ACCELERATED REGULATORY CLOSURE BY IN SITU REMEDIATION FOR A 1,4-DIOXANE, CHLORINATED SOLVENT, AND PETROLEUM MIXED PLUME IN A CLAY AQUIFER

Former Alteon Flight Training Center
DFW Airport, Texas

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Project Summary

- Innovative in situ chemical oxidation (ISCO) remediation project at the Dallas/Fort Worth International Airport
- Releases were from large flight simulators, associated underground drainage lines, and an underground storage tank (UST) system located in the building's basement
- Remediation overseen by Texas Commission on Environmental Quality (TCEQ) Voluntary Cleanup Program (VCP)
- Extensive source and groundwater plume investigation (2008 to 2012)
- Accelerated ISCO treatment of recalcitrant compounds: 1,4-Dioxane, Trichloroethene (TCE), and 1,1-Dichloroethene (DCE) in groundwater (2012 to 2015)
  - Achieved default residential cleanup standards with no controls or restrictions
  - Accelerated remediation allowed for regulatory closure in less than 3 years
  - Project completed same month as the start of building redevelopment

Project Background

- Stakeholders were Boeing, DFW Airport, Verizon, Dex Media, and TCEQ
- Site was a flight training facility from 1978 to 2008
- Building sits over tight clay and shale with thin sands in clay downgradient
- Water table is approximately 25 feet below grade, with bedrock at 35 feet
- Contaminants were mostly released from crushed PVC drain pipes under the basement floor, isolated to under the older west side of the building
- LNAPL (hydraulic fluid) under basement with dissolved-phase groundwater plumes of 1,4-Dioxane, TCE, and DCE downgradient to southwest

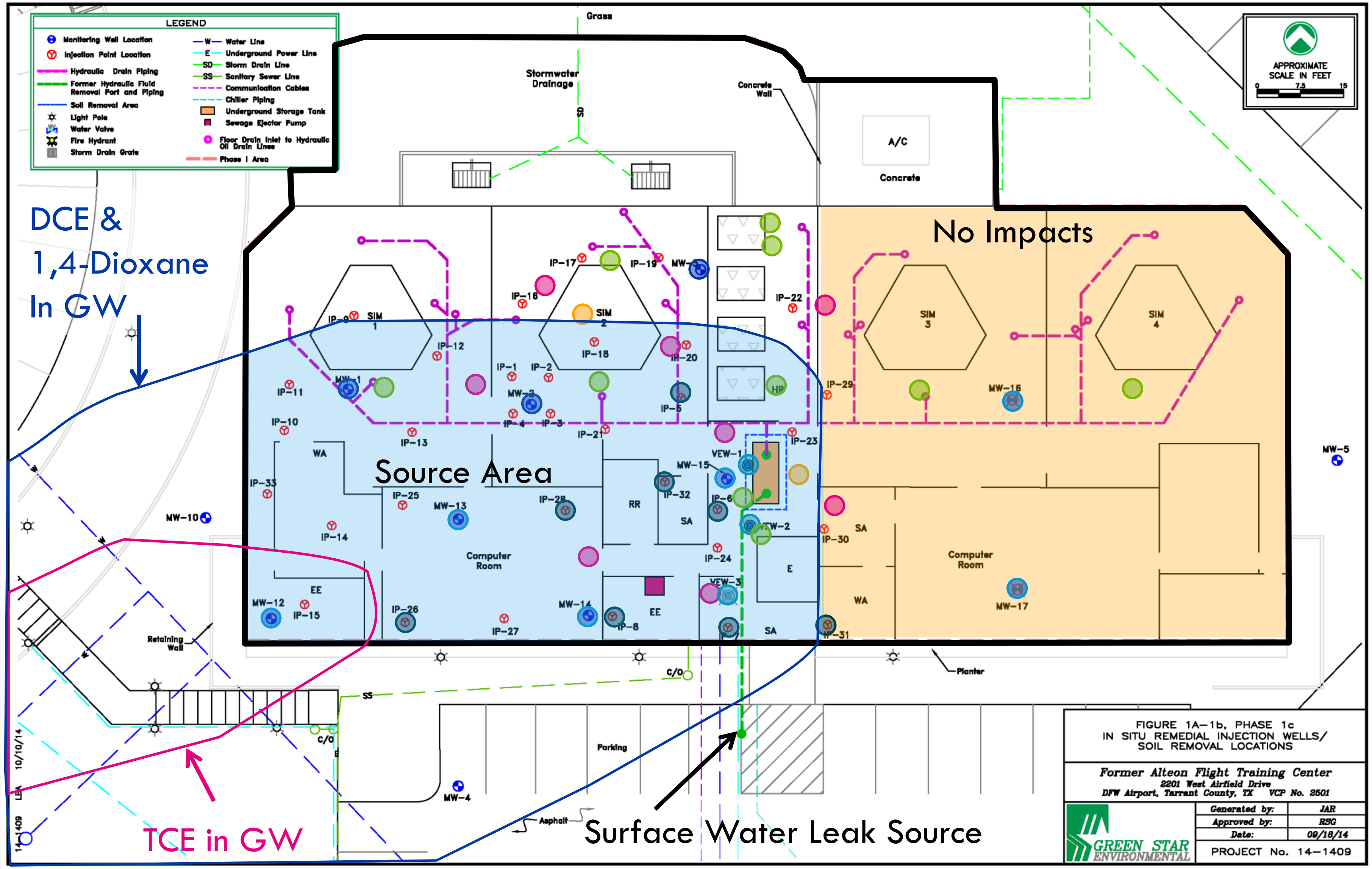
Project Investigation – Source Area Delineation

Source Area Investigation

- Investigation area 15,052 ft^2
- 10 soil borings
- 3 monitor wells
- 3 tankhold SVE wells
- 8 sub-slab vapor points
- 2 ambient air samples

Remedial Additions

- 6 additional monitor wells (MW-12, 13, 14, 15, 16, 17)
- 8 additional injection wells used as monitor wells (IP-5, 6, 7, 8, 26, 28, 31, 32)



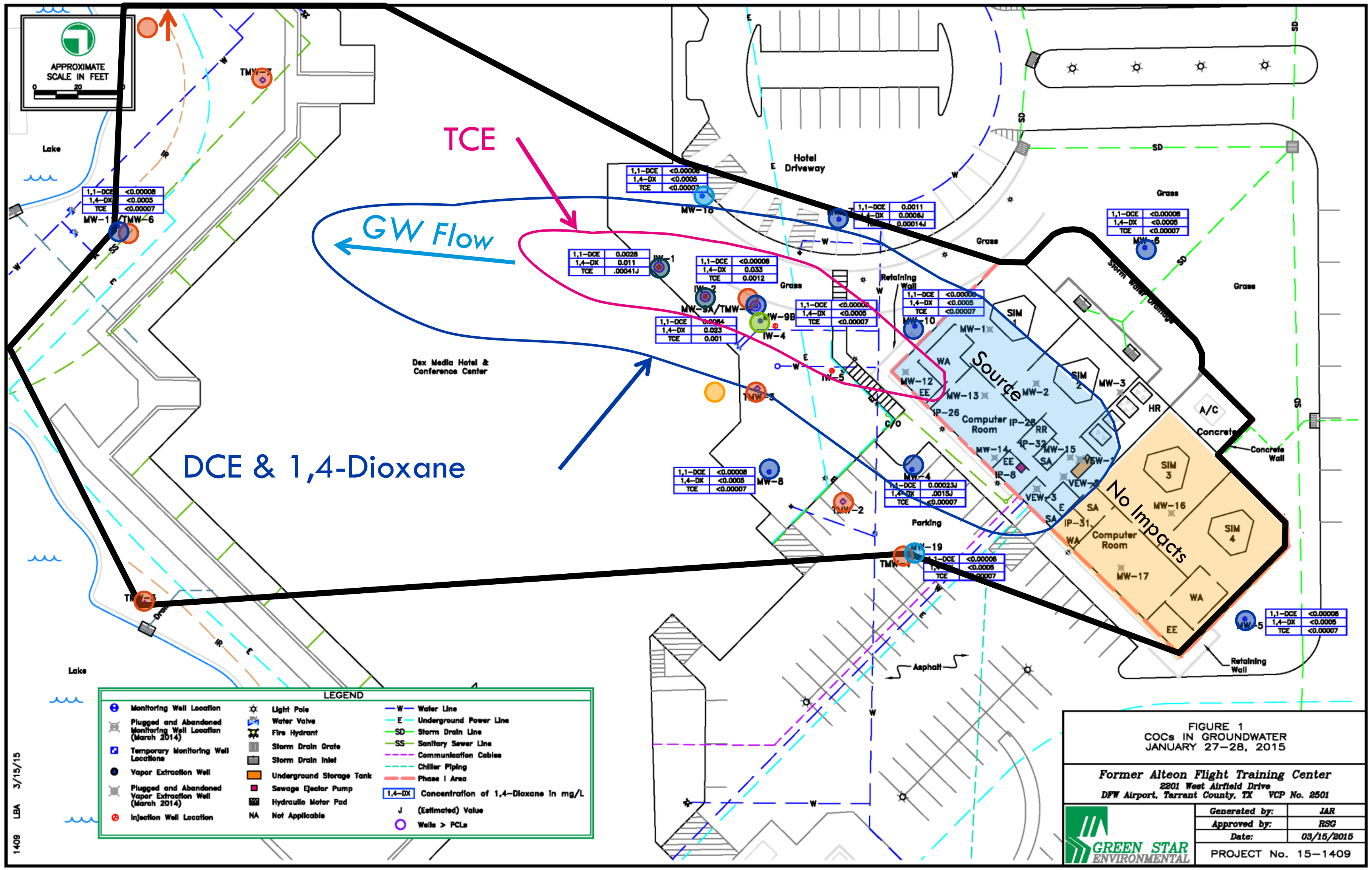
Project Investigation – Plume Delineation

GW Plume Area Investigation

- Investigation area 113,522 ft^2
- 8 monitor wells
- 8 temporary wells
- 1 double-cased well (to deeper aquifer)
- 1 ambient air sample (in downgradient building crawl space)

Remedial Additions

- 2 additional side-plume monitor wells (MW-18, 19)
- 2 additional injection wells used as monitor wells (IW-1, 2)



Project Investigation Results Summary

- Perched water table in the tankhold backfill
- Two aquifers at Site: 1) Clay (source area) 2) Clay and sand (downgradient plume)
- Former drain lines still partially full of hydraulic fluid
- Sub-slab soils, void space, and tankhold backfill coated with hydraulic fluid
- Apparent LNAPL thickness of 1.0 foot in 2 wells inside the basement (MW-1 and MW-2)
- Tankhold and former drain lines were the source of DCE and 1,4-Dioxane
- Drains associated with the sanitary sewer were the suspected TCE source

Maximum levels in groundwater		Remedial goals in groundwater
DCE	1.007 mg/l	0.007 mg/l
1,4-Dioxane	0.980 mg/l	0.041 mg/l (TCEQ PST residential std.)
TCE	0.025 mg/l	0.005 mg/l

Remedial Technology Selection and Remedial Design

- ISCO technology was selected through a competitive bid procedure over other remedial technologies
- Stakeholders were allowed to review a Work Plan prior to the remedy selection
- A site-specific sequential treatment train for injections was designed
- Lab and field pilot studies showed ISCO was capable of reaching remedial goals

Remedy Implementation

- Top of former tankhold backfill removed to eliminate residual source impacts
- Surface water infiltration path was removed
- Former drain lines were cleaned in situ
- Sub-slab void space and tank backfill was remediated through floor ports
- Groundwater plume was treated in two phases with sequential ISCO treatment train injections
    - Phase I source treatment: 33 wells and 66,000 gallons over 128 days
    - Phase II plume area treatment: 19 wells and 19,000 gallons over 112 days
    - Phase IIB plume area treatment: 36 wells and 84,000 gallons over 84 days
- Constant observation of injections allowed real-time treatment adjustments
- Aquifer clay treatment, prior to introduction of oxidants, allowed for better contact, which accelerated the destruction of the recalcitrant compounds
- Phased implementation allowed for design validation prior to next injection phase

Remedy Implementation

Surfactant enhanced remediation (SER®) was employed in the groundwater saturated zone using Ivey-sol® 106, a biodegradable non-ionic surfactant product, achieving two objectives:

- It improved wettability of reagent injected into groundwater by reducing the surface tension from ~73 dynes to <30 dynes; and
- It selectively desorbed the adsorbed chlorinated solvents (TCE, DCE, 1,4-Dioxane), greatly increasing contaminant availability for REDOX reaction

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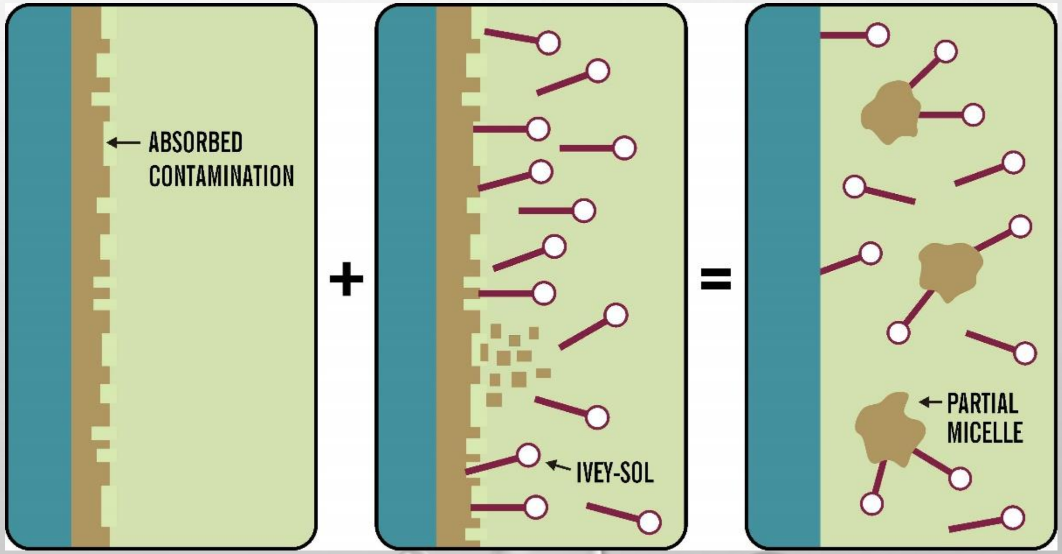
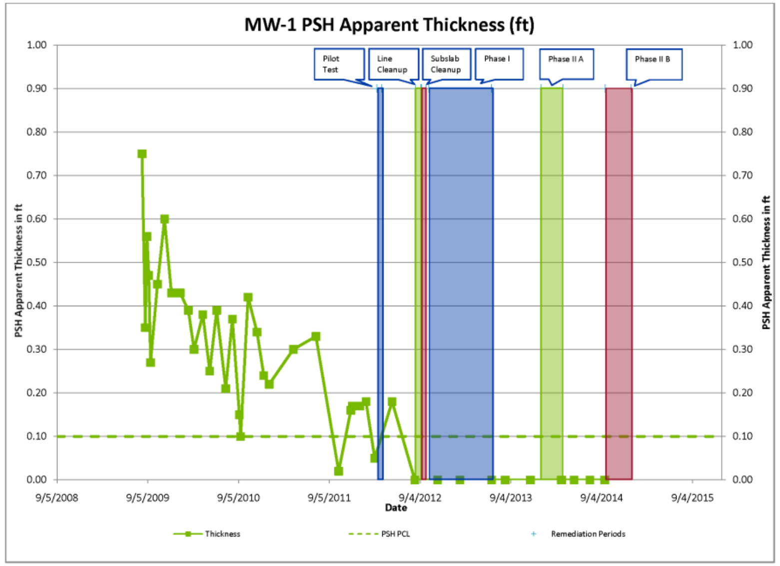
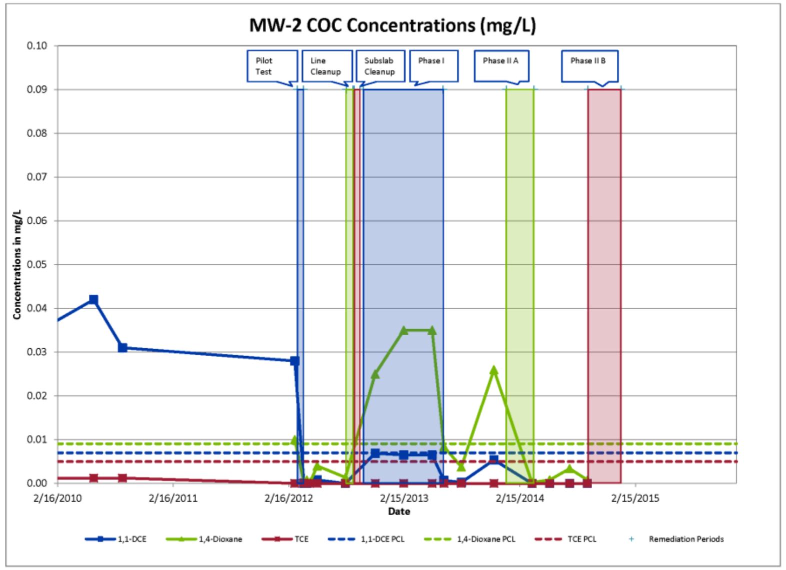


Remedial Results – Selected Phase I Source Area Wells

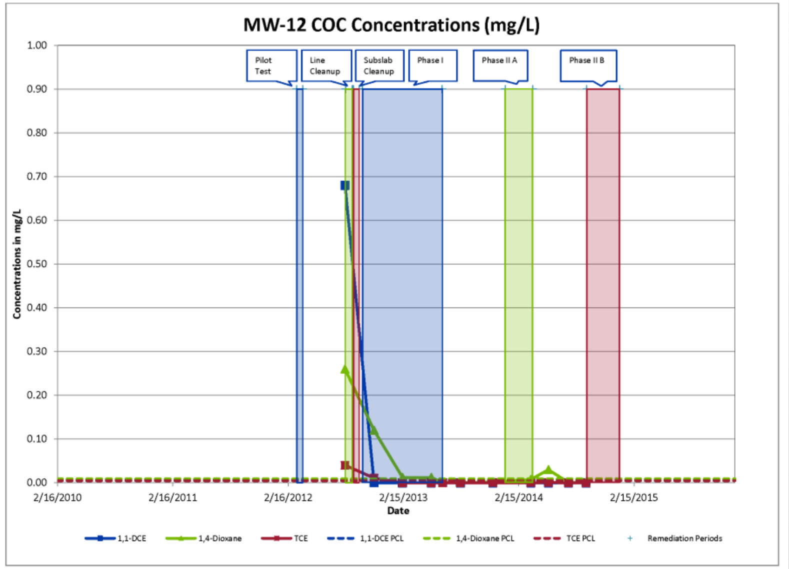
MW-1 LNAPL eliminated after sub-slab ISCO



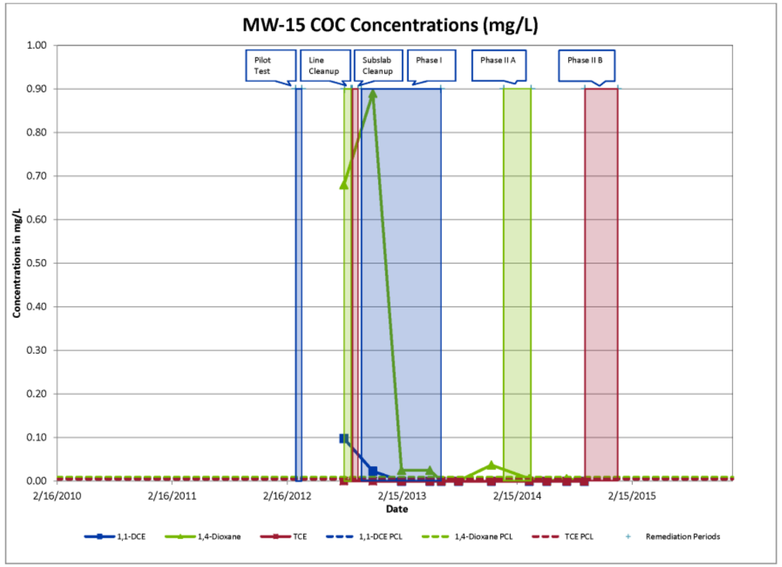
MW-2 VOCs tankhold rebound eliminated after backfill excavation and ISCO polish



MW-12 VOCs plume eliminated after Phase I ISCO

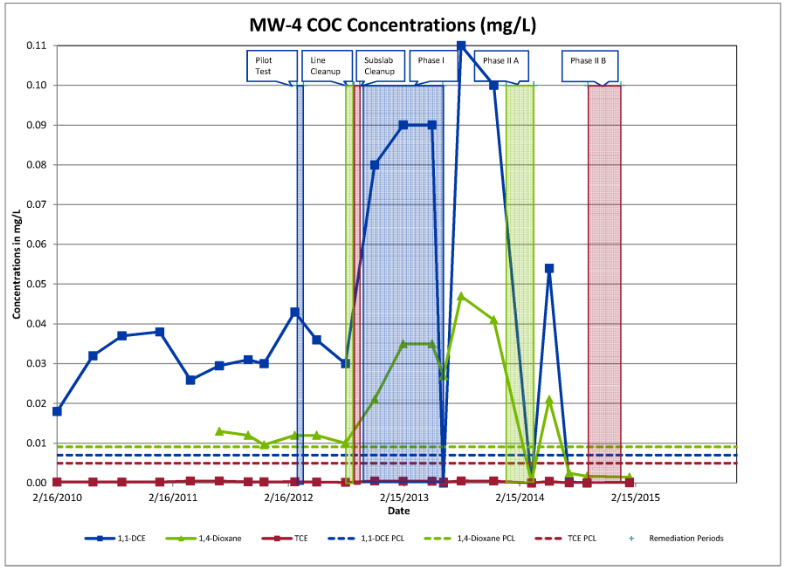


MW-15 VOCs tankhold rebound eliminated after backfill excavation and ISCO polish

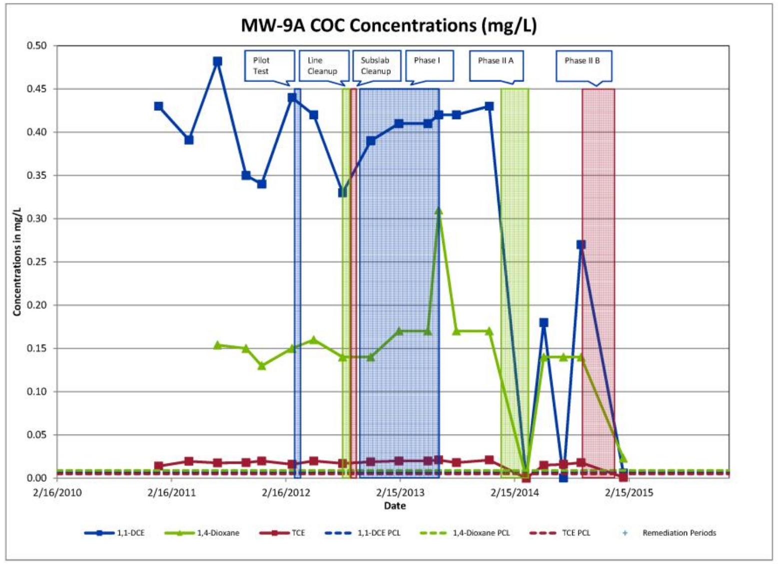


Remedial Results – Selected Phase II GW Plume Area Wells

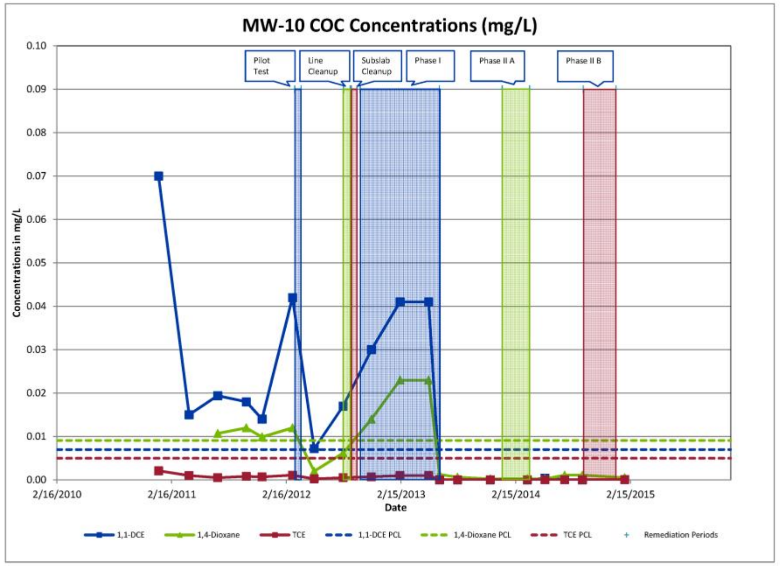
MW-4 VOCs plume eliminated after Phase II ISCO



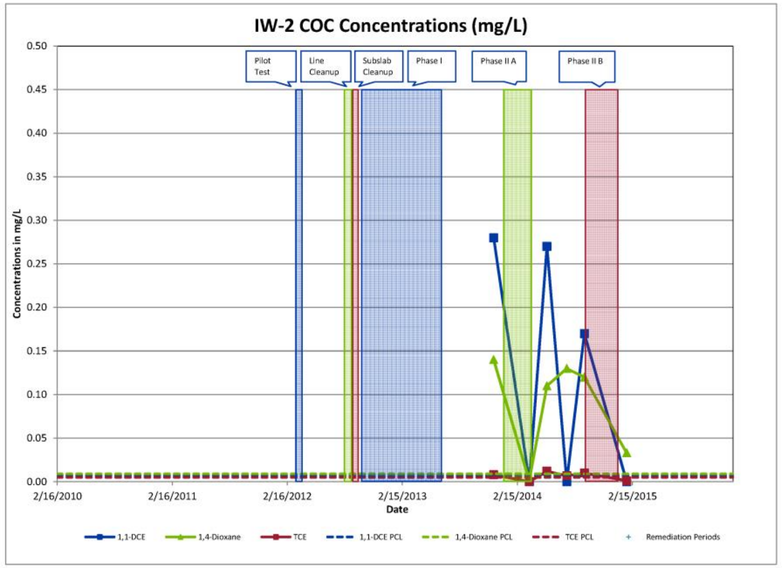
MW-9A VOCs eliminated after Phase IIB ISCO



MW-10 VOCs plume eliminated after Phase I ISCO



IW-2 VOCs eliminated after Phase IIB ISCO



Remediation Results Summary

- The source of the perched water table in the tankhold was eliminated
- All secondary source areas in the building were reduced to the point at which there was no longer detectable PSH or associated groundwater rebound
- Groundwater under the source area showed sustained levels below the remedial goals for four consecutive quarters of sampling

	Maximum in groundwater	Remedial goals in groundwater
DCE	0.006 mg/l	0.007 mg/l
1,4-Dioxane	0.033 mg/l	0.041 mg/l (TCEQ PST residential std.)
TCE	0.001 mg/l	0.005 mg/l

ISCO Remedial Best Management Practices

- Diligently look for additional source areas
- Define possible vertical and horizontal migration pathways for injections prior to start (sumps, utility lines, deeper aquifer, et cetera)
- Use injection wells for additional delineation points prior to ISCO
- Use laboratory and field pilot tests to design injection spacing and reagent dosing
- Continuously monitor individual well response to adjust to injections
- Use a phased approach
- Realize the limit of ISCO technology and adjust accordingly

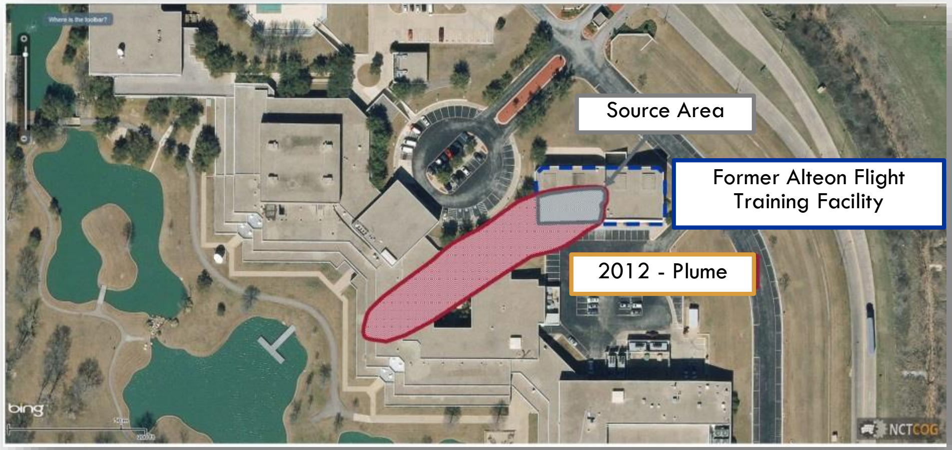
Lessons Learned

- Stakeholder participation slows projects at first but pays off in the long run
- Cleaning up sites pays dividends over risk-based closures
  - More regulatory cooperation
  - More stakeholder cooperation
  - Less long-term potential liability exposure
- ISCO can remediate 1,4-Dioxane and other recalcitrant compounds
- ISCO application is not just site-specific, but borehole-specific
- ISCO implementation is as important as chemical selection
- ISCO is quieter, faster, less expensive, and more sustainable than most conventional remedial technologies

Conclusions

Innovative ISCO treatment of recalcitrant compounds in groundwater resulted in:

- Potential liability exposure being substantially reduced
- Implemented cleanup receiving regulatory closure with no controls or restrictions in three years
- A 50% reduction in cost compared to conventional technology in much less time



Source and Groundwater Contamination - 2012

After Remediation - 2015

Questions and Answers