Focus on Geology to Improve In-Situ Remediation Outcomes: Perspectives for the Remediation Engineer

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Full Disclosure

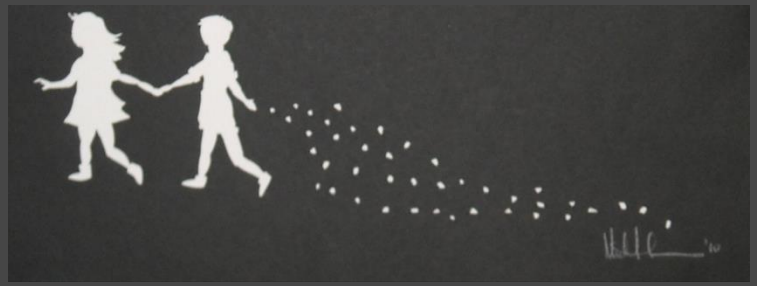
Engineer: person who uses scientific knowledge to design, construct, or maintain machine, structures, or systems

- Assemble Data and Observations
- Utilize Best Science
- Design Remediation
- Implement, Monitor, Optimize

Focus on Geology

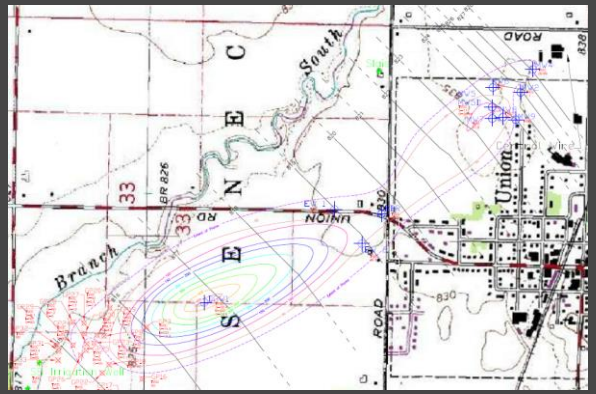
- Where is contamination?
- Where is it traveling? How did it get there?
- What amendment is being delivered?
- Can air or fluid move through site subsurface?
- How does site geology impact the answers to these questions?

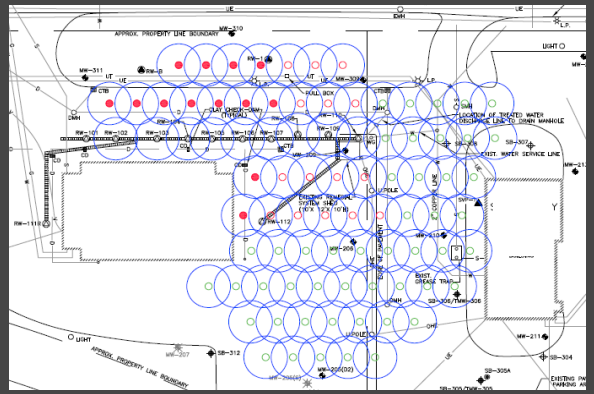
- Injected amendments likely to follow path similar to groundwater flow

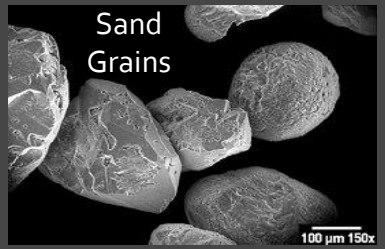


Scales of Remediation Geology

Regional Plume Remediation Micron Scale







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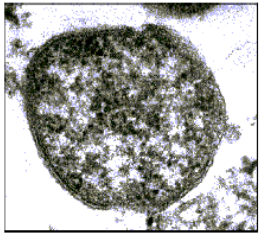


Dehalococcoides mccartyi Strain 195

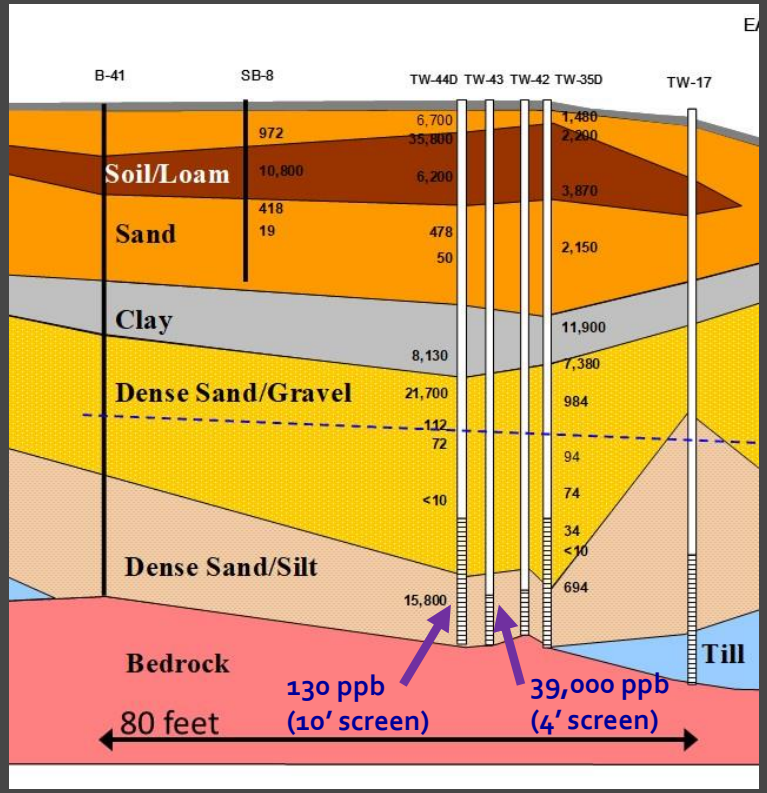
Macro-scale designs for micro-scale processes
Gallons, pounds, cubic yards

Geology Matters

TCE Source Area Re-Evaluation

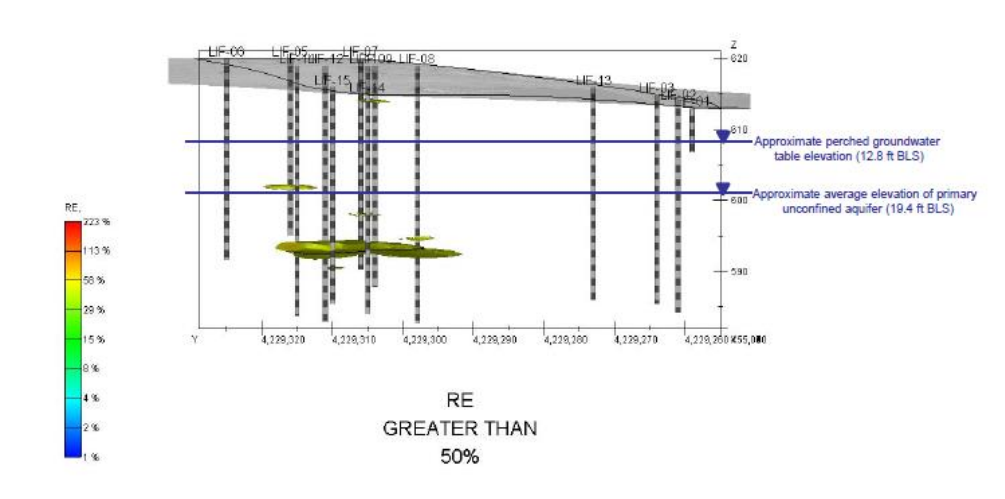
- ISCO pilot test planned
- 16 new borings in ~ 7,000 sf
  - Compliment historic borings
- EPA Mobile Lab allowed responsive investigation
  - Borings/wells modified from plan

- Remedial Decision making impacted by TCE concentrations
  - 300x difference over 3 feet

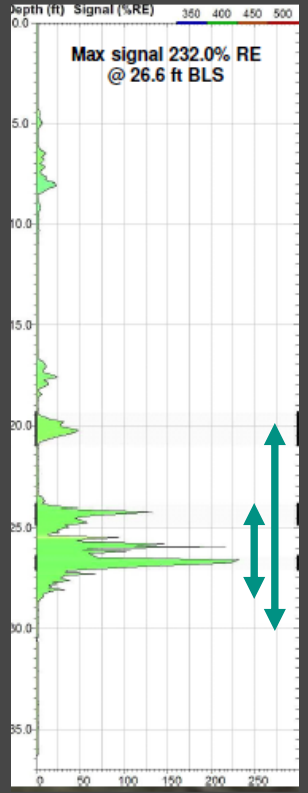


Follow Geology, Not the Sample

- Request for pricing for 10’ injection interval (20-30’) corresponding to MW interval

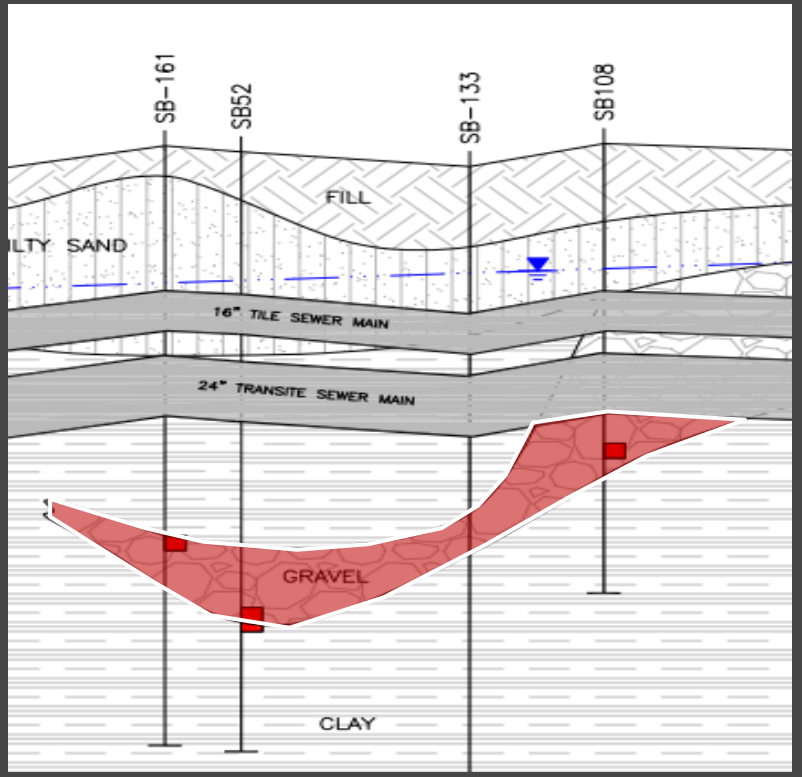


- Fine grained silty sands and clays with high permeability pebble lens identified at depth of ~25’, which correlates to highest LNAPL detection



Case Study: MGP Site

- Downgradient area impacted
  - Residential neighborhood
  - Middle of road
  - Numerous utilities
- Geology = Primarily clay
- Sand and gravel lens at variable depths where blebs and impacts observed



Case Study: MGP Site

- 4,900 sf area
- Injection well screens based on geologic observations
- Tight spacing (10' ft)
- Additional soil borings with logs (15%) during injection well install
  - Field adjustments
- Reduced BTEX and PAH concentrations
- Site transitioned to MNA phase

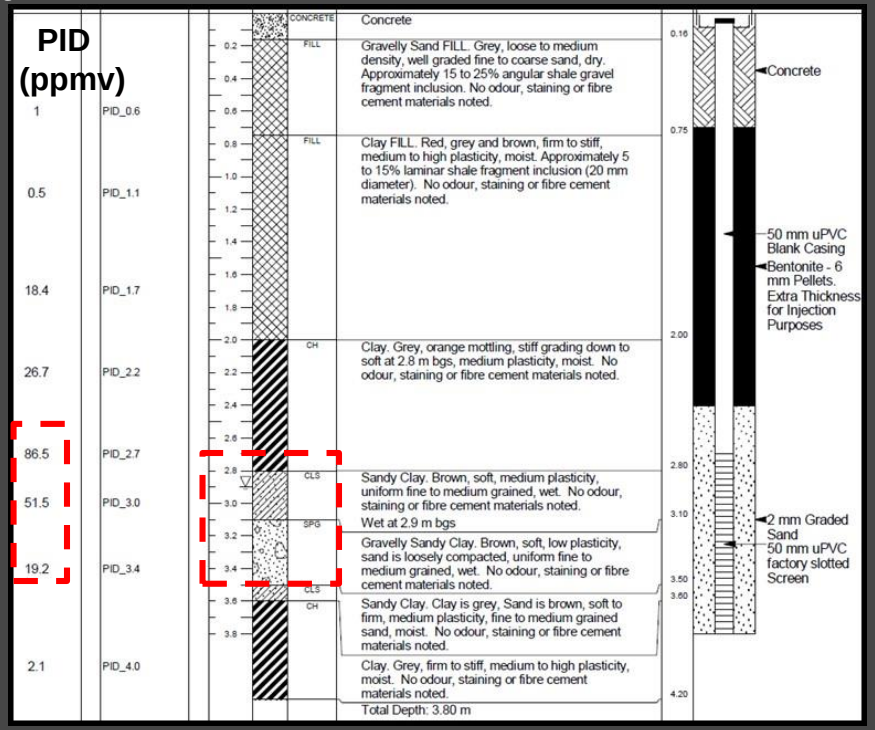
Boring/ Monitoring Well	Top of Gravel/ Sand Layer (ft bgs)	Top of Lower Clay Layer (ft bgs)	Coarse Sand/Gravel Layer Thickness (ft)	Visible Tar/Blebs (ft bgs)	Injection Points	Injection Interval (ft bgs)
MW-C12	12.5	15	2.5	None	AC-25, AC-26, AC-31 to AC-42	10-15'
HP-2	No Boring Log Prepared			On Rods		
MW-C13	11	12	1	None		
MW-C14	12	13	1	None		
SB-133	12.25	13.5	1.25	None		
MW-C17	10	11.5 (gravel at 12-12.2 ft	1.5-2	12-12.2		
SB-52	15.2	15.9	0.7	15-16	AC-14, AC-20	11-17'
C20	Thin fine sand lens at 13.7 ft bgs.			10-14	AC-8 to AC-13 AC-15 to AC-19 AC-21 to AC-24 AC-27 to AC-30	10-16'
C24	9.8	14	4.2	11-14		
C18	11	11.5	0.5	11-12, 12-14		
MW-C16	11	11.75	0.75	11.3-11.6		
SB-161	13	13.5	0.5	13-13.5		
C19	9.8	12	2.2	9.8-10; 11.6-12	AC-1 to AC-7	9-14'
C22	10	10.5	0.5	None		
SB-132	20	22	2	None		

Case Study: TCE in Clay

- Clay
- Low permeability (K ~10^{-6} cm/s)
- Inside building
- Property transfer/Rapid schedule
- >50 mg/L TCE

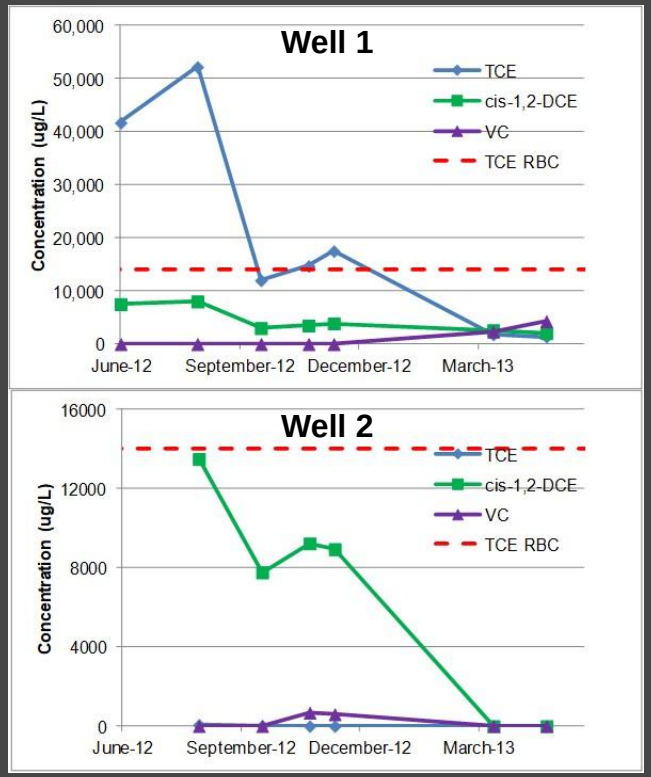
Case Study: TCE in Clay

- Additional soil borings during water injection test
- Identify thin sandy clay lens (1-3 ft thick)



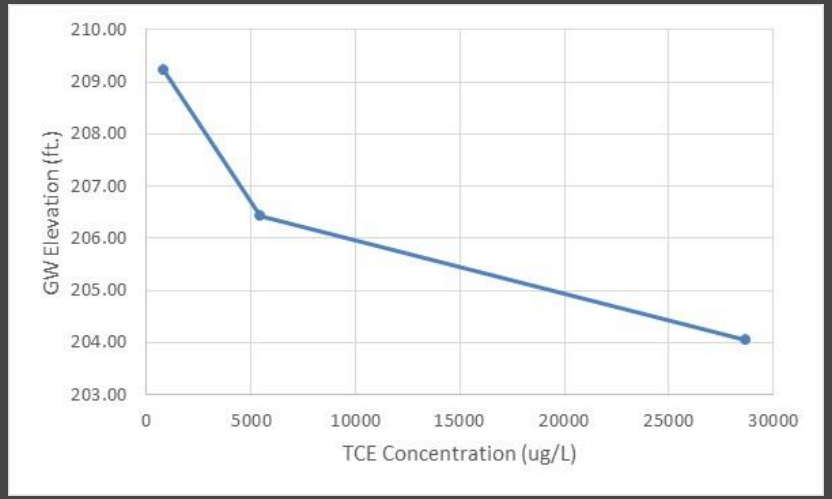
Case Study: TCE in Clay

- Log every injection well (16)
  - Vertically targeted screens – 3-4 feet
  - Close injection spacing – 10 feet
- 2 $KMnO_4$ injections
  - High injection volume - >20% eff. porosity
  - >95% reduction in TCE in 3 wells
  - 70 to >95% reduction in DCE in 3 wells
- No Further Action achieved
  - Client sold the property ~12 months after 1st injection



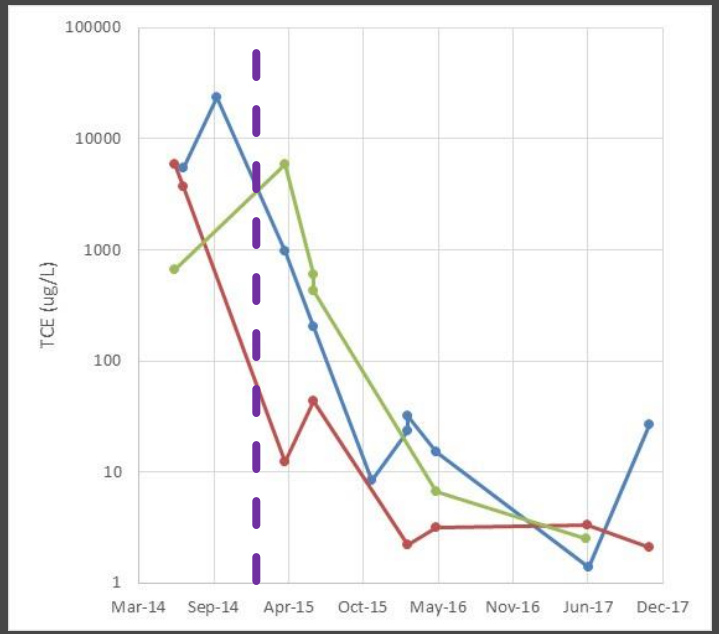
Case Study: Targeted Direct Push ISCO

- Sand underlain by dense till
- Highest TCE noticed in wells screened in both sand and till
  - TCE decreases with depth into till based on soil and groundwater
  - Lower TCE concentration when the water table rises
- Residual TCE mass located at interface of sand and till

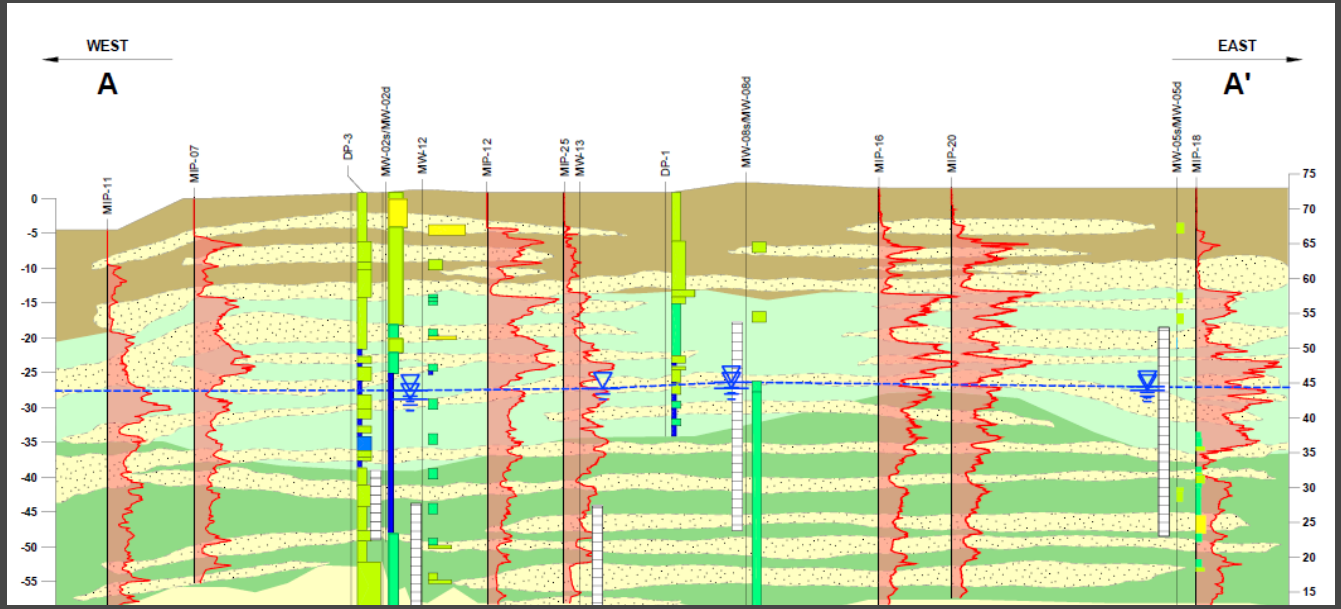


Case Study: Targeted Direct Push ISCO

- 1,500 sf Treatment Area – 1 Event
- ISCO to target 2-3' above and 2-3' below till
  - 2 foot injection intervals, bottom-up injection
  - During injection, had driller "feel" for till

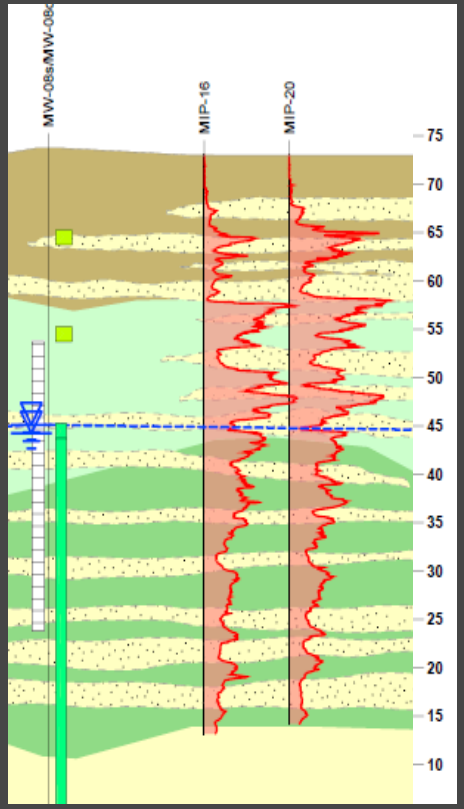


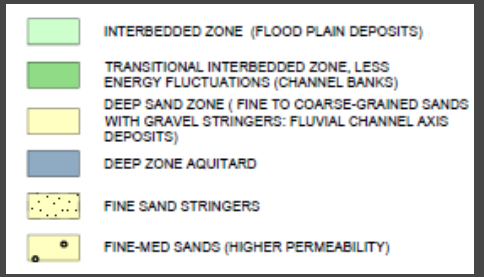
Case Study: with Stratigraphy



Case Study: with Stratigraphy

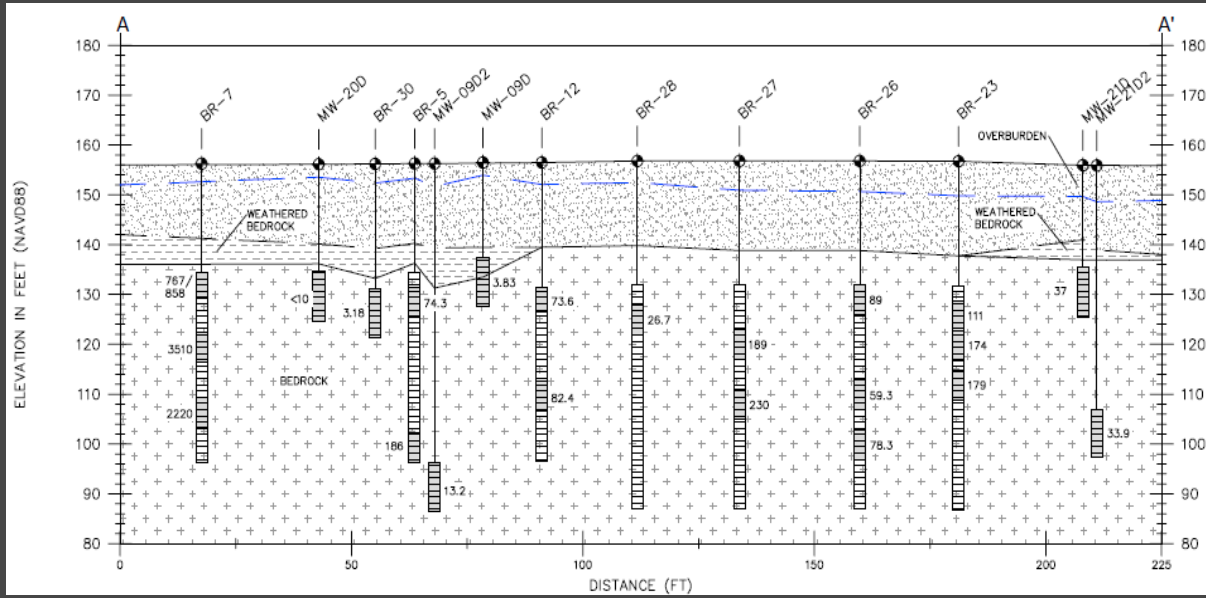
- Monitoring wells screened over many lenses
- MIP responses correlated with geology
  - Lower response in sand
  - Higher response in "lower energy zone," notably at top of zone
- Injections utilize small injection interval (2')





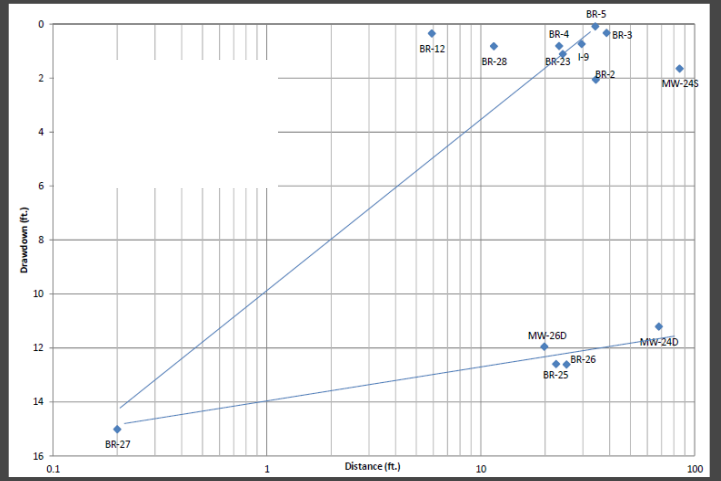
Case Study: Bedrock

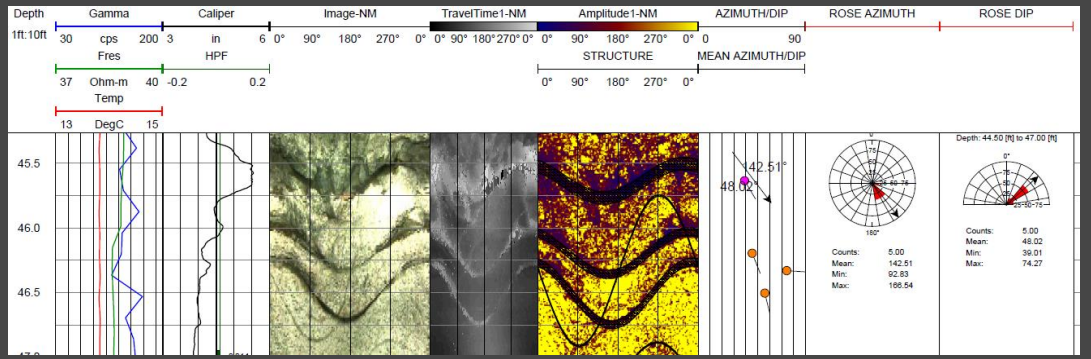
- Granite – Tight Bedrock
- Chlorinated and Petroleum VOCs
- VOCs observed 100-120 ft bgs
- ISCO – 2000 & 2001
  - 9,880 gallons into 31 points
  - mixed results
  - limited distribution
- Record of Decision
  - 10+ years after ISCO
  - Enhanced Bioremediation for CVOCs



Case Study: Bedrock

- Remedial Design Investigation
- Geophysical Investigation
  - Existing and new boreholes (>20 wells)
  - Caliper
  - Temperature
  - Fluid Resistivity
  - Natural Gamma
  - Acoustical Televiewer
  - Optical Televiewer
  - Flow meter (heat pulse)
  - Pump Test / Connectivity
  - Borehole packer sampling for PCE

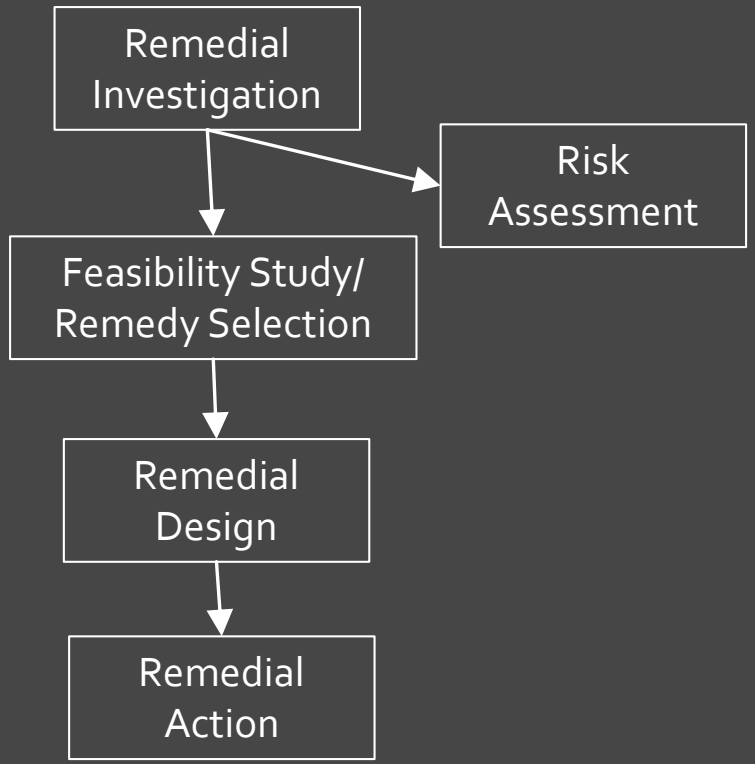




Case Study: Bedrock

- Lactate + EVO + bioaugmentation injections
- Targeted approach to inject in water bearing fractures with PCE
- Inflatable packers used to isolate target intervals
  - 15 injection boreholes
  - 7,170 gallons of EVO + lactate solution
  - 37 liters of DHC
  - 1,560 gallons of anaerobic chase water
- 3-month Post Injection Samples
  - Increases in TOC in all monitoring wells
  - Decreases in PCE
  - Daughter products

Investigation & Remediation Process



What contaminants?
Extents?

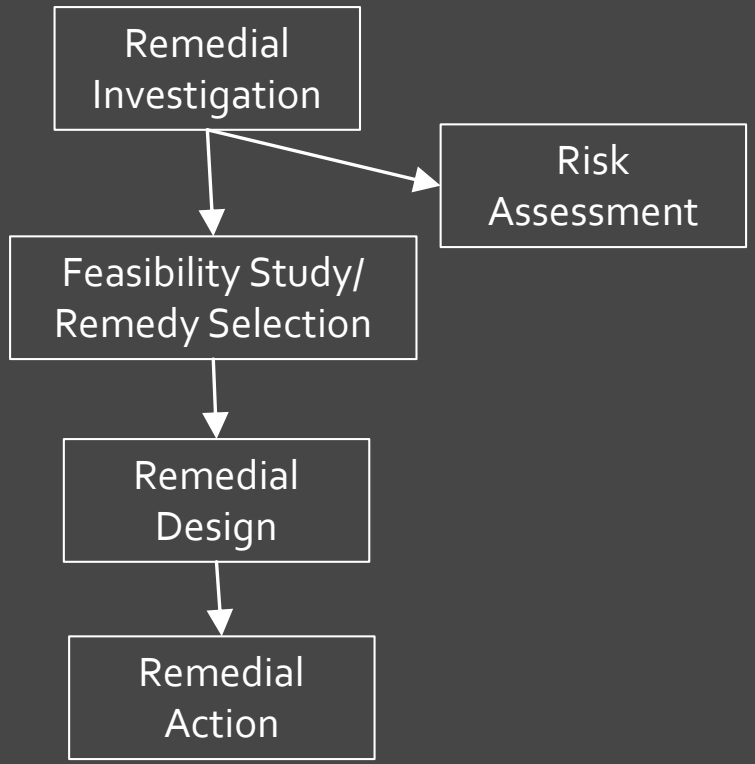
Who is at risk?

How much might it cost?
How long could it take?

How are we really going to treat this site?

How well do we understand the Source Area?

Investigation & Remediation Process



http://www.readersareleadersngn.net/more-of-a-relay-than-a-marathon/

http://wintechracing.com/wp-content/uploads/2016/03/WinTech-World-Pictures-090.jpg

Summary & Take Away

- Geology is central to fate and transport and to remediation success
- Investigation, design, and implementation is a team approach
- Many lines of evidence..
  - Boring logs, PID readings, field notes/visual observations
  - Groundwater and soil concentrations
  - High resolution screening (MIP, HPT, UVOST)
  - Stratigraphy
- Subsurface is dynamic
  - Plan to allow field optimizations
- Follow the geology, not the sample or screen
- Well screens do not have to be 5 or 10 feet

Questions?

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