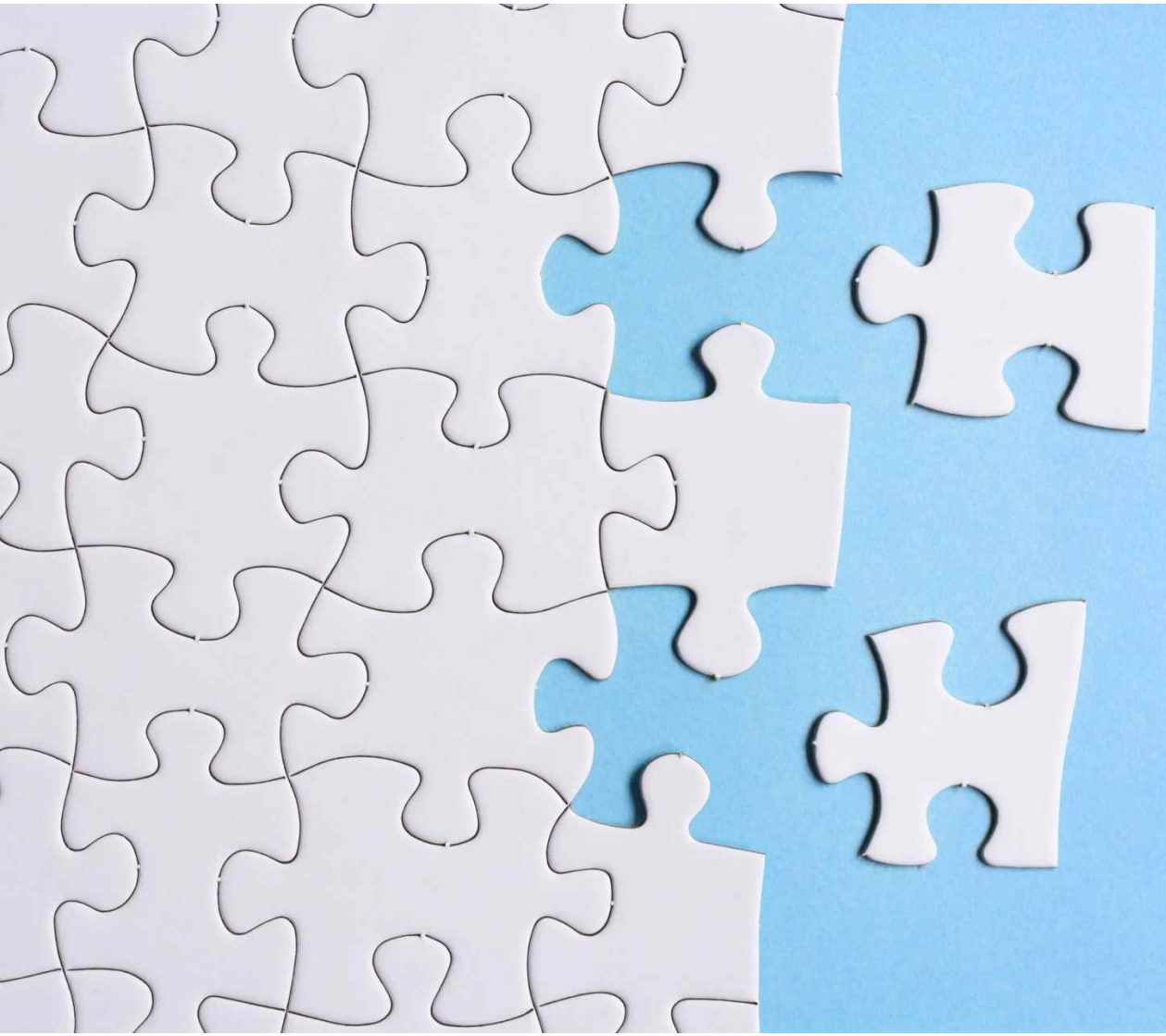
USK
AIR SOIL WATER

High Resolution Site Characterization of a Complex Chlorinated Compound Impacted Fractured Bedrock Site in South Africa

Steve Kalule PhD, Pr.Sci.Nat, MSAICE
USK Consulting Africa

Introduction



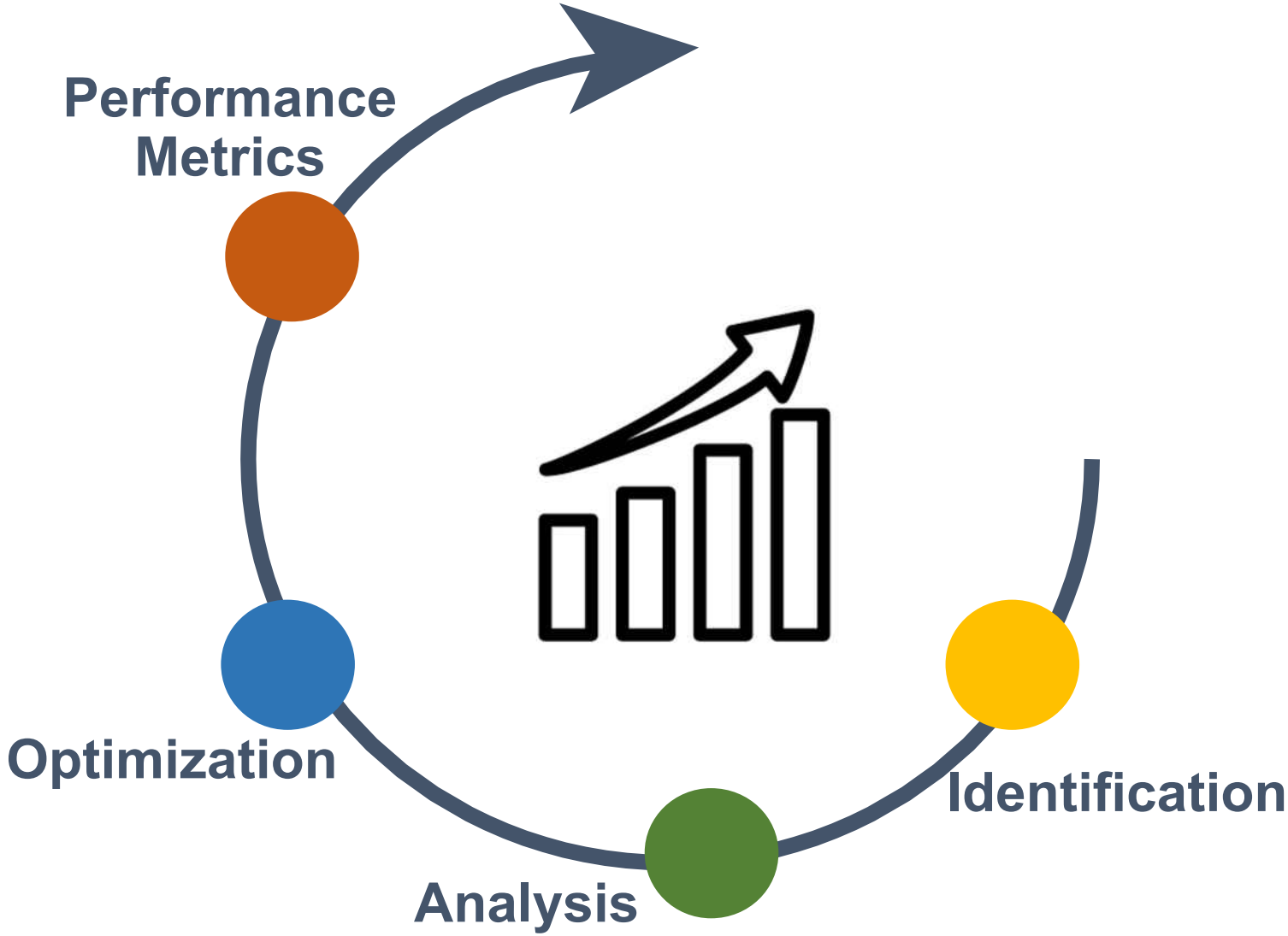
Developing a Conceptual Site Model (CSM) is like piecing together a complex puzzle, where each data point and investigation result forms a crucial piece in revealing the full picture of the challenge and remedial strategy

Background

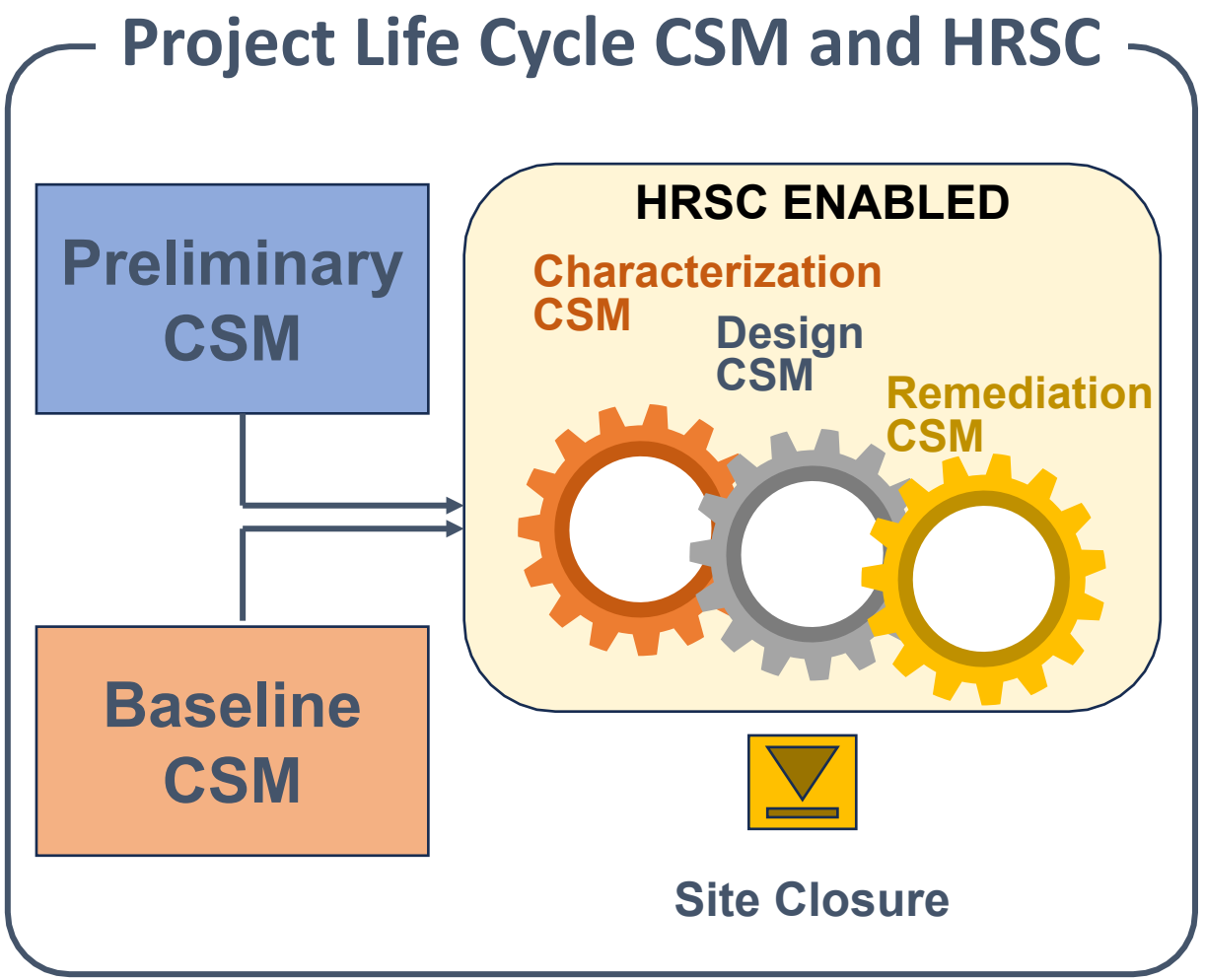
Conceptual Site Model

The Conceptual Site Model (CSM) is an iterative, 'living representation' of a site that summarizes and helps project teams visualize and understand available information

EPA 542-F-11-011



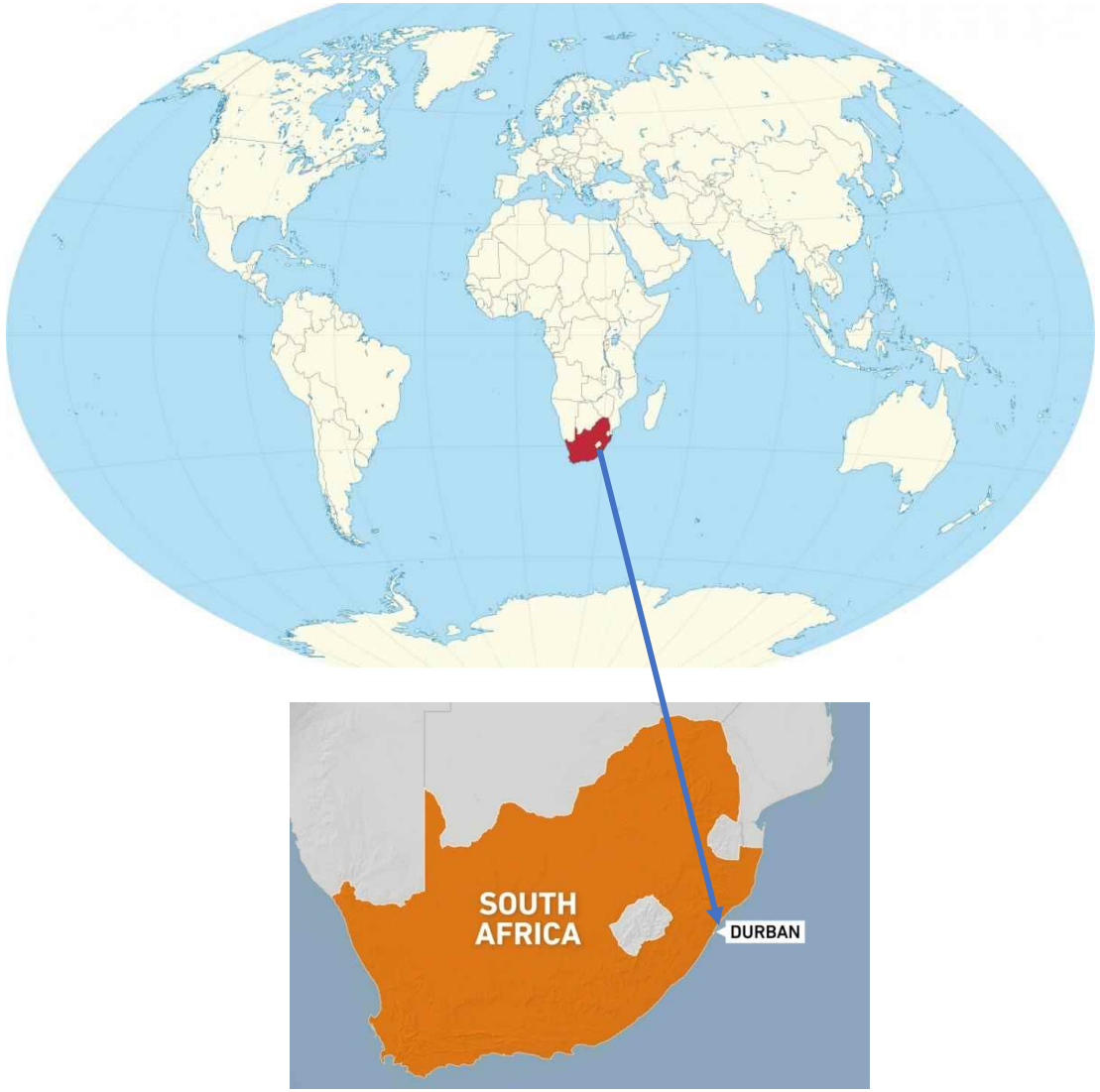
Background (Cont.)



HRSC:

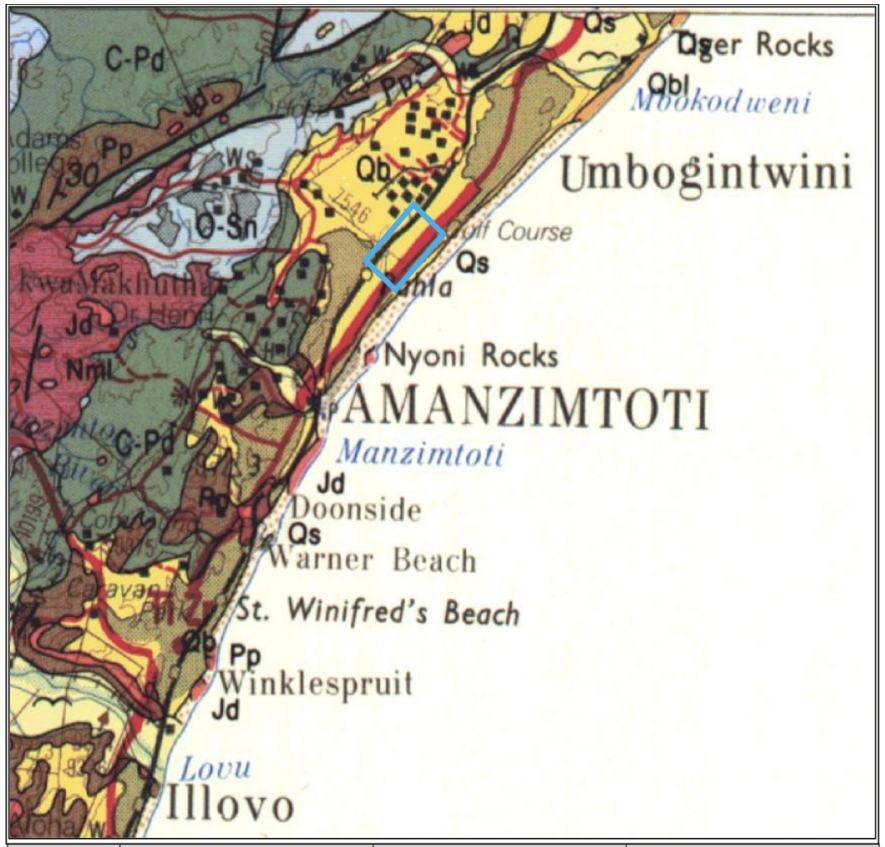
- **Tools and techniques that provide high-density, high-quality data for accurate 3D visualization of contaminant distribution.**
- Leads to better-informed decisions, targeted remediation, reduced uncertainties, and overall cost savings in site management.
- HRSC supports continuous CSM refinement throughout the project lifecycle ensuring effective remediation and transparent communication with stakeholders.

Site Background



- An industrial complex with > 100 years of operational history.
- Extensive area ~ 200 Hectares (0.78 sq mi).
- Multiple chemical manufacturing plants and waste dumps and dams w/in the complex.
- The release was first discovered in 1999.
- Main COCs include a suite of Chlorinated Compounds, heavy metals, etc.
- Surrounded by a mix of residential and commercial land uses.
- Numerous water, agricultural, and recreational water use receptors within 500m.

Site Background



Symbol	Group/Formation	Lithology	Approximate Age
Qb	Umkwelane (Berea) Formation, Uloa Subgroup, Maputaland Group	Red sand, subordinate white, yellow, and brown sand, basal conglomerate	Quaternary. Mid Miocene – Pliocene. 10 – 2.5 Ma

- **Geology and hydrogeology**
  - Quaternary sediment of the Berea Formation
  - Fine-grained clayey sand-dune deposits from 5-8m (NW) of the site and 35-40m in the SE of the site.
  - Weathered, moderate & fresh fractured tillite of the Dwyka Group.
  - The highly weathered tillite presents as yellow residual tillite gravel with stiff clay infilling.
  - The tillite underlain by fresh fractured sandstone.
  - Regional block faults - SE dipping to Indian ocean.
  - Groundwater varies ~5m (NW) to 23m in the SE.
  - Groundwater flows from NW to SE.

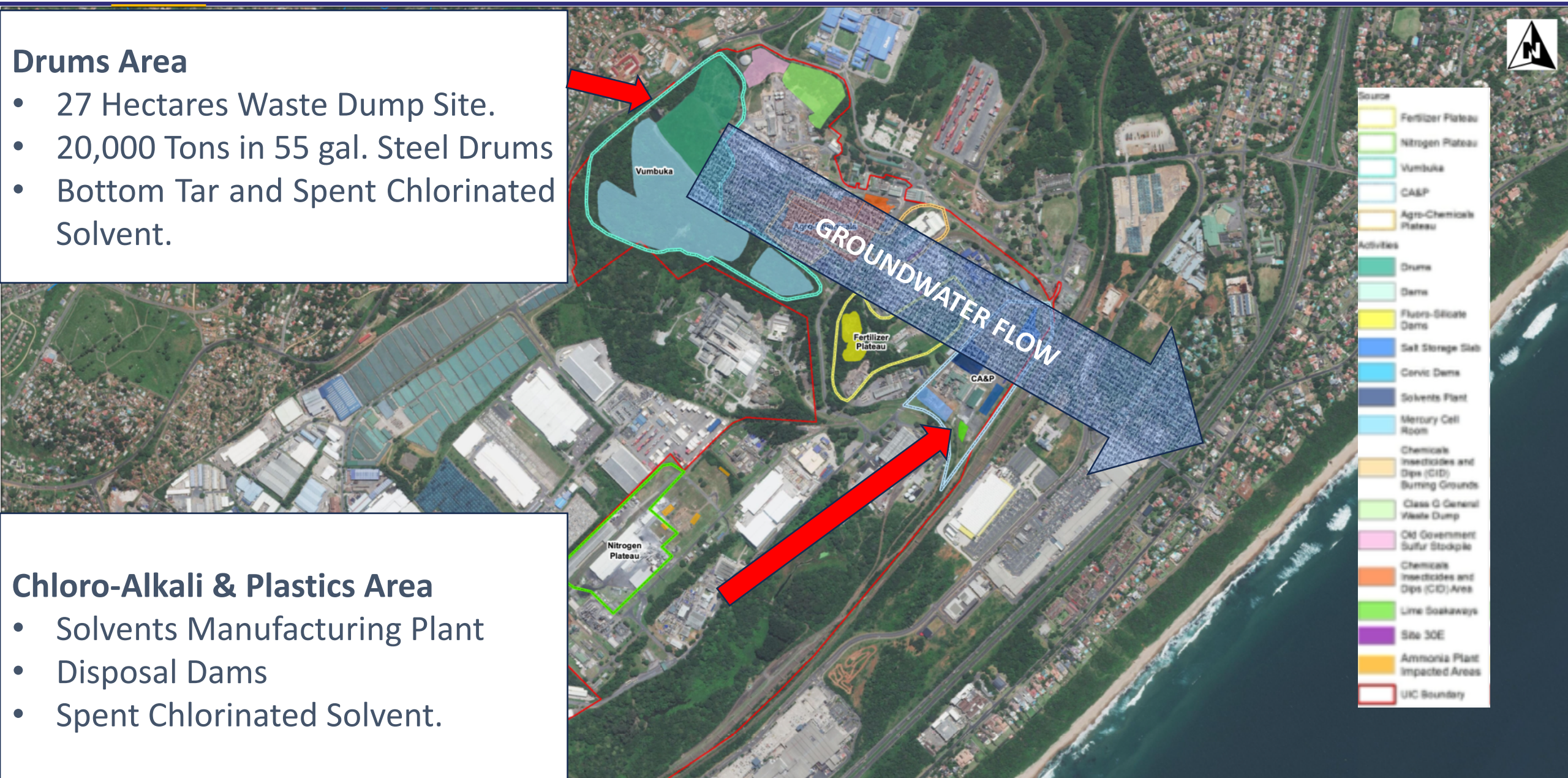
Preliminary CSM

Drums Area

- 27 Hectares Waste Dump Site.
- 20,000 Tons in 55 gal. Steel Drums
- Bottom Tar and Spent Chlorinated Solvent.

Chloro-Alkali & Plastics Area

- Solvents Manufacturing Plant
- Disposal Dams
- Spent Chlorinated Solvent.



Client Objectives

- **Historical Investigations and Remedial Activities**
  - Over 300 groundwater MWs installed since 1999.
  - 2013-2015, an enhanced in situ bioremediation system (EVO gravity feed) was installed in the Drums and CA&P areas.
    - Contain the source (natural attenuation)
    - Reduce dissolved CVOC flux to offsite receptors (PRB).
  - USK contracted in 2020 to perform monitoring performance reviews and a remedial solution.

- **Client Objectives**
  - **Justify expenditure > $25M EISB infrastructure $1M annu. perpetuity.**
  - **Reduce risk and liability (offside receptors).**
  - **Systematically Move the site towards closure.**
  - **Open up sites for redevelopment.**

Approach

Existing Information Review

- Site history
- Geology
- Boring logs
- Well construction logs
- Well gauging data
- GW analytical data
- Remedial system performance
- Client objectives/goals

Lateral / Vertical Extent

- MIHPT
- Direct Push Soil borings
- Detailed boring logs
- Rock Coring
- Rock Core logs
- High-density soil sampling
- Rock matrix sampling and analysis

Define Transport, Storage and Flux

- Down Hole Geophysics
  - ERT
  - Optical/Acoustic TV
  - Caliper
  - Gamma
  - NMR
- Straddle Packer Testing
- Packer Sampling
- Tracer Tests (SBDT)

Update CSM

- Distribution
  - Storage
  - Transport
- Mass Flux/Discharge
- Goals/Objectives
- Performance Metrics
- Models (Visualization)

Historical Data Review

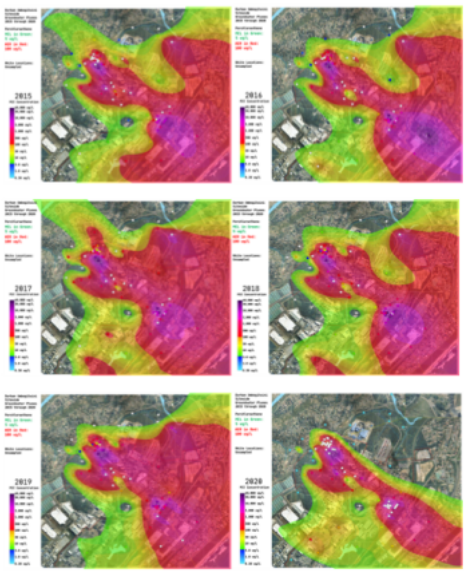
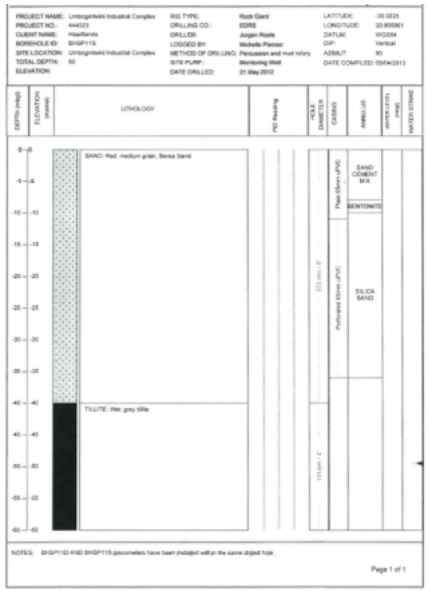
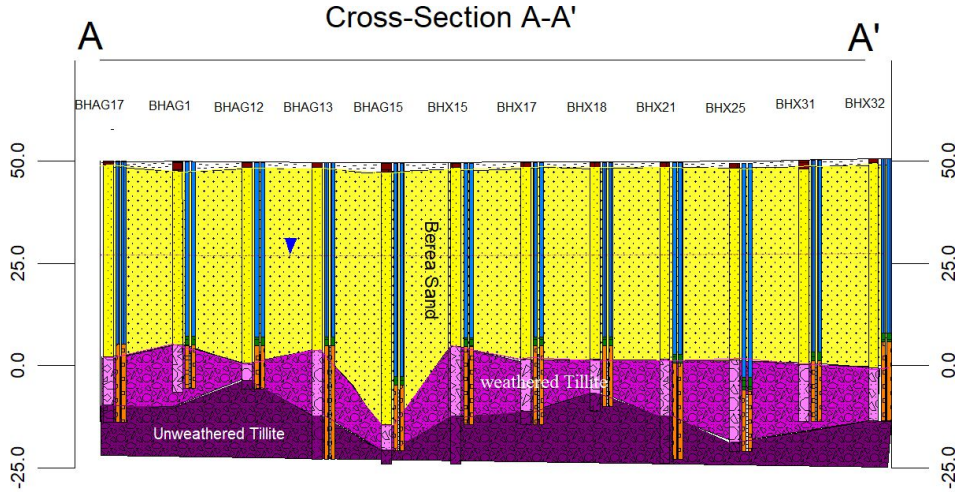


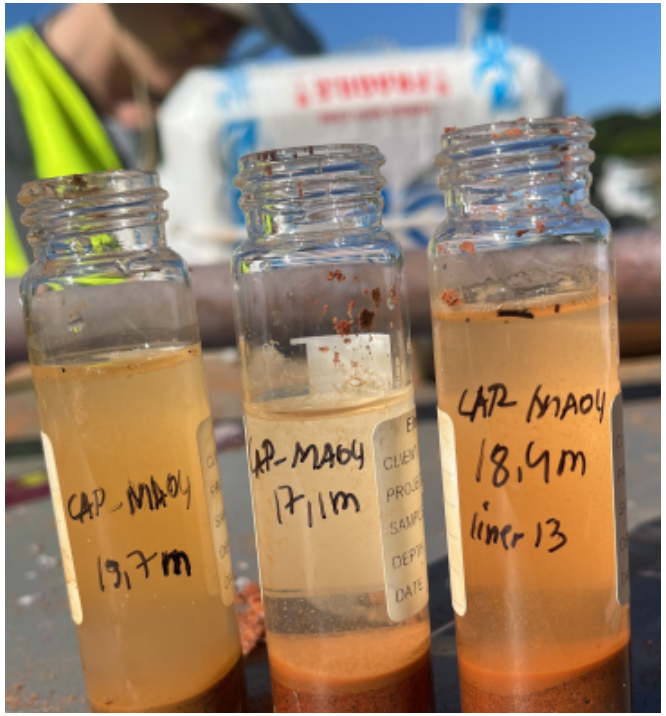
Figure 1 PCE Plume evolution 2015 - 2020



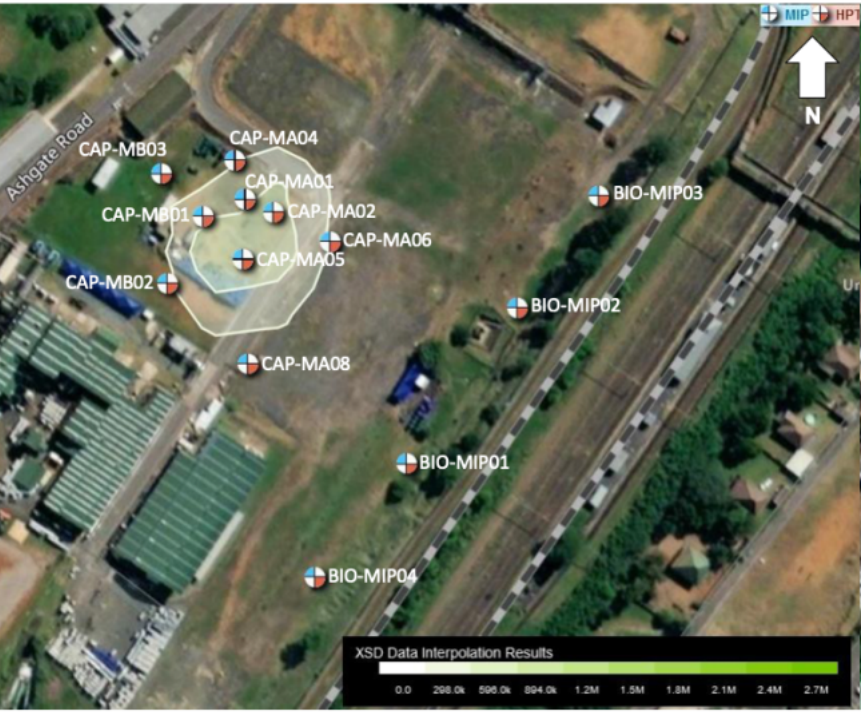


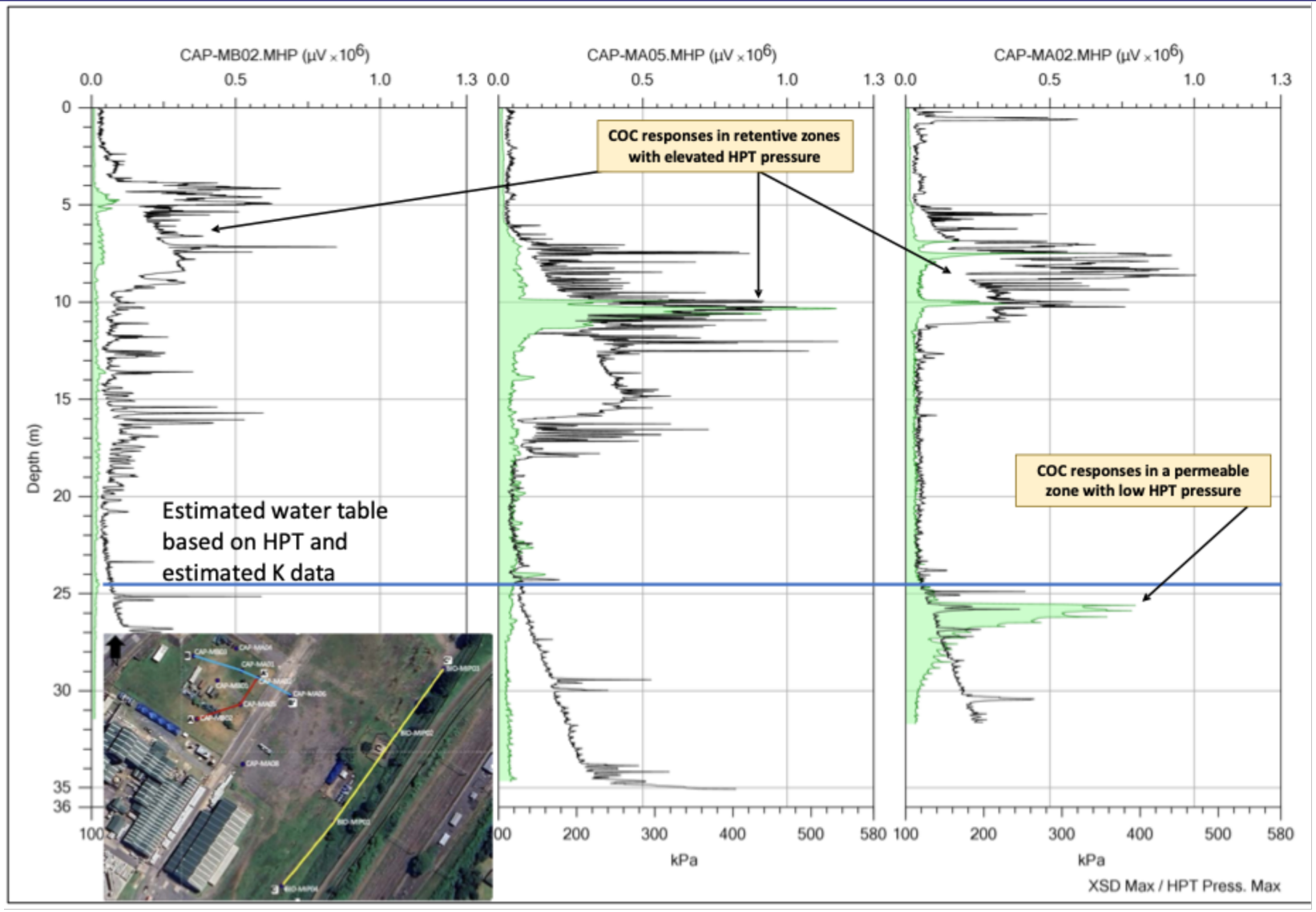
- High variability and anomalies in data.
- Source conc. PCE, TCE, and TCA > 175,000 ug/L. Daughters DCE, VC, DCA >40,000 - 90,000 ug/L.
- VC to Ethene inhibited
- Low *Dehalococcoides* DHC population < 1 x 10^4 cells/mL.
- Incomplete reductive dichlorination.
- Highly fluctuating plume geometry and trends.
- Poor low -resolution soil borings obscuring subsurface heterogeneity.
- Long screen wells screened across HGUs

HRSC Field Work

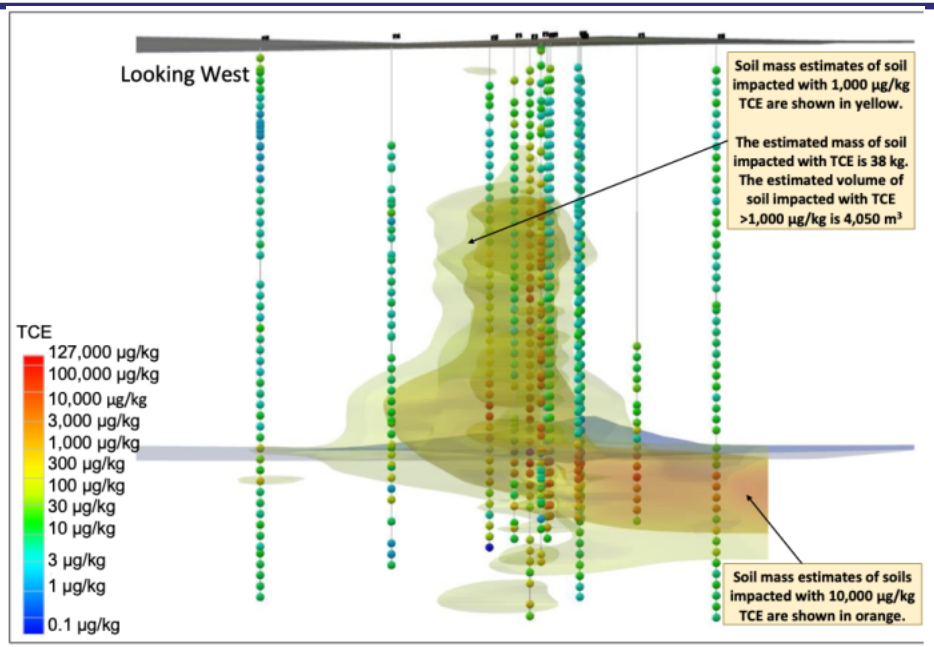


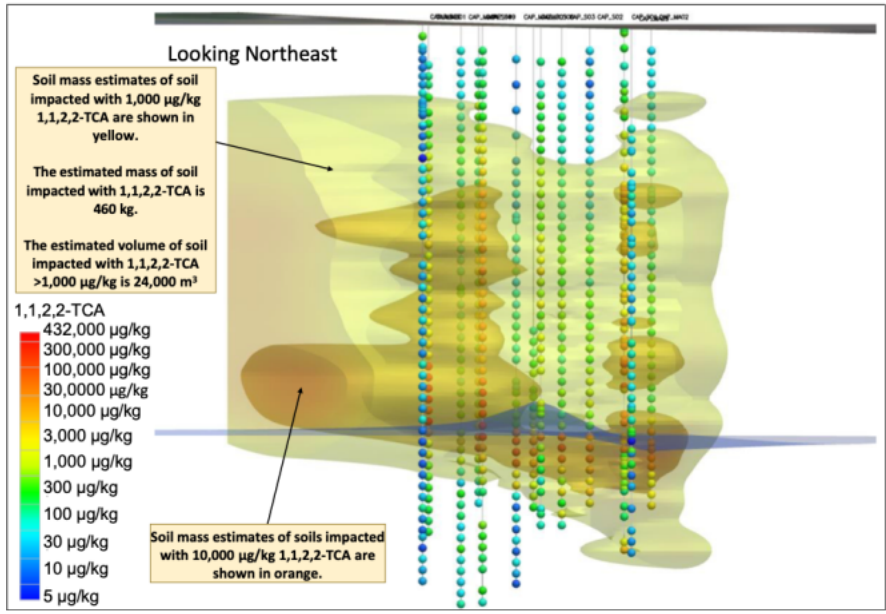
MIHPT Results

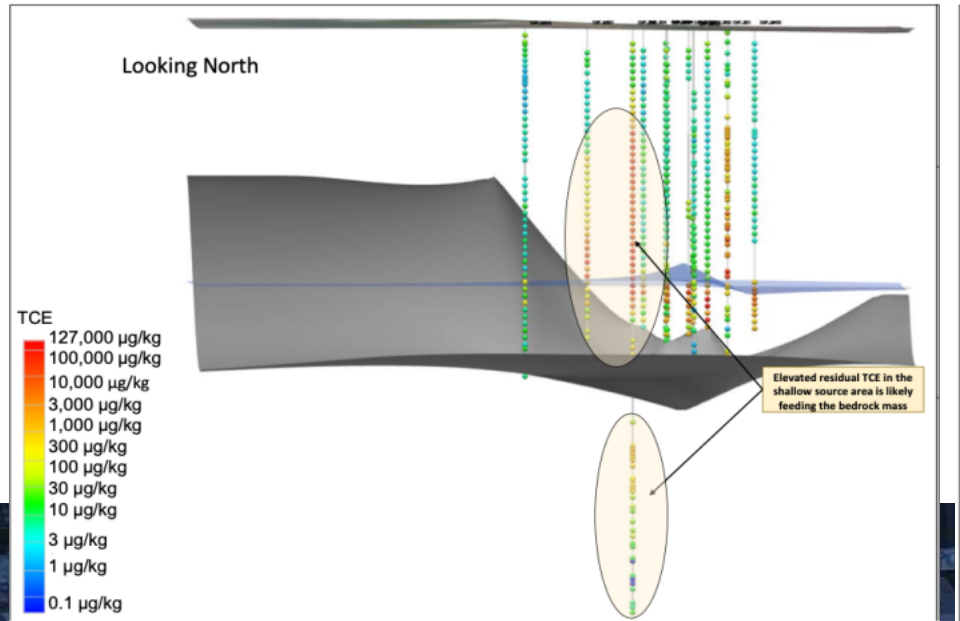


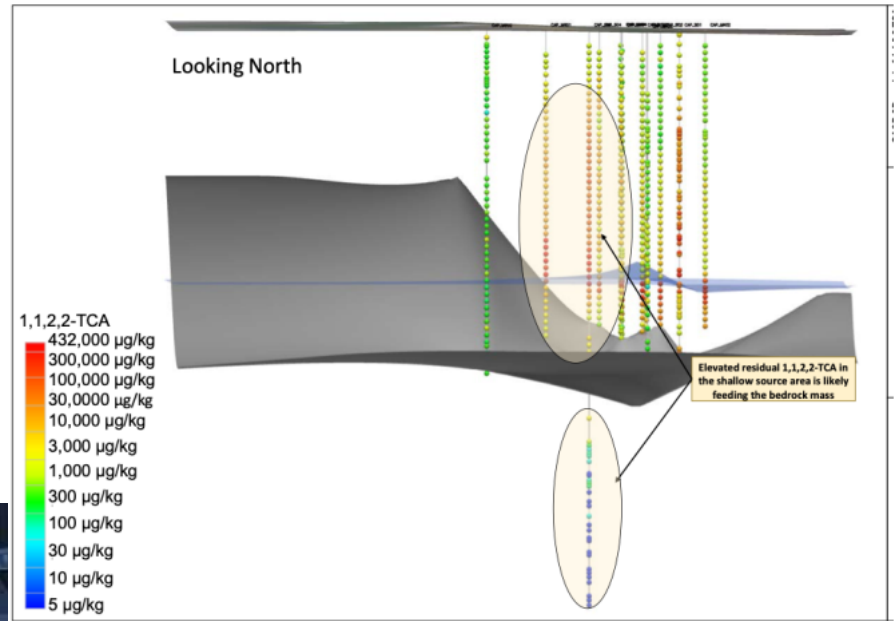


qHSRC (Soils Analytical Results)

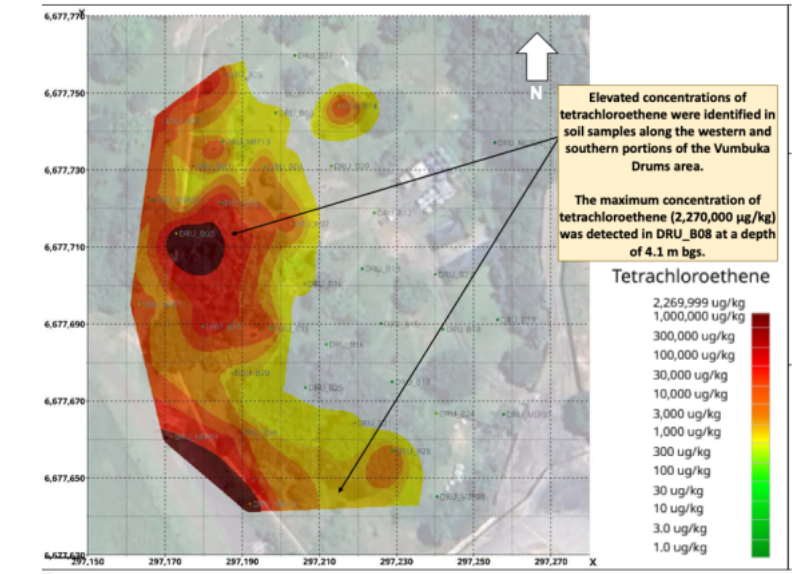


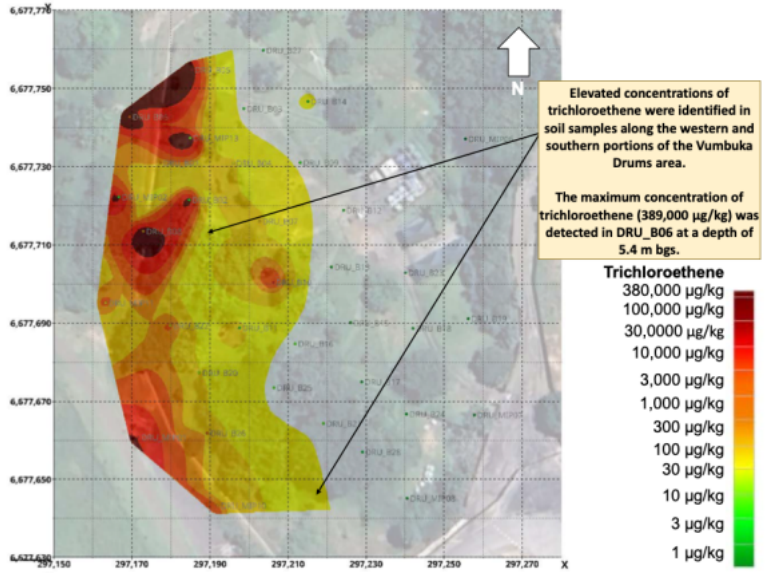


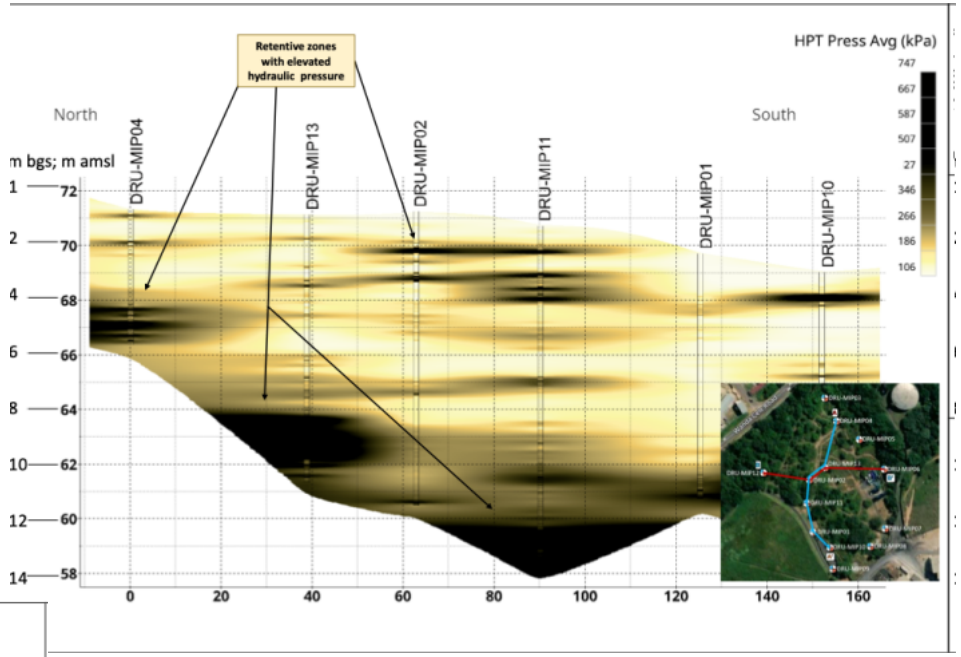


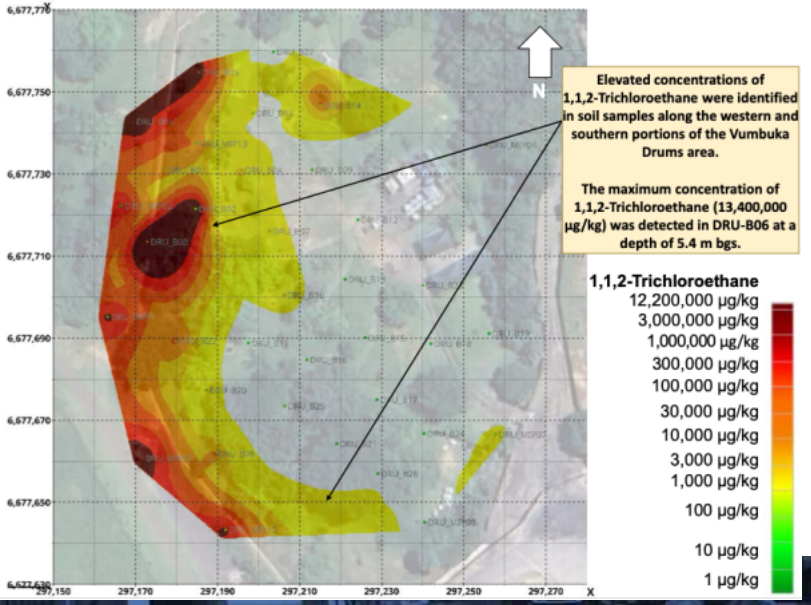


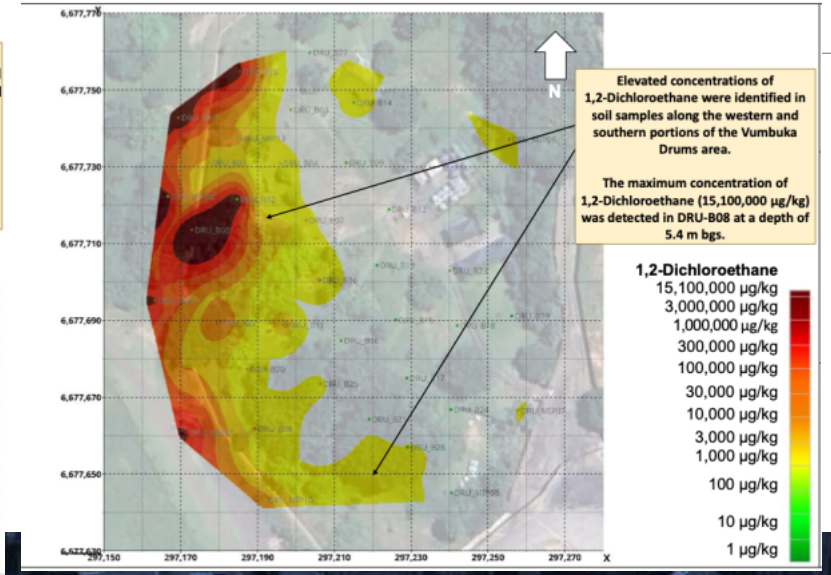
qHRSC (Cont.)


Elevated concentrations of tetrachloroethene were identified in soil samples along the western and southern portions of the Vumbuka Drums area.
The maximum concentration of tetrachloroethene (2,270,000 µg/kg) was detected in DRU_B08 at a depth of 4.1 m bgs.
Tetrachloroethene
2,269,999 ug/kg
1,000,000 ug/kg
300,000 ug/kg
100,000 ug/kg
30,000 ug/kg
10,000 ug/kg
3,000 ug/kg
1,000 ug/kg
300 ug/kg
100 ug/kg
30 ug/kg
10 ug/kg
3.0 ug/kg
1.0 ug/kg

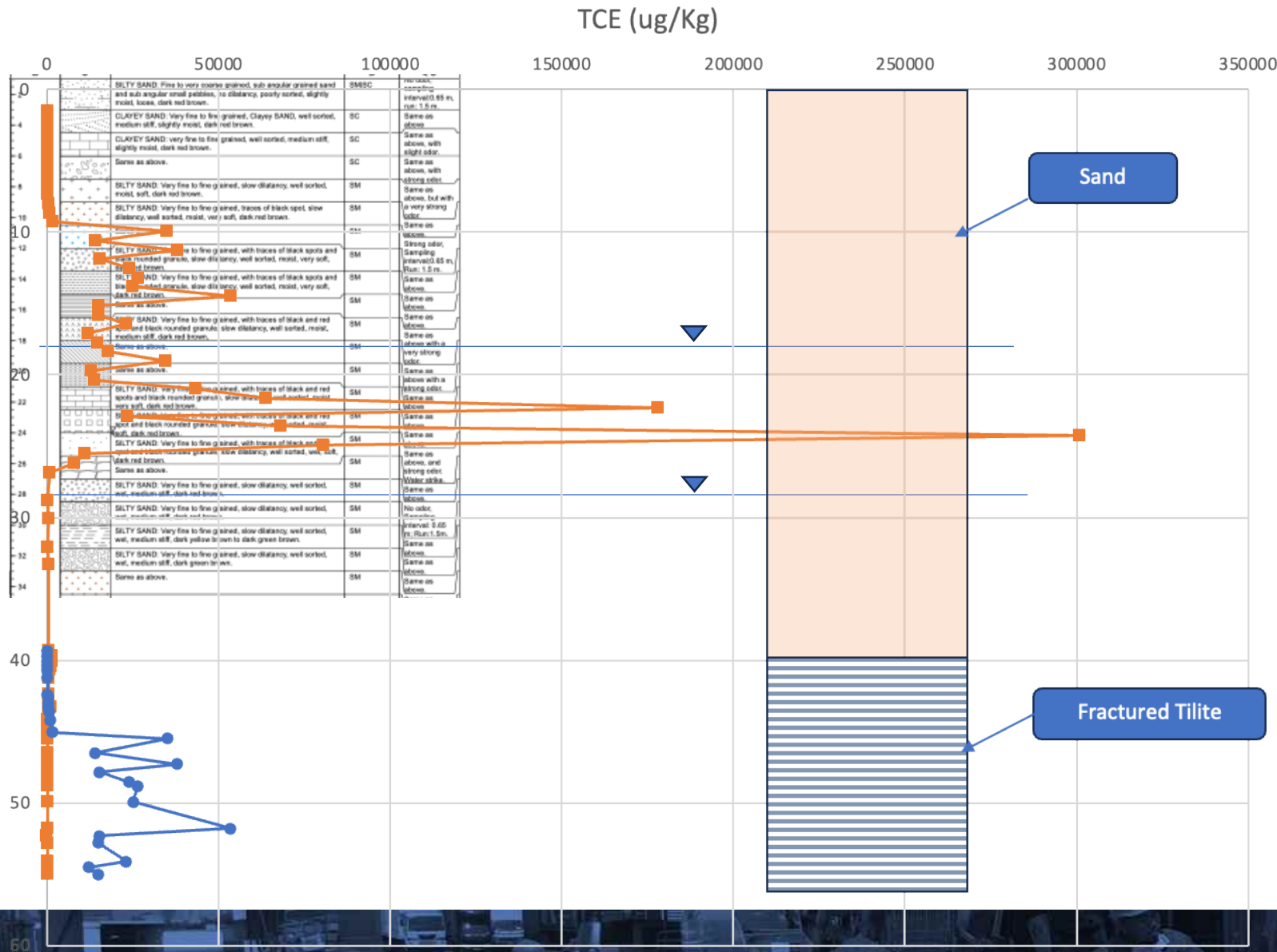

Elevated concentrations of trichloroethene were identified in soil samples along the western and southern portions of the Vumbuka Drums area.
The maximum concentration of trichloroethene (389,000 µg/kg) was detected in DRU_B06 at a depth of 5.4 m bgs.
Trichloroethene
380,000 µg/kg
100,000 µg/kg
30,0000 µg/kg
10,000 µg/kg
3,000 µg/kg
1,000 µg/kg
300 µg/kg
100 µg/kg
30 µg/kg
10 µg/kg
3 µg/kg
1 µg/kg


Retentive zones with elevated hydraulic pressure
HPT Press Avg (kPa)
North
South
m bgs; m amsl
DRU-MIP04
DRU-MIP13
DRU-MIP02
DRU-MIP11
DRU-MIP01
DRU-MIP10


Elevated concentrations of 1,1,2-Trichloroethane were identified in soil samples along the western and southern portions of the Vumbuka Drums area.
The maximum concentration of 1,1,2-Trichloroethane (13,400,000 µg/kg) was detected in DRU-B06 at a depth of 5.4 m bgs.
1,1,2-Trichloroethane
12,200,000 µg/kg
3,000,000 µg/kg
1,000,000 µg/kg
300,000 µg/kg
100,000 µg/kg
30,000 µg/kg
10,000 µg/kg
3,000 µg/kg
1,000 µg/kg
100 µg/kg
10 µg/kg
1 µg/kg


Elevated concentrations of 1,2-Dichloroethane were identified in soil samples along the western and southern portions of the Vumbuka Drums area.
The maximum concentration of 1,2-Dichloroethane (15,100,000 µg/kg) was detected in DRU-B08 at a depth of 5.4 m bgs.
1,2-Dichloroethane
15,100,000 µg/kg
3,000,000 µg/kg
1,000,000 µg/kg
300,000 µg/kg
100,000 µg/kg
30,000 µg/kg
10,000 µg/kg
3,000 µg/kg
1,000 µg/kg
100 µg/kg
10 µg/kg
1 µg/kg

qHSRC Analytical Results



Soil

Primary Contaminants of Concern (CoCs) in Soil	Concentrations in µg/kg
Vinyl Chloride	3.2- 20
1,2 Dichloroethane	0.5-1100
1,1 Dichloroethene	2.1-18
cis 1,2 Dichloroethene	0.7-1600
Trichloroethene (TCE)	1.1-144000
Tetrachloroethene (PCE)	3.7-72700
1,1,2,2 Tetrachloroethane	100-432000
Carbon Tetrachloride	0.7—28
Chloroform	0.5-500

Groundwater

Primary CoCs in GW	Concentrations in µg/L
Vinyl Chloride	2.1- 130
1,1-DCE	1.4-44
trans-DCE	6-410
cis 1,2 Dichloroethene	120-61600
Trichloroethene (TCE)	130-138000
Tetrachloroethene (PCE)	3.7-7400
1,1,2,2 Tetrachloroethane	100-292000
1,1-DCA	0.9—1.3
1,2-DCA	3.1-3.9

Outcomes

Source Treatment in the CA&P Area

- Decommissioned all long-screen wells
- Installed appropriately screened wells
- Remedial Design/Implementation
  - RPI BOS100® /CAT 100®
  - 40 Injection Points across the source area
  - Overburden - bedrock interface 60’ – 100’ bgs.
  - ~ 960 targeted injection Intervals.
  - 18,500 lbs (8.4 Tonnes) of BOS 100/CAT100®

Cost

- ~ $800,000, relatively lower than the perpetuity cost of EISB.

Lessons Learned

1. **Leverage Historical Data**
   - Historical data - valuable insights and a solid foundation for HRSC.
2. **Segmenting the Site for Strategic Management**
   - Manageable sections are cost-effective and practical.
   - Allows for achievable goals and objectives for each section.
   - Stakeholders can visualize progress with tangible quicker results.
3. **Collaboration with Experts Enhances Project Success**
   - Improves the quality of data collection and analysis.
   - Instills trust in the project outcomes, leading to more effective decision-making and long-term project success.
4. **Comprehensive Approach**
   - Do not to overlook the overburden layer, as it can serve as a significant source feeding contaminants into the bedrock.

Conclusion

Future Work

- Post-injection monitoring at the CA&P source
- Injections in the drum source area (overburden and bedrock).
- NMR and Packer Sampling along the fenceline.
- PRB Remedial Design.
- Installation of new fenceline PRBs.

HSRC driven CSMs are the key to unlocking successful, sustainable, and cost-effective management and cleanup at complex sites

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THANK YOU

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