Lessons Learned Applying Multiple Remediation Technologies at Air Force Plant 4

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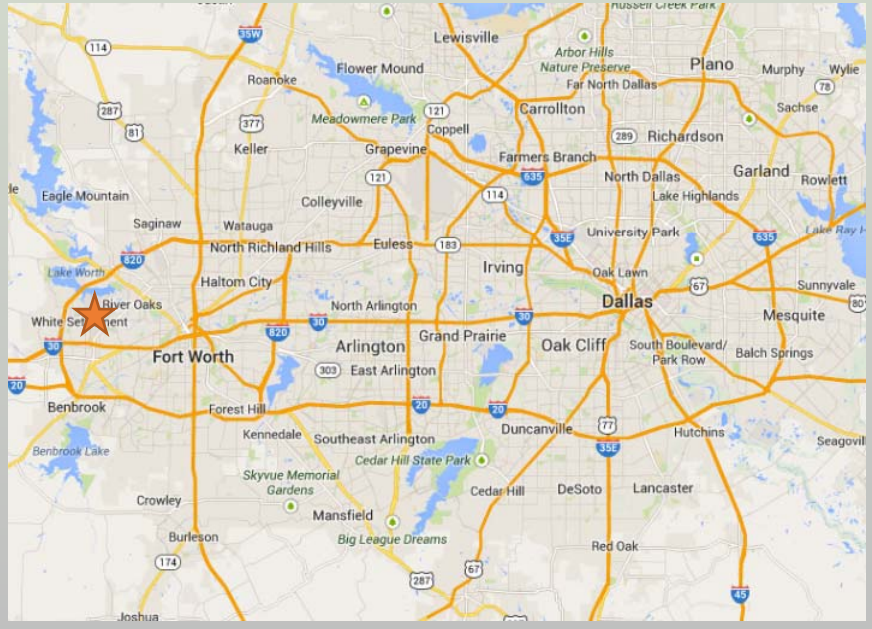
9 May 2018

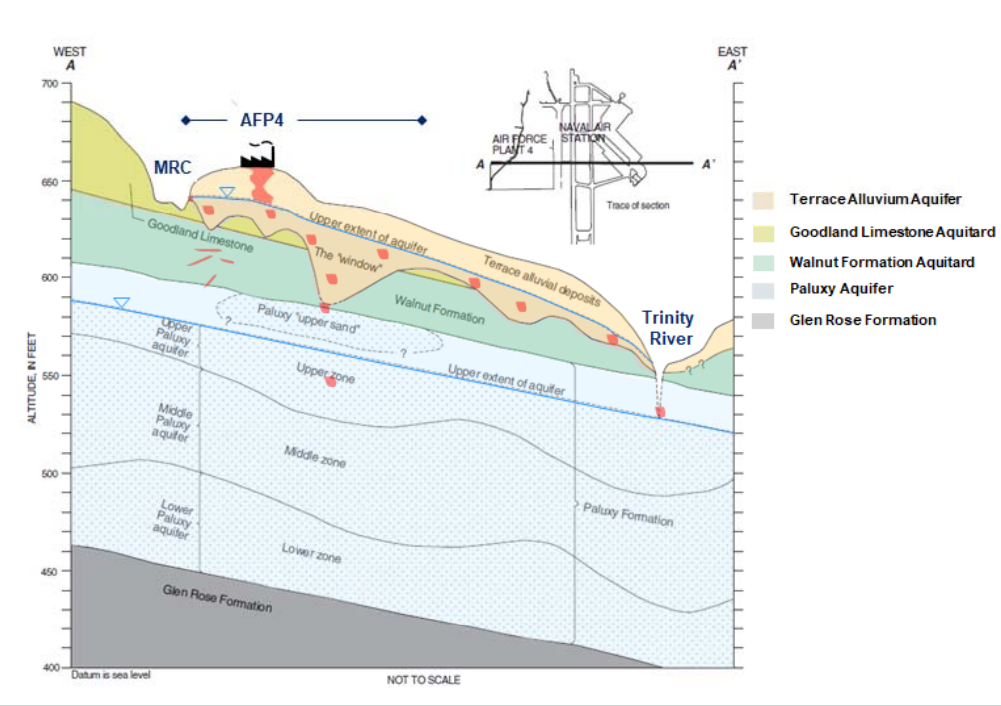
Presented at the FRTR Annual Meeting, Reston VA

Air Force Plant 4

- Occupies ~750 acres near Fort Worth, Texas
- Manufacturing military aircraft since 1942
- Includes portions of former Carswell AFB/NAS Fort Worth Joint Reserve Base
- Active production facility can make gaining access difficult

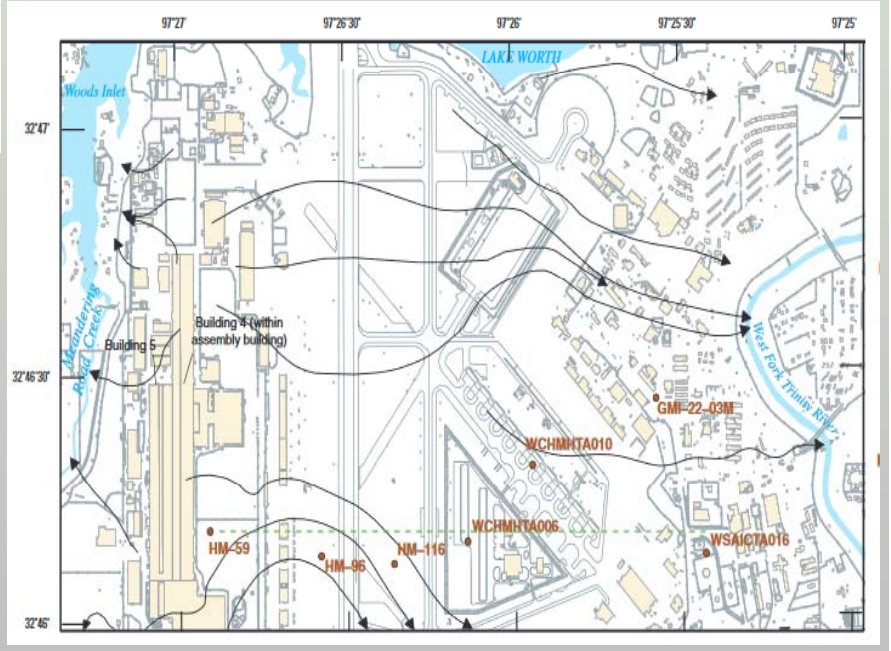


Hydrogeologic Setting

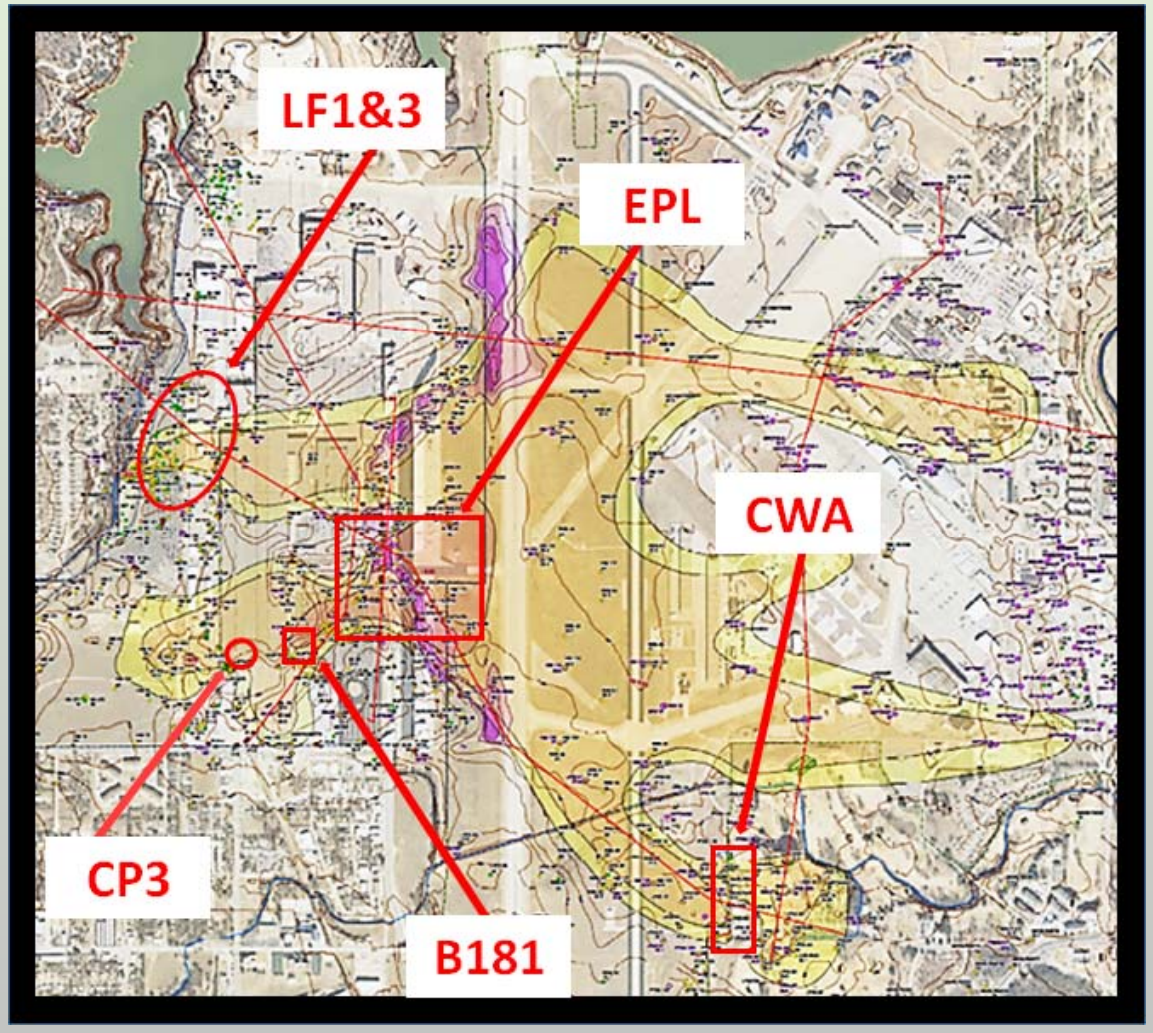


- Terrace alluvial deposits
- Goodland Limestone
- Walnut Formation
- Paluxy Formation
  - Upper, middle and lower zones
- Glen Rose Formation

- Groundwater divide along Bldg 5
  - Eastward West Fork of the Trinity River
  - Westward flow to Meandering Road Creek (MRC)



TCE Plume Areas of Concern



- Building 181 (B181)
  - Source of eastern plume
- East Parking Lot (EPL)
  - Dissolved-phase plume
- Carswell Area (CWA)
  - Southern Lobe of the EPL Plume
- Landfill 1 and Landfill 3 (LF1&3)
  - DNAPL source and dissolved-phase plume
- Chrome Pit 3 (CP3)
  - Chrome waste disposal pit
  - Separate TCE source from B181

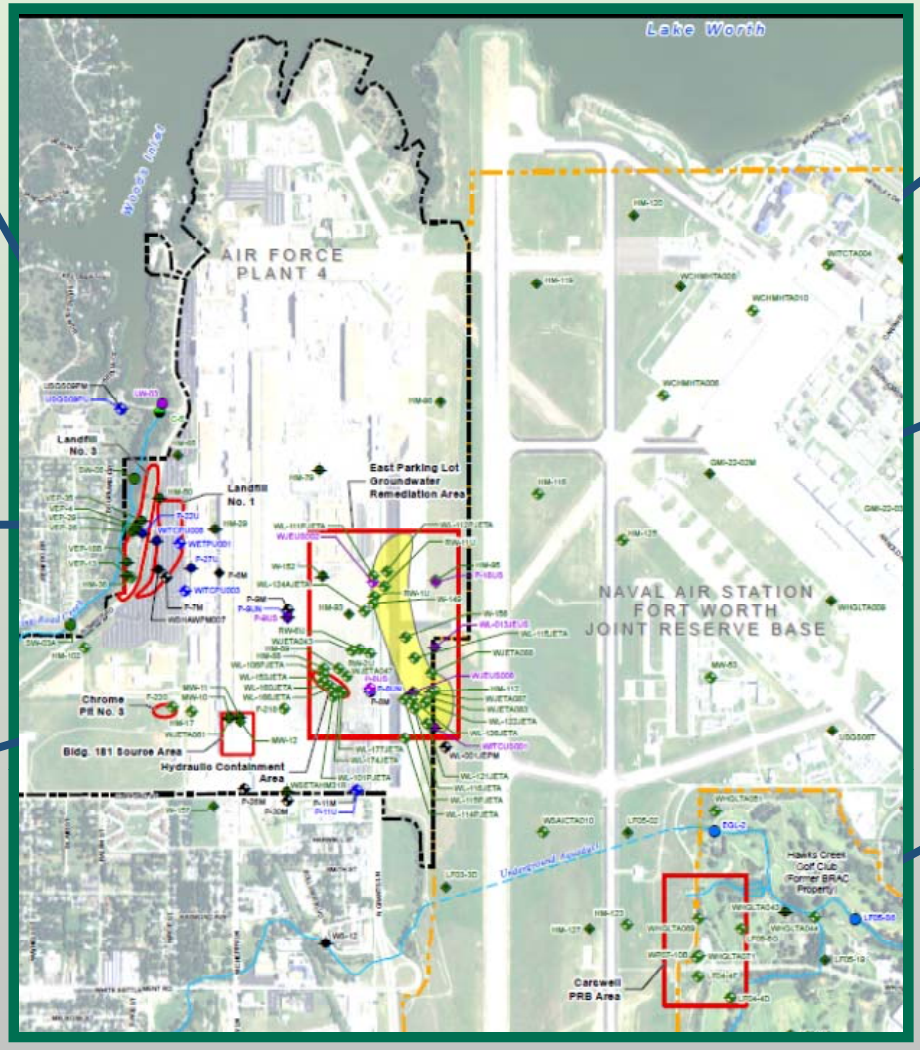
AFP4 Remedial Technologies

Technology assessments bolded and underlined

LF1
Excavation (1983)
P&T/French Drains (FDs) (1983-2014)
EISB FDs (2013-2014)
DNAPL Recovery
(2013 to Present)

LF3
VEP (1994-2001)
Phyto (1998)
Biowall (2004)
GCW (2008-2012)
EISB (2008-2015)

CP3
Excavation (1983/1984)
ISCO (2008)
EISB (2010)



EPL
P&T (1993-2015)
EISB (2013-2018)

B181
SVE (1993-2002)
ERH (2002-2004)
EISB (2008-2011)
ISCO (2013)

CWA
P&T (1994-2002)
Phyto (1996-2005)
ZVI PRB (2002)
Off-base ICs (2007)
PRB extension & conversion to EISB (2013-2015)

AFP4 Regulatory Status

- Current 1996 Record of Decision (ROD) contains alternate concentration limits for on-Federal-property groundwater
- ROD Amendment (ROD-A) requested to address long-term protectiveness of groundwater
- Air Force proposed ROD-A completion by 30 Sep 2018
  - Date may move to 30 Sep 2019 due to budget and technical delays
  - Determine if attaining MCLs is technically possible
  - Identify remedies for portions of AFP4 where achieving MCLs is possible within reasonable timeframes
  - Provide justification for Technical Impracticability (TI) waiver where applicable
- Planning for ROD-A through the AFCEC Complex Site Initiative (CSI) began in FY15
  - Performed Critical Process Analyses
  - Identified data gaps
  - Developed strategy/schedule to address

Complex Site Initiative

- The CSI focuses AFCEC technical expertise on sites where hydrogeology or recalcitrant contaminants pose long-term and high-cost remediation challenges. Specifically:
  - Deep dive into site data
  - Identifies data gaps in site characterization and remedial system performance
  - Provides in-depth assessments/updates of remediation strategies
  - Determines feasibility of reaching remedial objectives using existing technology to materially advance remediation
  - Clarifies technical requirements for AFCEC restoration contracts

AFP4 CSI

AFP4 CSI Part I – April & May 2015

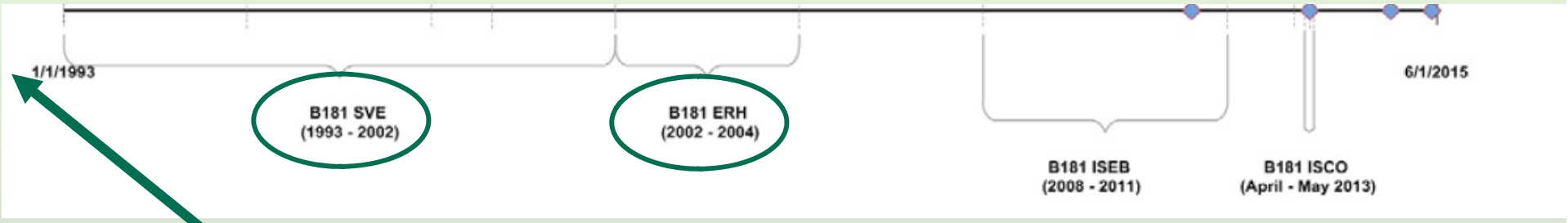
- Evaluate conceptual site model (CSM) and data needs
- Screen remedial technologies: application potential vs. technical impracticability
- Develop GIS: Tool for rapid evaluation of CSM & remedy progress
- Critical Process Analyses (CPA) of current remedial systems
  - Purpose: Assess CSM adequacy, performance monitoring and remedy effectiveness (RoD goals vs. potential RoD-A goals)
- June 2015: EPL & eastside plume
- July 2015: CWA, LF1/3, and CP3

AFP4 CSI Part II – August 2015

- Integrate progress and results of previous CSI/CPAs
- Prepare detailed scope for work for activities leading to RoD-A

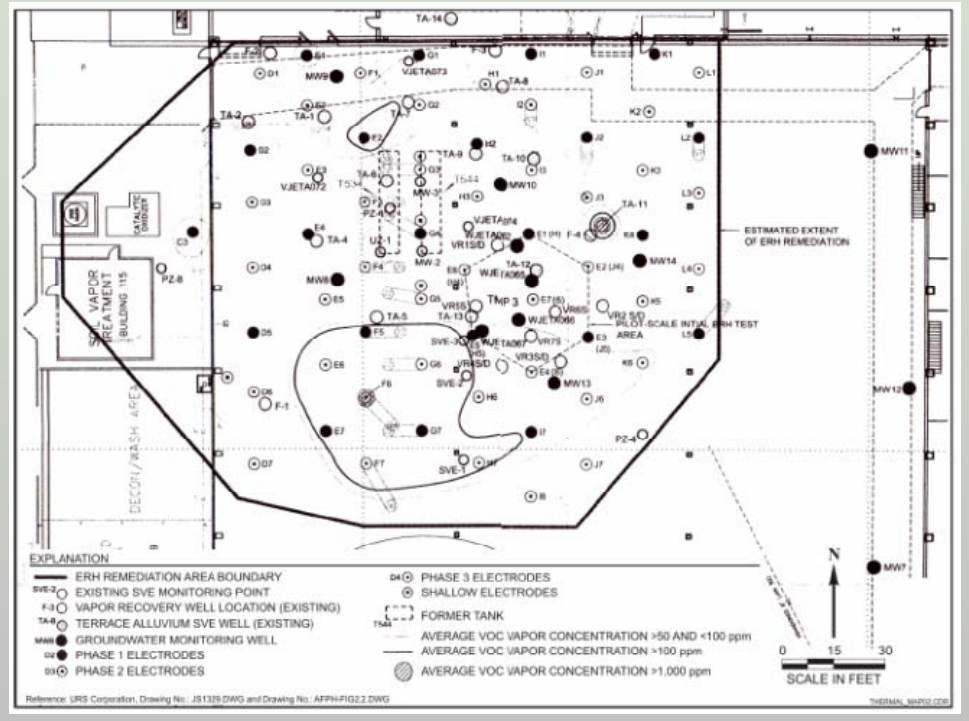
Remediation History and “Select” Technology Assessments

B181 Remediation History



In 1991, 20,000 gallons of TCE spilled from the bottom of a vapor degreaser tank

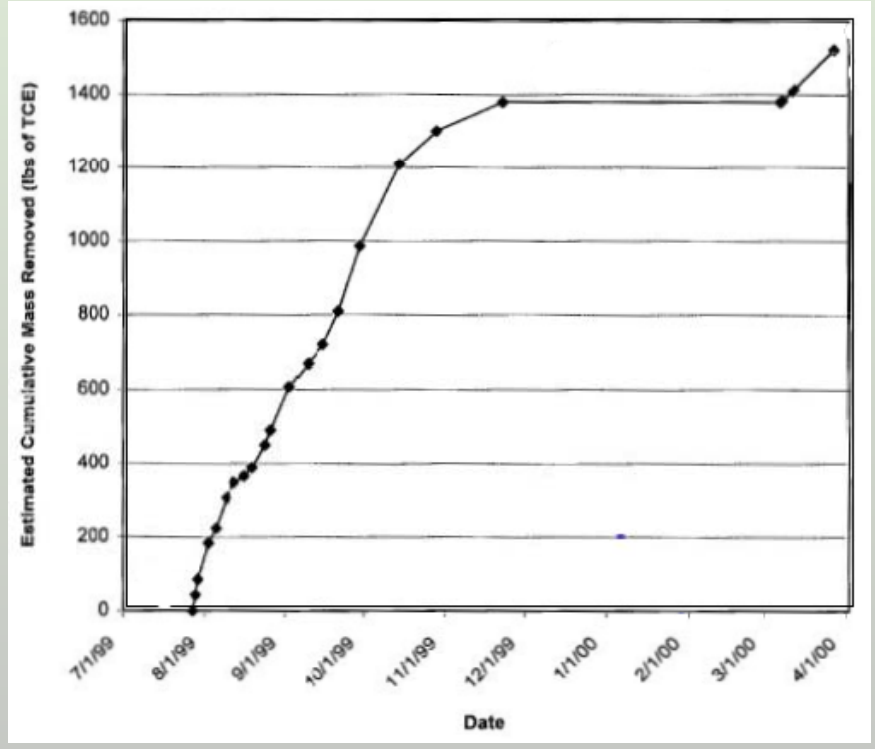
- B181 technologies discussed below
  - SVE
    - 1993 - 2002
  - ERH (with SVE)
    - 2002 - 2004



Bldg 181 SVE Performance Assessment

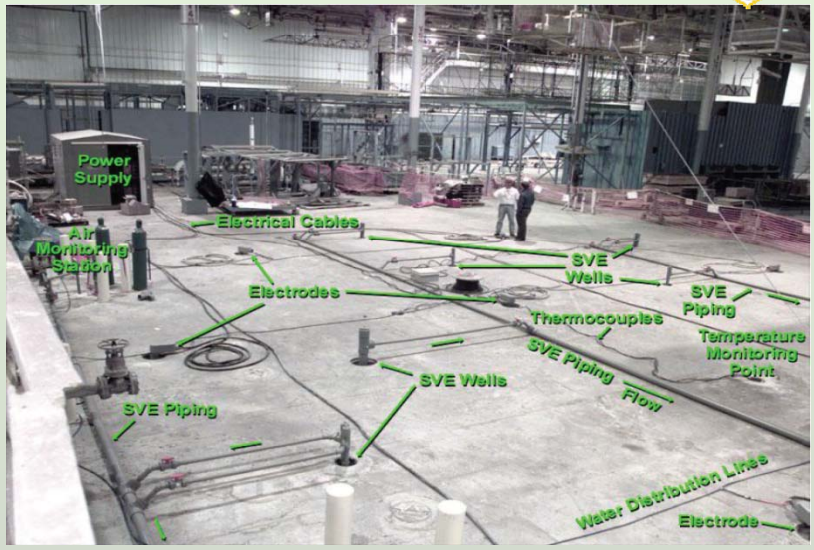
- Pilot test in 1993, full scale in 1999
- Operation from 1993 to 2002
- Removal rates started high and became asymptotic by 2000
- ~ 1,500 lbs of TCE were removed through SVE as of April 2000
- System augmented with electrical resistive heating (ERH) to facilitate volatilization and increase the TCE removal rate

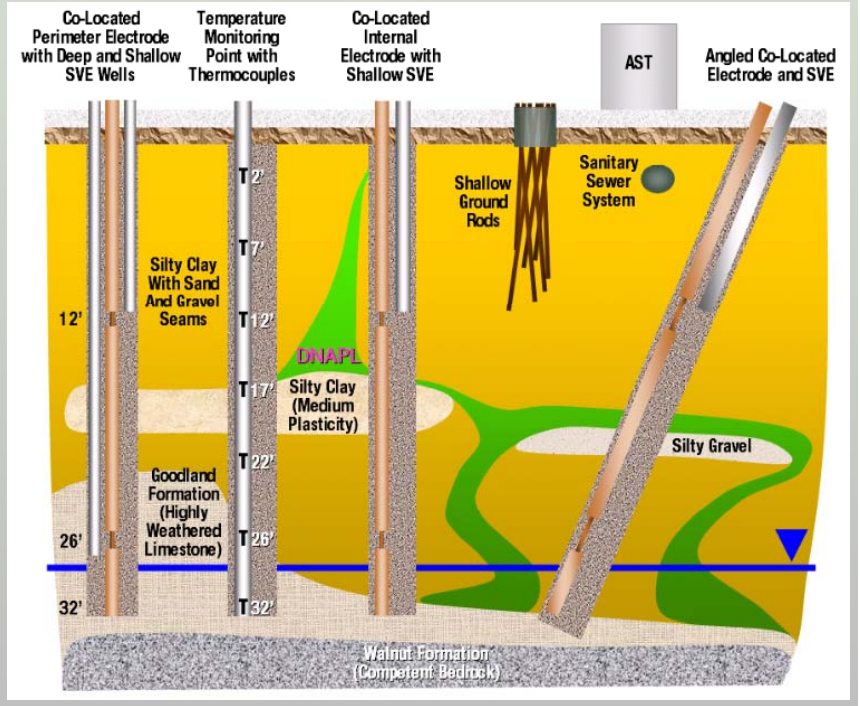
Cumulative TCE removal from August 1999 through April 2000



B181 ERH Layout and Operation

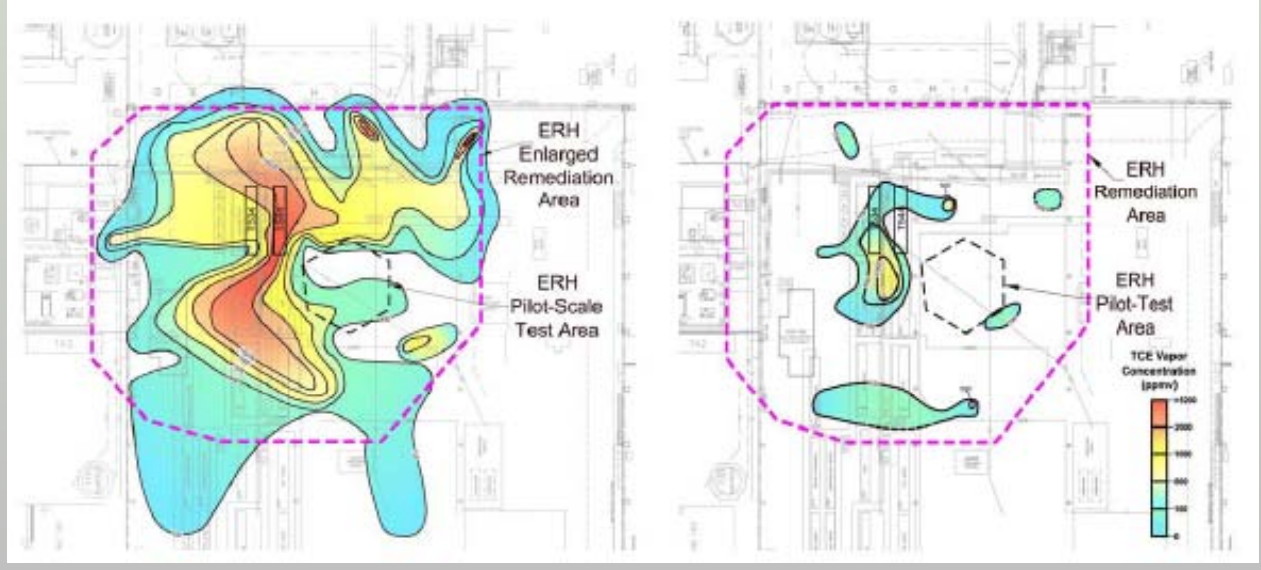
- 6-phase heating
- Pilot tested for 13 weeks
- Scaled up to cover ~ 22,000 ft^2
  - (200 ft × 140 ft)
- Design Summary
  - 73 electrodes placed to 35 ft bgs
  - 10 TMPs at 7 discrete depths
  - 81 groundwater sampling points
  - ~150 soil-vapor locations
- Larger-scale system installed and operated for ~8 months
  - 5/13/02 to 12/19/02
  - Heated GW to ~90°C



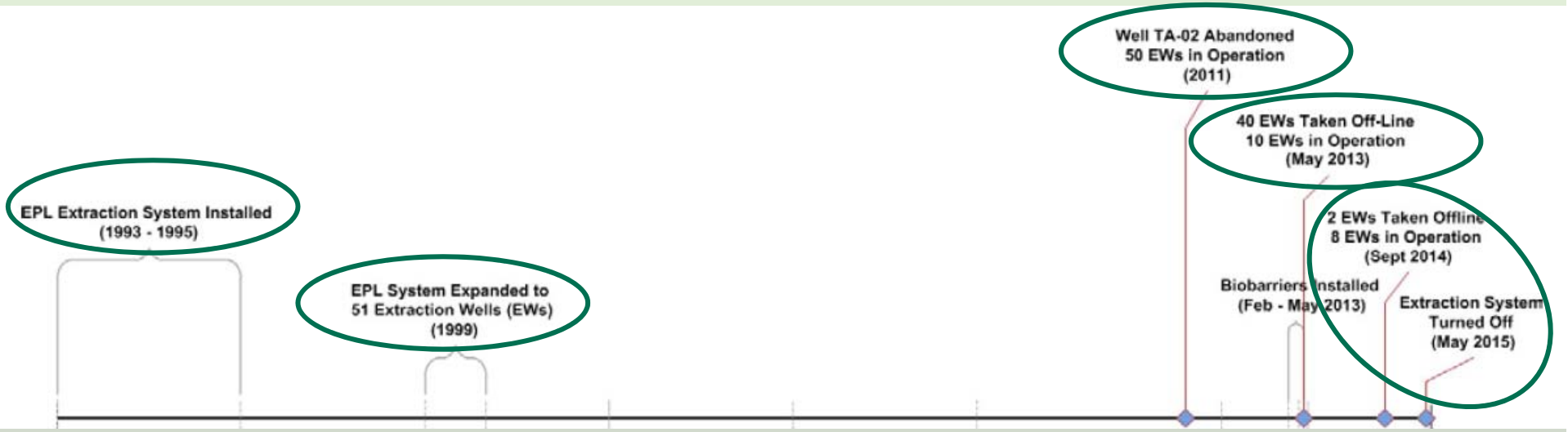


ERH Performance Assessment

- Total TCE mass removed (1,417 lbs)
- Soil-vapor concentrations:
  - Mean SV TCE concentration was reduced by 93%
  - Max conc. decreased from > 5,200 to 1,358 ppmv
  - Vapor plume greater than 100 ppmv reduced in size
- Groundwater TCE concentrations:
  - Mean GW TCE concentration reduced by 87% (33.2 to 4.3 mg/L)
  - 353% increase in average chloride concentration
- Follow-on includes ISCO (hot spot) and EISB
  - Note: TCE concentration rebounded and was measured at 16,400 µg/L in 1/18



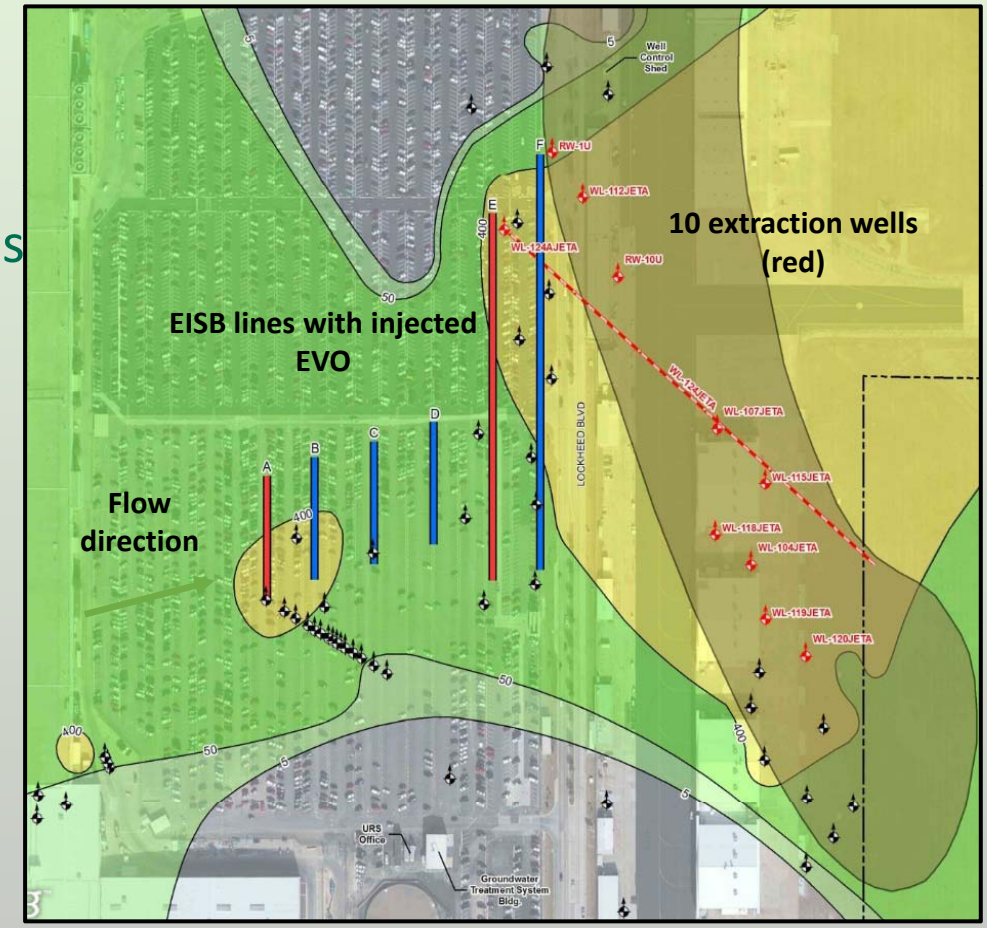
EPL Remediation History



- EPL technologies discussed below
  - Pump and treat
    - 1993 - 2015

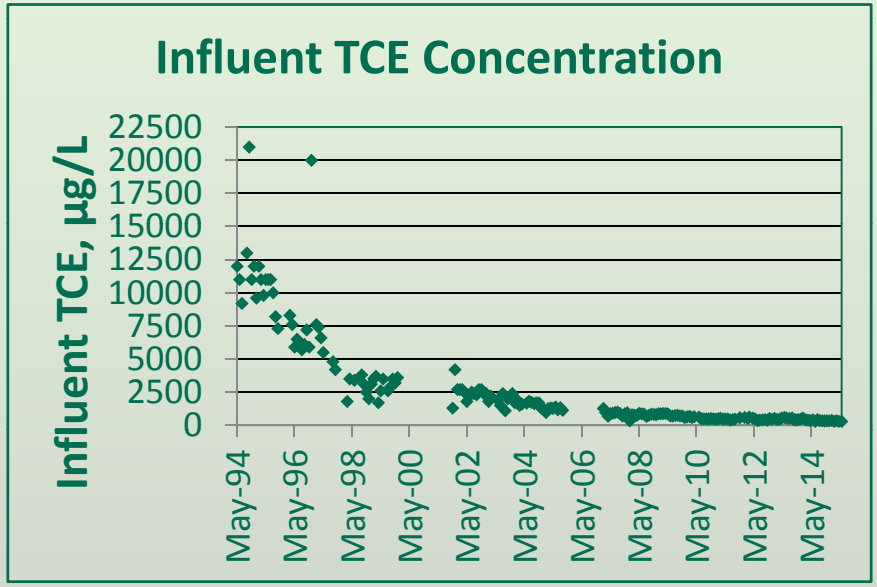
EPL Systems Layouts

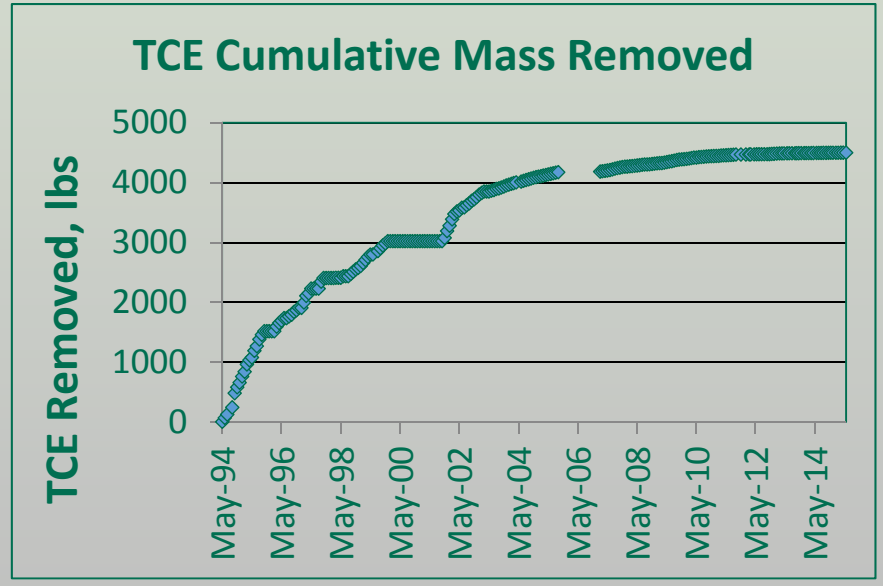
- Pump and treat
  - Installed in 1993 with 7 extraction wells
  - Expanded to 51 extraction wells in 1999
  - Down to 50 extraction wells in 2011
  - Down to 10 extraction wells in 2013
  - 8 extraction wells in 2014
  - System shutdown in 2015
    - EISB continues



EPL P&T Performance

- P&T operated ~25 years
- Design for 150 gpm, ~50 gpm max achieved
- Initial influent TCE concentrations ~10,000 to 15,000 µg/L
- Below 5,000 µg/L in ~ 3 years
- Asymptotic at ~400 µg/L for ~7 to 8 years
- Overall TCE mass removed estimated at ~4,500 lbs

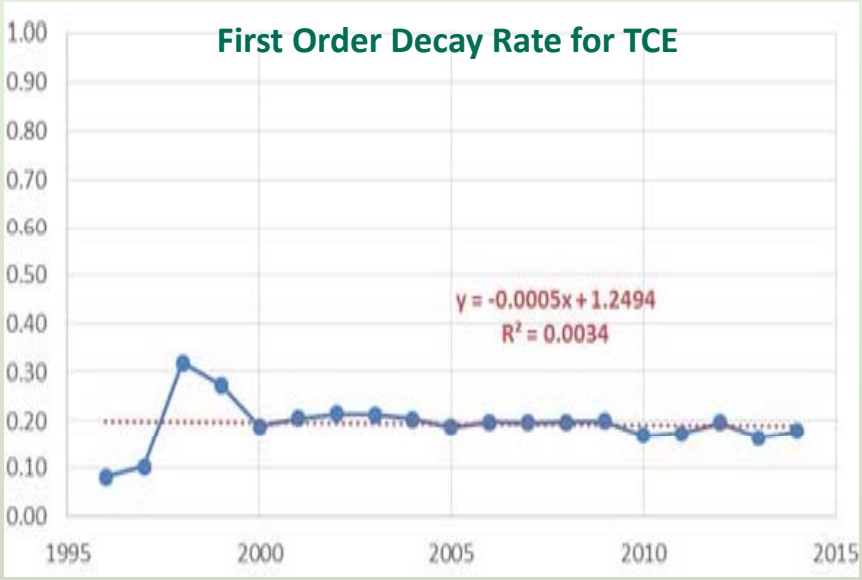


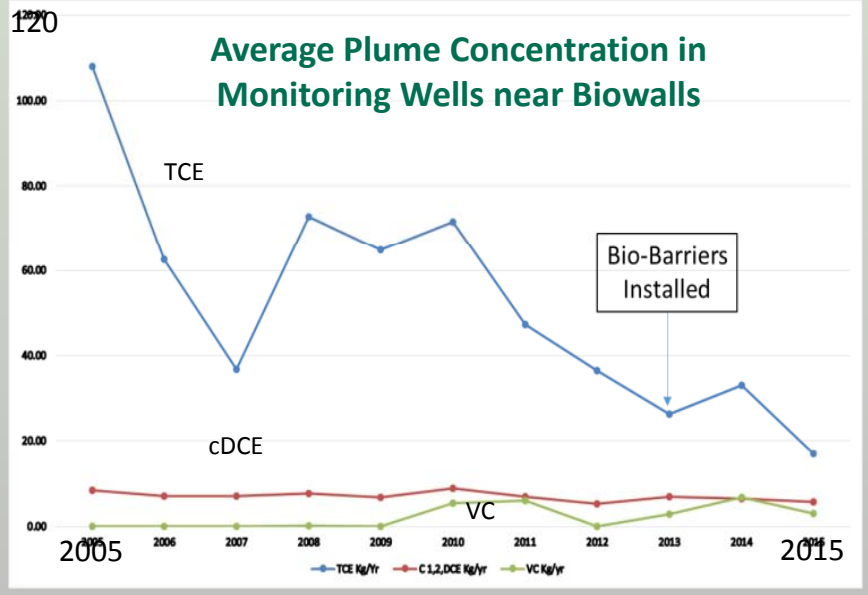


Overall Performance Analysis (EPL)

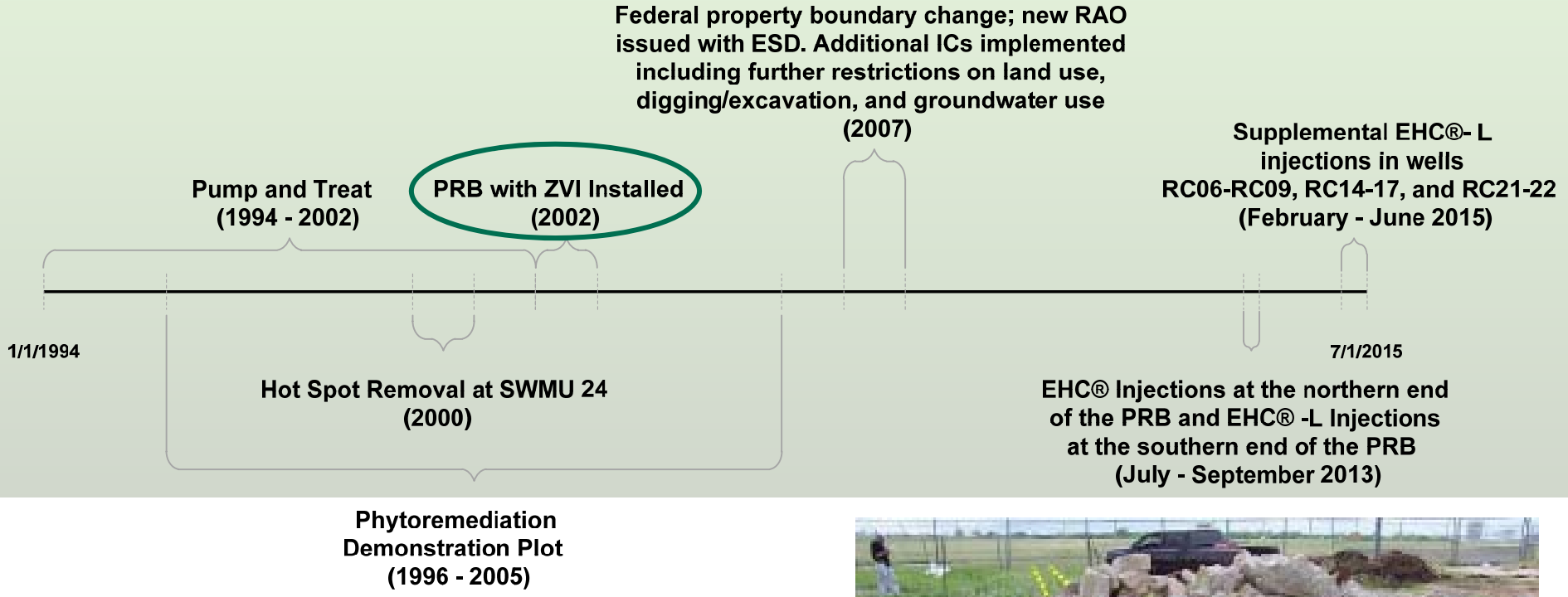
Remedial System Effectiveness

- Uniform decay rate regardless of remedial actions (P&T, biowalls, MNA)
- Engineered remedies have no greater impact than natural attenuation on plume mass
- Back diffusion mass flux may overwhelm mass removed by engineered systems





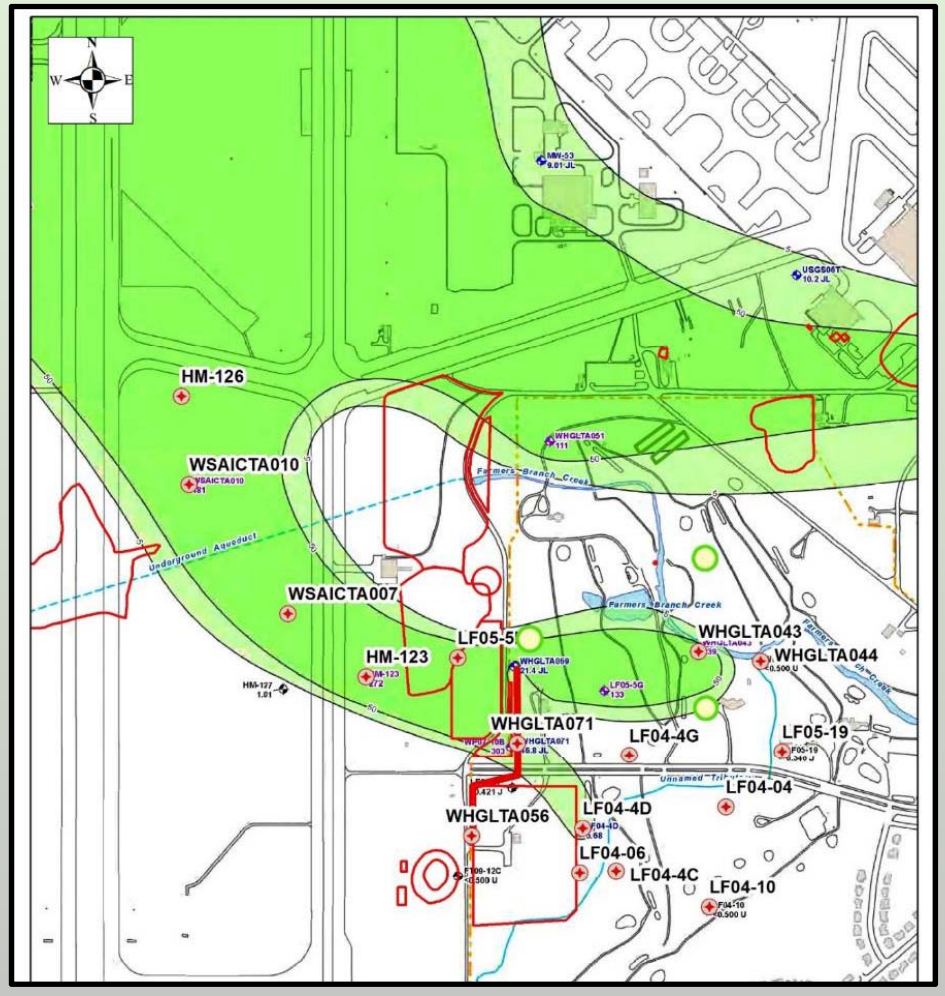
CWA Remediation History



- Focus on the ZVI PRB

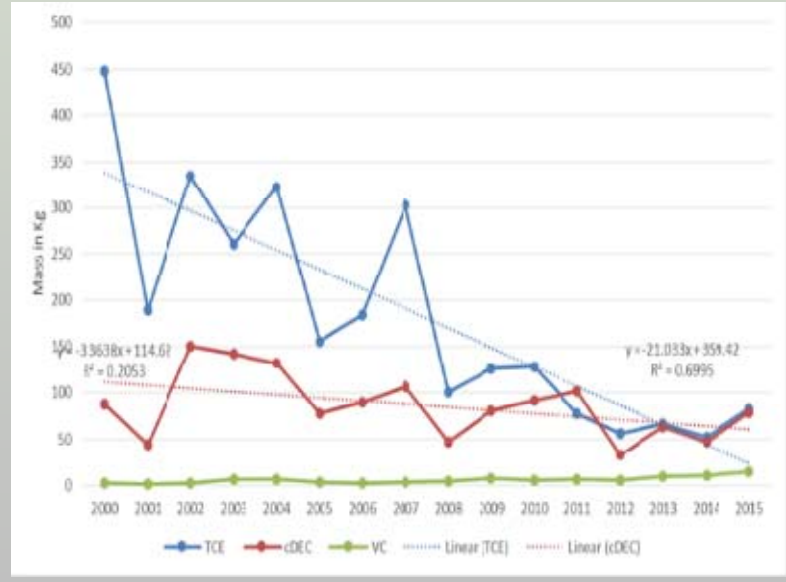
CWA Systems Layouts

- ZVI PRB
- Designed to prevent further migration of TCE beyond installation boundary
- 1,170 foot long, 2 foot wide, 35 foot deep
- 50-50 mix of iron filings and sand
- Construction Completion on September 15, 2006



CWA PRB Assessment

- PRB performance Assessment
  - Adversely effected GW flow pattern; violating design constraints
  - ZVI has lost its effectiveness
    - No method to effectively rejuvenate
  - Conversion to biobarrier
    - Downgradient VC concentrations increasing
    - Benefit for TCE degradation is not sustainable for long-term effectiveness



LF1&3 Background

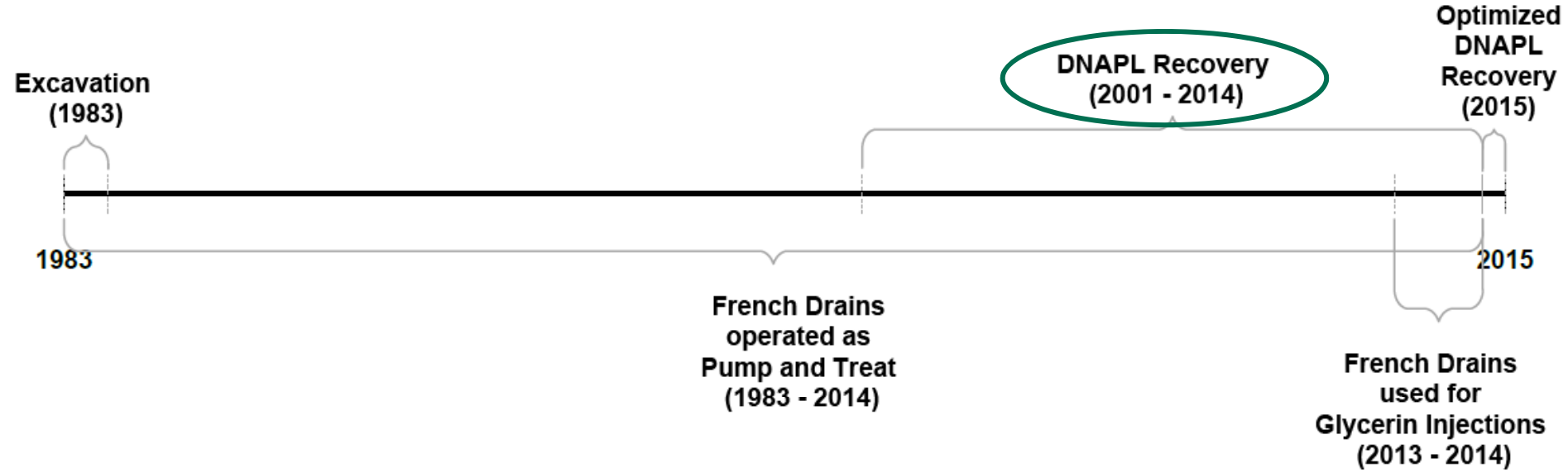
LF1

- Former landfill with multiple waste pits
- Converted to a parking lot

LF3

- Received misc. wastes, including mixed oils and solvents, from 1942 to 1945
- Inactive from 1945 to 1966
- Dirt and rubble used to fill and grade the landfill in 1966 and 1967

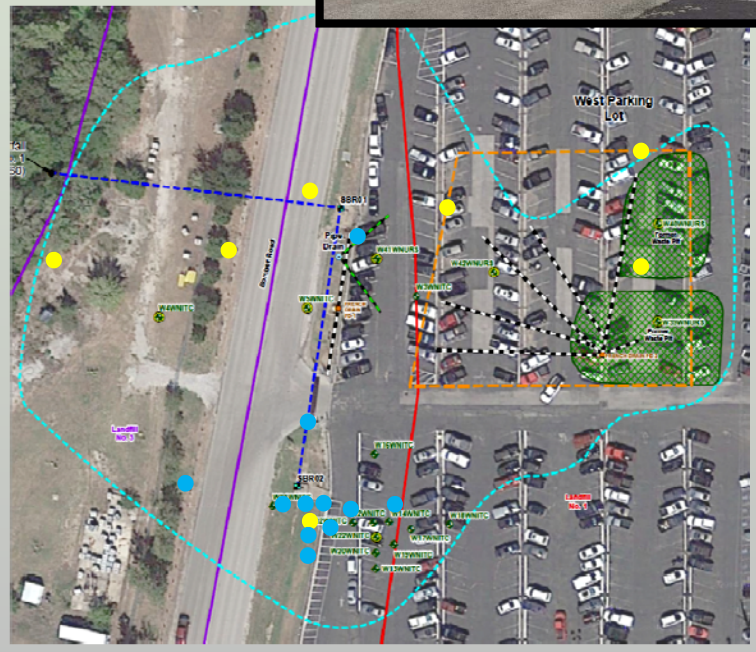
LF1 Remedial History



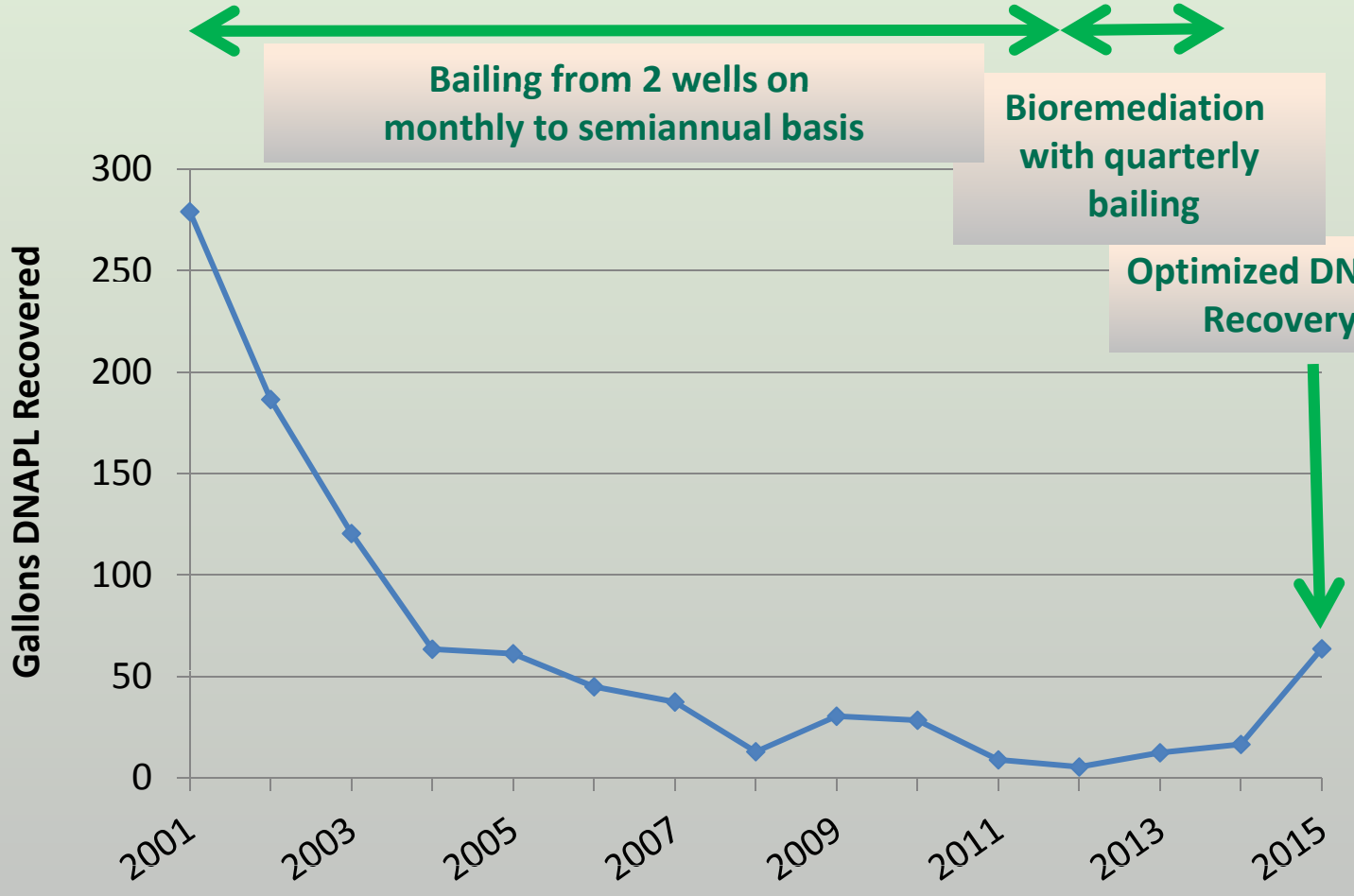
- LF1 technology discussed below
  - DNAPL Recovery
    - 2001 - Present

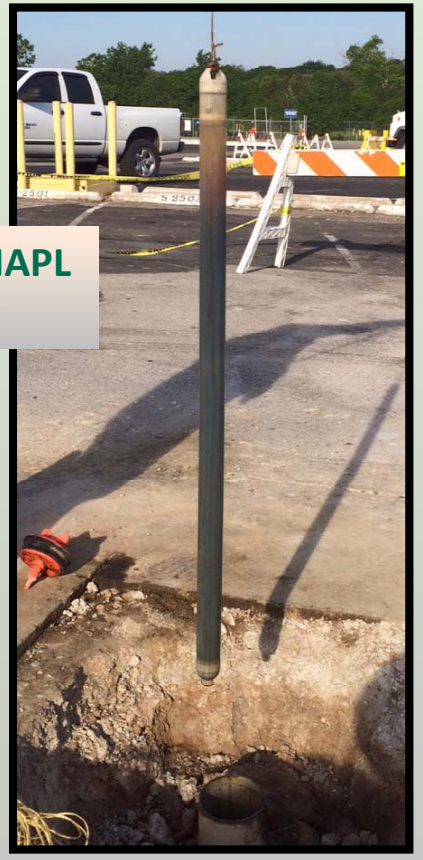
LF1 DNAPL Recovery

- Objective
  - Determine practicability of removing mass through DNAPL extraction wells
- Installed 4 new extraction wells in the Walnut Formation
  - Recover DNAPL via pumping or bailing
  - Frequency based on how quickly product accumulates in the well
- Monitor DNAPL thickness in neighboring Walnut wells monthly to determine how recovery is affecting surrounding area

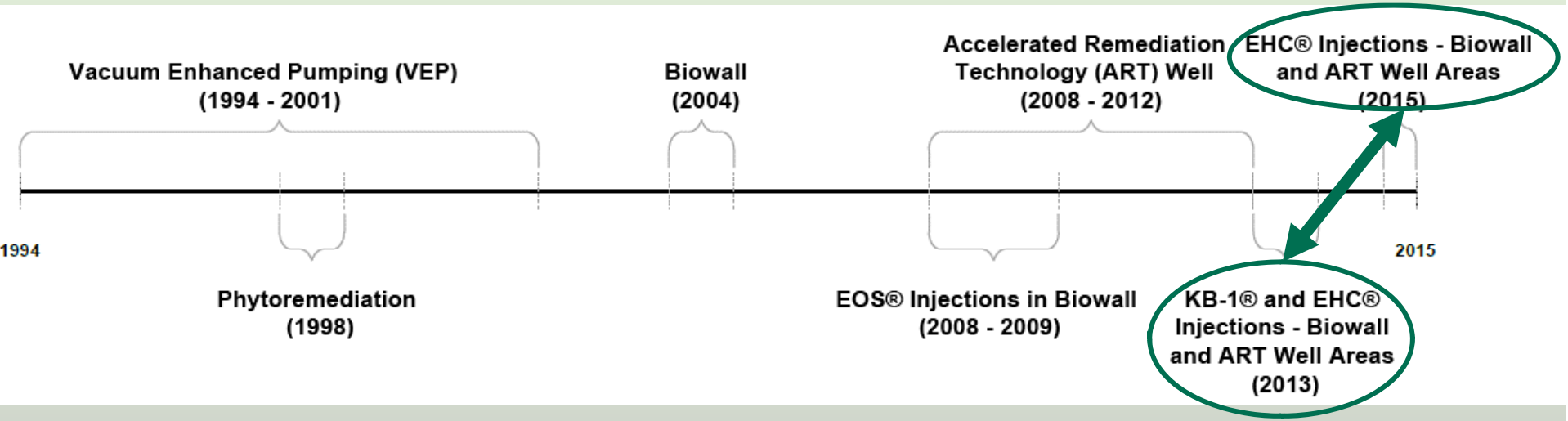


LF1 DNAPL Recovery



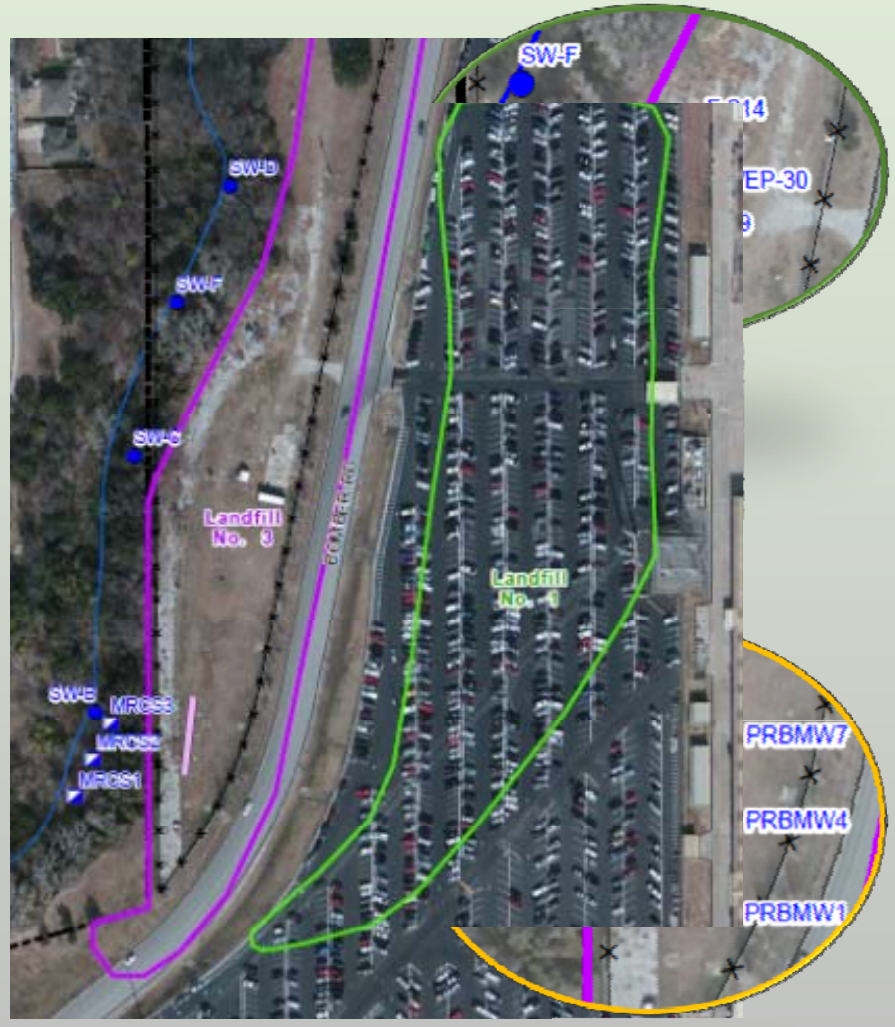


Landfill 3 Remedial History



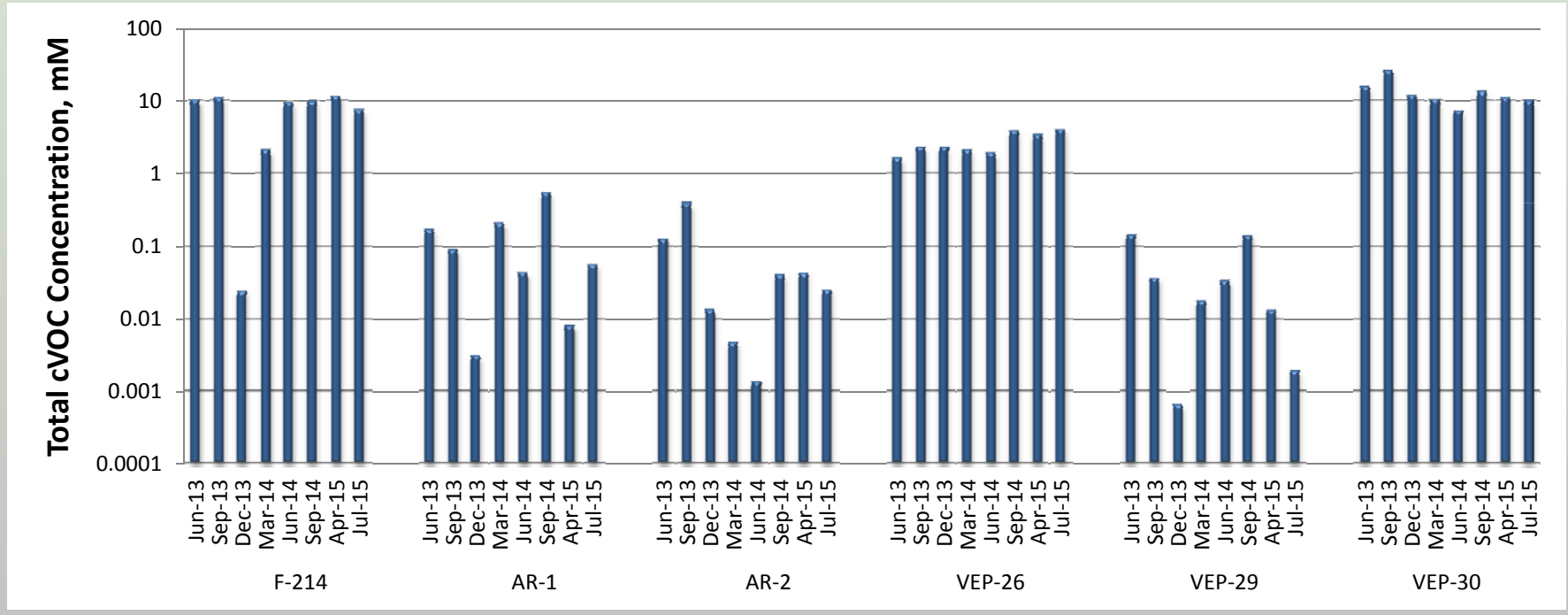
LF3 EISB Pilot Study

- Objective
  - Inject biostimulants into the biowall and ART well area to reduce LF3 groundwater cVOC concentrations
- Implementation Overview
  - First injections performed May - October 2013
    - EHC-L *(food)*
    - KB-1 *(bacteria)*
  - Second injections performed March - September 2015
    - EHC-L *(food)*
    - EHC *(food + ZVI)*



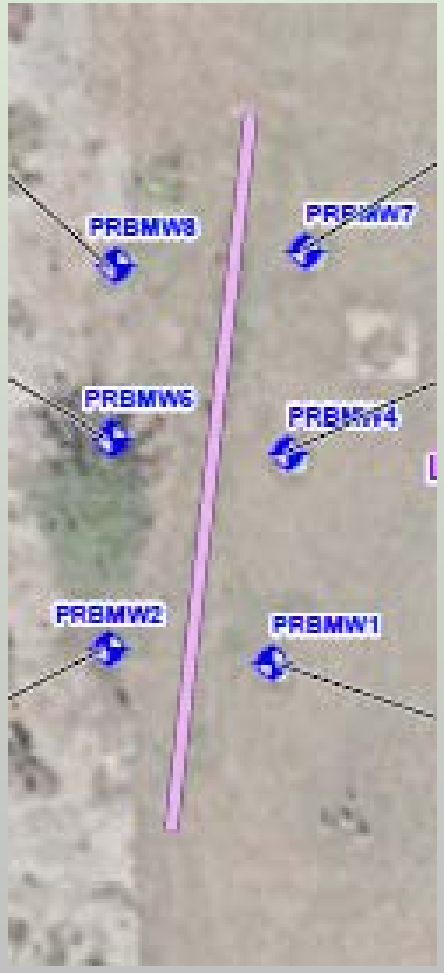
Landfill No. 3 Pilot Study

ART Well Area Results
Total cVOC Concentrations
(~28% decrease overall)

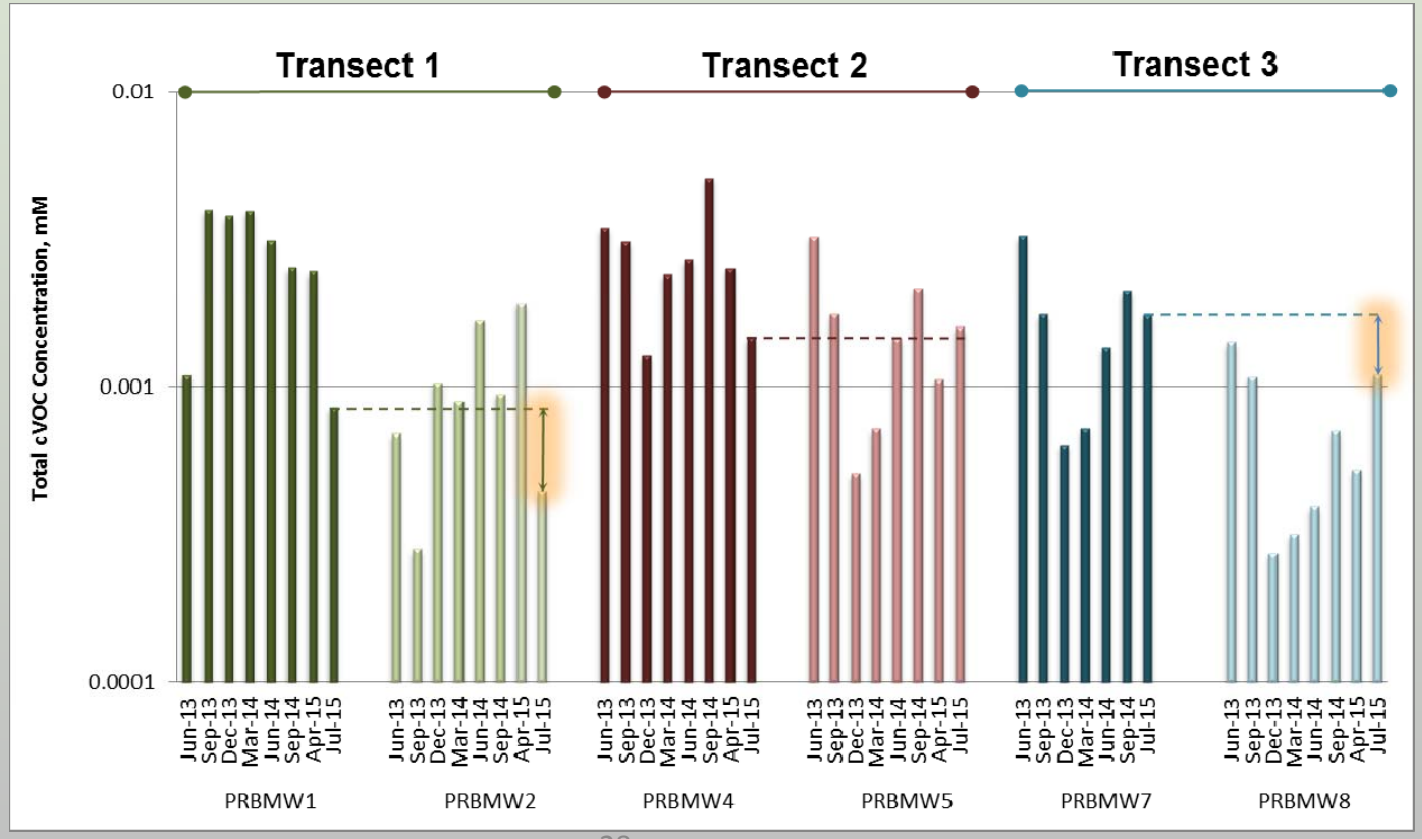


Percent Change Since June 2013	F-214	AR-1	AR-2	VEP-26	VEP-29	VEP-30
	-27%	-67%	-80%	+144%	-99%	-36%

Landfill No. 3 Pilot Study



Biowall Area Monitoring Results



Summary of Lessons Learned

- Aggressive technologies effectively treated source area
- Technologies removed mass in localized areas, but quickly became mass transfer limited
  - Substantial mass in lower permeability soils
  - Back diffusion governs plume responses
- Comprehensive CSMs are crucial for technology selection and design at complex sites
  - Site Characterization is key
    - HRSC can improve complex site CSMs
    - MNA data are essential to assess NA potential and evaluate remedial alternatives
    - Biogeochemical data provide insight into:
      - Existing degradation pathways and the potential to enhance those or stimulate others
      - Potential challenges for select remedial technologies

Summary of Lessons Learned

- Technology guidance documents should be consulted when selecting and implementing remedial approaches
- Monitoring must include the necessary parameters and spatial coverage to:
  - Effectively assess technology performance
  - Understand causes for poor technology performance
- AFCEC's CSI approach has benefitted remedial programs
  - Teams that include regulators, Base contractors, AFCEC support contractors, and SMEs to brainstorm and develop remedial approaches
    - Enhances communication among concerned parties
    - Benefit from the collective experience/expertise of the group
    - Substantially shortens regulatory approval times
    - Ensures proper technology selection, implementation, optimization, and termination

Path Forward

- Update the CSM
  - Implementing HRSC approaches to provide better resolution of the subsurface
    - Stratigraphic delineation
    - Identify preferential flow paths
    - Target in on remaining DNAPL
  - Conduct synoptic water-level event to refine groundwater flow map for the terrace alluvial deposits
- Expand analyte list to provide data necessary to evaluate and optimize remedial approaches
- Prepare FS addendum and Proposed Plan
  - Evaluate technology alternatives based on current data and site info
- Prepare RoD-A

CZTE HRSC Site Characterization

Project	AFP4 Site	Project Scale / Hydrogeology	Technology or Methods
Base-Wide CSM Update for Preferential Flow Paths	Base Wide	Plume scale / Terrace alluvium	Environmental Sequence Stratigraphy (ESS)
Delineation of Complex Preferential Pathways	Carswell / Off Base	Pilot scale / Terrace alluvium	Geophysical-Hydraulic Tomography
High Resolution Delineation of Contaminant Mass Flux	East Parking Lot / Window, Chrome Pit 3	Remedial system scale / Terrace alluvium	ESS and Relative Mass Flux Mapping
Innovative DNAPL Remediation Using High-Resolution Characterization and Low Level Heat	LF1	Pilot scale/Walnut and Terrace alluvium	NAPL and subsurface temperature profiling