

# Evaluating Natural Attenuation Using Multiple LOEs in Complex Geologic/Hydrogeologic Conditions

## INTRODUCTION

At a former manufacturing facility, groundwater in two areas (Area A & B) of the site is impacted with chlorinated volatile organics and has been historically monitored to identify the potential for potential offsite impacts. Based on the ongoing review of historical groundwater monitoring data, a program to further evaluate natural attenuation versus other potential remedial alternatives, should they be required, has been implemented. Historical data indicated that natural attenuation mechanisms are active at the site, but a more thorough evaluation was needed given the complex geologic/ hydrogeologic site setting. Groundwater flow is present in three units 1) Overburden, 2) Weathered Rock, and 3) Fractured Bedrock.



## **Goals/Objectives**

- Collect additional data to develop multiple LOEs to bolster the current understanding of subsurface conditions with respect to natural attenuation
- Evaluate the potential to prevent migration of the VOCs beyond the property
- Prevent exposure of potential receptors; and
- Identify the potential need for additional remedial actions and associated technologies.

## **Complex\Geologic/Hydrogeologic Conditions**



**Overburden Conditions** 

## **Geology/Hydrogeology**

- Variable upward and downward vertical gradients; highly variable hydraulic conductivities
- Bedrock incised and infilled with overburden; controls groundwater flow direction
- Bedrock comprised of upper weathered/fracture zone and deeper more competent bedrock
- Conditions control potential fate and transport of constituents of concern (COCs)
- Conditions separate identified former sources in Areas A & B

**Bedrock Conditions** 

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Location Aerial Photo



#### **Biogeochemical Conceptual Site** Model (BioG-CSM)

- Combined evaluations of: - Groundwater flow and contaminant transport pathways
- Geochemical/natural attenuation/microbial data
- Groundwater flow and transport utilized historical site-specific data related to 1) hydraulic conductivity; 2) groundwater elevations; 3) hydraulic gradients; and 4) other hydraulic parameters based on observed subsurface conditions
- Compilation of geochemical/natural attenuation/microbial data based on historical and recent enhanced groundwater sampling events
- Above data synthesized to refine the Geo/Hydro CSM and generate a BioG-CSM, resulting in significantly enhanced understanding of subsurface conditions with respect to defining next steps and evaluation of potential remedial approaches

Area A – Weathered Rock Source Area 🔶 20-yr travel 📗 30-yr travel



Example GW Seepage Velocity Evaluation

![](_page_0_Picture_37.jpeg)

**Biogeochemical Evaluation Rating Matrix** 

- Subsurface conditions generally favorable for natural attenuation

- Identified the potential need for additional remedial actions and associated technologies.

#### Area A

![](_page_0_Figure_45.jpeg)

**GW Flow Pathways** 

Highest COC concentration i Bedrock proximal to MW -30 Dissolved gases present ( ow to ND NO3 and SO4 TOC >10 mg/L Increased chlorides comparea Natural attenuation parameters supportive of "reducing conditions" Natural Attenuation Matrix

![](_page_0_Figure_48.jpeg)

![](_page_0_Figure_49.jpeg)

**GW Flow Pathways** 

![](_page_0_Figure_51.jpeg)

MW-22D2 -27.5 -19 Area B – CSIA Results

-45 -40 -35 -30 -25 -20 -15 -10 -5

Natural Attenuation Matrix

Area A – CSIA Results

## CONCLUSIONS

- Evaluation provided enhanced understanding of subsurface conditions
- Diverse microbial community, but populations are less than ideal, indicating potential for biostimulation and/
- or bioaugmentation

## **PATH FORWARD**

- Collected additional data to further develop multiple LOEs evaluation and understanding of subsurface conditions with respect to natural attenuation
- Evaluated GW/Mass flux to identify zones of highest flow and transport
- Utilized collective data to implement targeted fieldscale pilot demonstration
- Advanced the site through the regulatory process

# AECOM

## **POSTER GROUP 1**

![](_page_0_Figure_66.jpeg)

qPCR/CSIA Matrix

Attenuation Mechanism Summary

gPCR/CSIA Matrix

### Attenuation Mechanism Summary

![](_page_0_Picture_72.jpeg)

### Geophysical Logging Example

- 0 100 200 300 400 500 600 700 800 900 1000 1100 1200 1300
- Areas A & B Passive Groundwater/ Mass Flux eploymen (Spring 2023)

![](_page_0_Picture_76.jpeg)