In-situ Laser Induced Fluorescence – Novel Applications for Contaminated Sediments Characterization

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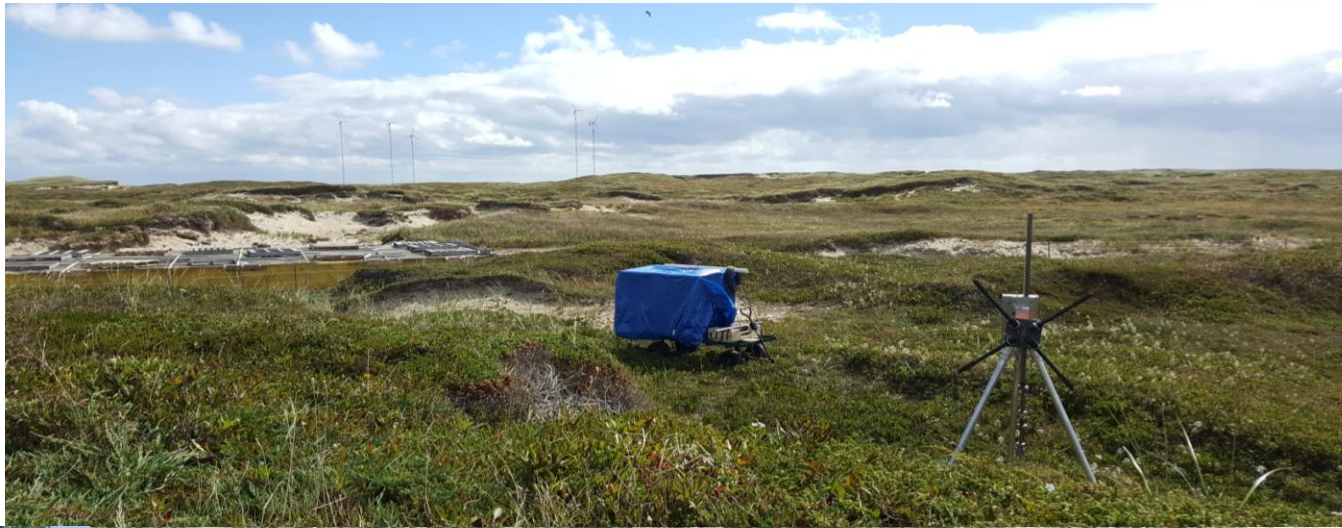
SCG Industries

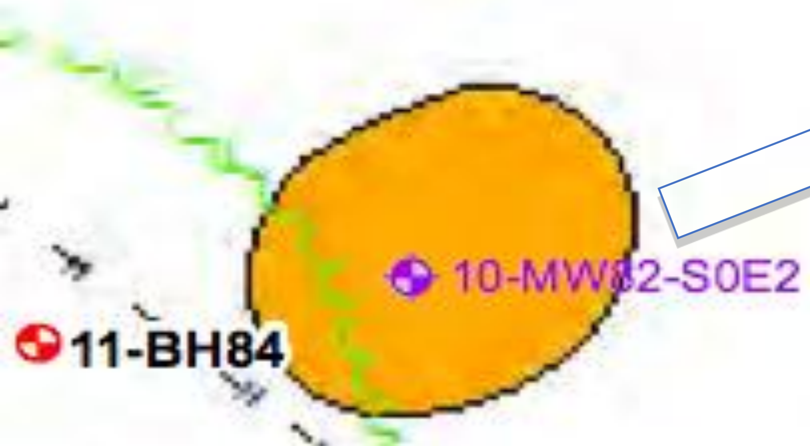
- HRSC – principals
- Laser Induced Fluorescence
- Novel Application Case Study

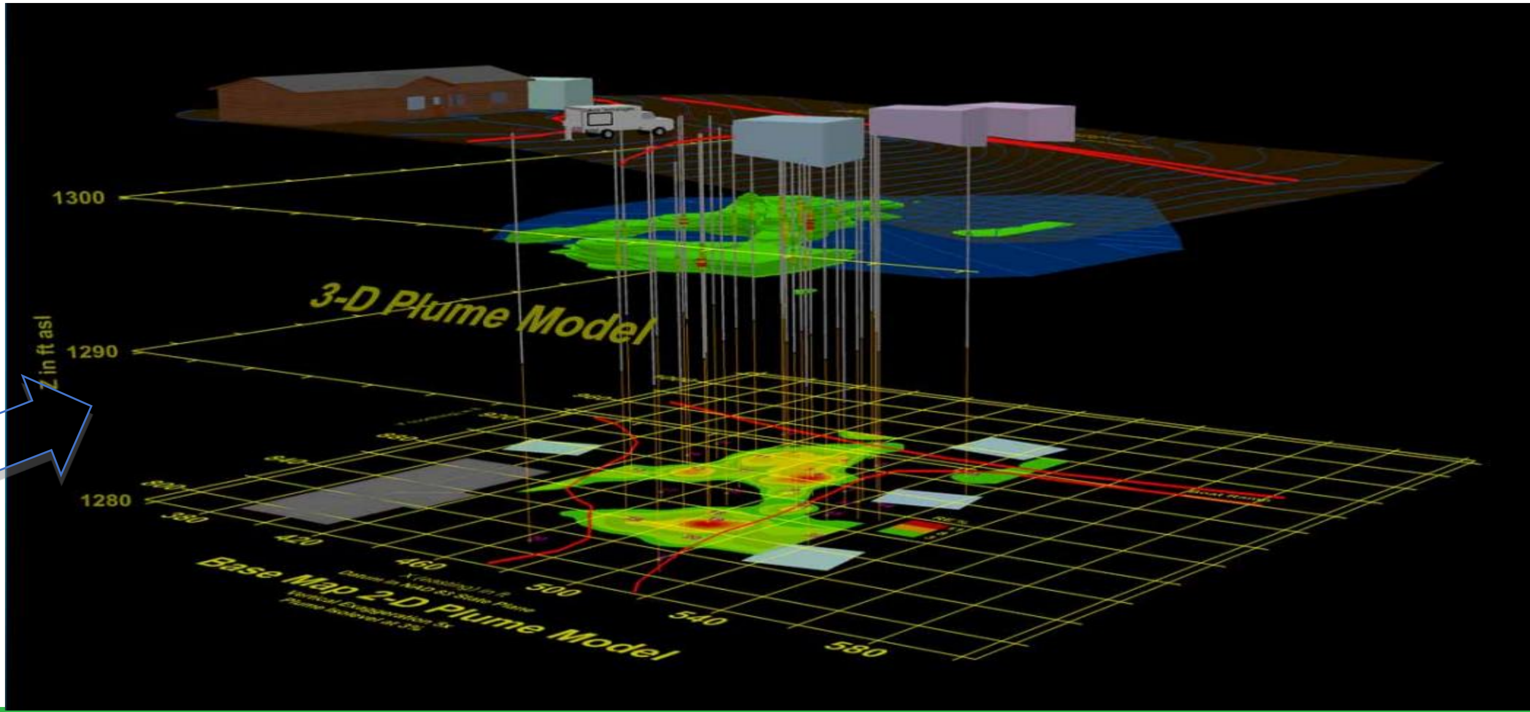


HRSC – Definition

- USEPA, 2013

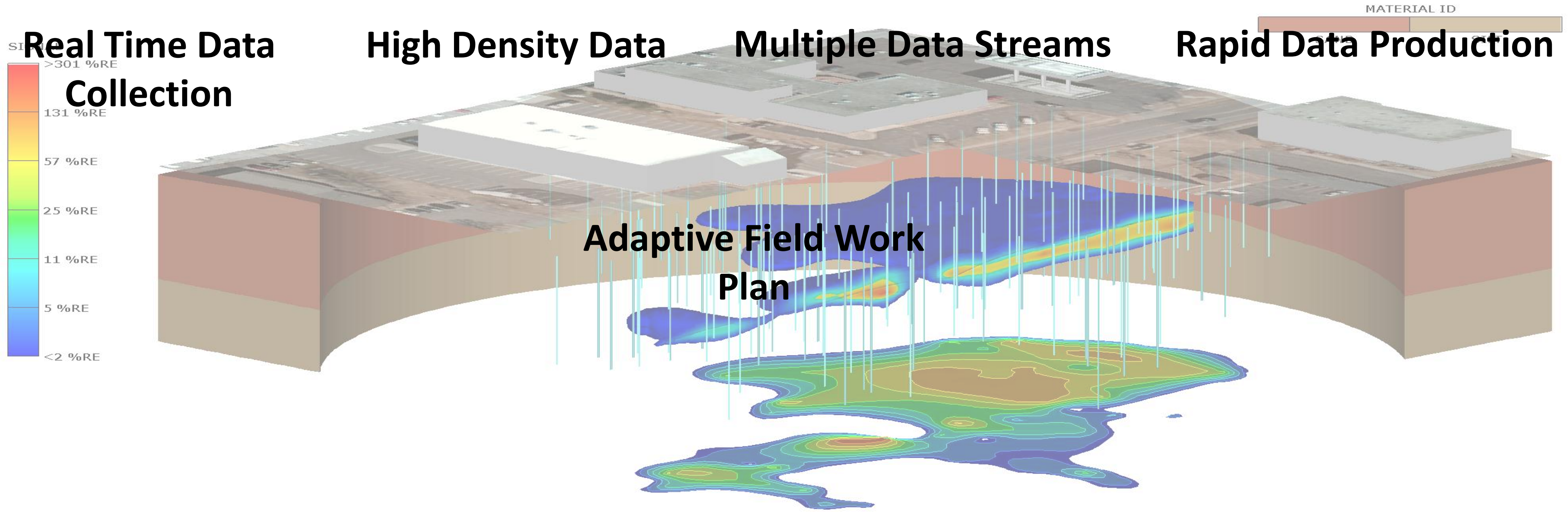
  "High-resolution site characterization (HRSC) strategies and techniques use scale-appropriate measurements and sample density to define contaminant distributions, and the physical context in which they reside, with **greater certainty**, supporting **faster and more effective site cleanup**."





Greater Certainty

Real Time Data Collection | **High Density Data** | **Multiple Data Streams** | **Rapid Data Production**



Adaptive Field Work Plan

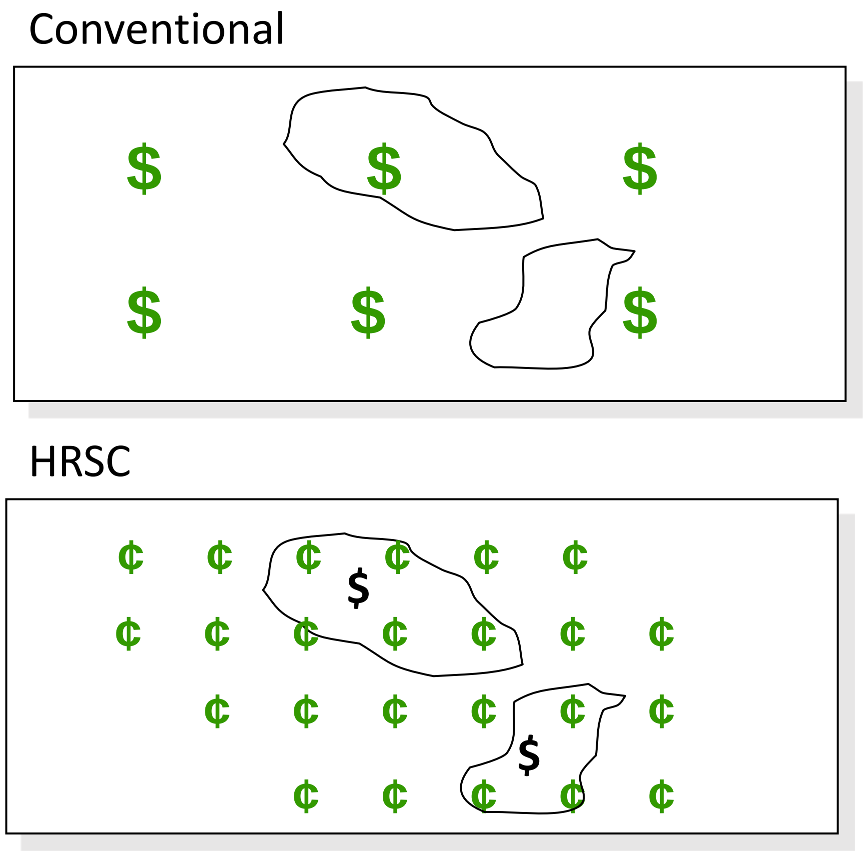
Scale, Extent, Data – density & diversity

Analogous to developments in medical imaging technology (X-ray, MRI, etc.)

How important is this step?

- Managing uncertainty:
  - Conventional sampling approach
  - Paradigm shift via HRSC technologies
    - Marked increase in representativeness

- Importance of representativeness
  - "... 70 to 90 percent of data variability was caused by "natural," inplace variability, with only 10 to 30 percent of variability being contributed by the rest of the data generation process..." (USEPA, 1991 from Crumbling et al., 2003)
  - COST & TIME SAVINGS
    - High return on investment

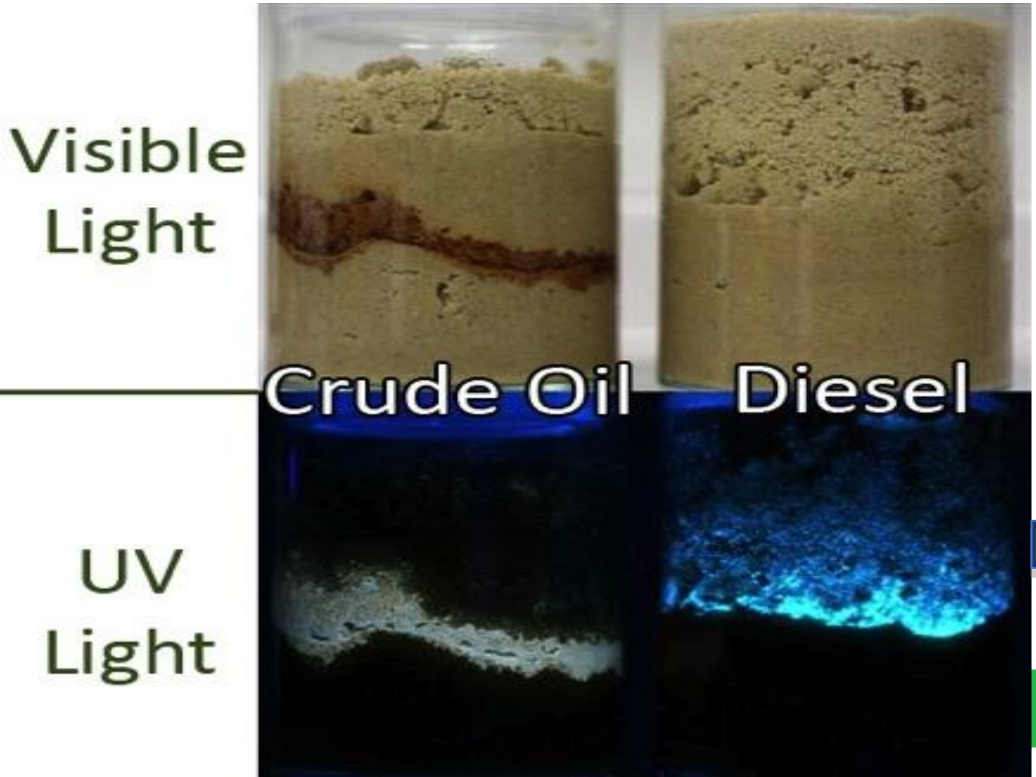


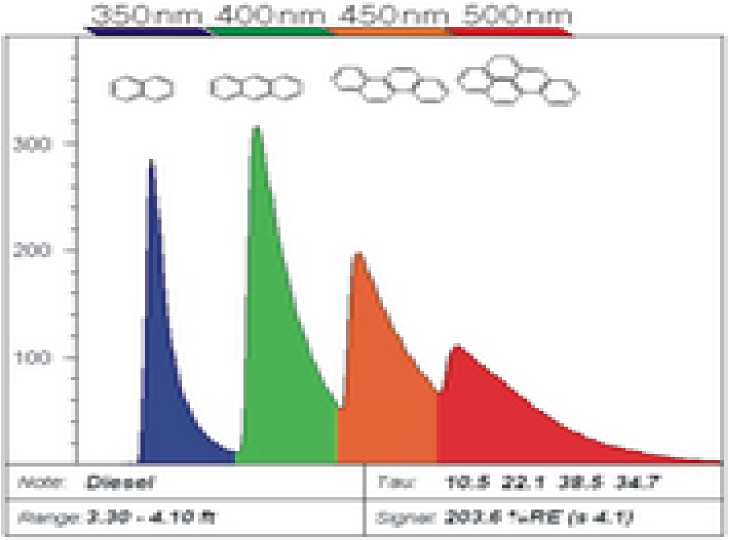
(After Crumbling, et al., 2001)

LIF – Laser Induced Fluorescence

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

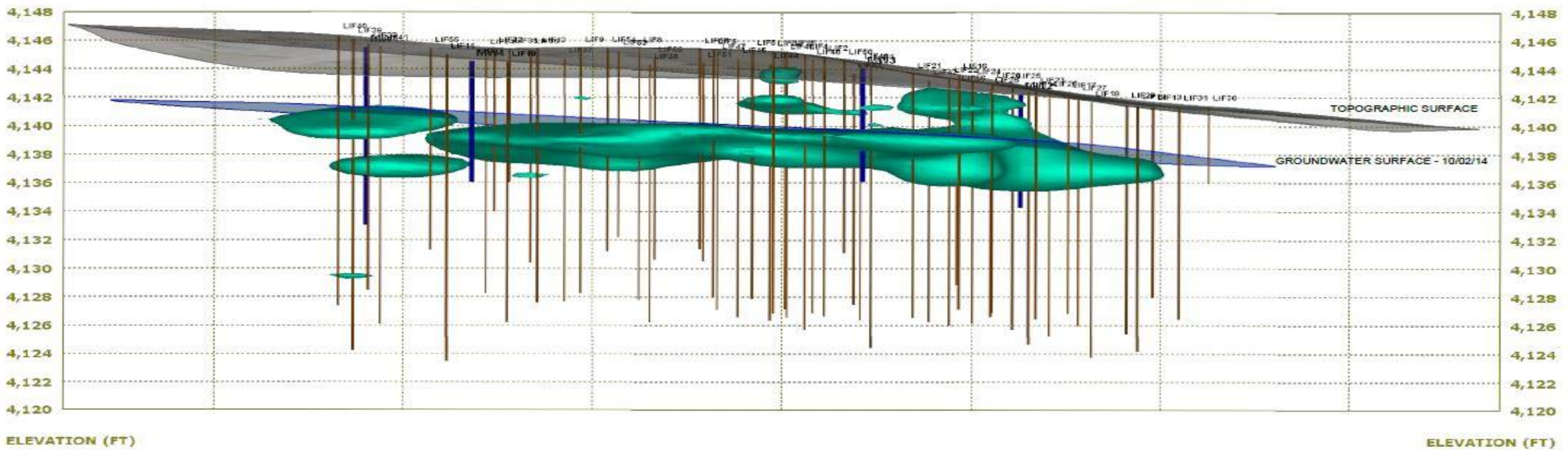
- Standard Practice - operation is based on two principles:
  - Fluorescence – PAHs
  - NAPL & PAH partitioning





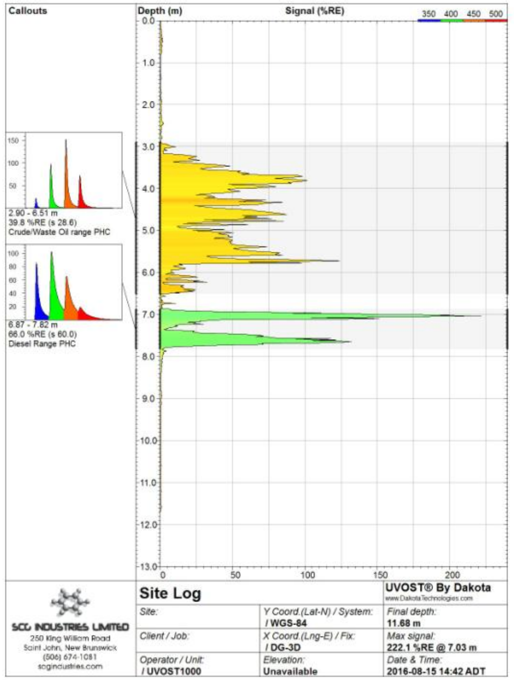
Goals

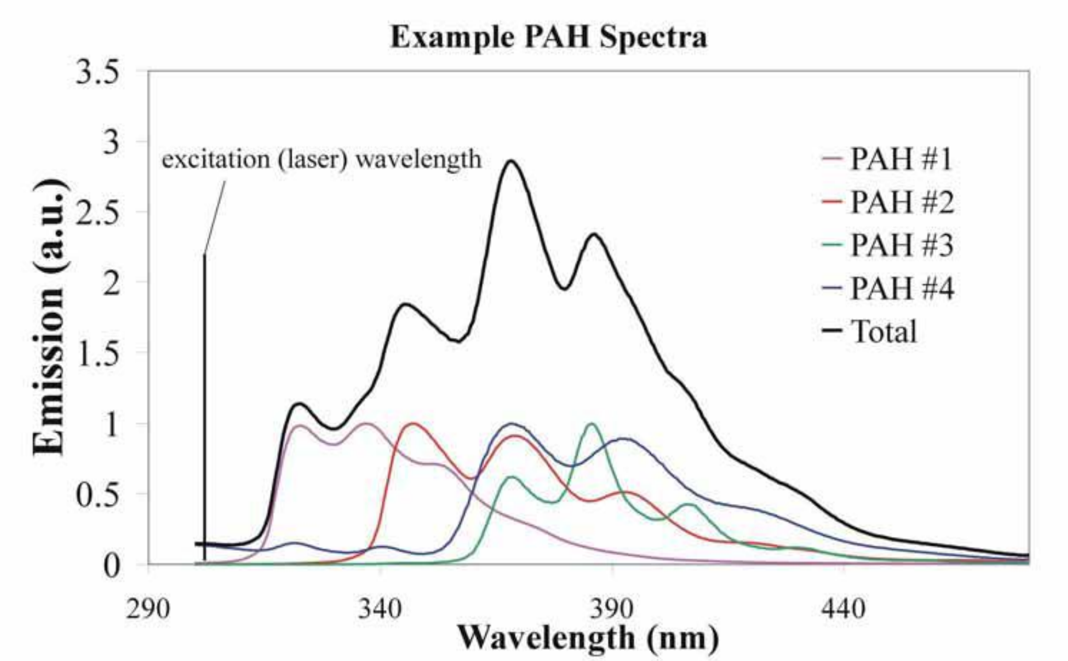
- Cost-effectively reduce uncertainty – significant return on investment.
  - Accurate delineation of contaminant distribution and hydrogeological properties – accurate Site Conceptual Model.
  - Empowers rapid, adaptive, and strategic management approaches.

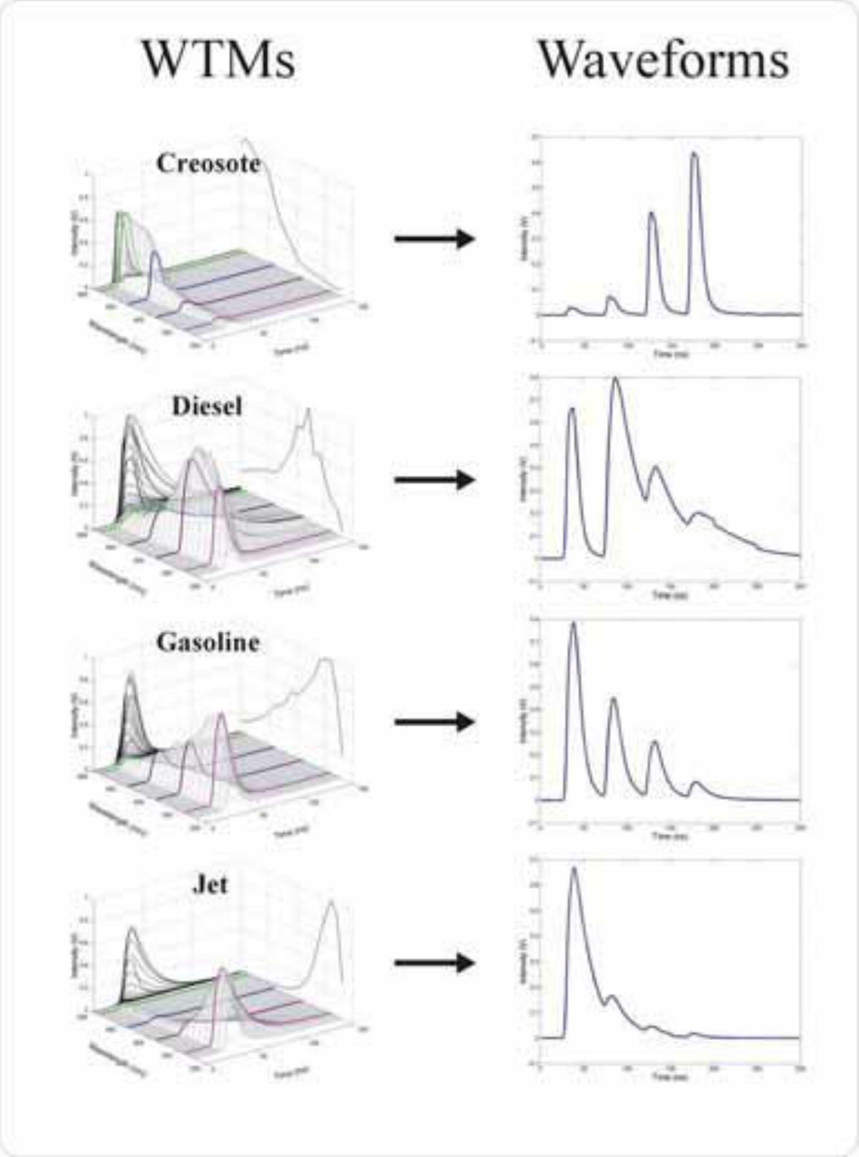


Can LIF do more?

- 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?

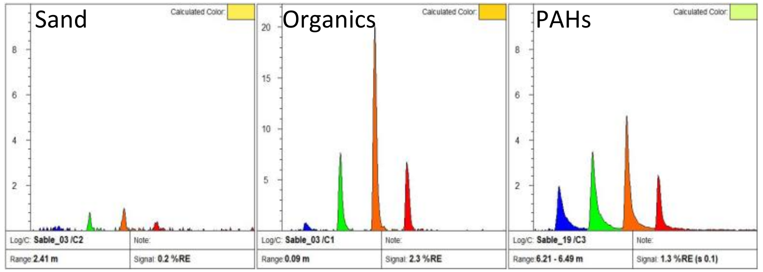




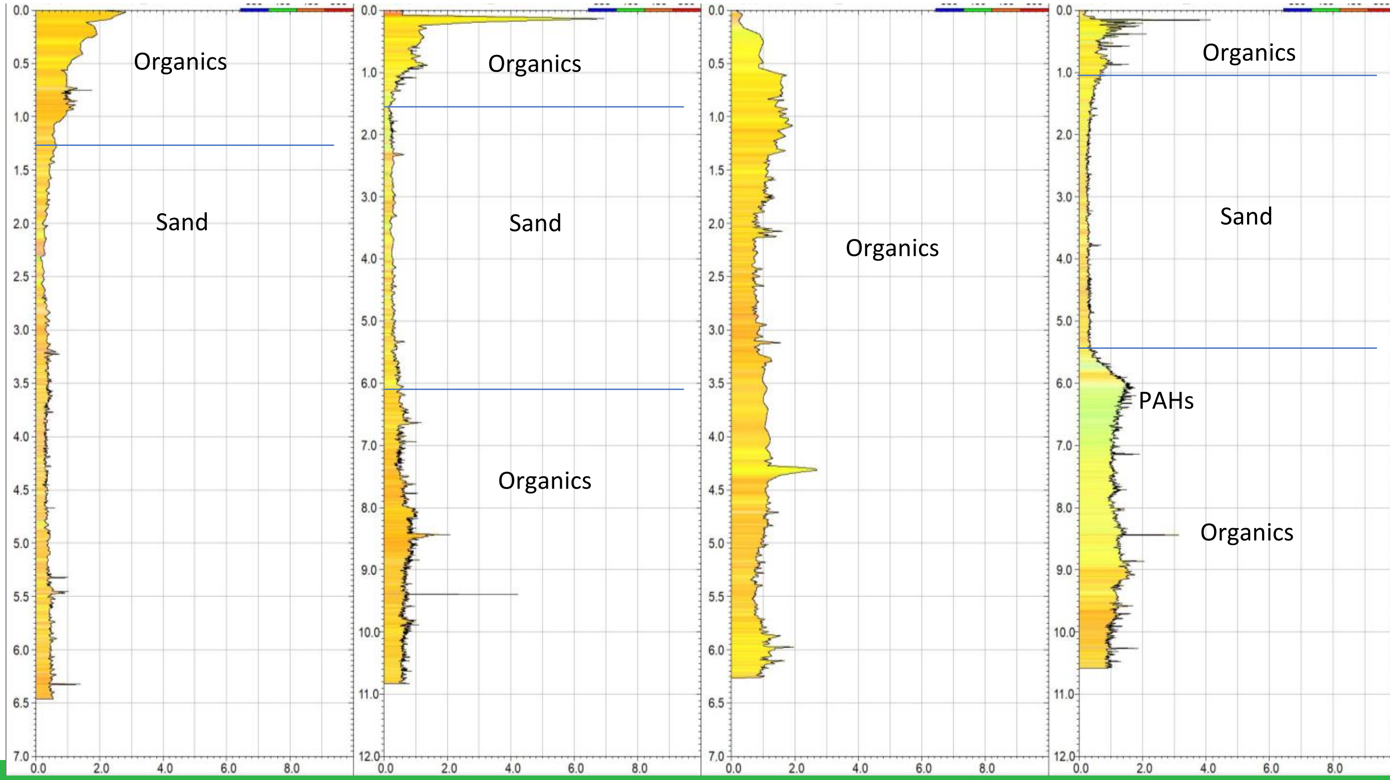


Example Application

- Can LIF separate materials accurately based on physiochemical/optical properties?
  - Yes! But...
  - Very complex process requiring additional data processing and interpretation techniques.
  - Variable costs/benefits depending on data quality, applied process, and end goals.



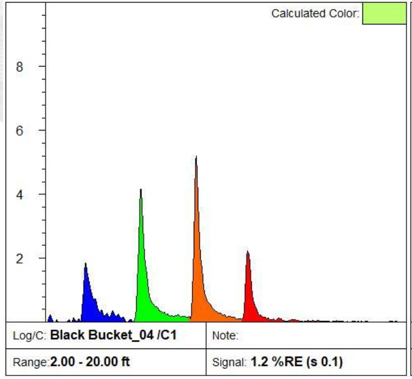
Raw visual log data representing various stratigraphic units (sand and organic layers) and PAH contamination

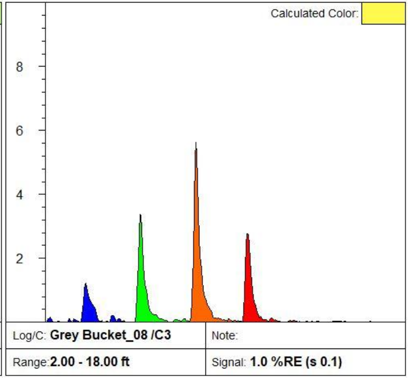


The Challenge

- Tidal Estuary converted to Stabilization Lagoon.
  - Received Industrial effluent since 1967, sealed 1972.
  - Project Goal - restoration to “natural” conditions.
- Restoration process:
  - Remediation:
    - Challenge - estimation of contaminated sediment volume:
      - Physical properties – inhibit delineation.
      - Significant area – 141 Hectares.
      - Heterogeneity.
- Can LIF help?

Project Approach



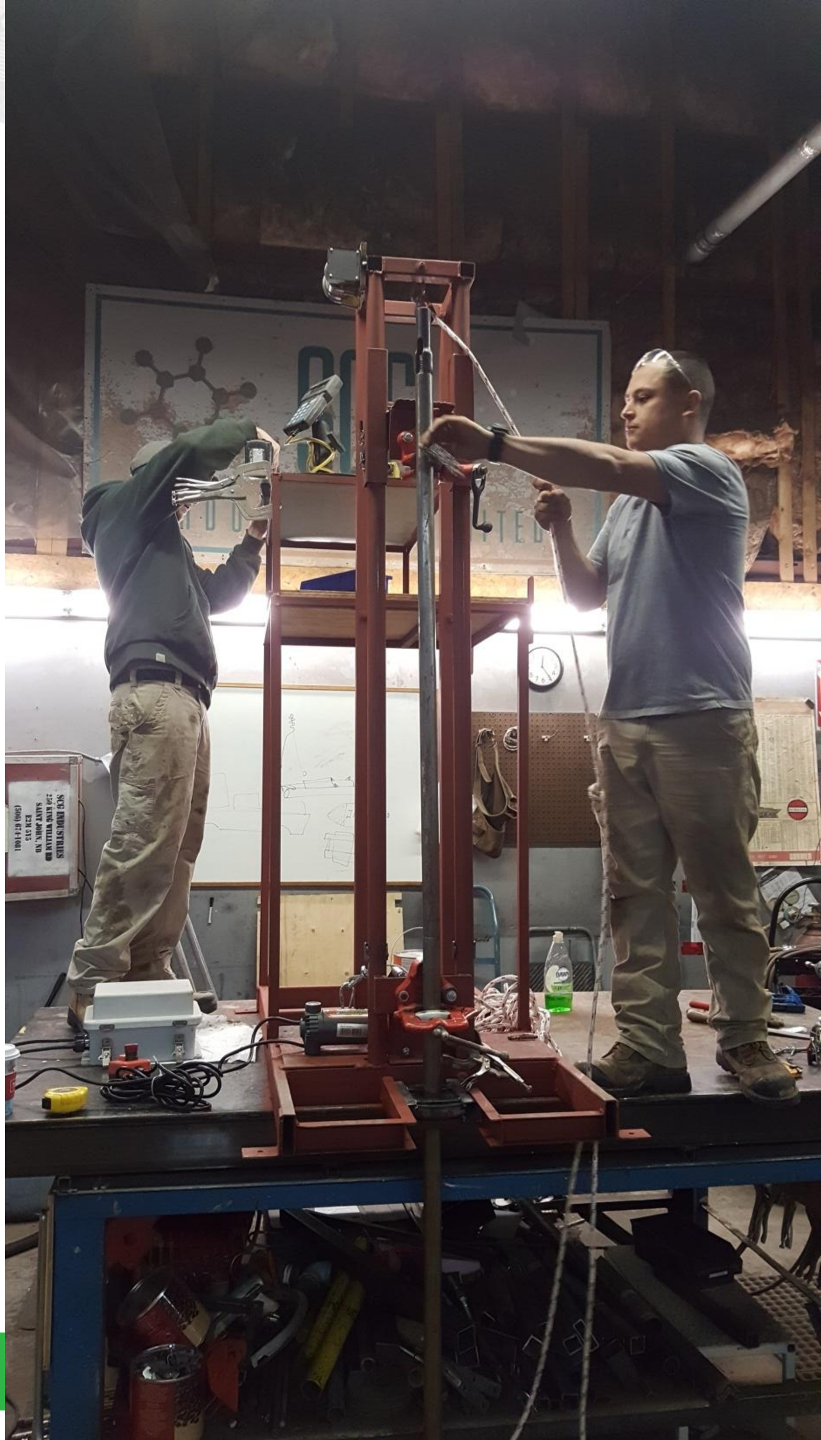


- Challenges:
  - Novel materials and significant uncertainty in performance:
    - Organic Pulp Sludge.
    - Background Native Sediments.
    - Development of chemometric methods and assessment of system performance.
  - Cost and risk mitigation at R&D initiation and project progression.

- NSERC Engage Grant
  - Phase I – Bench Scale Assessment
    - LIF and NIRS
  - Phase II – Field “Proof of Concept”
    - Comparative assessment

Phase II – Field Proof of Concept

- Project Challenges:
  - Technical:
    - Application of developed technique in-situ
  - Logistical:
    - How to deliver cost-effectively??
    - Built and deployed a mobile system for UVOST delivery.



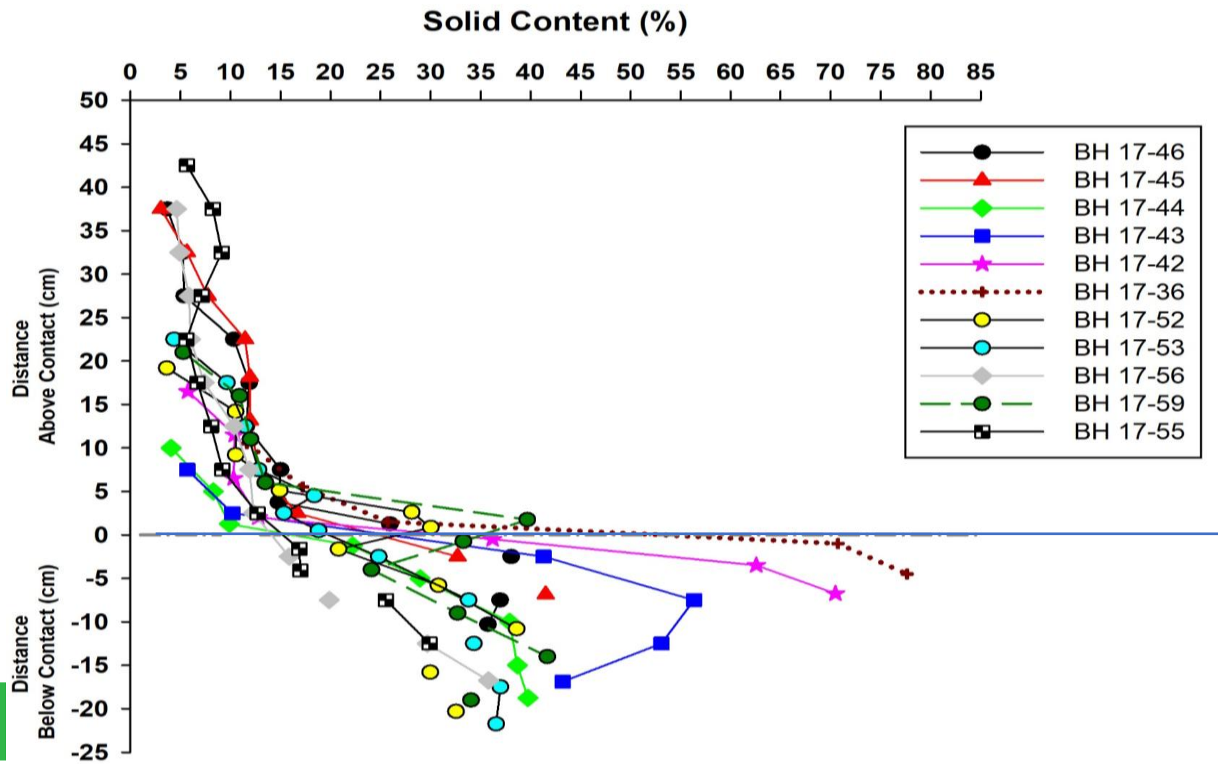
Phase III – Pilot Program

- Initial scope completion:
  - Uncertainty in delivery – safety & efficacy.
  - Technical performance – Identification of challenges to the process.
    - Both in data collection and interpretation.

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

Phase II & III

- **What does LIF "see" vs. core?**
  - Core recovers/logs only competent sludge layer
  - Chemical, material, and structural differences detectable via LIF
- Logs can be complex:
  - Mixing, Inter-bedding, variable background , and sludge properties.

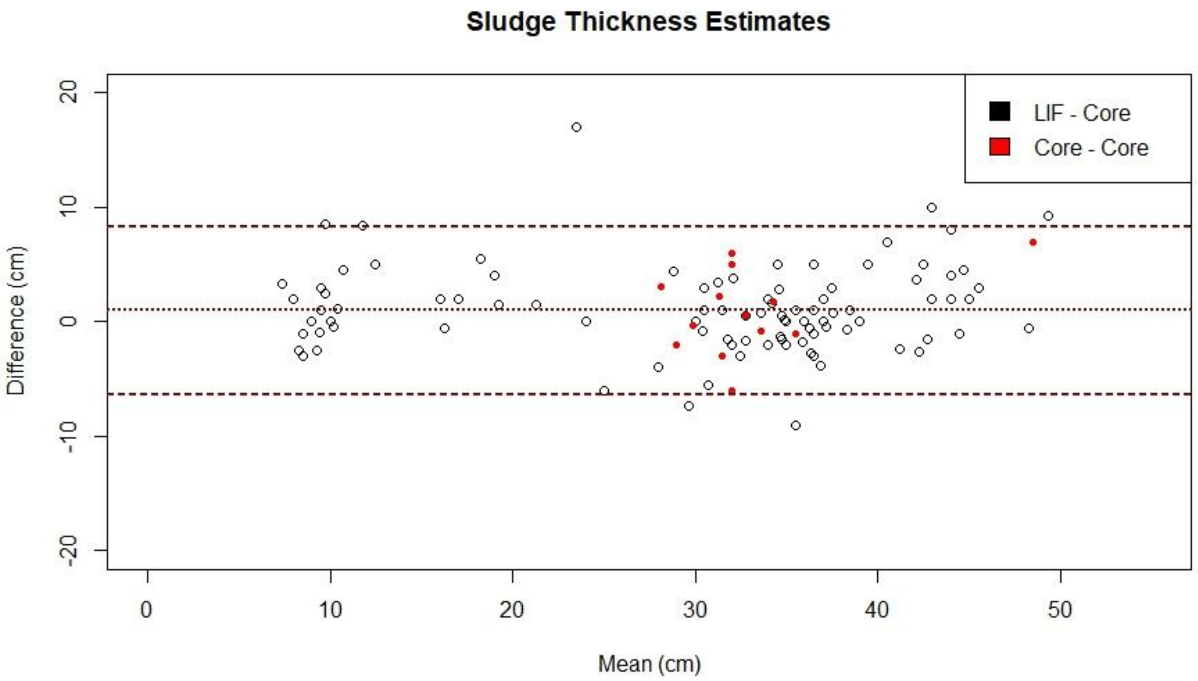


Density variance influencing optical properties and measurements within the sludge layer.

Clay Contact

Phase III – Pilot Program

- Delivery System 3.0.
- Robust comparative assessment.
- Results:
  - LIF interpretation technique able to accurately delineate sediments.



Phase III – Pilot Program

- Strengths of the LIF based approach:
  - Production of high resolution (cm scale), high volume, continuous data.
  - Approach limits data errors by collecting key variables through a single unified data collection process.
  - LIF able to record data in previously inaccessible locations (deep channels).
  - Data is produced in real-time.
  - LIF provides continuous data on the variation of sludge composition in-situ which may be of further value in the characterization of sludge mass and volume.

Thank You

Any Questions?

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