Adaptive Recirculation System Design for ISCR Cycling of Metal Plating Releases

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Session H1: In-Situ Technologies: Lessons Learned
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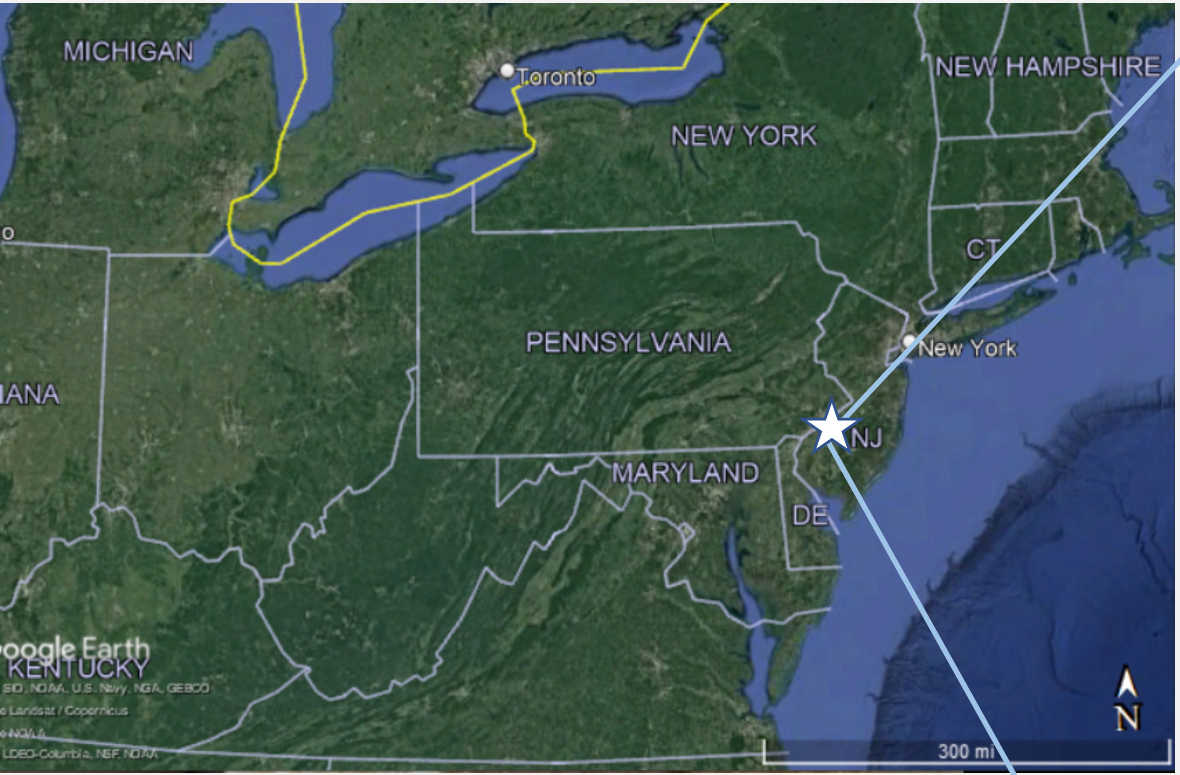
FOLLOWING
[DOING]
LEADING

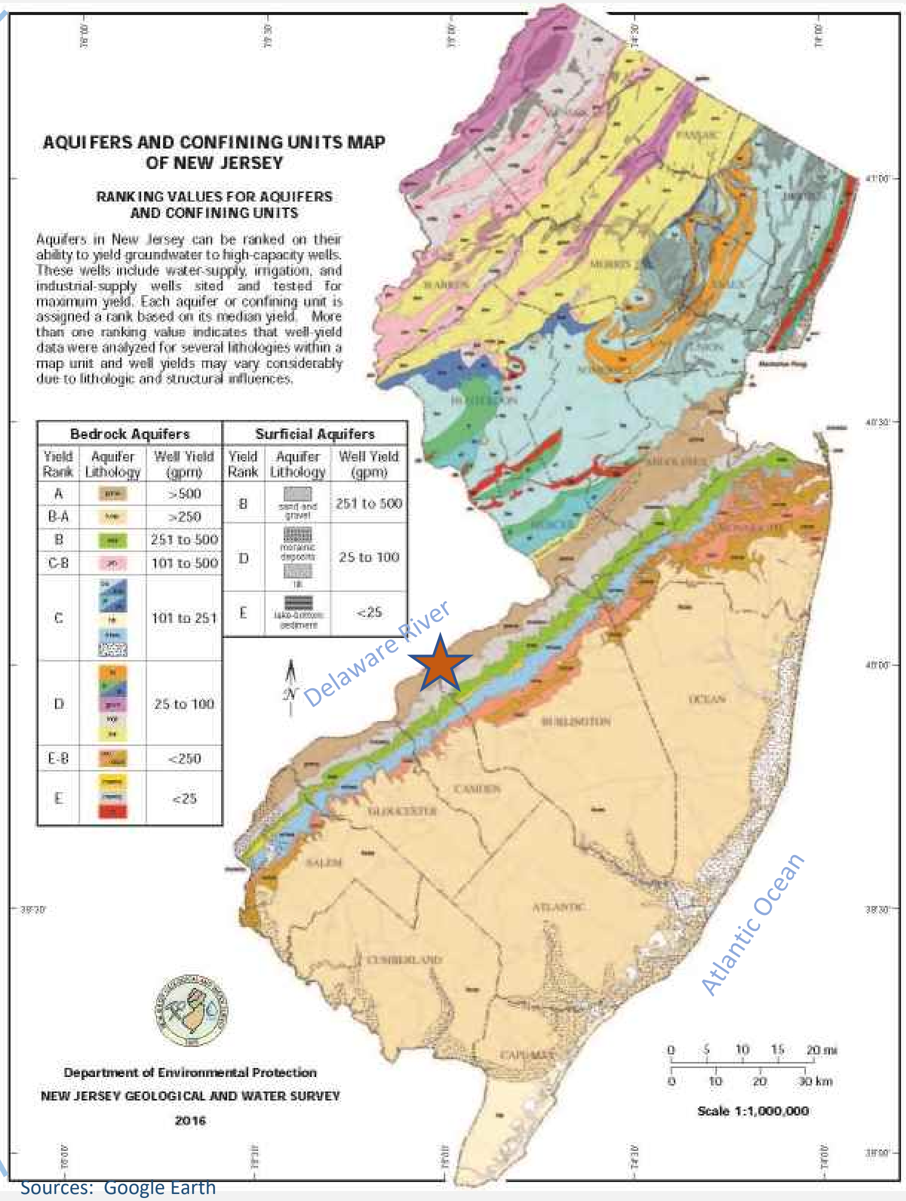
Presentation Outline

- A Look at the Site
- Pre-Design Investigation
- System Design and Installation
- Operation and Monitoring
- Lessons Learned and Best Practices

Site Location

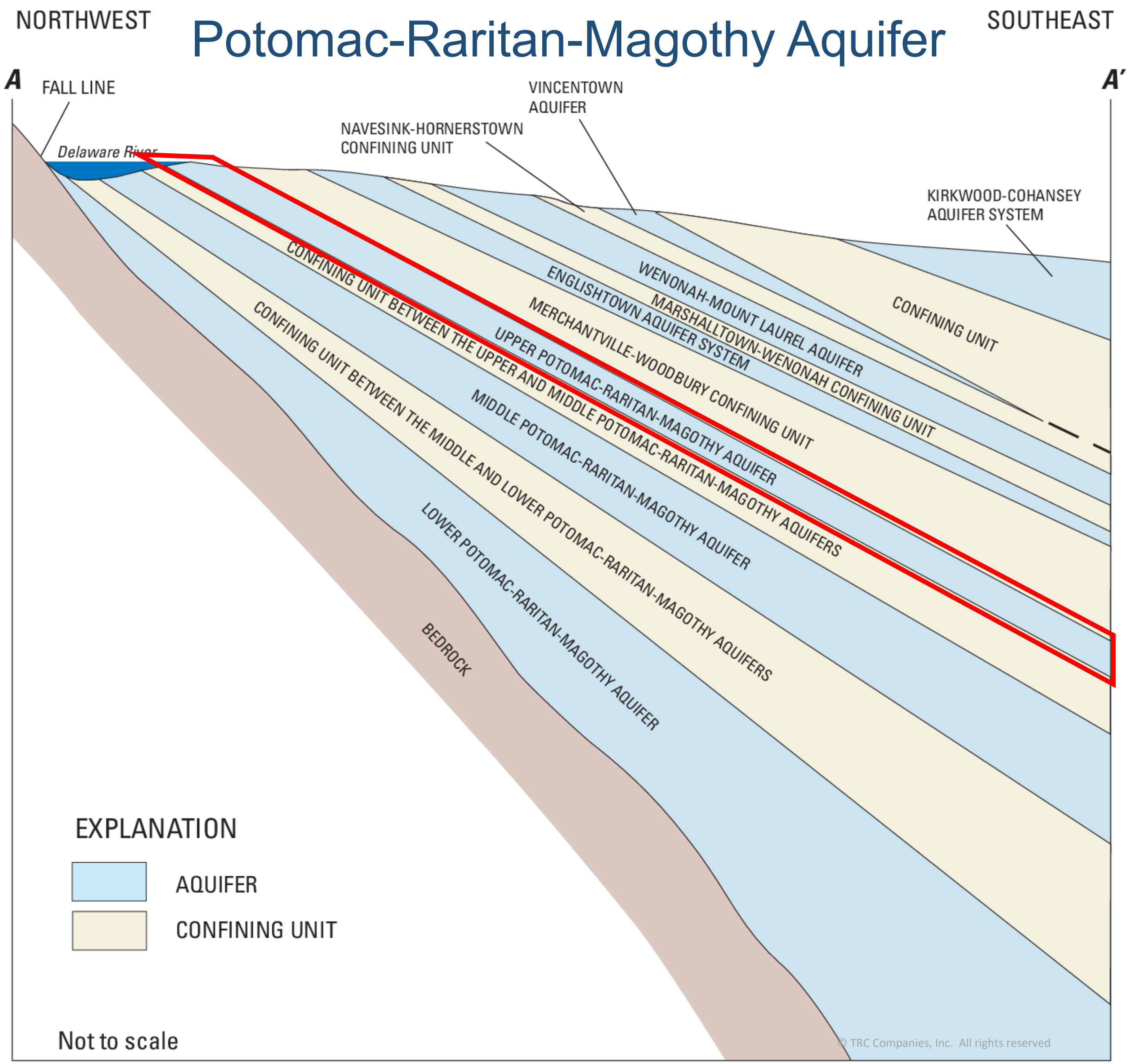


Area is home of baseball rubbing mud, used to give pitchers better grip on baseballs



Sources: Google Earth
https://www.nj.gov/dep/njgs/NJMaps.pdf
https://6abc.com/new-jersey-lena-blackburne-baseball-rubbing-mud-what-do-pitchers-put-on-baseballs/12665114/

Potomac-Raritan-Magothy Aquifer



Geology & Hydrogeology

- Fine to Medium Sand with lenses of silt and clay
- DTW = 10-12 ft bgs
- K = 2-20 ft/day
- i = 0.0025
- v_s = 20-30 ft/day

Example of roto cylinders at work

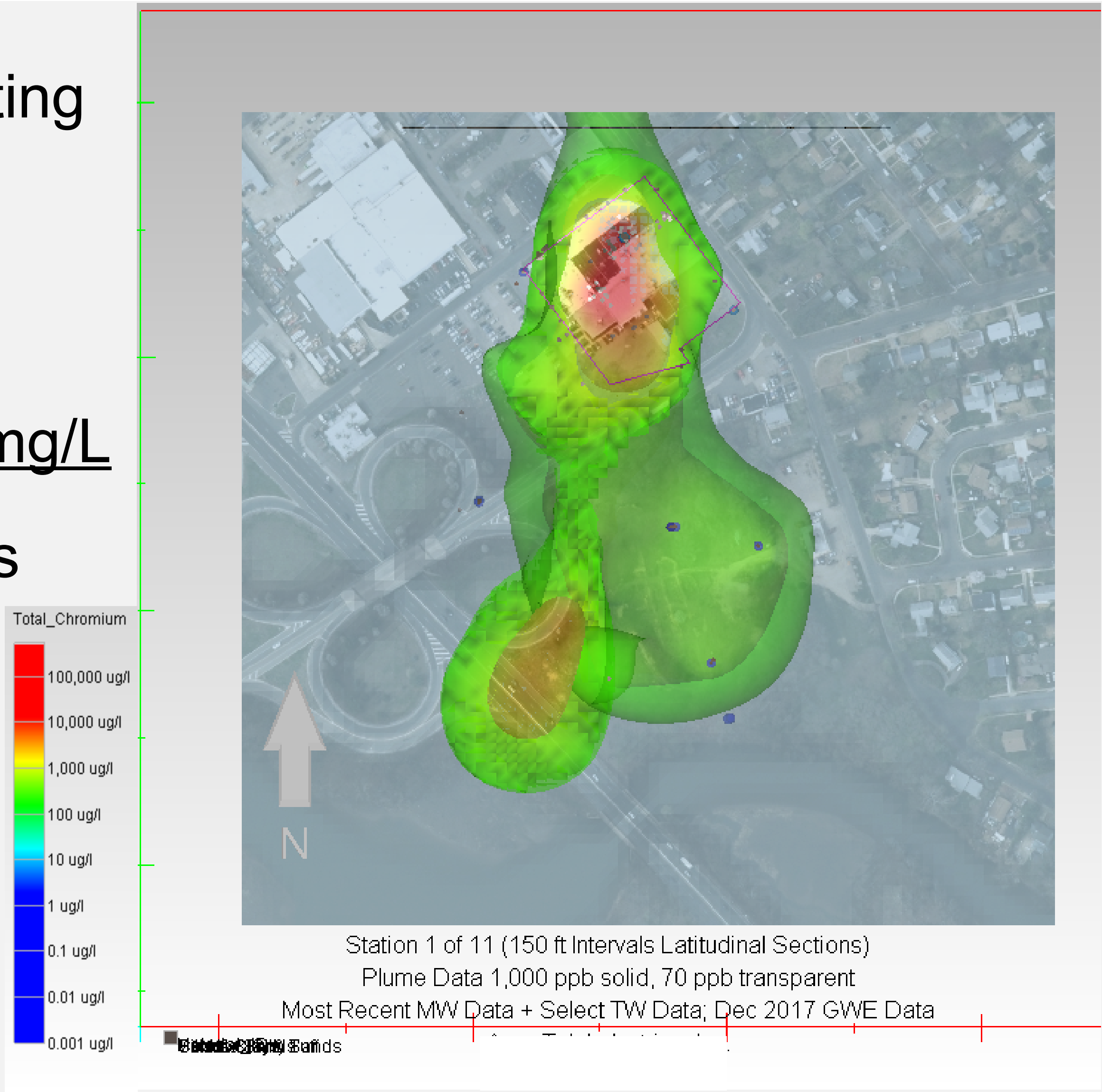
Source: https://www.reddit.com/r/mechanical_gifs/comments/9prvck/rotogravure_printing_process/

Site History

- Site developed in the 1960s
- Performed mechanical and electroplating for roto cylinders
- Process uses chromium, copper, and nickel
- ISRA triggered in 2005
- Remedial Investigation performed 2009-2019
- Identified soil and groundwater impacts

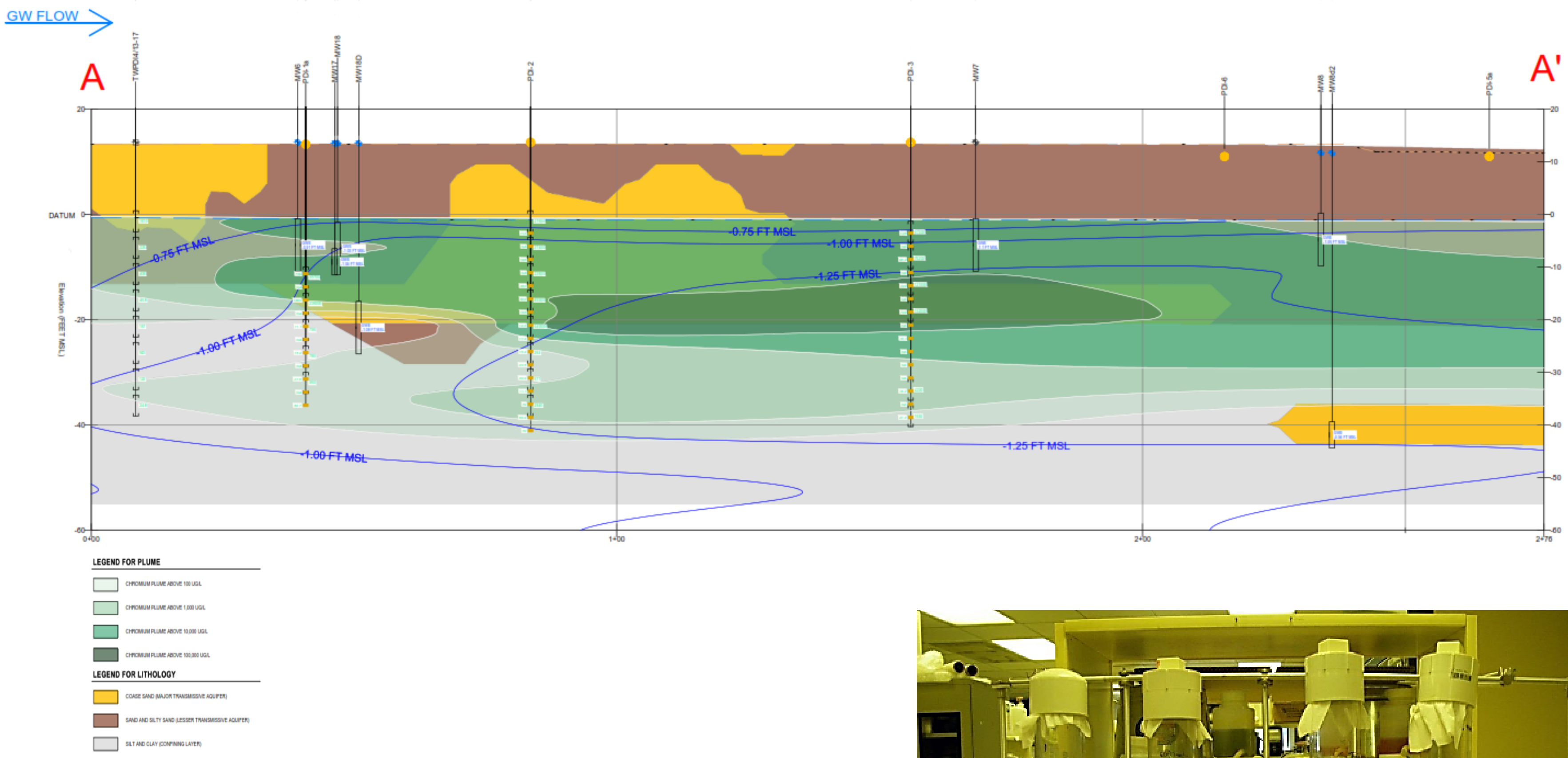
Subsurface Impacts

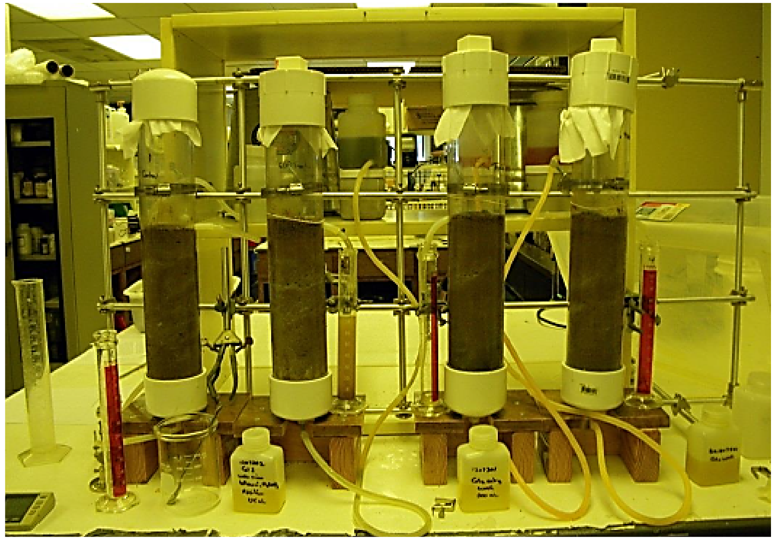
- Chromic acid & metals from historic metal plating
- Vadose Soil: Cr(VI) (2,700 mg/kg)
- Saturated Soil: Cr(VI) (1,000 mg/kg)
- GW: Cr(VI) (50-800); Cu (2-160); Ni (0.1-12) <u>mg/L</u>
- Plume extends >1,000 ft and dives to 60 ft bgs
- Challenges
  - Heterogenous subsurface
  - Highly acidic gw and soil
  - Oxidizing environment
  - Active facility



Pre-Design Activities

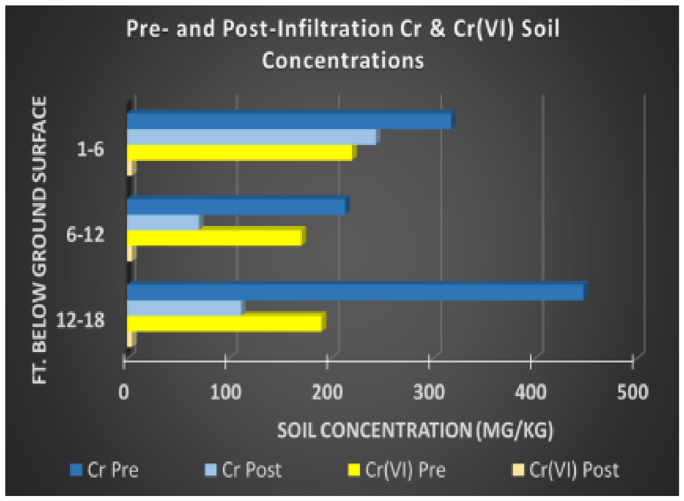
- Hydraulic profiling
- Treatability study
  - Batch tests & column study
  - Reagents
    - Calcium Polysulfide (CaSx or CPS), Ferrous sulfate w/ Magnesium hydroxide, Ferrous sulfide (FeS)

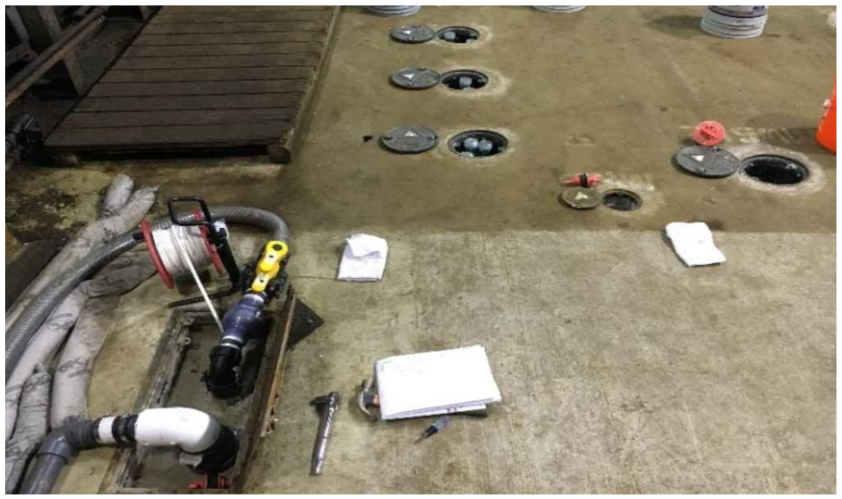


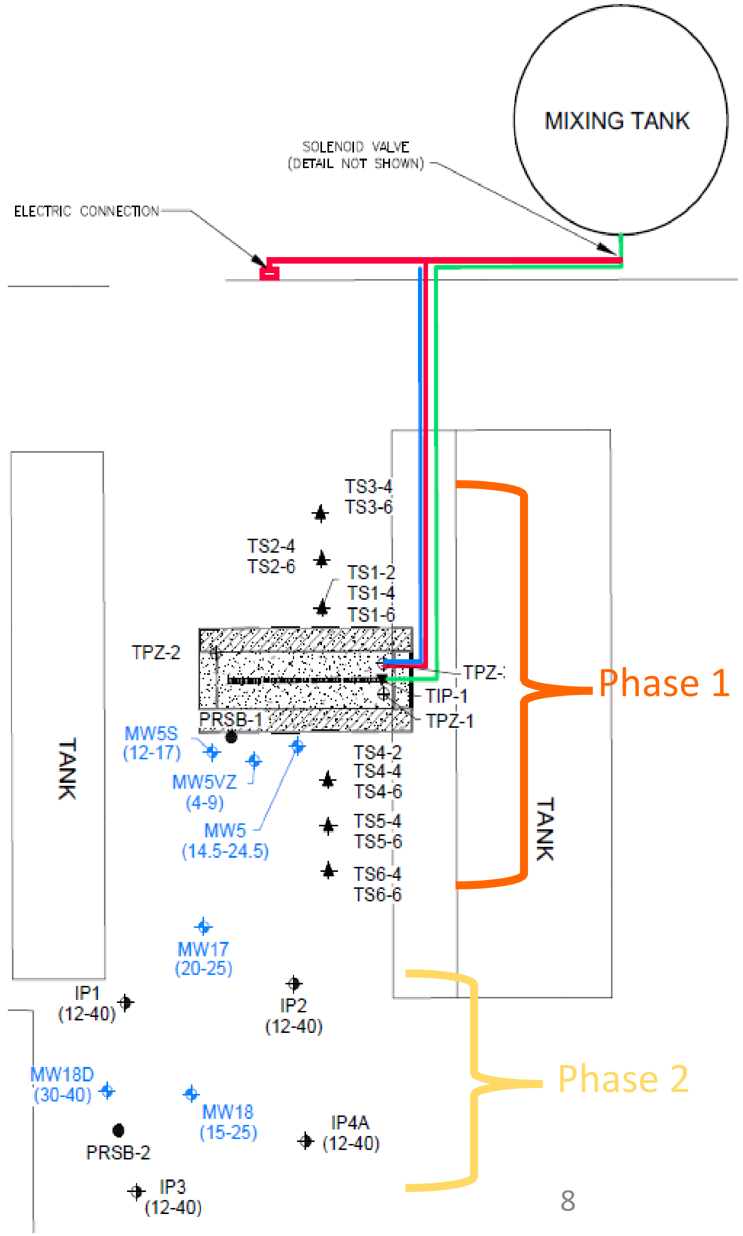


Pilot Tests

- Performed in 2 phases
  – Unsaturated & Saturated
- Lessons learned
  – Safety measures to avoid floating the slab
  – More effective remediation of deeper horizons required
  – CPS is most effective reagent







Pumping and Tracer Test

- Step-drawdown test
- Baseline WLM
- Constant rate pumping test
- Tracer injection and monitoring
- Recovery monitoring

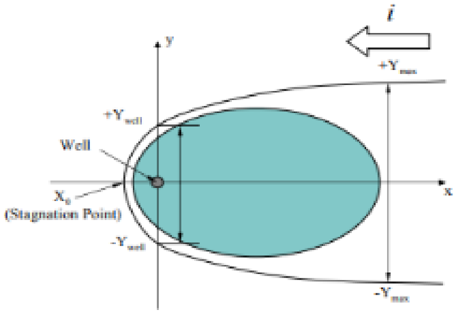
Capture Zone Width Calculation

i	0.002 ft/ft	natural gradient calculated from RIR GWE map
T	1500 ft2/d	avg T
Q	2887.5 ft3/d	15 gpm
Y_{max}	481.25 ft	
Y_{well}	240.625 ft	
X_0	-153.2643 ft	

Capture Zone Width Calculation, One Extraction Well

Assumptions:

- homogeneous, isotropic, confined aquifer of infinite extent
- uniform aquifer thickness
- fully penetrating extraction well(s)
- uniform regional horizontal hydraulic gradient
- steady-state flow
- negligible vertical gradient
- no net recharge, or net recharge is accounted for in regional hydraulic gradient
- no other sources of water introduced to aquifer due to extraction (e.g., from rivers or leakage from above or below)



$$x = \frac{-y}{\tan\left(\frac{2\pi T i}{Q} y\right)} \quad -or- \quad y = \pm\left(\frac{Q}{2Ti}\right) - \left(\frac{Q}{2\pi Ti}\right)\tan^{-1}\left(\frac{y}{x}\right)$$

$$X_0 = -Q/2\pi Ti \quad ; \quad Y_{max} = \pm Q/2Ti \quad ; \quad Y_{well} = \pm Q/4Ti$$

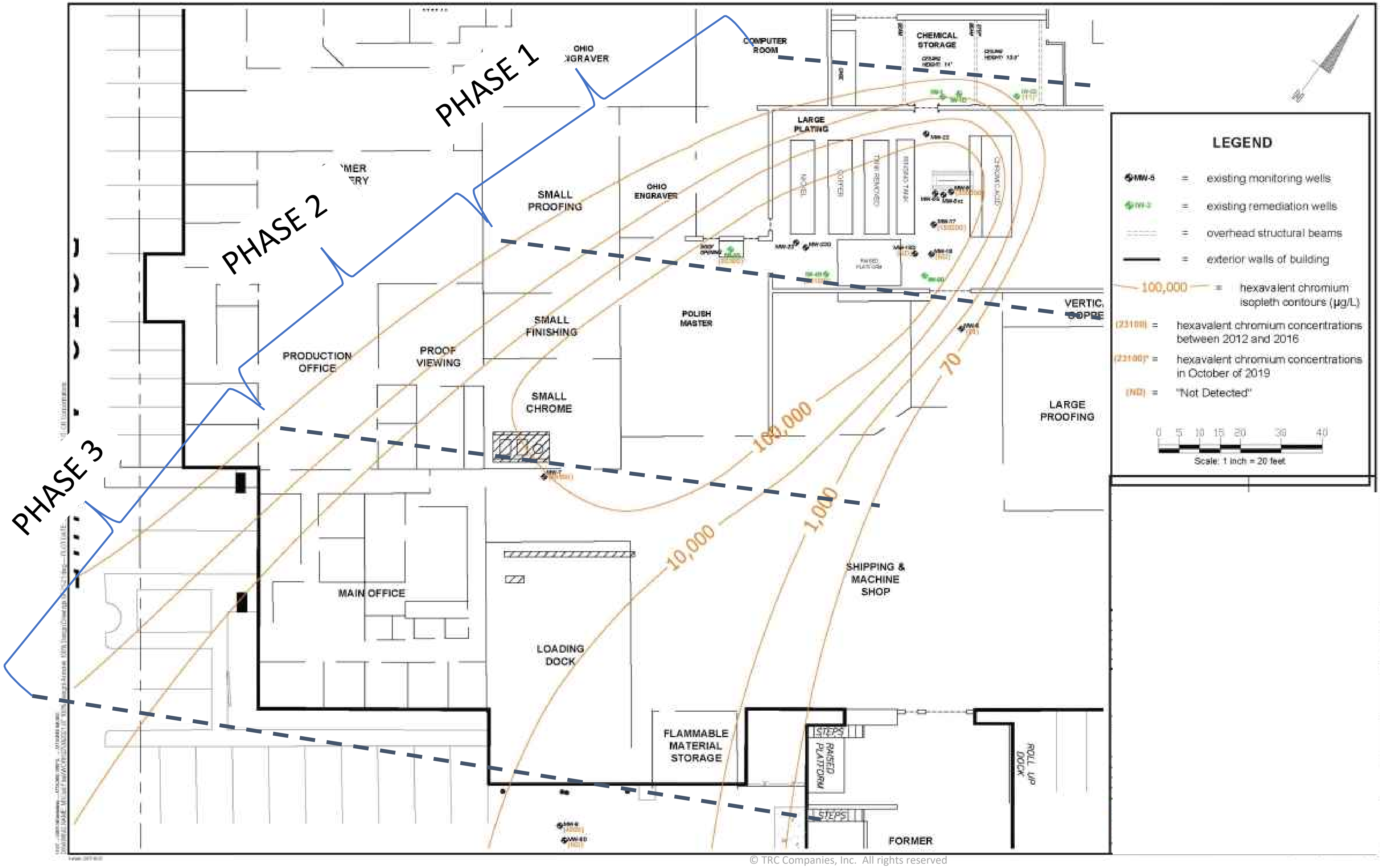
(must use consistent units, such as "ft" for distance and "day" for time)

Where:

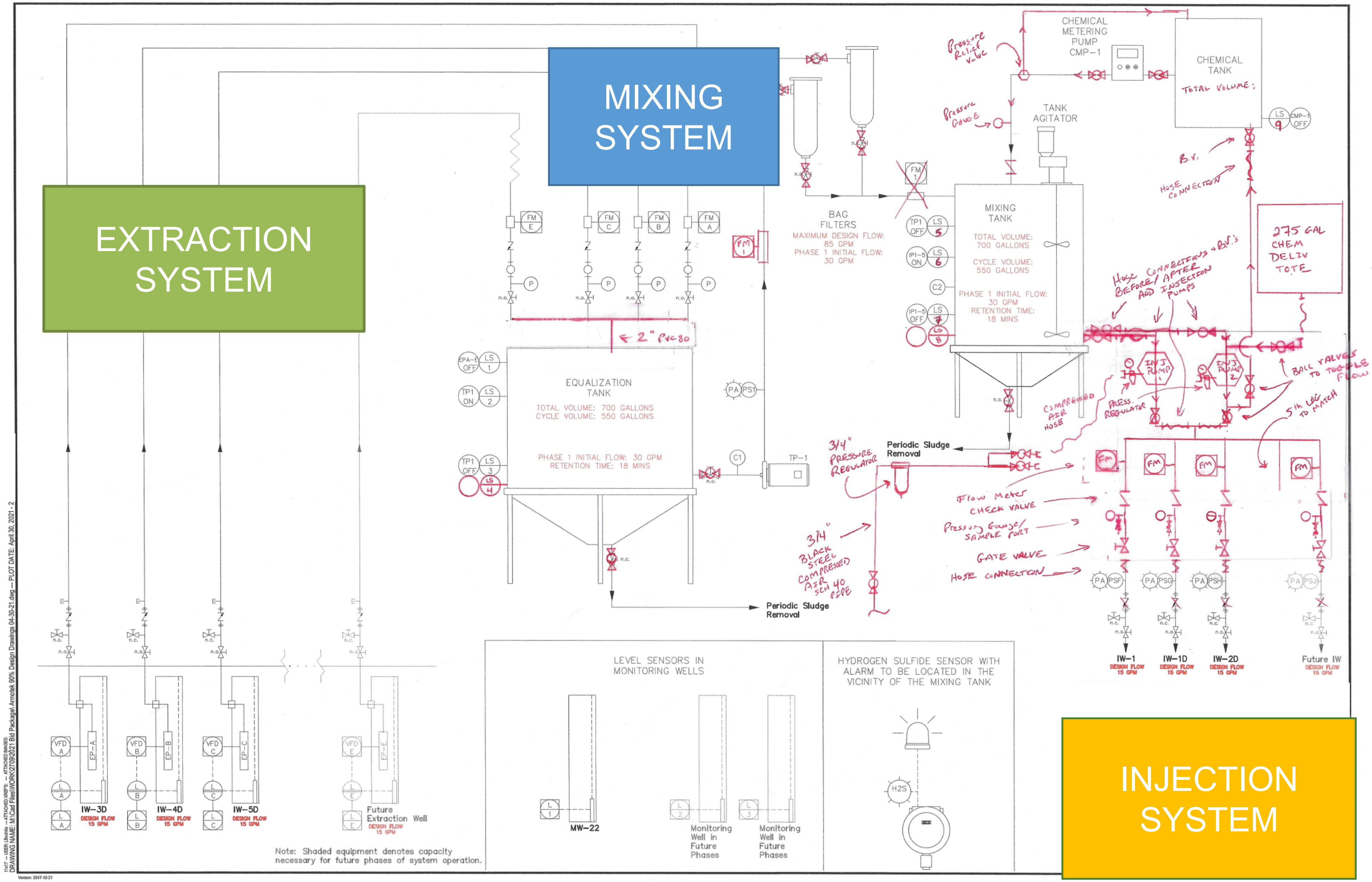
Q = extraction rate
T = transmissivity, $K \cdot b$
K = hydraulic conductivity
b = saturated thickness
i = regional (i.e., pre-remedy-pumping) hydraulic gradient
X_0 = distance from the well to the downgradient end of the capture zone along the central line of the flow direction
Y_{max} = maximum capture zone width from the central line of the plume
Y_{well} = capture zone width at the location of well from the central line of the plume

EXTRACTION SYSTEM → MIXING SYSTEM → INJECTION SYSTEM

System Design



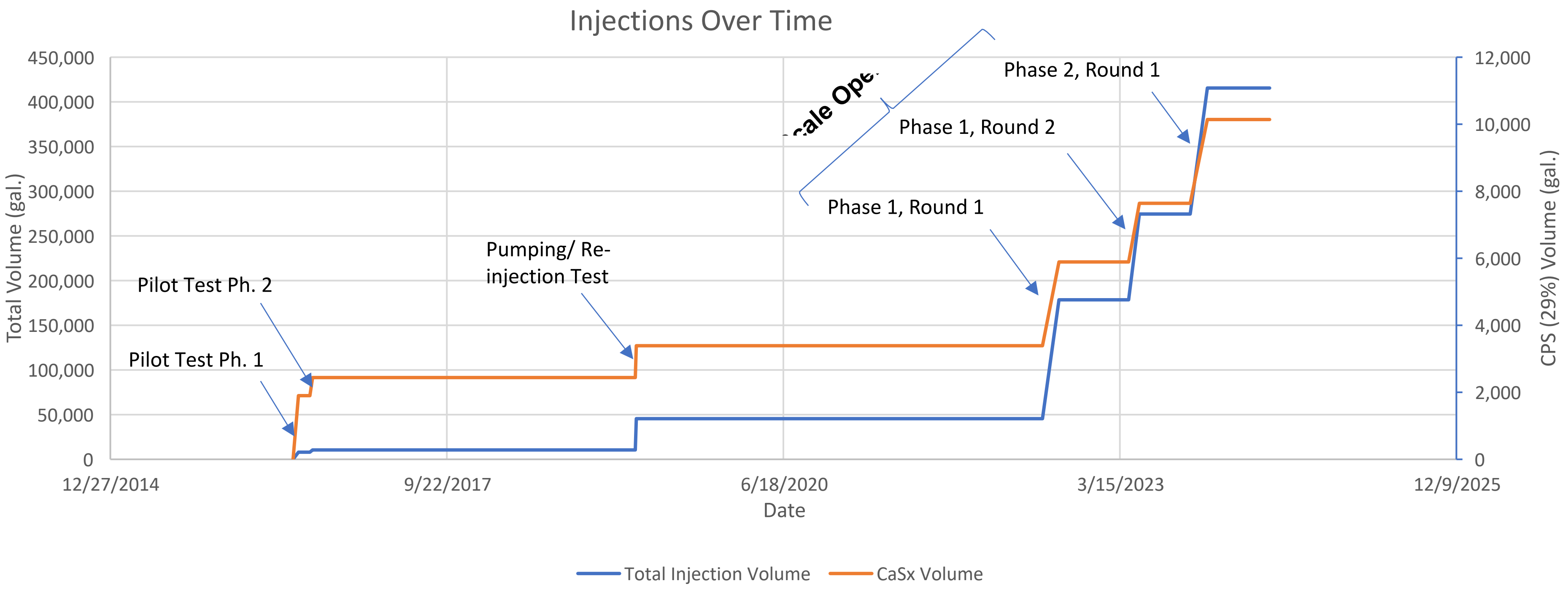
System Design



System Installation

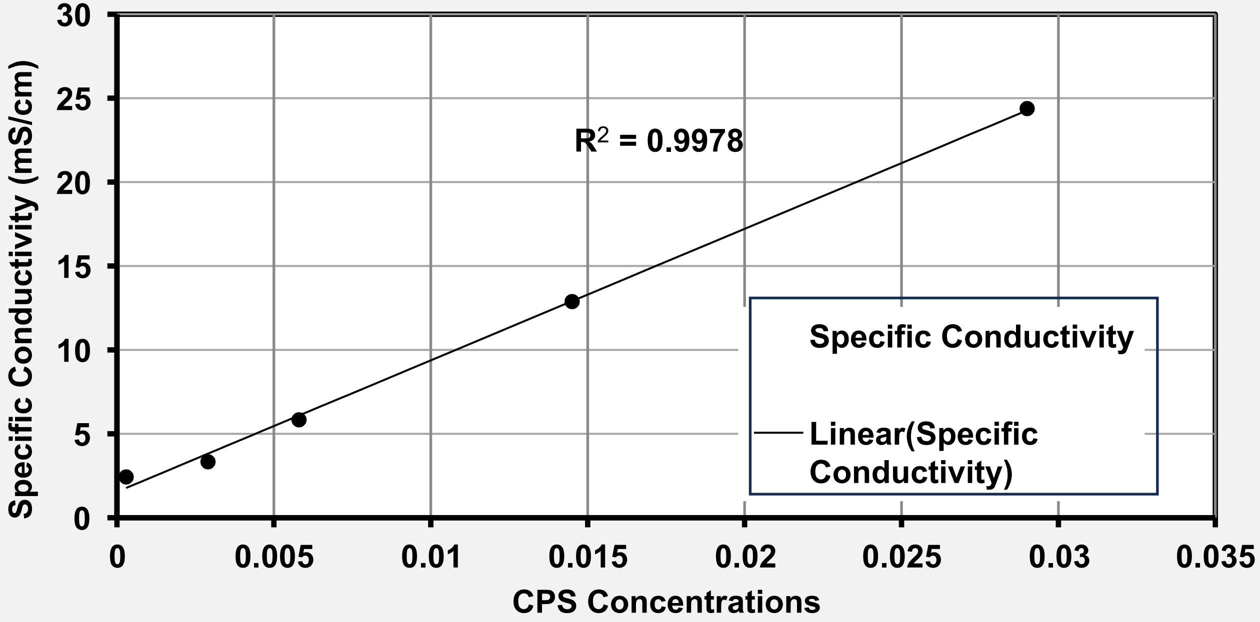
Full Scale Operations

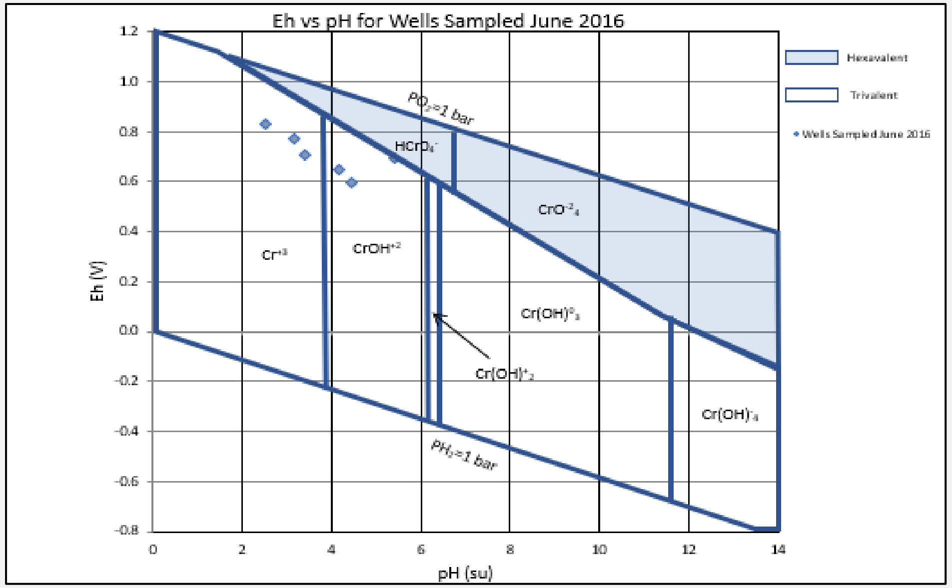
- Extraction w/ VFD pumps to adjust flow rates
- Injection using AOD pump w/ comp. air supplied by facility
- Totalizer monitoring for both injection and extraction
- Datalogging with PLC

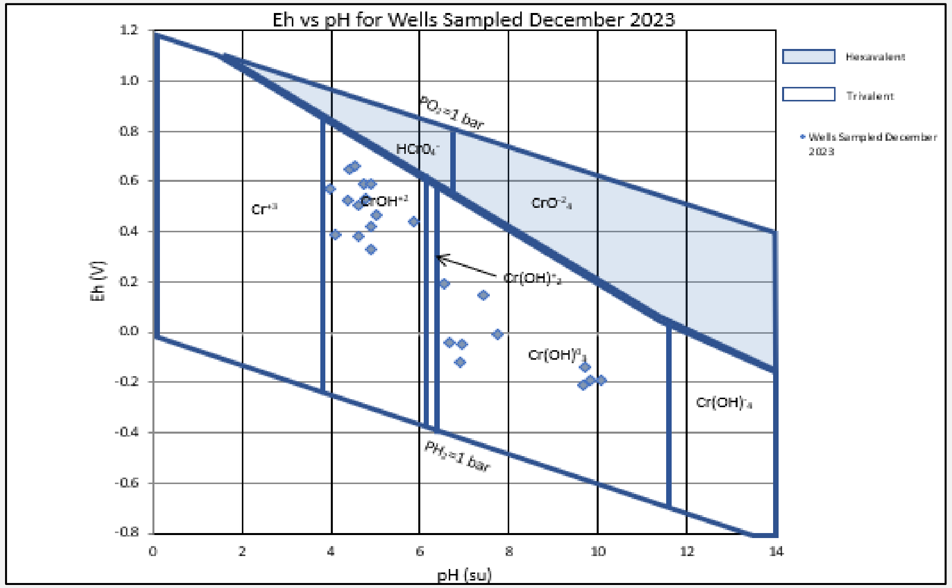


Geochemical Response

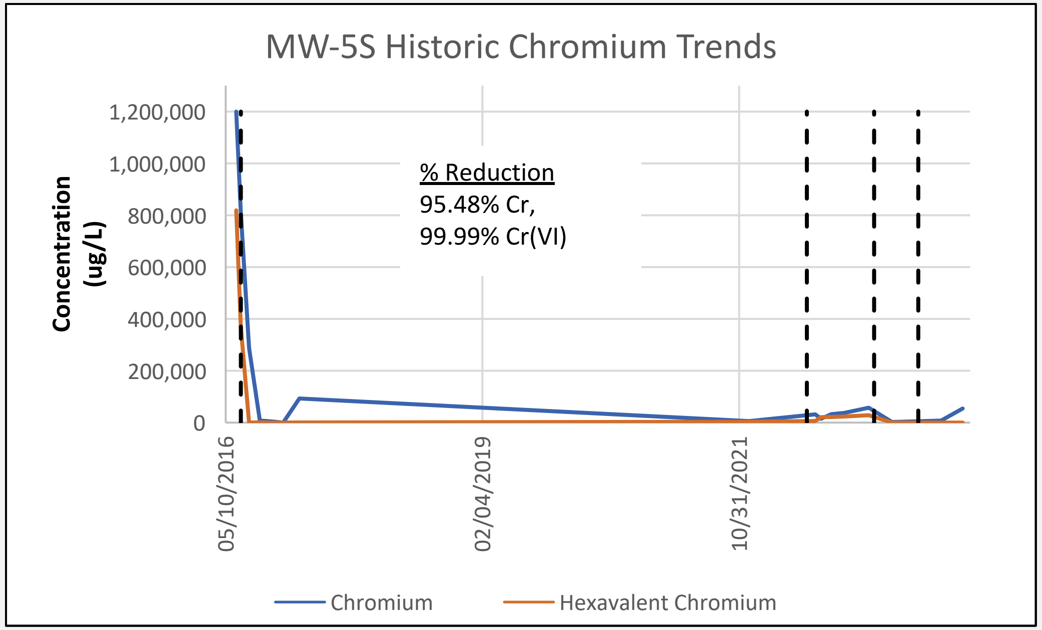
CPS Concentrations vs. Specific Conductivity

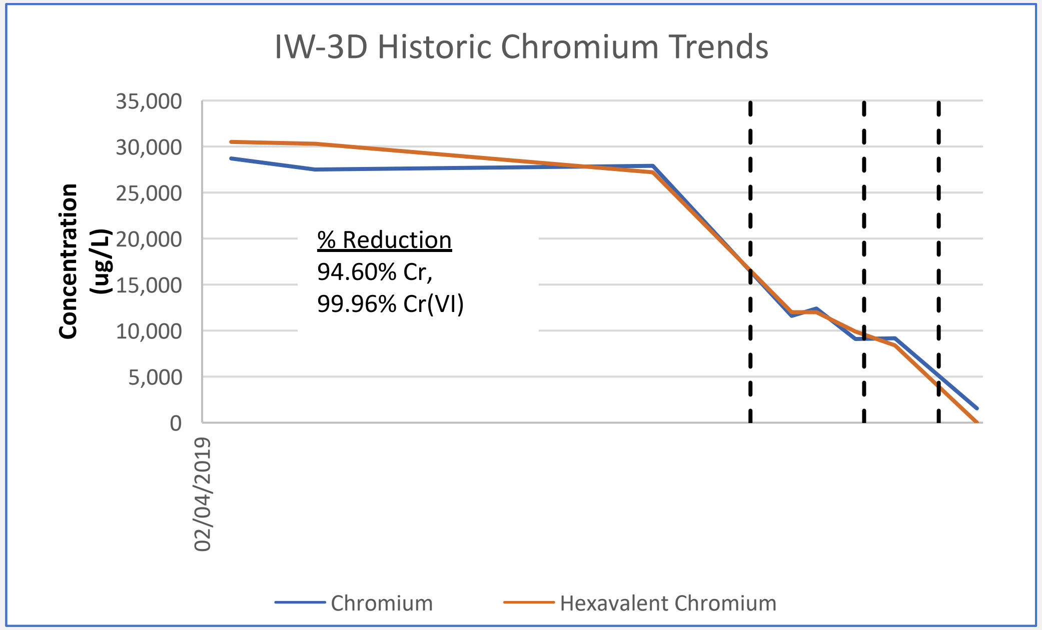


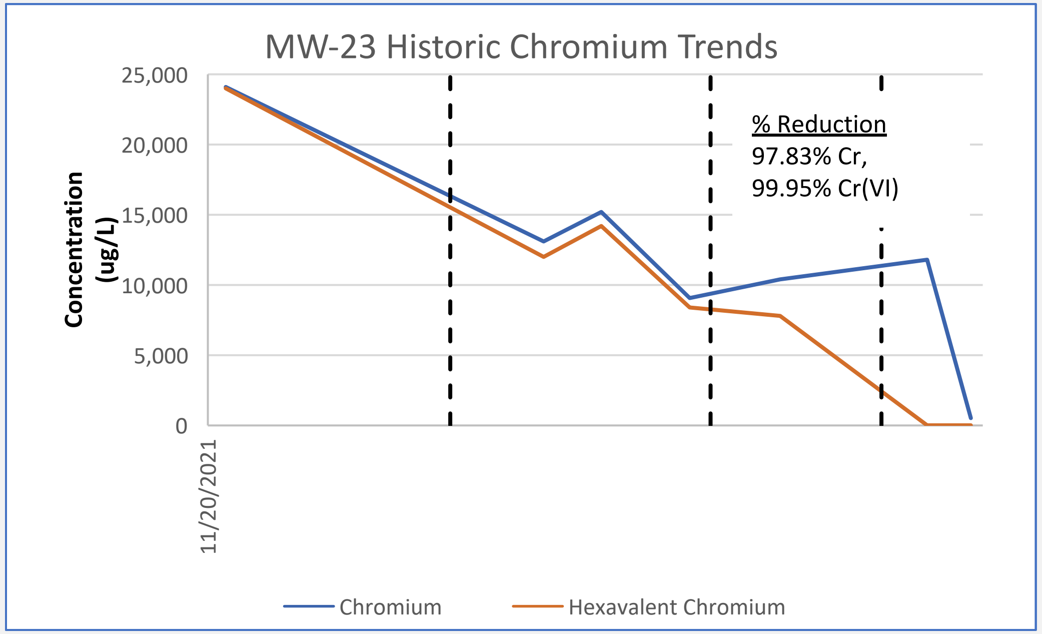


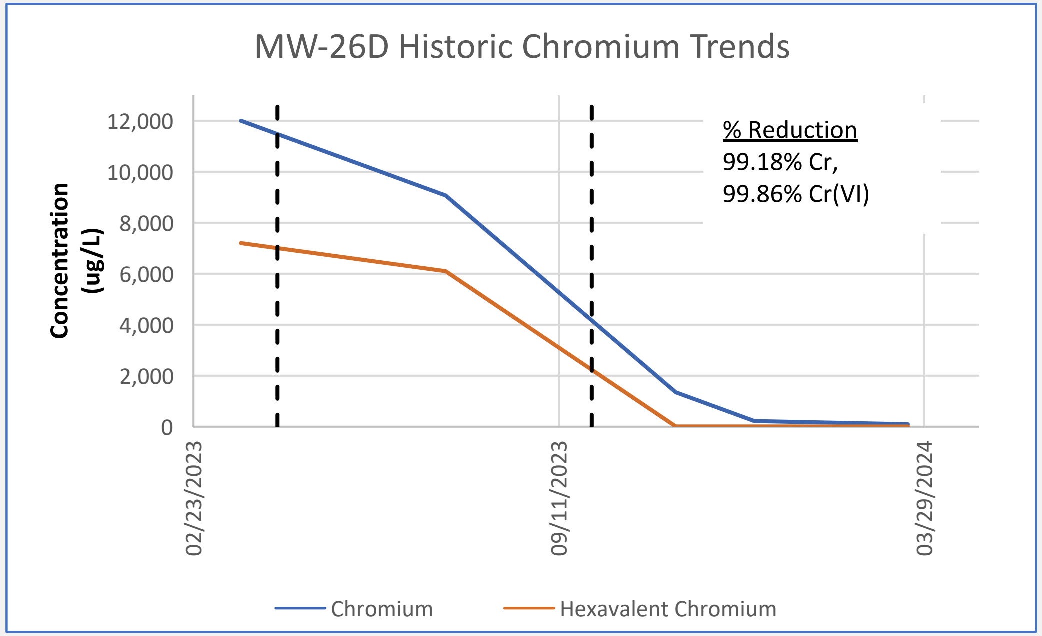


Chromium Trends









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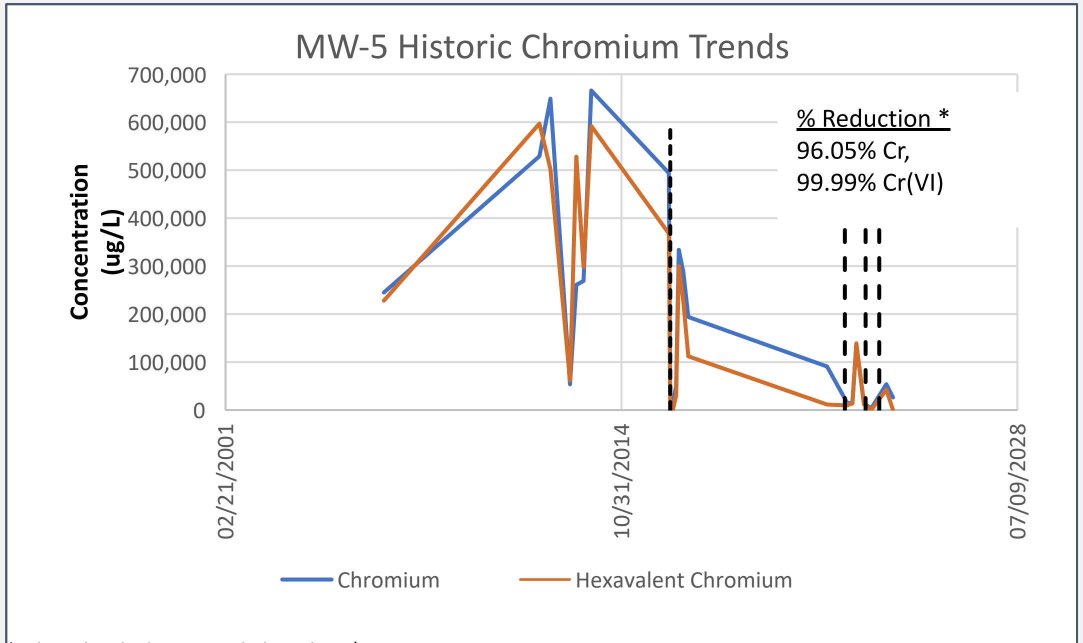
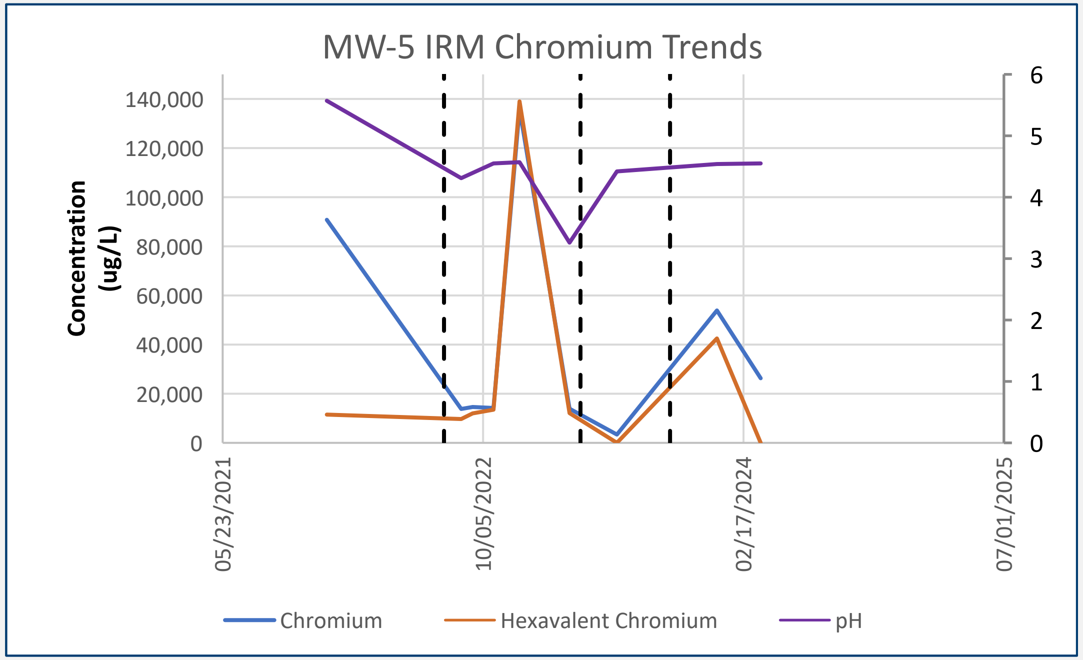
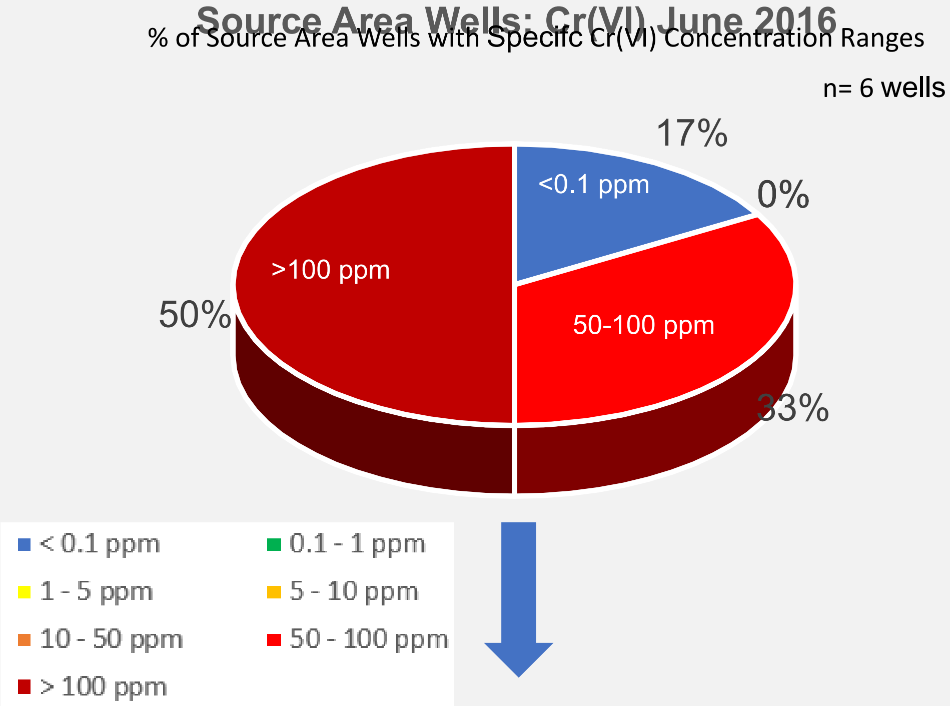
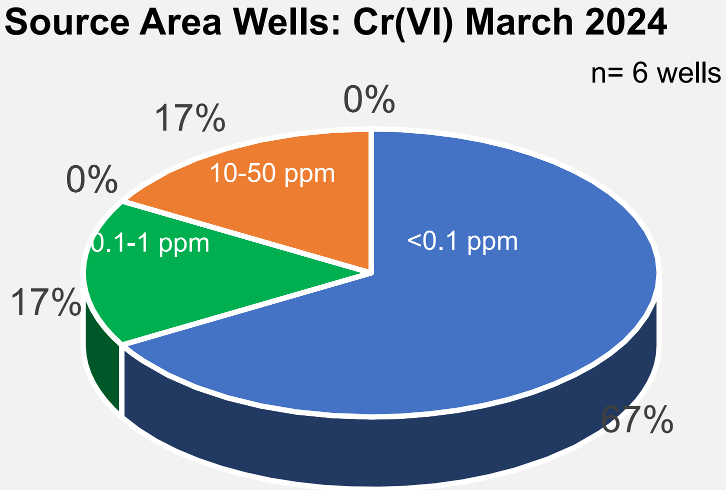


* = based on highest recorded result 10/2013





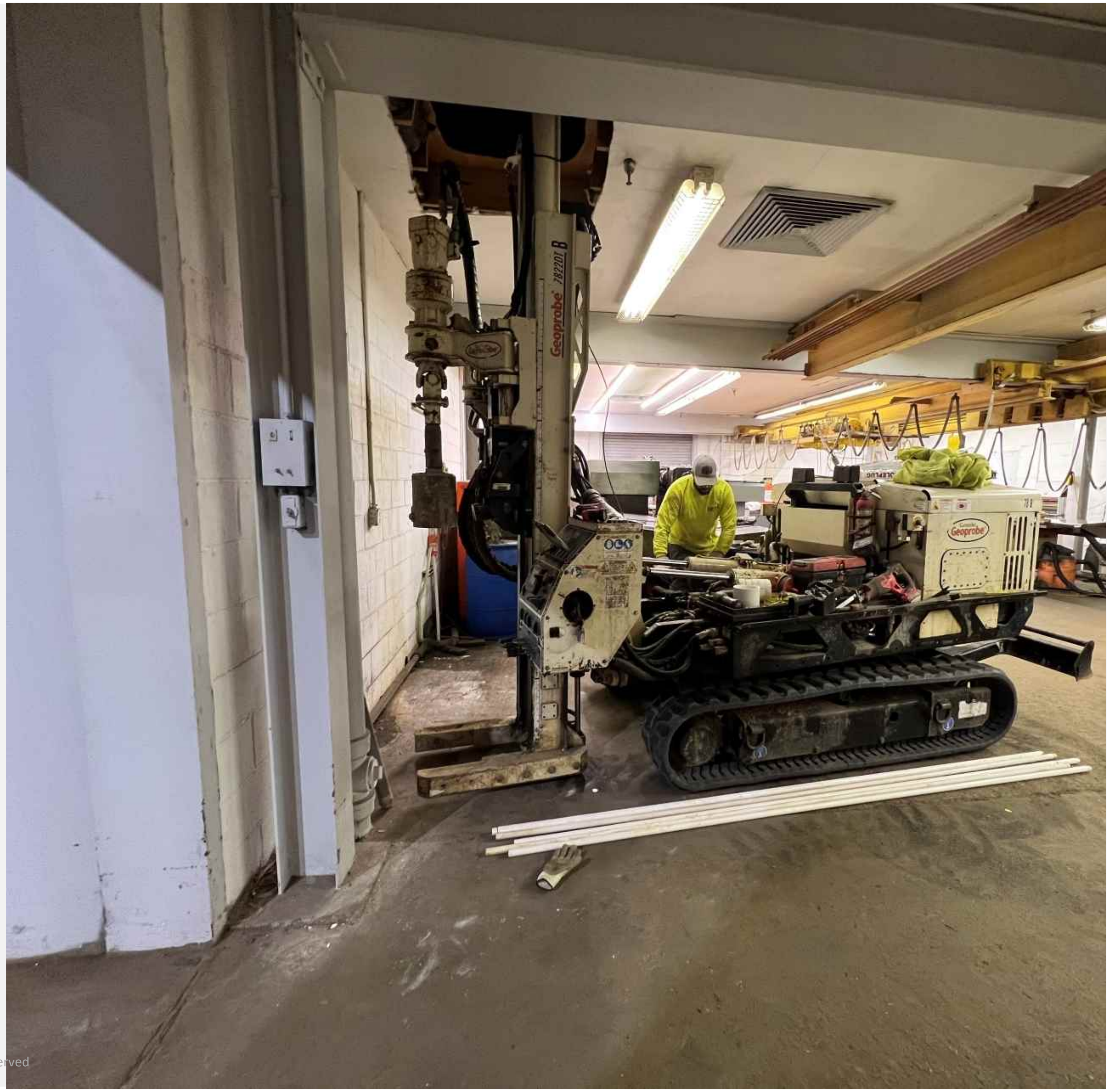


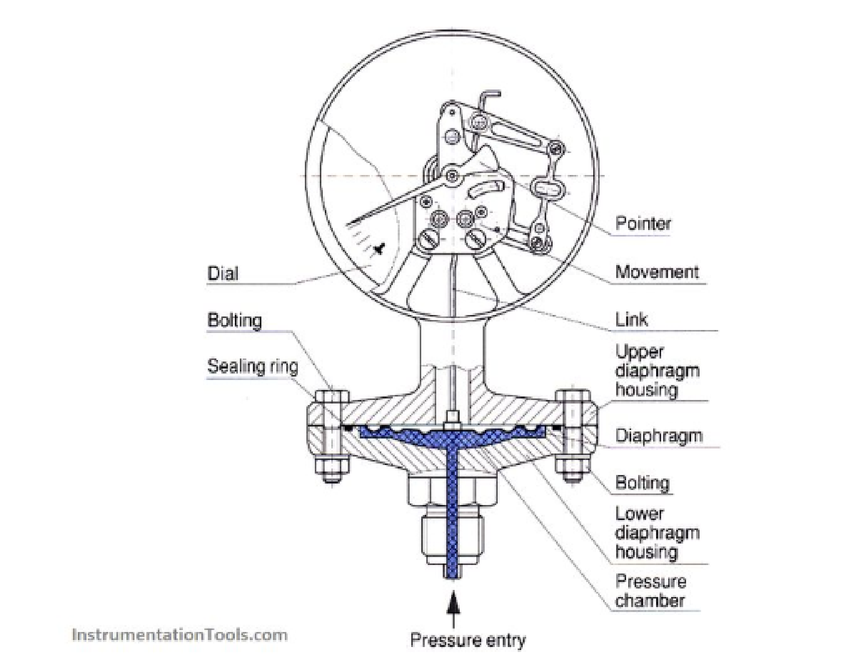
Lessons Learned: Safety

- Spills
  - Berm installed around system tanks
  - Gradations added to chem tank
  - Pressure test lines prior to starting system operations
- Emergency shut off on PLC controller
- H2S sensor installed near chem tank and personal monitor for staff
- Awareness training for facility staff

Lessons Learned: Site Features

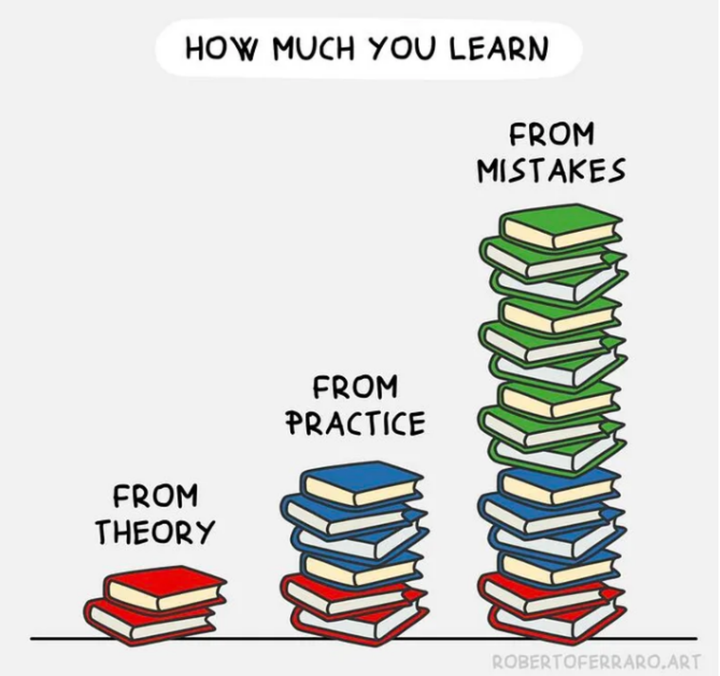
- Varying groundwater concentrations
  - Alternative dilution water needed for plume edges
- Area constraints due to working in active facility
  - Walk the site with the driller to make sure they can access where you want to put a well
  - Good relationship with client goes a long way
- Subsurface highly heterogeneous
  - Variable flow rates from well to well
  - VFDs on extraction well pumps to adjust flow rates
  - Ball valves on injection lines
  - More discrete screen intervals for certain horizons in source area





Lessons Learned: Operations

- Scaling
  - Pressure gauges on inj. side upgraded to have diaphragm seals
  - Totalizers needed to be cleaned periodically
  - Injection wells needed to be redeveloped
  - Increasing dosing in later phases reduced scaling
- Telemetry System
  - Confidence in remote operations improved after improved safety
- Upgraded from float to a transducer in PMW



Biggest Lesson Learned

- Take it one step at a time
- Take the time to properly perform PDI
- More digestible for the client
- Constantly improving on lessons learned

Acknowledgements

- **TRC Project Team**
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Thank You