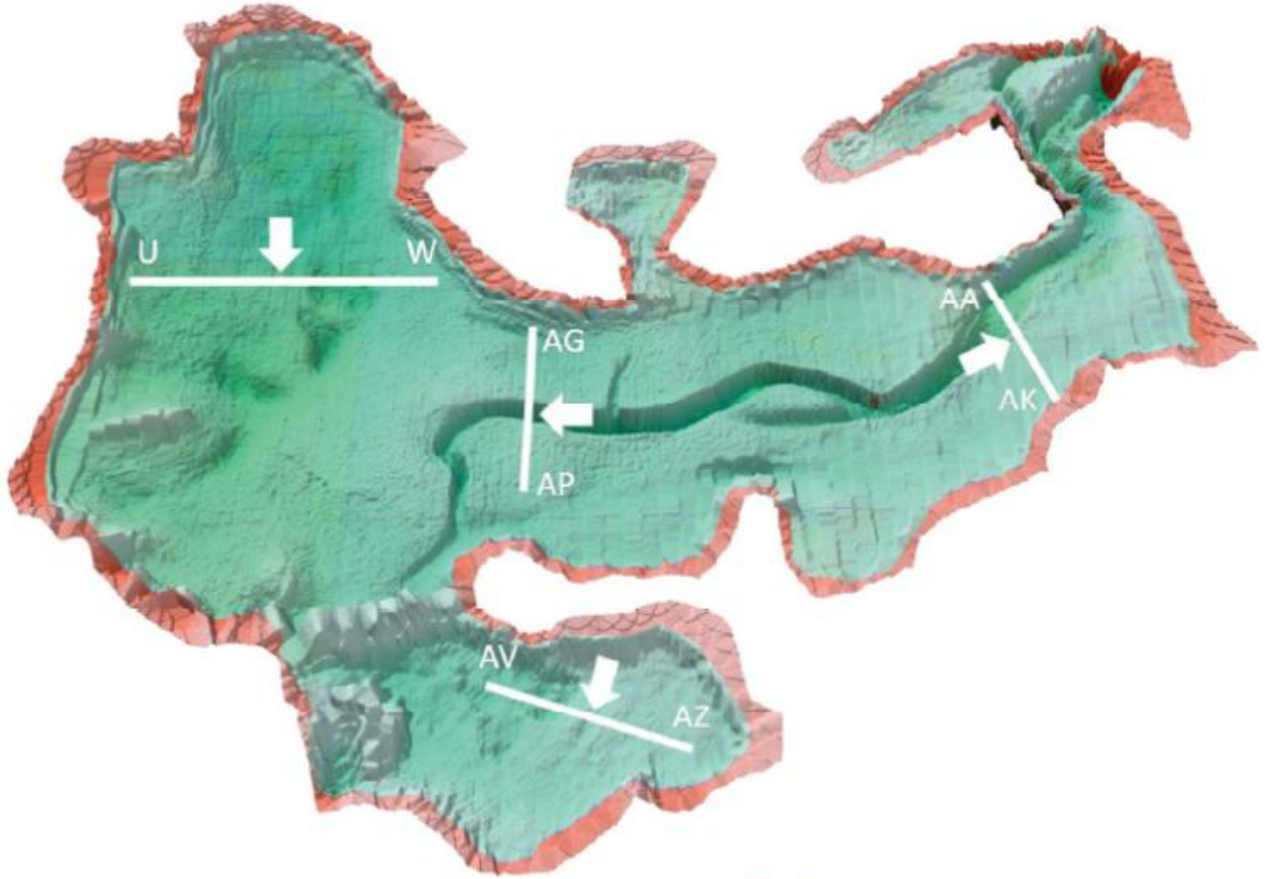


Historic tidal channels

Deeper in the western bay

Historic Island

Channel

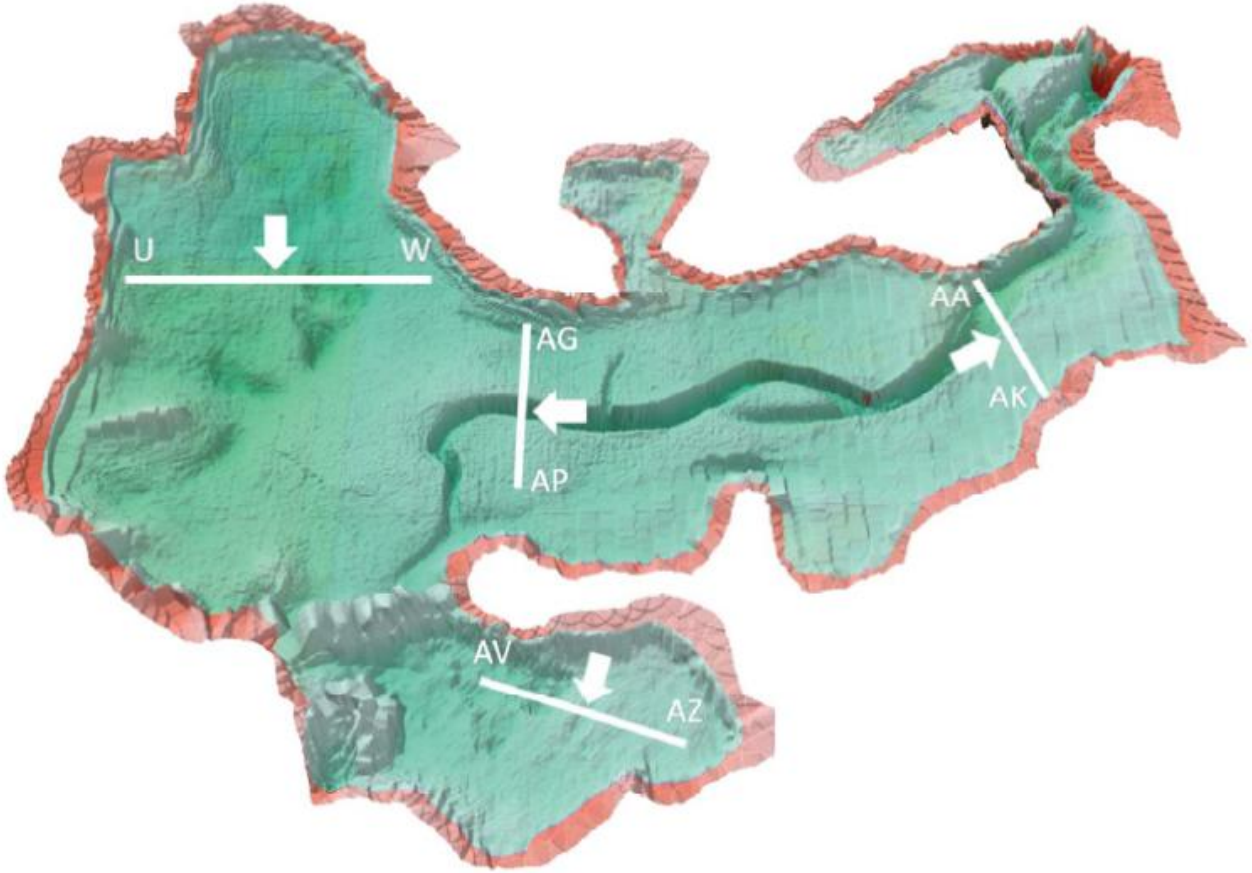


LEGEND:

- TEAL: TRANSITION ZONE
- RED: BATHYMETRY
- PURPLE: SLUDGE TOP
- BROWN: SEDIMENT BOTTOM

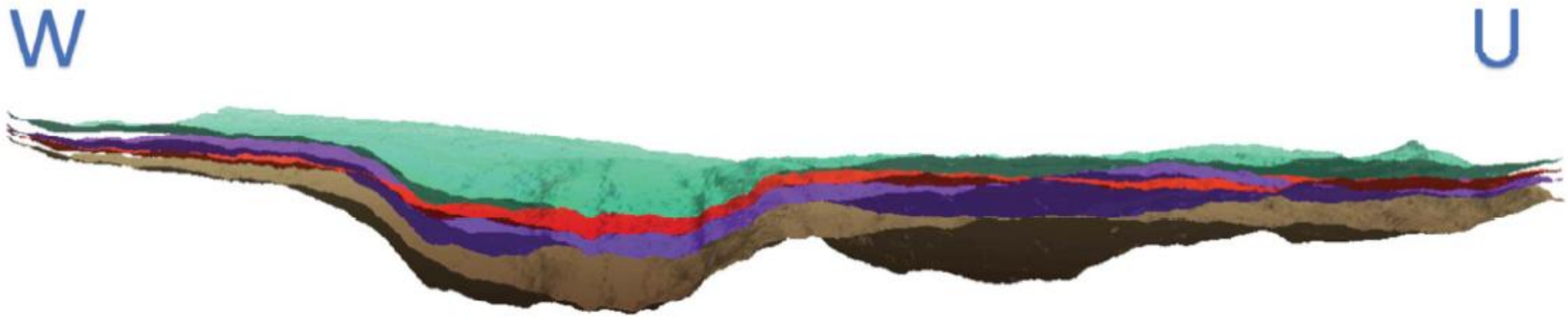
AA AK

Western Basin

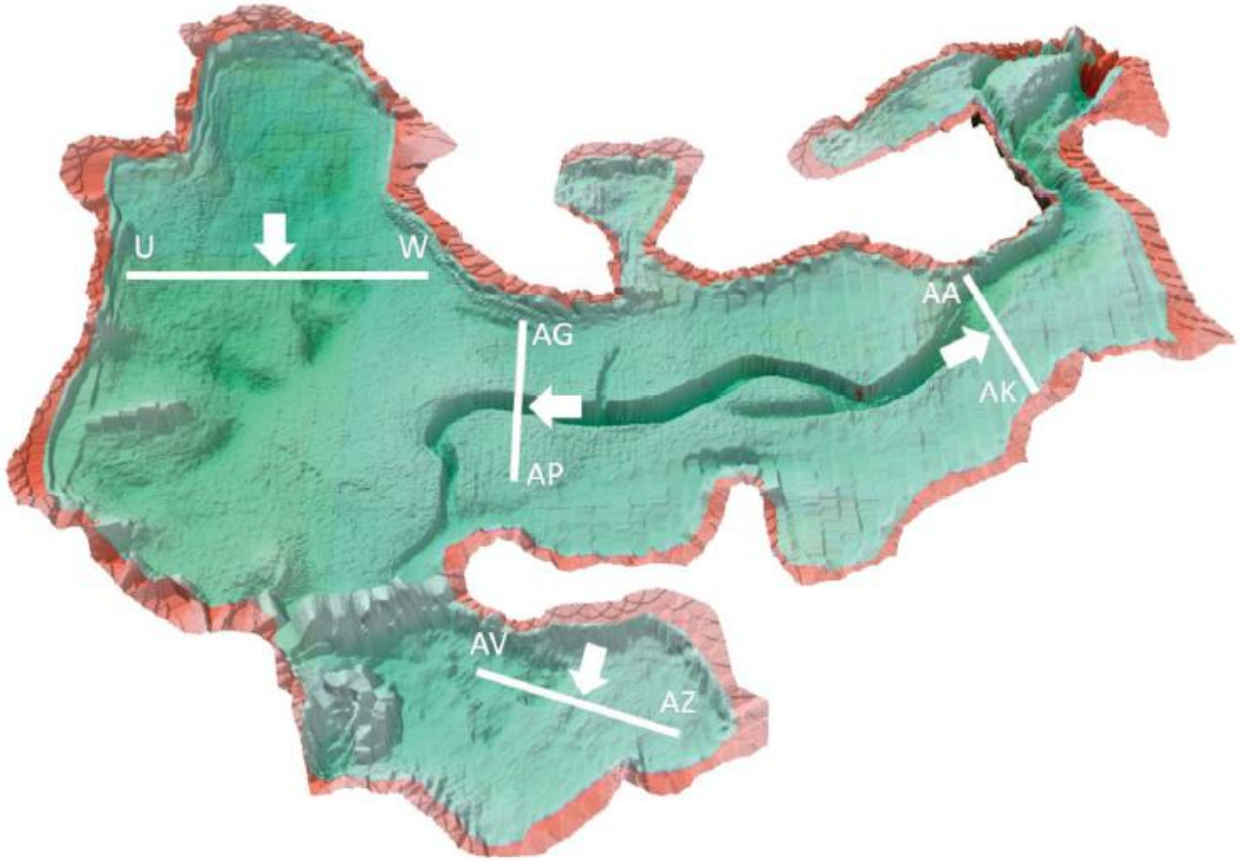


LEGEND:

- TEAL: TRANSITION ZONE
- RED: BATHYMETRY
- PURPLE: SLUDGE TOP
- BROWN: SEDIMENT BOTTOM



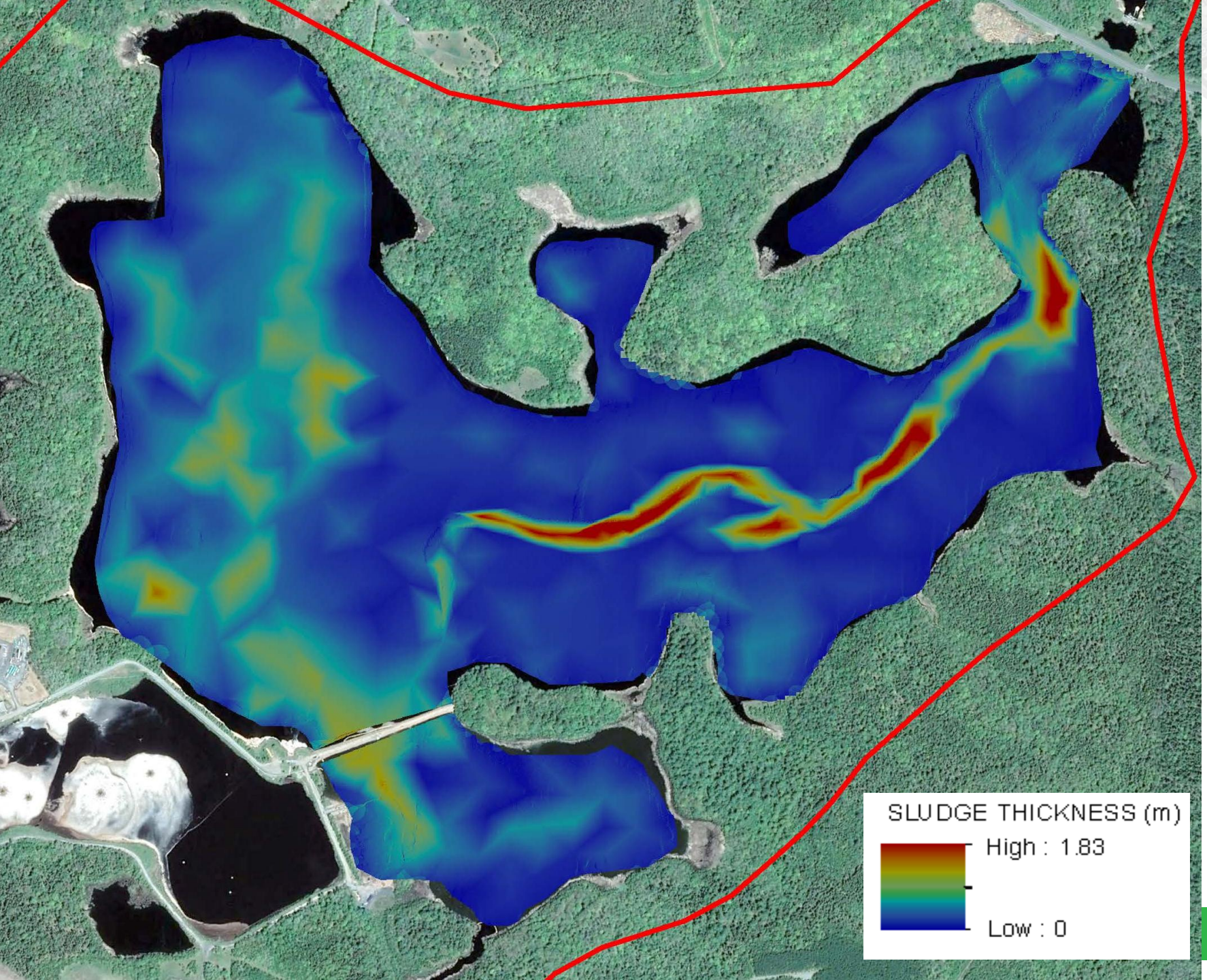
Cove A



LEGEND:

- TEAL: TRANSITION ZONE
- RED: BATHYMETRY
- PURPLE: SLUDGE TOP
- BROWN: SEDIMENT BOTTOM

AZ AV



- Sludge volume estimates:
  - Competent sludge: 271,000 m^3
  - Competent sludge plus transition zone: 400,500 m^3

Future Applications

- Boat Harbour remediation:
  - Approach can provide verification assessment and QA/QC assessment during remediation.
    - LIF/EC profiling after dredging to identify areas of sludge/sediment mixing and identifying ‘hot spots’ where sludge remains;
    - LIF/EC profiling following dredging to quantify the settling of suspended sediment.
  - Approach may provide further details concerning sludge characteristics.
    - Couple LIF/EC with chemical analyses to provide semi-quantitative interpretation;
    - Identification of natural materials, mixing, etc. to inform remediation approach/endpoints.

- Applications beyond Boat Harbour:
  - Novel approach to sludge characterization and quantification;
  - Waste water treatment systems;
  - Ports and marine facilities.

Thank You

Questions:

jwbsweet@scgindustries.com

Thanks to Project Partners: