



A Sustainable Multi-Faceted Remediation Approach to Address Chlorinated Solvent Impacts from Onsite and Offsite Sources

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Presentation Outline

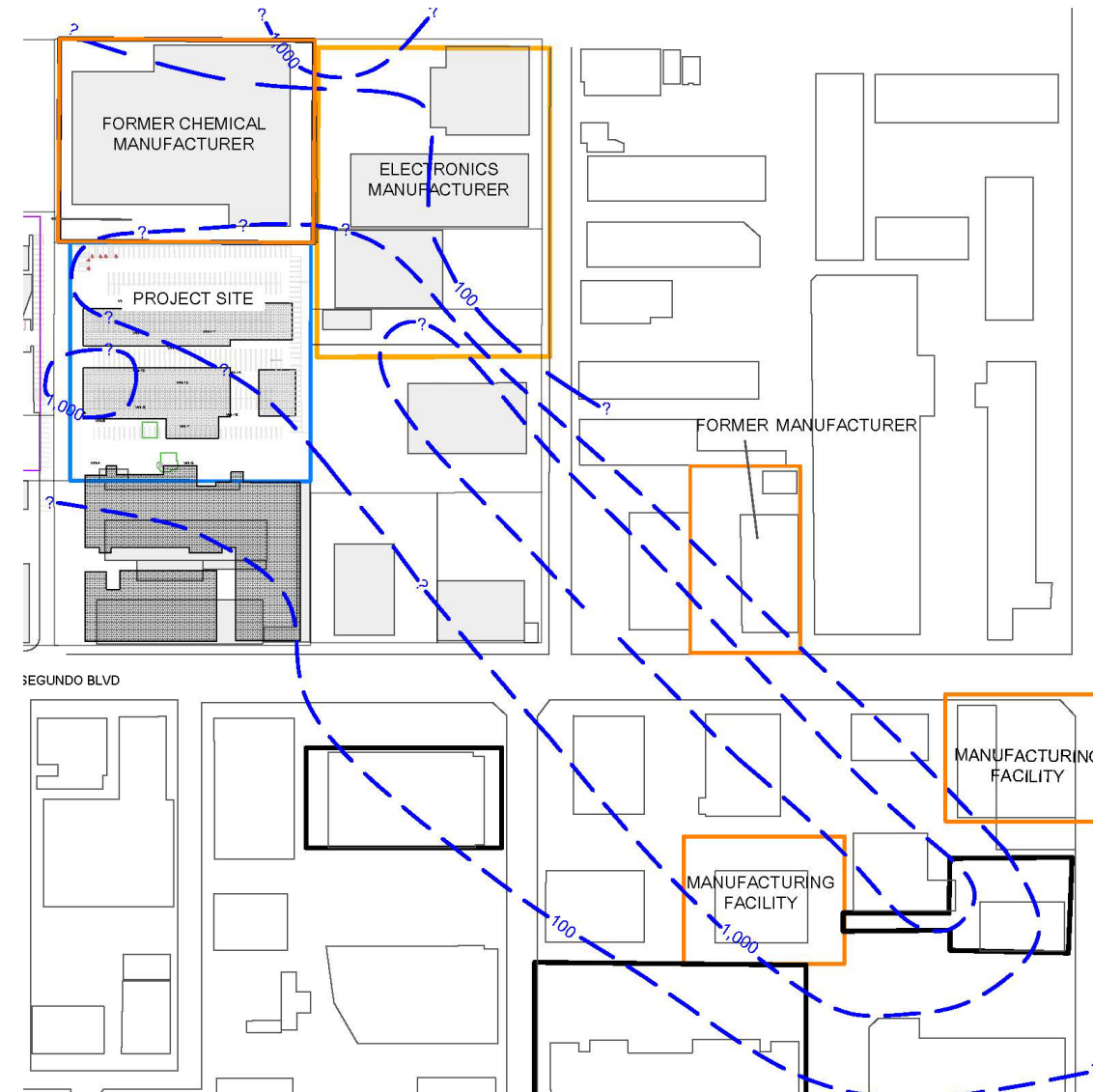
- Site Background
- Overview of Remedial Technologies
- Performance Results
- Sustainability
- Lessons Learned

Site Background

- Former latex & foam rubber manufacturing facility
- Currently a commercial parking lot
- DTW: 28 ft bgs – 40 ft bgs
- GW Flow Direction: 0.01 ft/ft northwest
- Predominantly fine-grained alluvial deposits interbedded with silty sand, sand, silt, and clay
- Previous remedial activities included excavation around the source area

Site Background – Offsite Impacts

- Multiple potential off site impacts:
 - North and West: Former chemical manufacturing site with chlorinated hydrocarbon impacts.
 - Northeast: Current electronic manufacturing site with chlorinated solvent impacts.
 - East and Southeast: Former manufacturing sites with chlorinated solvent impacts.
- Source Area:
 - Sand Traps



Contaminants of Concern and Impacted Media

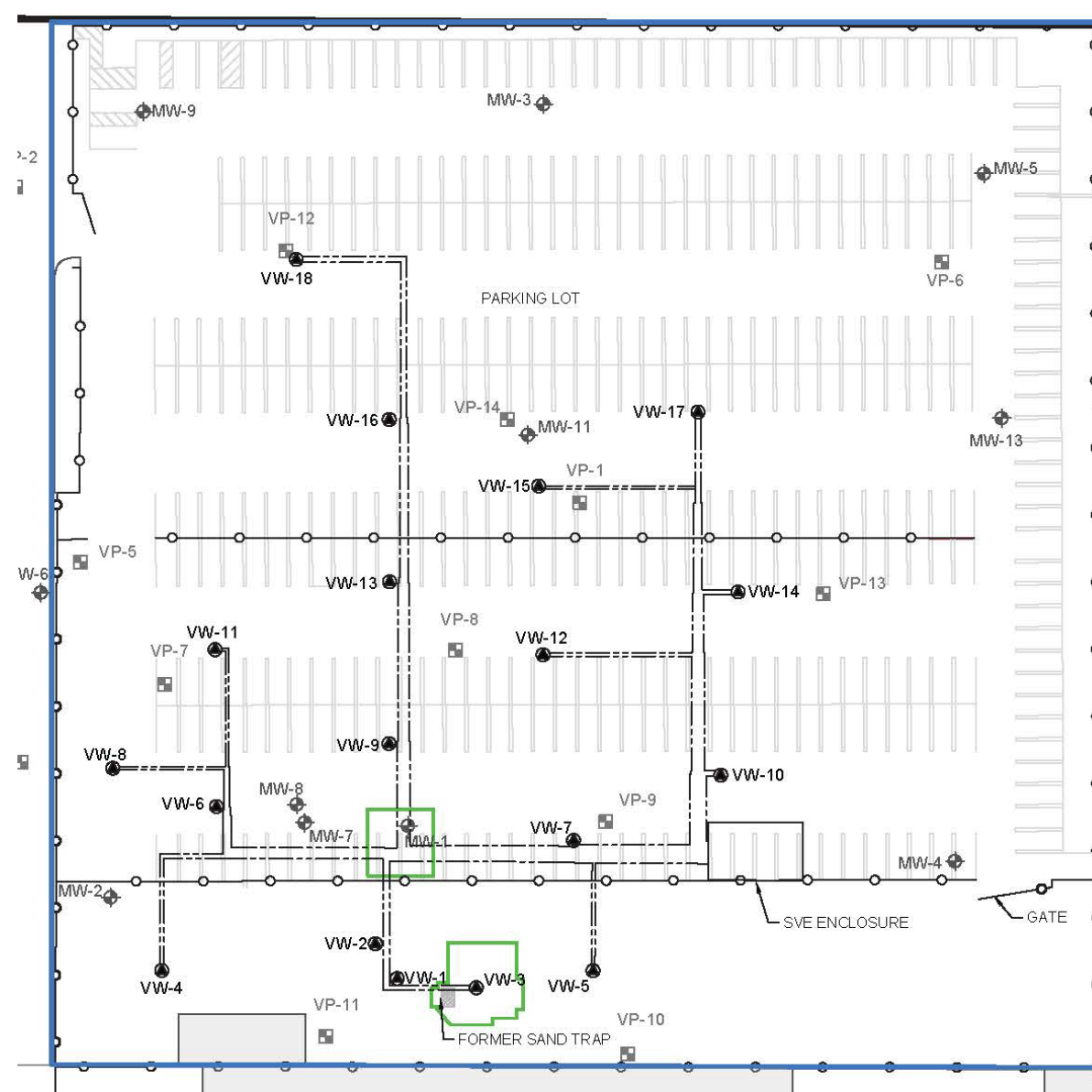
- Primary COCs:
 - PCE, TCE, 1,4-dioxane and hexavalent chromium
- Impacted Media:
 - Vadose zone soils
 - Groundwater
 - Soil vapor

Remedial Strategy Overview

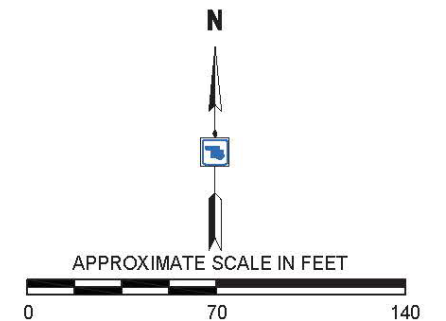
- In Situ Chemical Oxidation (ISCO): Alkaline activated persulfate injections
- Enhanced Reductive Dechlorination (ERD): Molasses, emulsified vegetable oil, and bioaugmentation culture Injections
- Soil Vapor Extraction (SVE) System: 18 shallow and 15 deep wells
- TreeWell® Phytoremediation: Off-site plume mitigation on the Eastern and Northern boundaries

Soil Remediation

SVE Layout



Trench Location
SVE Well
Vapor Probe



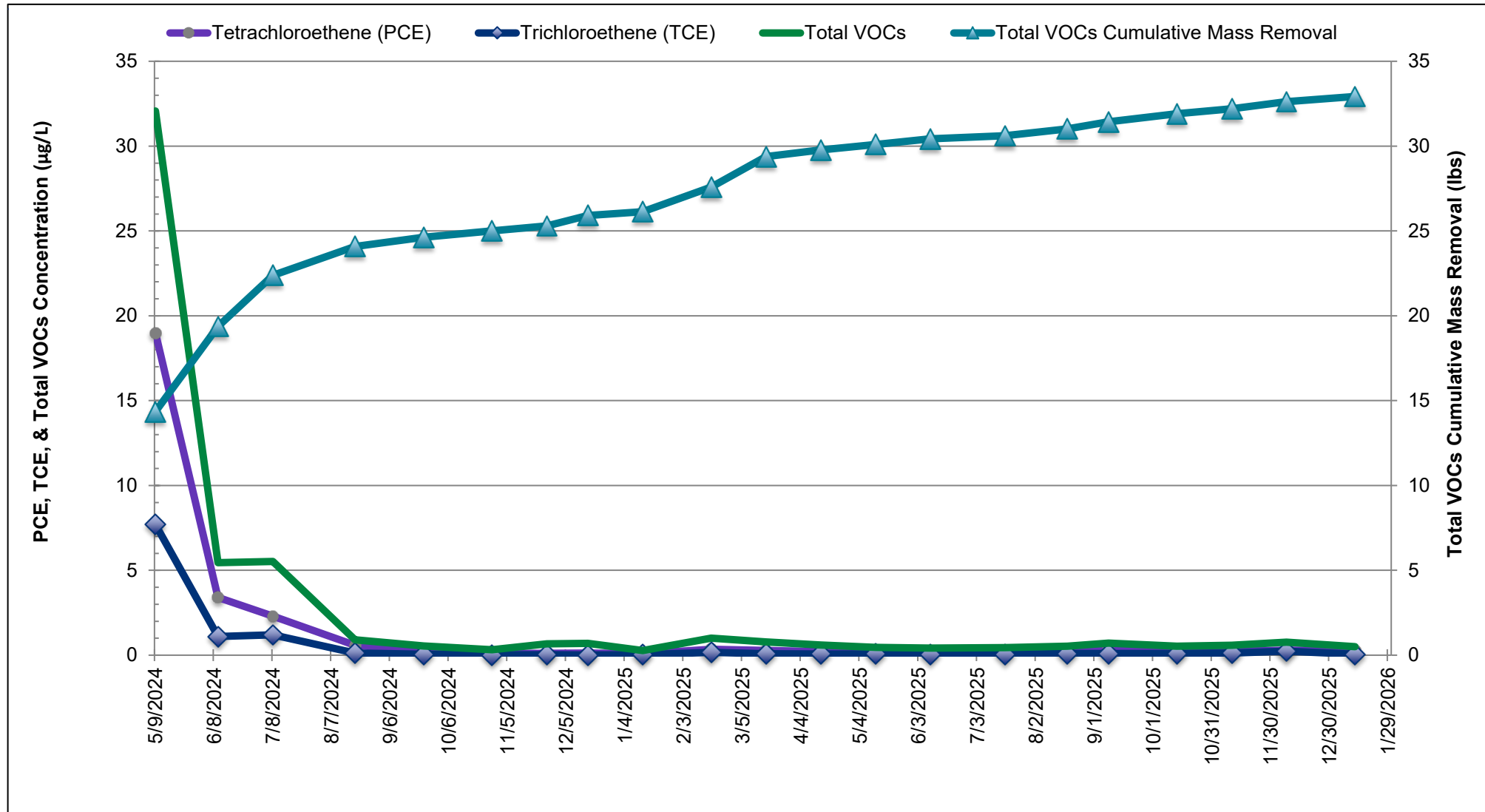
Why SVE?

- Avoids excavation and ex-situ treatment
- Targeted contaminant removal
- Minimal site disturbance

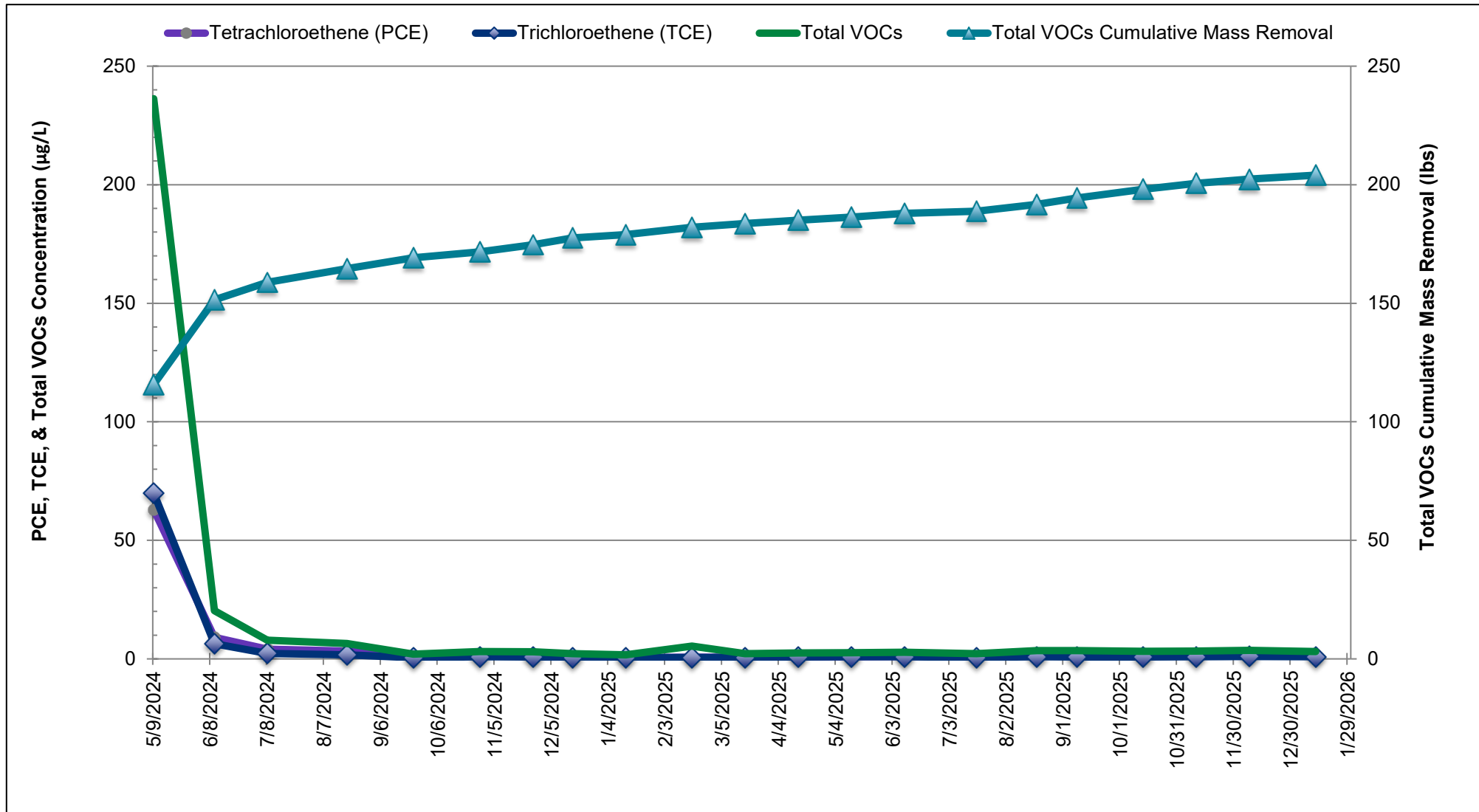


- 14,300 operational hours since May 2024
- Concentration Reductions
 - Shallow System
 - PCE at start up: 29 ug/L
 - Current PCE: 0.28 ug/L
 - 99% reduction
 - Deep System
 - PCE at start up: 65 ug/L
 - Current PCE: 1.1 ug/L
 - 98% reduction
 - Combined removal of 238 lbs of VOC mass

SVE Shallow System Results



SVE Deep System Results

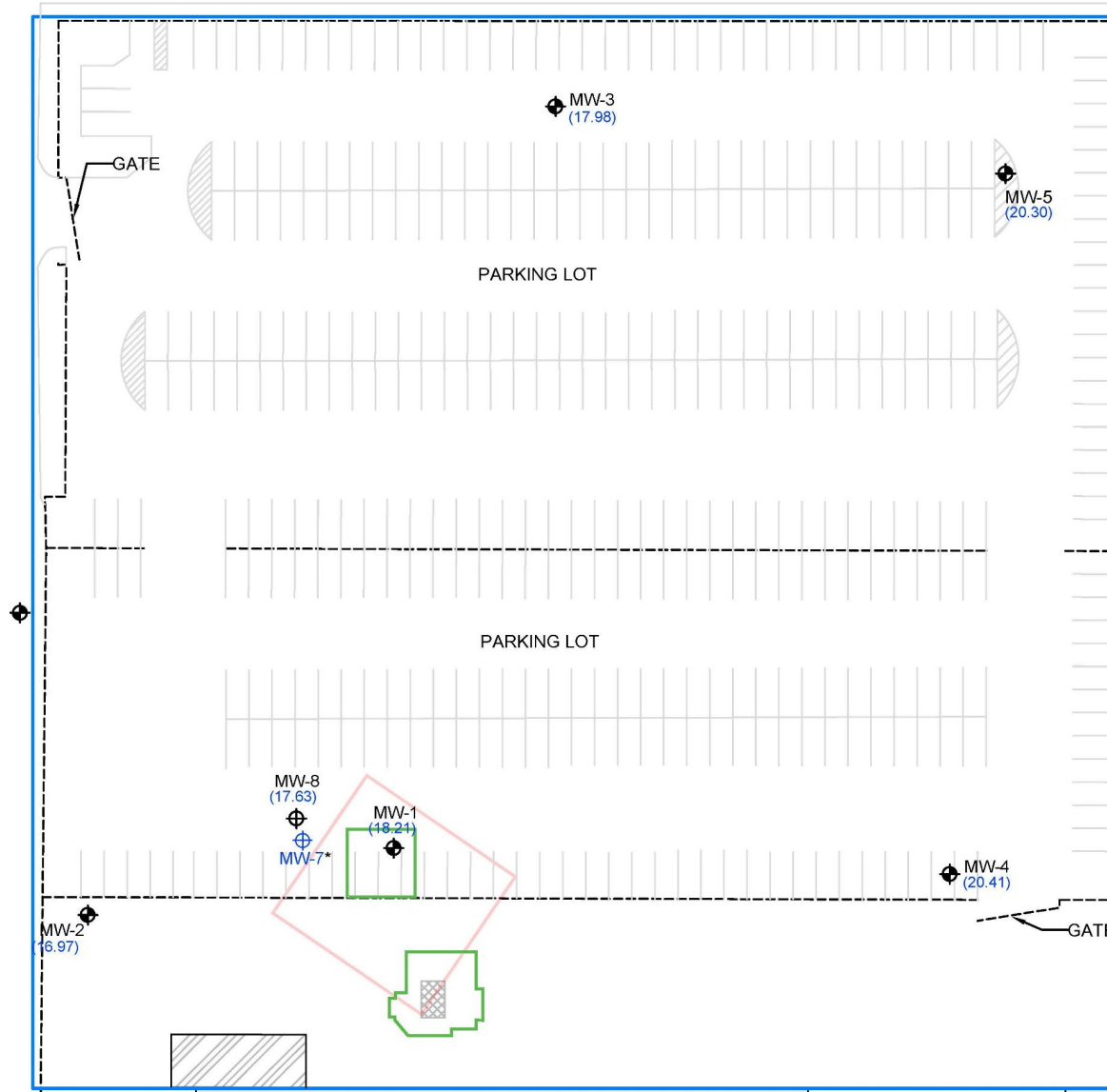


- How did we optimize?
 - Replaced motor
 - Led to a 85% increase in influent vacuum
 - Shut off vent wells strategically
 - Repairing bentonite seals on shallow wells
 - During installation, ensuring that the design prevents condensate buildup
- Implemented reactivated GAC
 - Virgin GAC emits 80% more CO₂ than reactivated GAC¹
 - Coal GAC emits 86% more CO₂ than coconut GAC¹

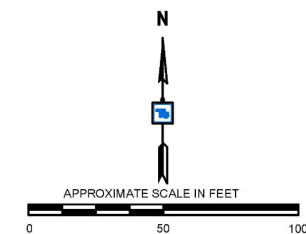
¹<https://www.sciencedirect.com/science/article/pii/S0301479722019296>

Groundwater Remediation

ISCO Treatment Area

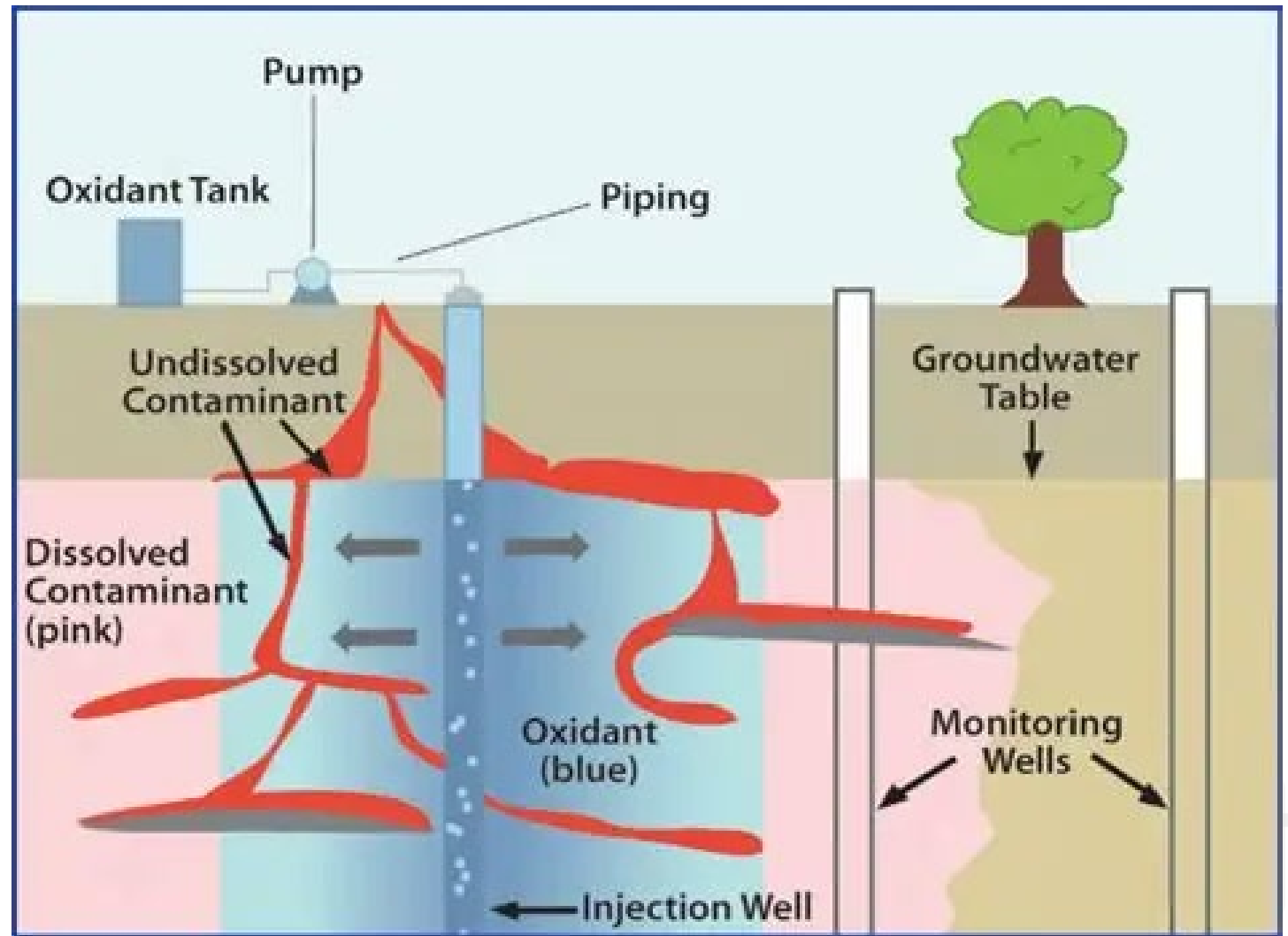


- ISCO Treatment Area
- Former Excavation
- Shallow Monitoring Well
- Second Zone Monitoring Well



Why ISCO?

- Not energy intensive
- Cost effective
- Avoids excavation
- Avoids off-site disposal



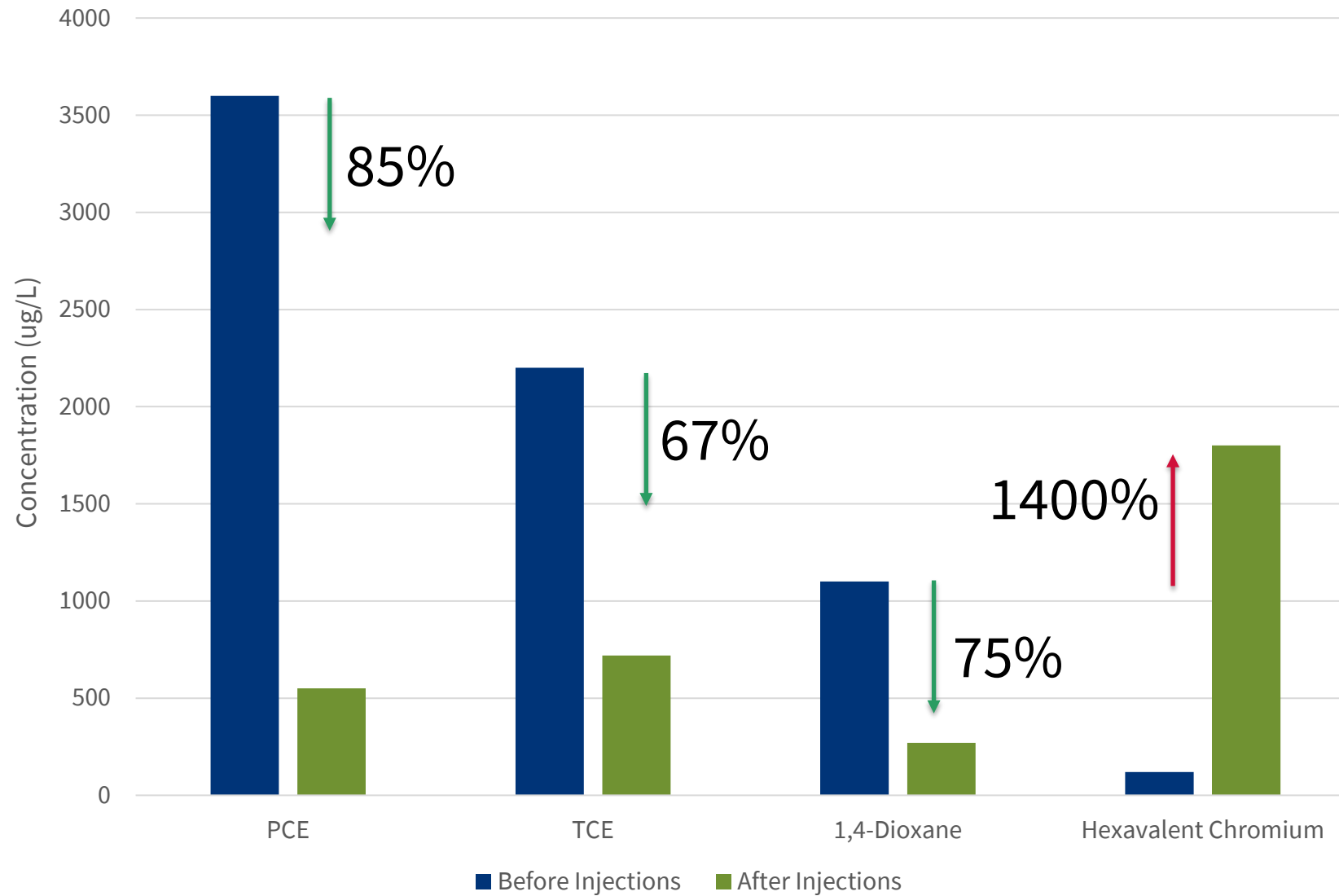
[A Citizen's Guide to In Situ Chemical Oxidation](#)

ISCO Injections

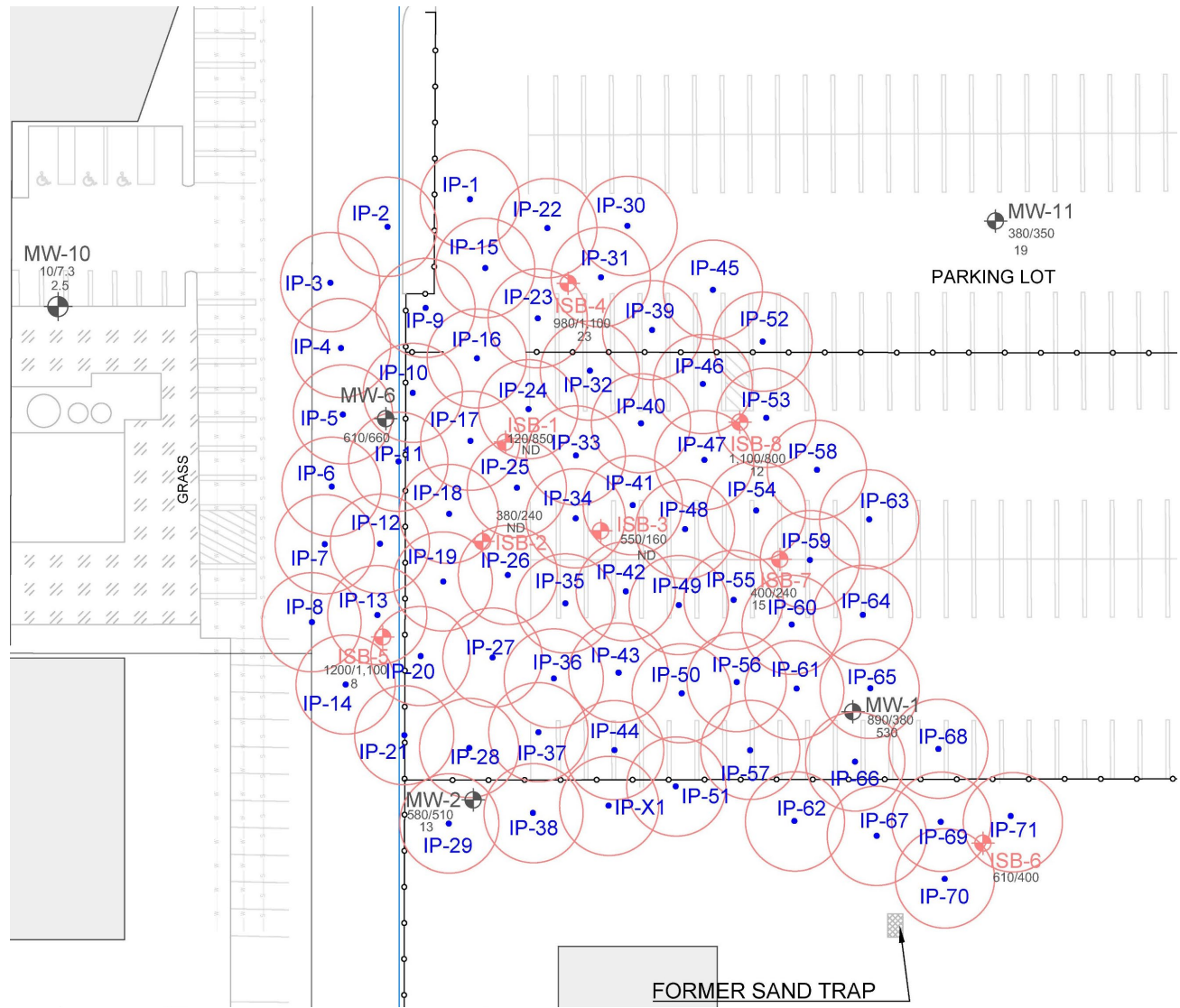
- 8,816 pounds of sodium persulfate
- 2,248 gallons of 25% sodium hydroxide
- 4,318 gallons of water



ISCO Results



ERD Treatment Area

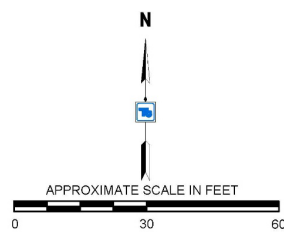


Injection Location and ROI



Monitoring Well

MW-1



Why ERD?

- ISCO elevated hexavalent chromium concentrations
- Reestablishes reducing conditions
- Cost effective

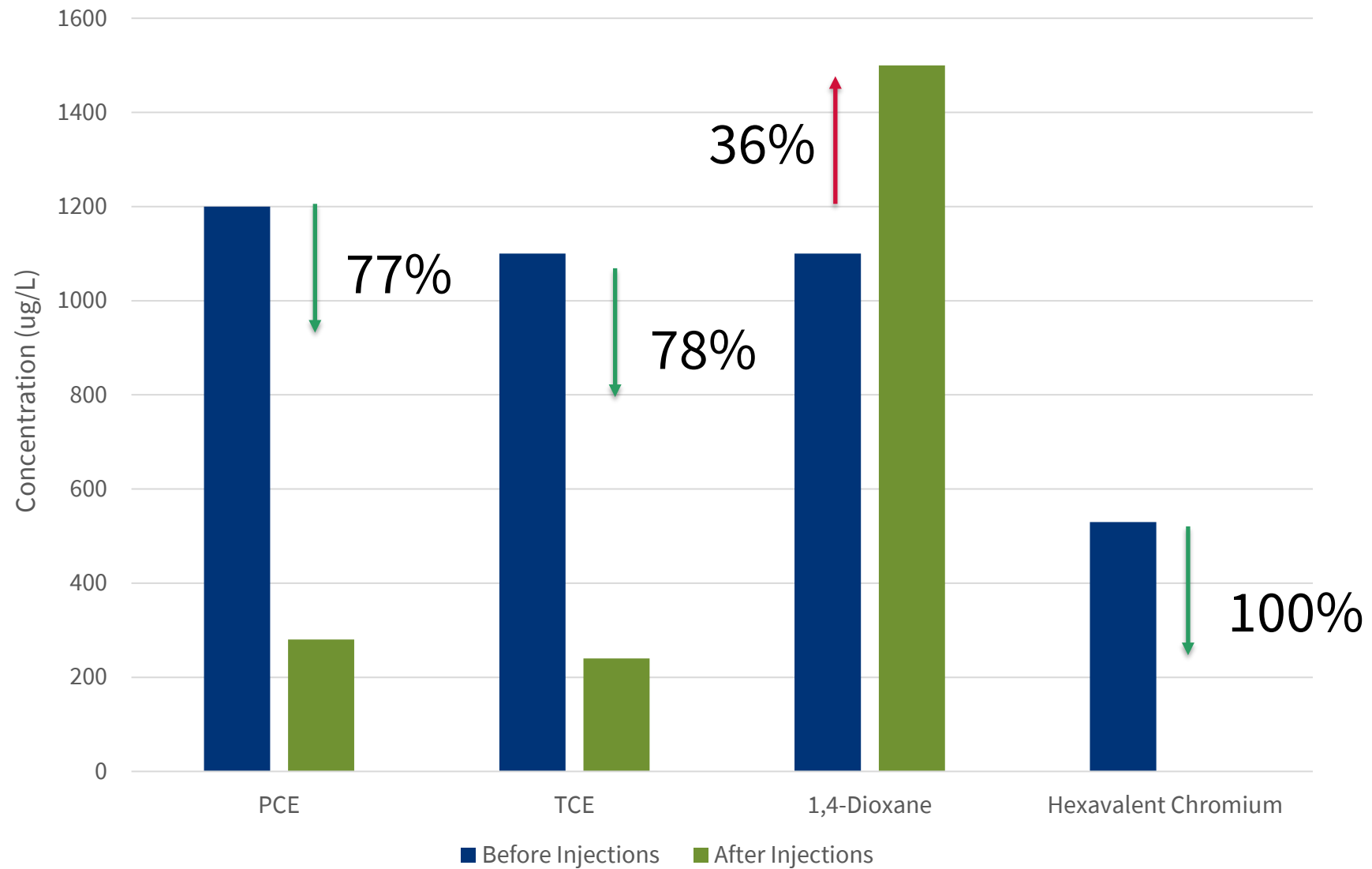


ERD Injections

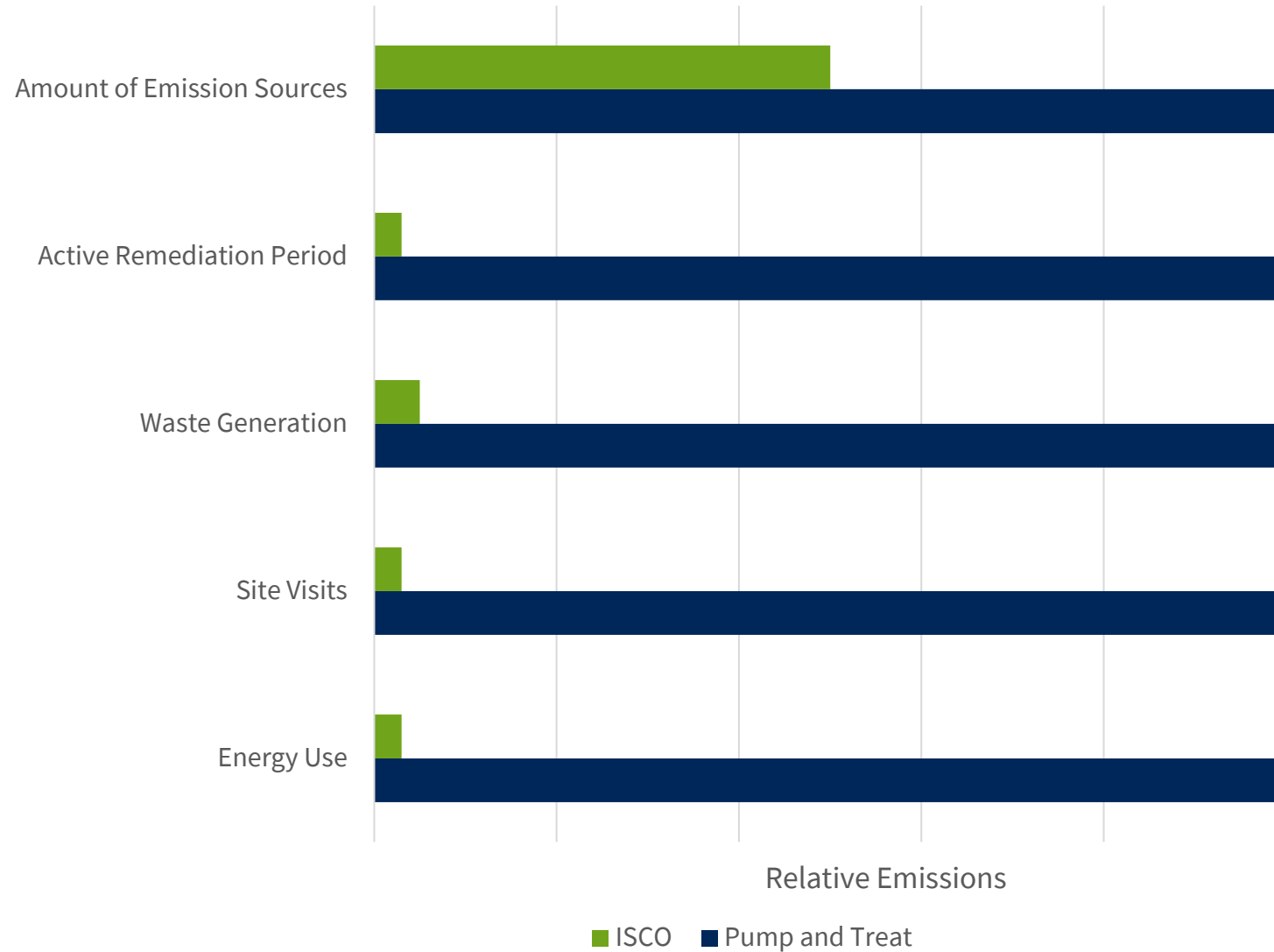
- 106,200 gallons of water
- 6,329 gallons of blackstrap molasses
- 5,759 gallons of EOS Pro[®]
- 5,300 pounds of sodium bicarbonate
- 142 L of bioaugmentation culture



ERD Results



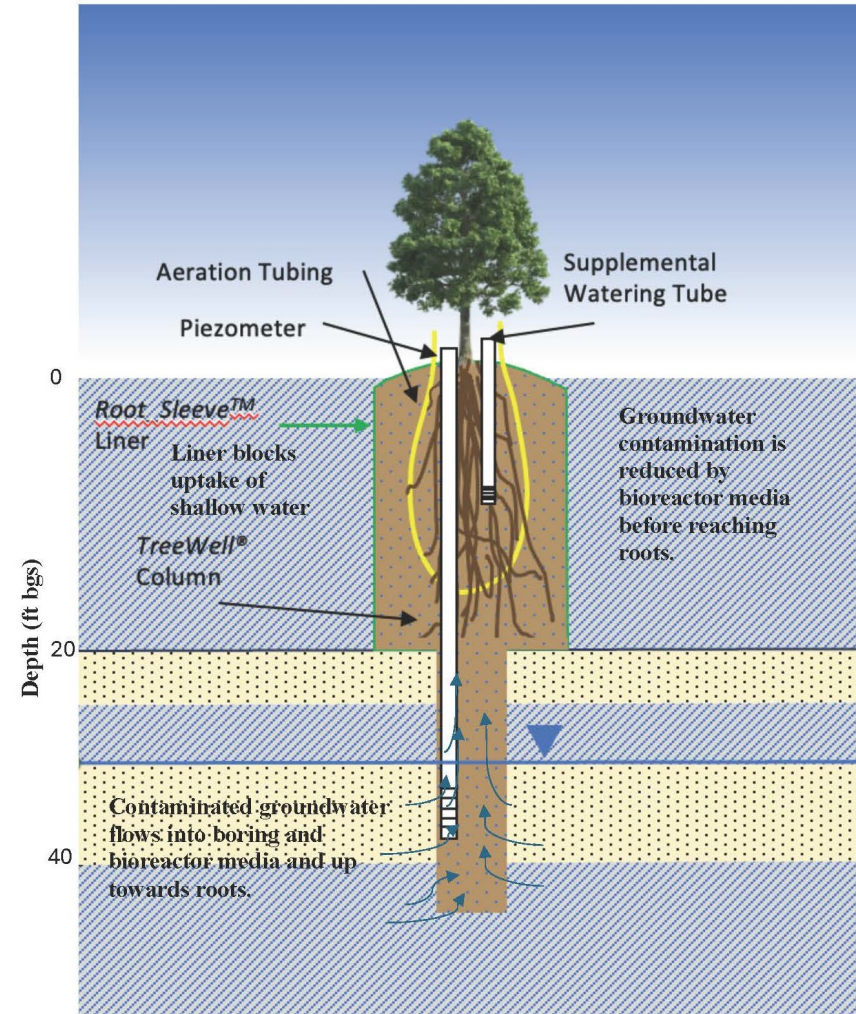
Sustainability Comparison – Injections vs Pump and Treat



Why TreeWell Phytoremediation?

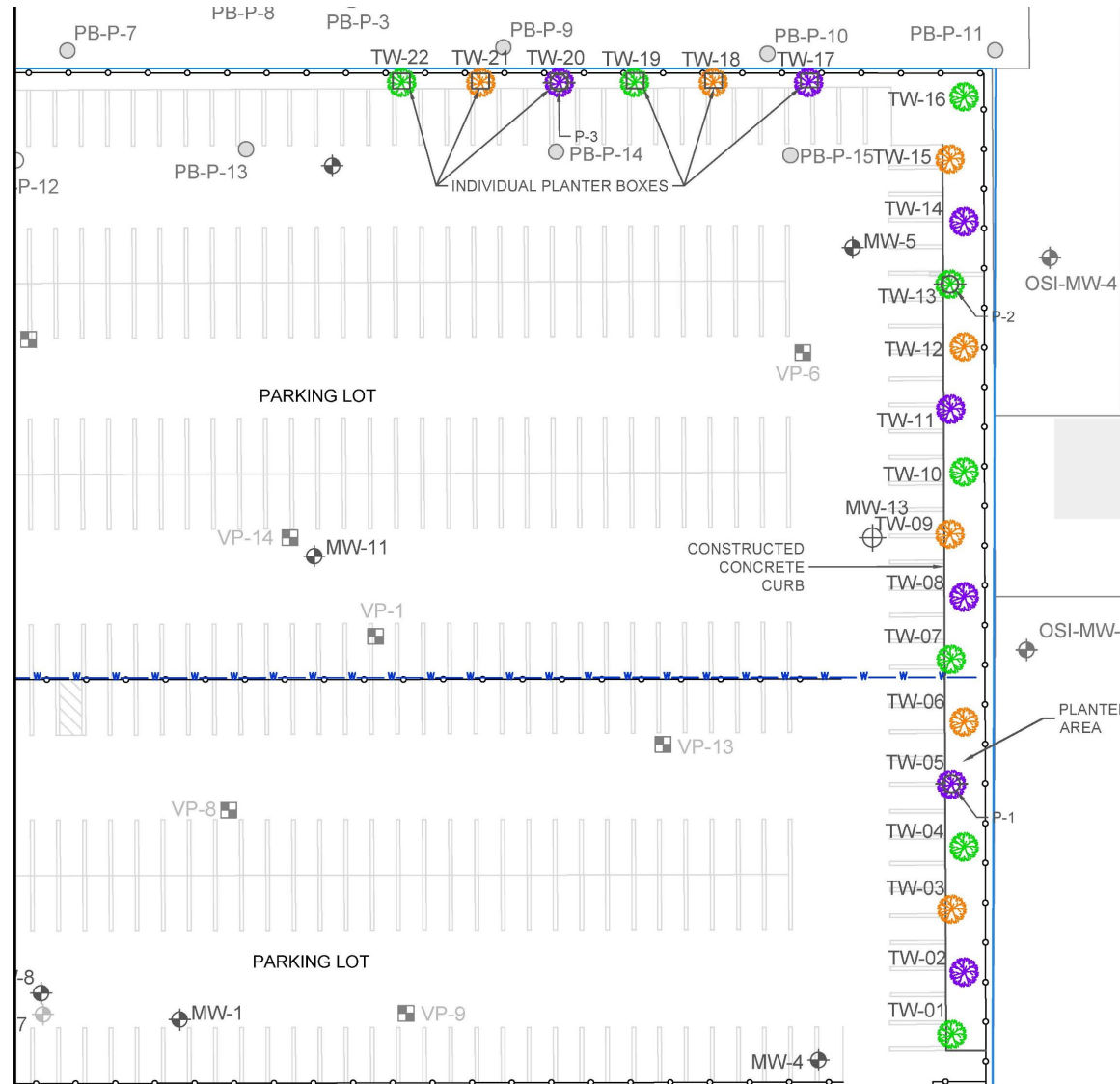
- Treats shallow groundwater migrating onto the site from the adjacent property
- Long term remedial strategy
- Aesthetics

Typical *TreeWell*® Unit Schematic Drawing



Applied Natural Sciences. Typical *TreeWell*® Unit Schematic Drawing

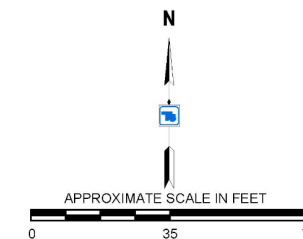
TreeWell Phytoremediation – Tree System



Australian Willow

Purple Acacias

California Sycamore



TreeWell Phytoremediation – Tree System

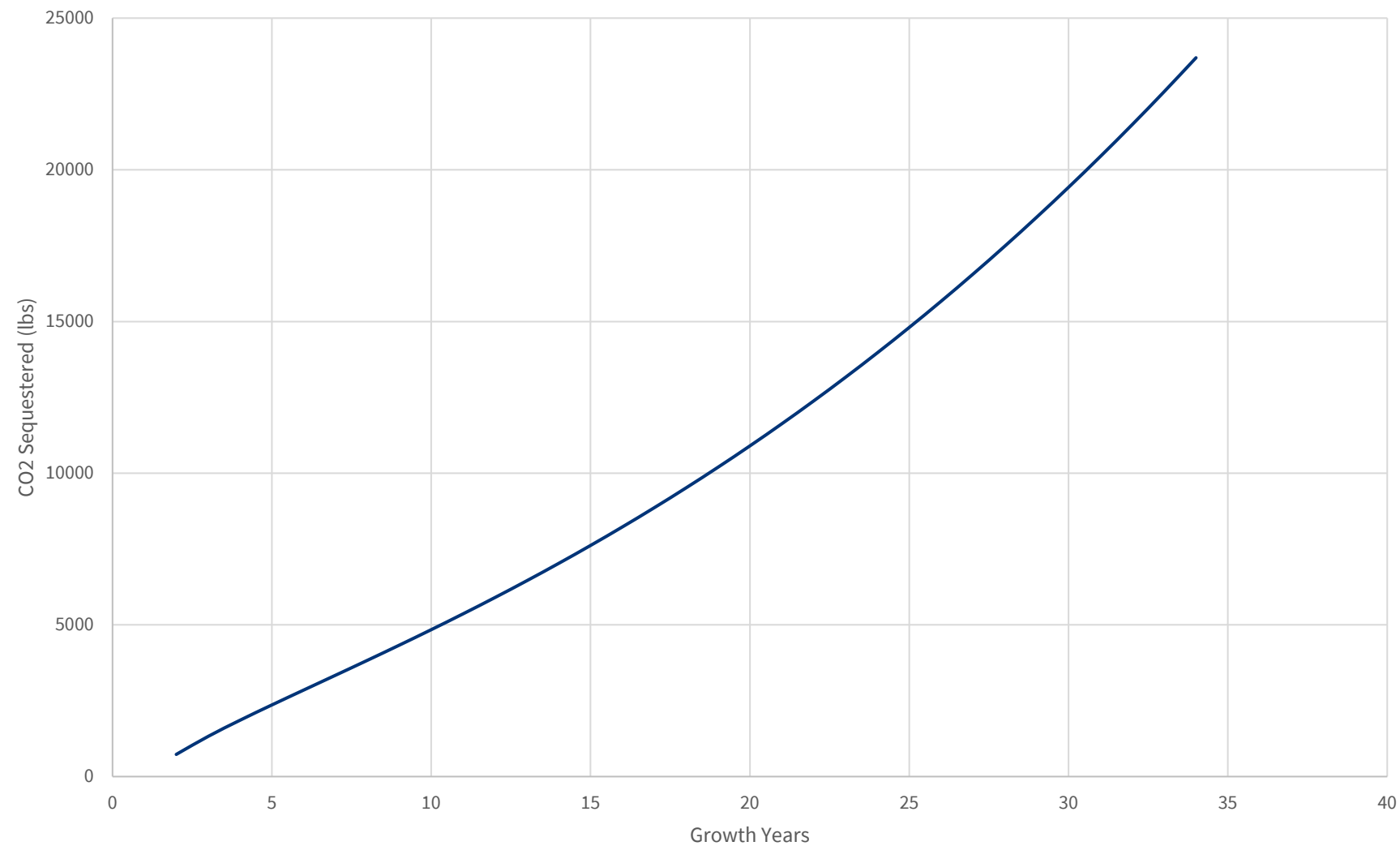
- California Sycamore
- Australian Willow
- Purple Leaf Acacia



TreeWell Phytoremediation - Pests



Carbon Intake Potential



Results and Performance Summary (So Far....)

- Groundwater
 - PCE: 240 ug/L - 92% removal
 - TCE: 2,400 ug/L - 56% removal
 - Hexavalent Chromium: 73 ug/L - 96% removal
 - 1,4-Dioxane: 2,600 ug/L (current max concentration)
- Soil
 - Reached asymptotic conditions near zero
 - Rebound test planned

Lessons Learned and Next Steps

- Install protective covers for trees during growth phase
- Picking native trees
- Use tools like SiteWise™ and Spreadsheets for Environmental Footprint Analysis (SEFA)
- How can we address the residual impacts?
 - Enhanced aerobic biodegradation
 - Microbes reduce the need for energy!
 - Advanced oxidation process



Questions?

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Injection vs Pump and Treat Sustainability Comparison

- Sodium persulfate: 1 lb CO₂ eq per lb¹
 - Total of 8,816 lbs of CO₂ eq
 - Sodium hydroxide, 50% in water: 1 lb CO₂ eq per lb¹
 - Total of 2,248 lbs of CO₂ eq
 - Pump and Treat?
(will probably have to make more generalizations)
-
- CO₂ eq: Measurement used to compare the emissions of other green house gasses to carbon dioxide.

¹[Naval Facilities Engineering Command. October 2018. SiteWise™ Version 3.2 User Guide](#)

ISCO Results (OPTION 1)

- Concentration Reductions
 - PCE
 - Max pre-injection concentration: 3,600 ug/L (March 2013)
 - Max post-injection concentration: 550 ug/L (October 2019)
 - 85% reduction
 - TCE
 - Max pre-injection concentration: 2,200 ug/L
 - Max post-injection concentration: 720 ug/L
 - 67% reduction
 - 1-4 Dioxane
 - Max pre-injection concentration: 1,100 ug/L
 - Max post-injection concentration: 270 ug/L
 - 75% reduction
 - Hexavalent Chromium
 - Increased concentrations! From 120 ug/L to 1,800 ug/L a 1400% increase

ERD Results (OPTION 1)

- Concentration Reductions
 - PCE
 - Max pre-injection concentration: 1,200 ug/L (November 2024)
 - Max post-injection concentration: 280 ug/L (August 2025)
 - 77% reduction
 - TCE
 - Max pre-injection concentration: 1,100 ug/L
 - Max post-injection concentration: 240 ug/L
 - 78% reduction
 - 1-4 Dioxane
 - Max pre-injection concentration: 1,100 ug/L
 - Max post-injection concentration: 1,500 ug/L
 - 36% increase
 - Hexavalent Chromium
 - Max pre-injection concentration: 530 ug/L
 - Max post-injection concentration: ND
 - 100% reduction

Sustainability Comparison – Injections vs Pump and Treat (OPTION 1)

Injections

- Less energy intensive
- Fewer long term emission sources
- Less field visits
- Shorter active period

Pump and Treat

- More energy intensive
- Longer term remediation
- More site visits for O&M
- Generates waste

Conceptual Site Model

Figure 1
Conceptual Site Model for Groundwater and Soil Vapor Exposure

