Managing Challenging Leaking Petroleum Storage Tank Sites with Case Studies

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Office of Waste | Remediation Division | PST/DCRP Section

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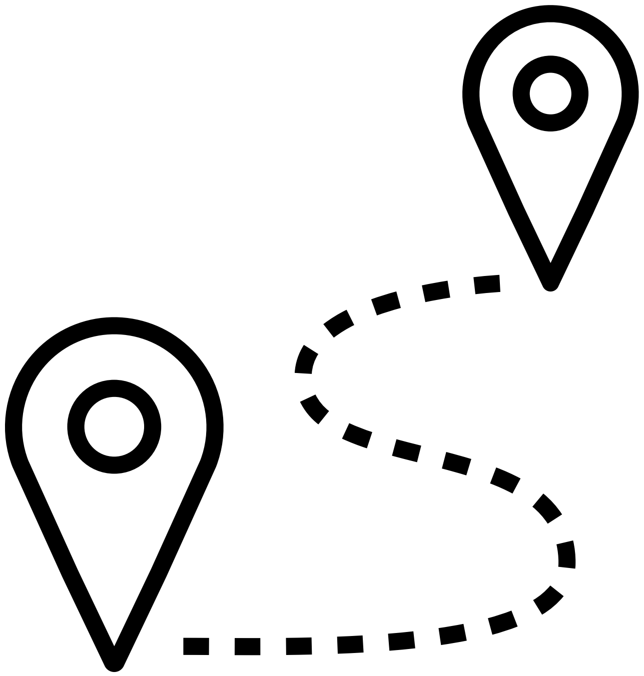
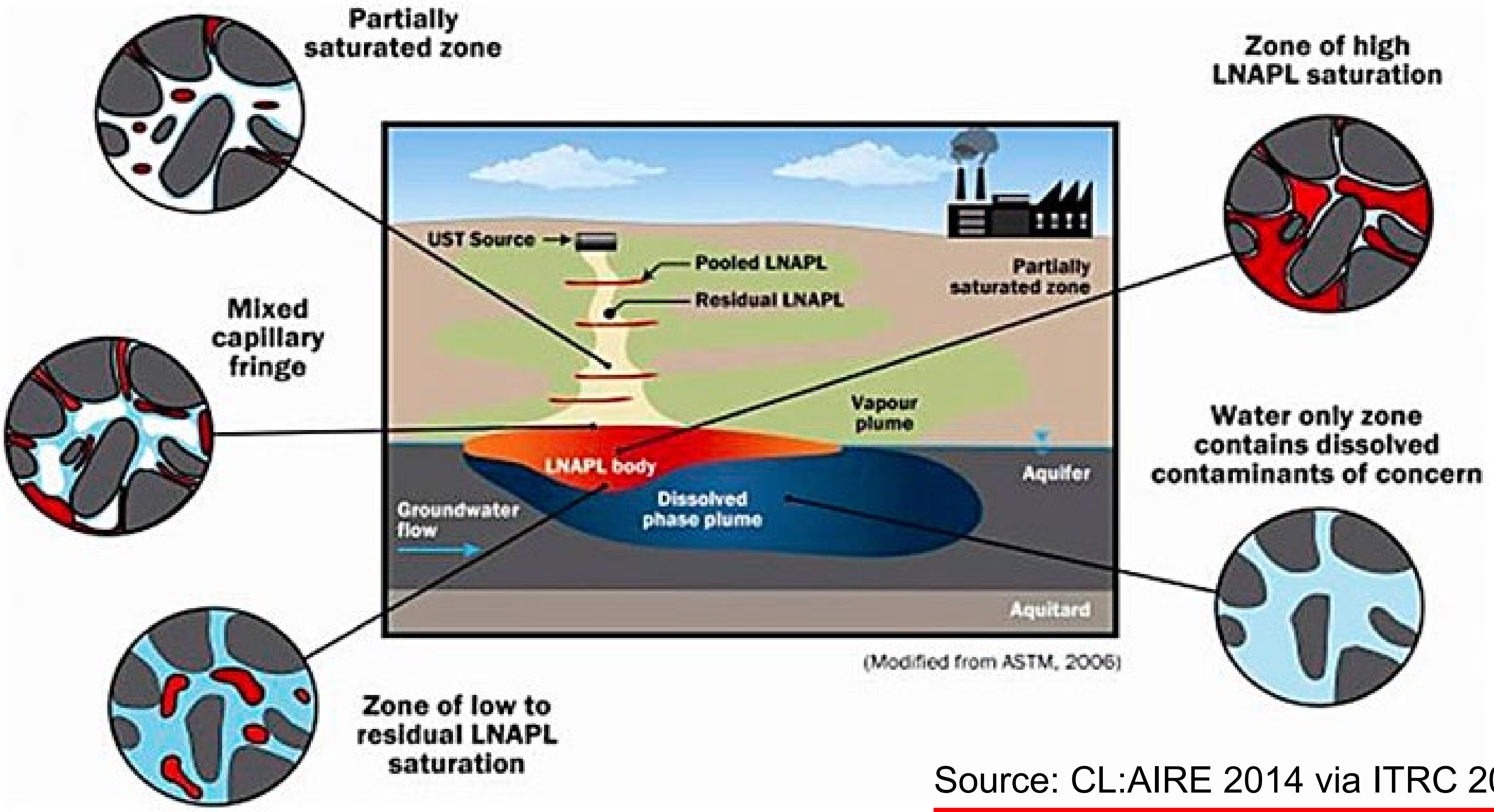
Outline

- Background
- Objective
- Case Studies (4)
- Summary



Schematic of Contamination from LUST



Source: CL:AIRE 2014 via ITRC 2018

LNAPL = light non-aqueous phase liquid

Common Challenges to Timely Remediation

- Residual LNAPL
- Complex geology
- Cost considerations
- Plateauing effectiveness of remedial efforts

Leaking Petroleum Storage Tank (LPST) Cleanup Status

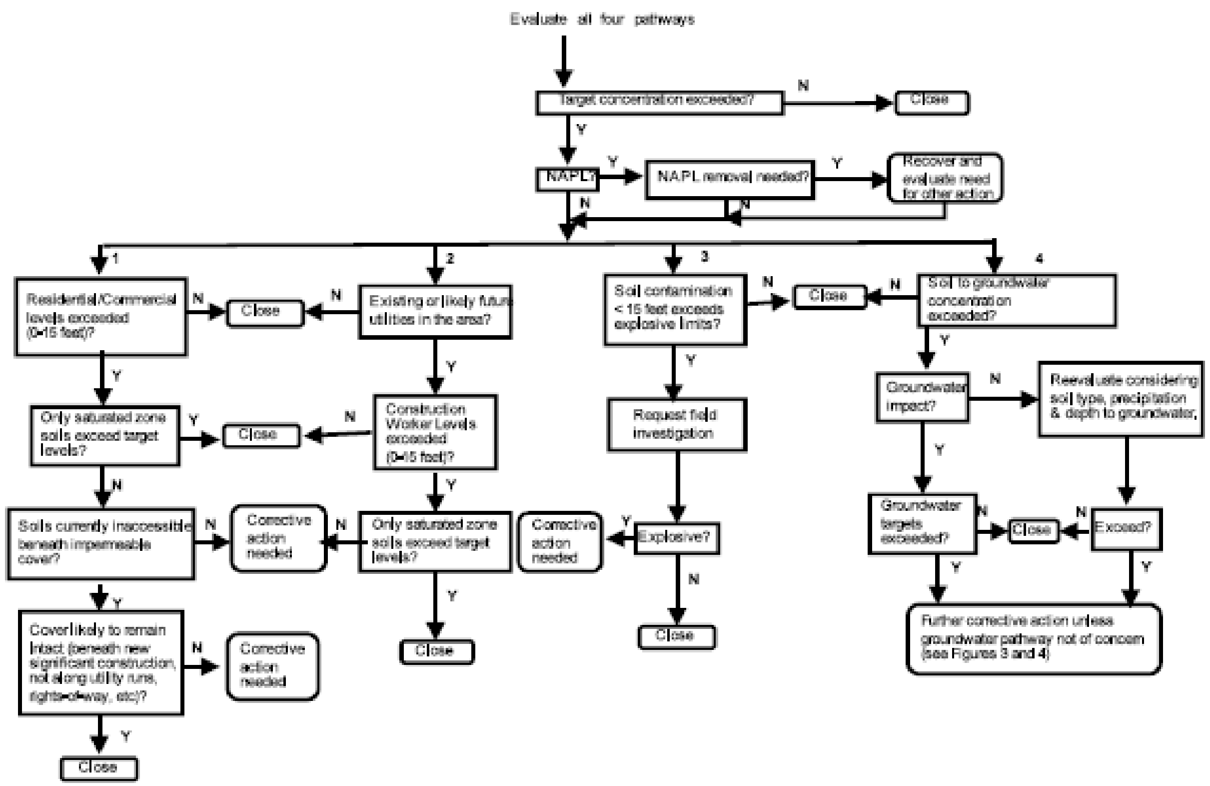
- As of January 2025
  - 29,000 cleanups completed (96% of all known releases in Texas)
  - 1,000 cases remain active
    - 800 Responsible Party Program
    - 200 State Lead Program
  - On average ~ 250 cases close every year, while 200+ new releases are added per year in last 5 years
  - Average age of open cases: 11 years
- Some cases remain open for longer
  - 191 cases open for >25 years

Risk-based Corrective Action Process

LPST sites evaluated using RBCA process

- Focus resources on releases with greatest risk to human health and environment
- Cleanup target levels established based on risk
  - Soil and groundwater pathways
- When all pathways can be closed, site closure may be appropriate

Figure 5. Soil Pathways.



Soil Flow Chart from RG-523/PST-03

Addressing Challenges to Timely Remediation

Re-evaluate risk

- Update of receptor information
- Plan B assessment
- Qualitative elimination of open exposure pathways

Re-evaluate remedial technologies

- Combination of remediation techniques
- Site-specific investigation and remediation strategies for complex geology
- Phased remediation with multiple treatment zones

Presentation Objective

Highlight opportunities to accelerate cleanups at LPST sites using case studies

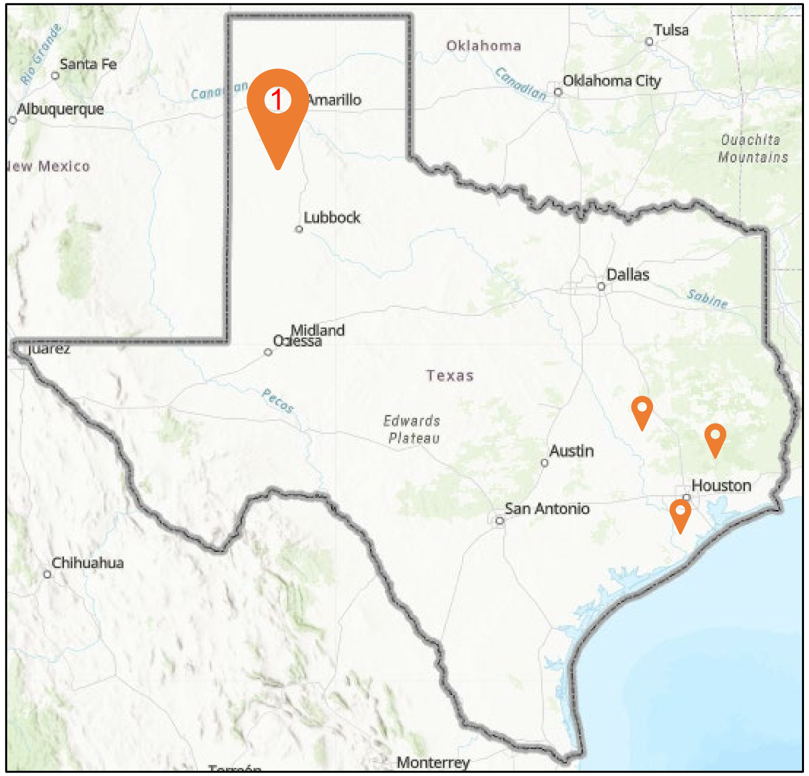
- Re-evaluate risk
- Re-evaluate remedial technologies

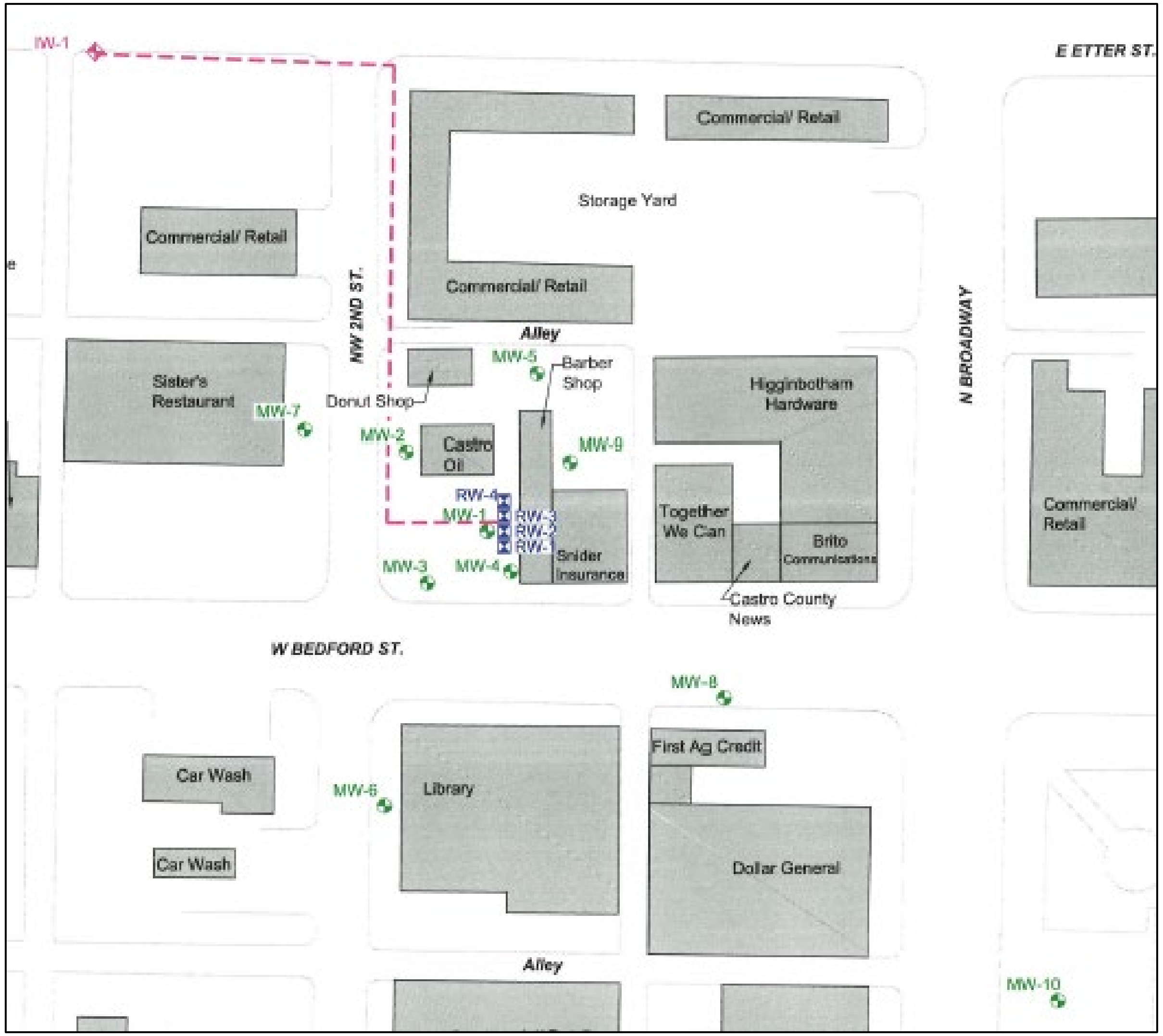
Case studies selected based on one or more technical challenges

- Residual LNAPL removal
- Groundwater contaminant of concern (COC) concentrations remaining above target levels
- Soil COC concentrations exceeding target levels

Case Study 1

Dimmitt, Texas





Case Study 1 Background

Former UST facility - USTs removed in 1991
Commercial/industrial use

Predominant soil type: sand
Depth to groundwater: ~315’ below ground surface (bgs)
Ogallala Aquifer

3 public/municipal wells (one ~980’ downgradient)

Remediation system used to address LNAPL and dissolved phase COCs

- Dual phase extraction (2010-2020)
- Transitioned to groundwater pump and treat (during FY2022-2023) due to very low vapor recovery

Challenges to Highlight

Water table declining >0.5’ per year

Remediation system limited to pumping at fixed depth due to depth to water (~315’ bgs)

Groundwater COC concentrations above target levels

Tracking Remedial Effectiveness

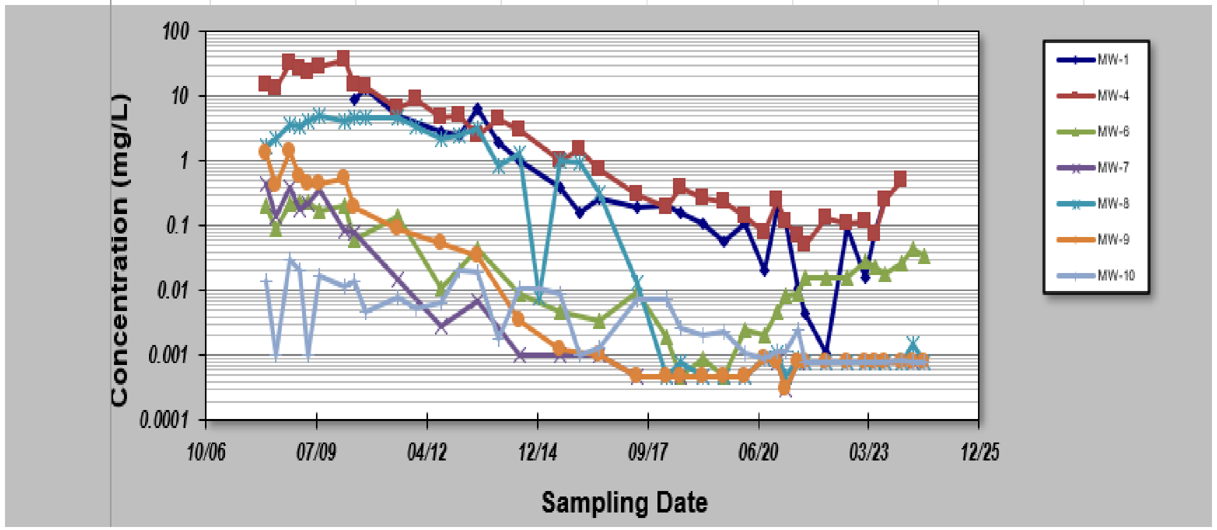
Track movement of LNAPL and contaminant plumes over time

- Spatiotemporal modeling
  - **G**round**W**ater **S**patiotemporal **D**ata **A**nalysis **T**ool (GWSDAT)
- Mann-Kendall trend analysis
- Groundwater hydrographs

Use these tools to make informed decisions

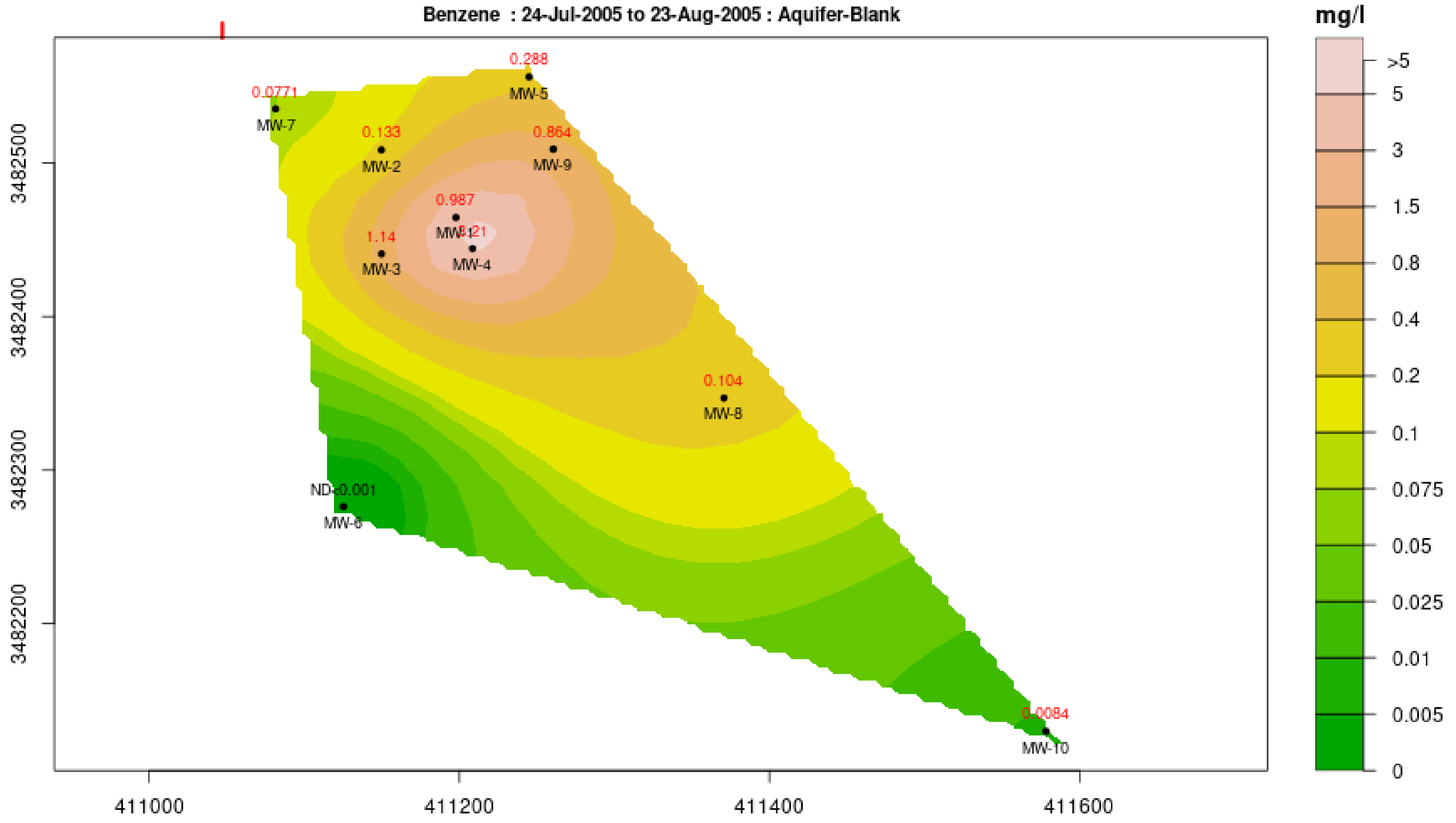
- Adjust remedial strategy
- Evaluate for case closure

Sampling Point ID:		MW-1	MW-4	MW-6	MW-7	MW-8	MW-9	MW-10
Sampling Event	Sampling Date	BENZENE CONCENTRATION (mg/L)						
Coefficient of Variation:		1.96	1.52	1.38	2.07	1.29	2.12	1.16
Mann-Kendall Statistic (S):		-253	-484	-108	-275	-437	-276	-441
Confidence Factor:		>99.9%	>99.9%	95.1%	>99.9%	>99.9%	>99.9%	>99.9%
Concentration Trend:		Decreasing	Decreasing	Decreasing	Decreasing	Decreasing	Decreasing	Decreasing

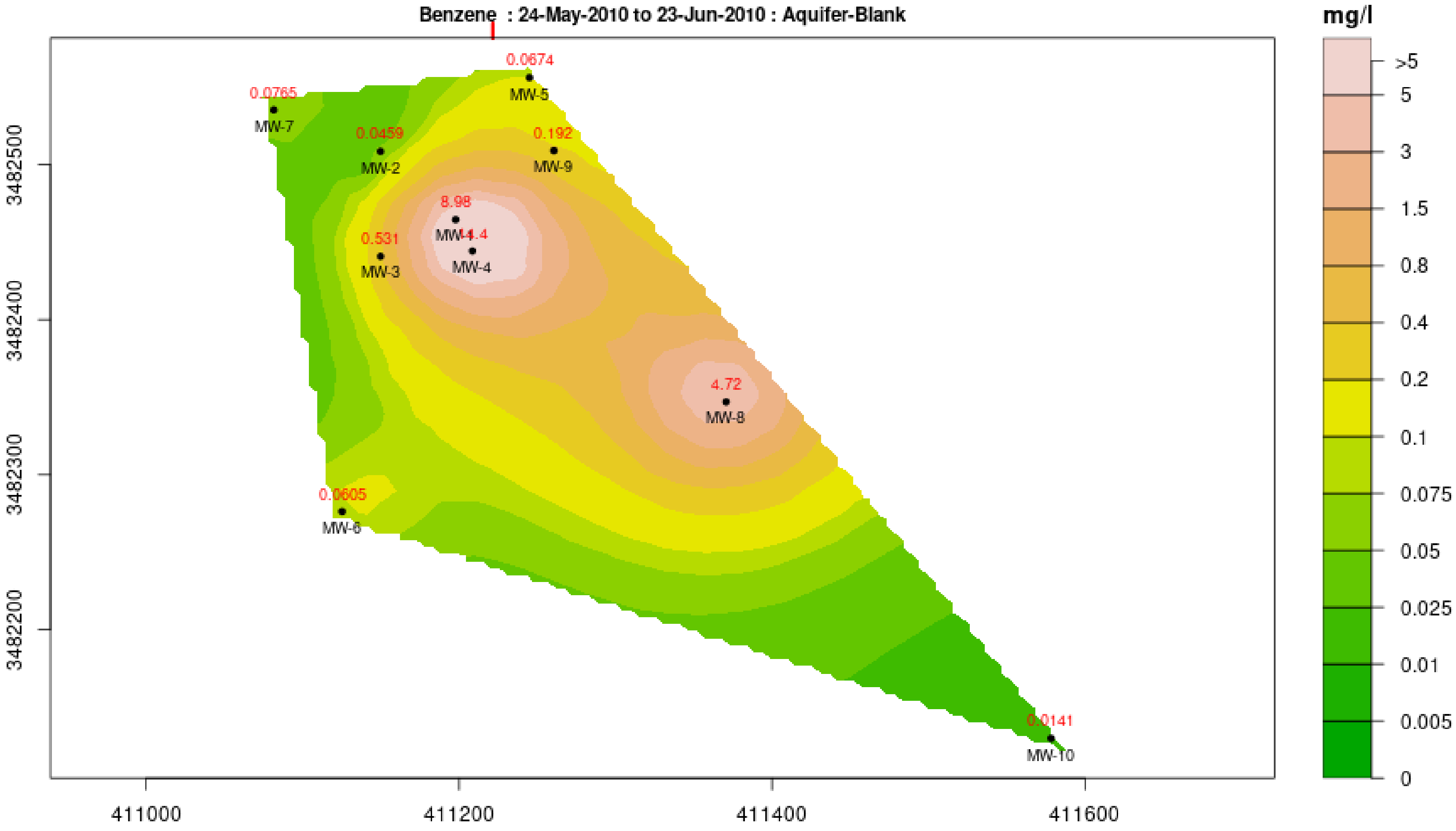


Benzene trend using GSI Mann-Kendall Toolkit

GWSDAT Output – Jul/Aug 2005



GWSDAT Output – May/Jun 2010



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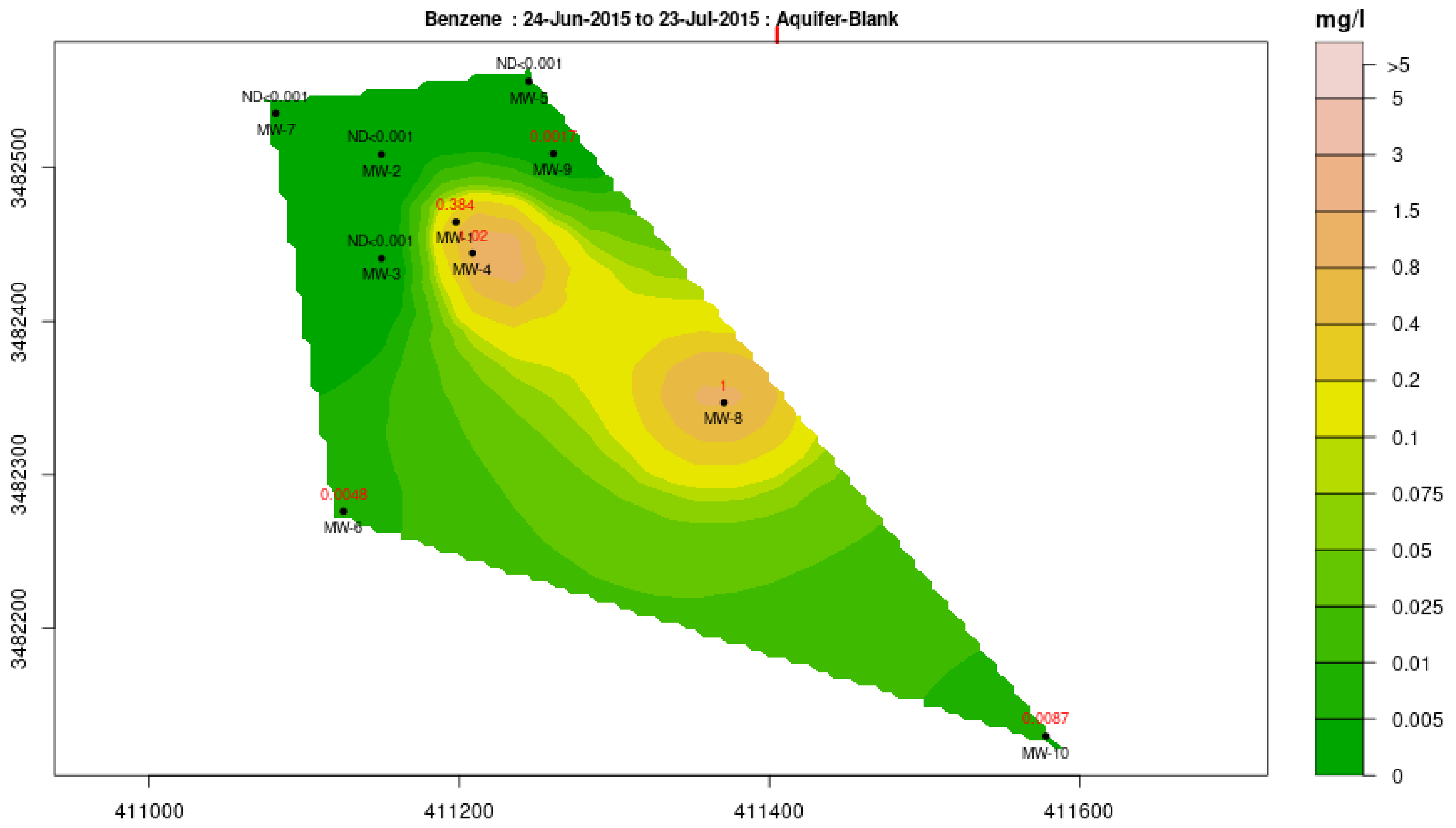
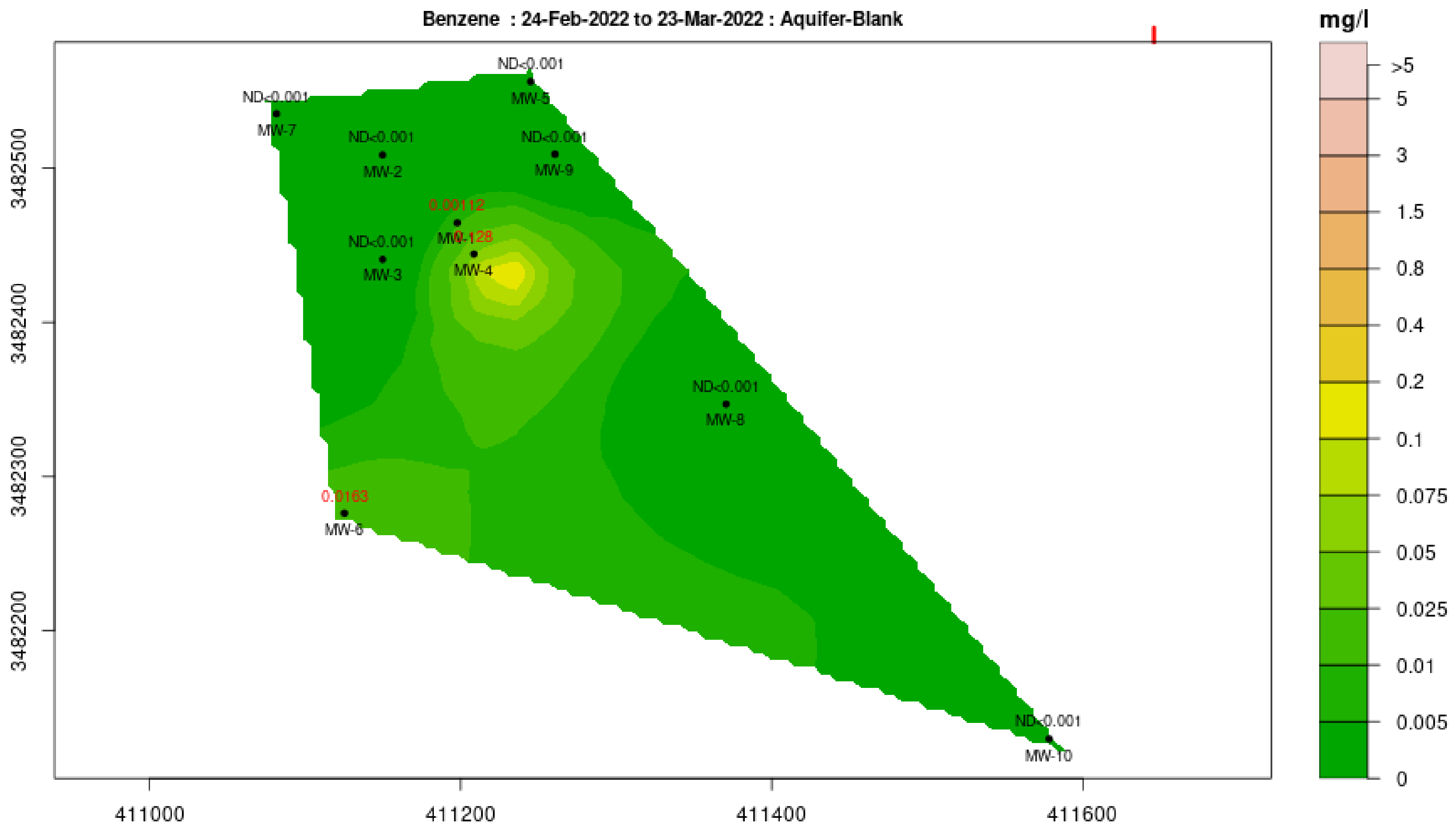
GWSDAT Output – Jun/Jul 2015



GWSDAT Output – Feb/Mar 2022



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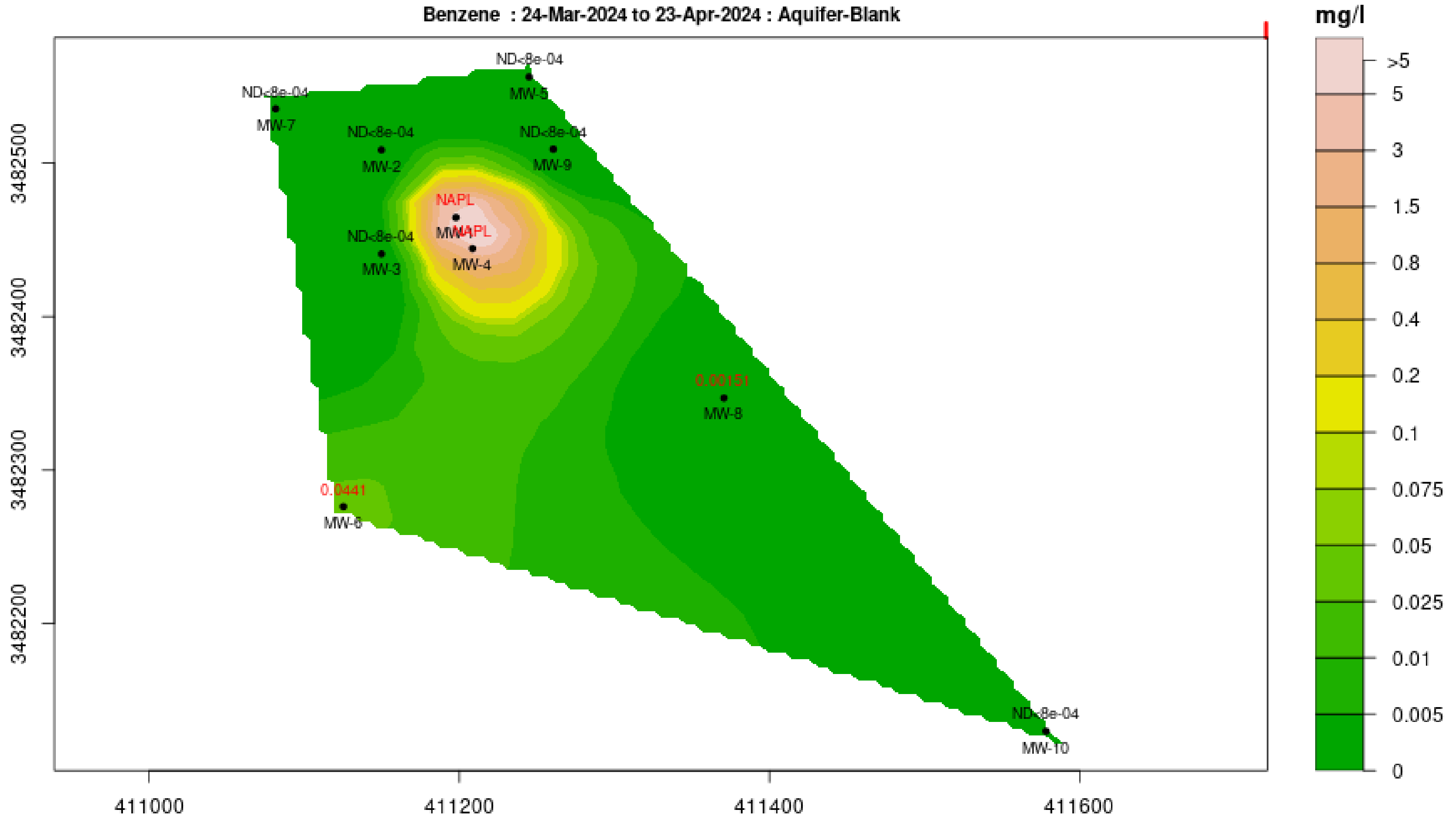
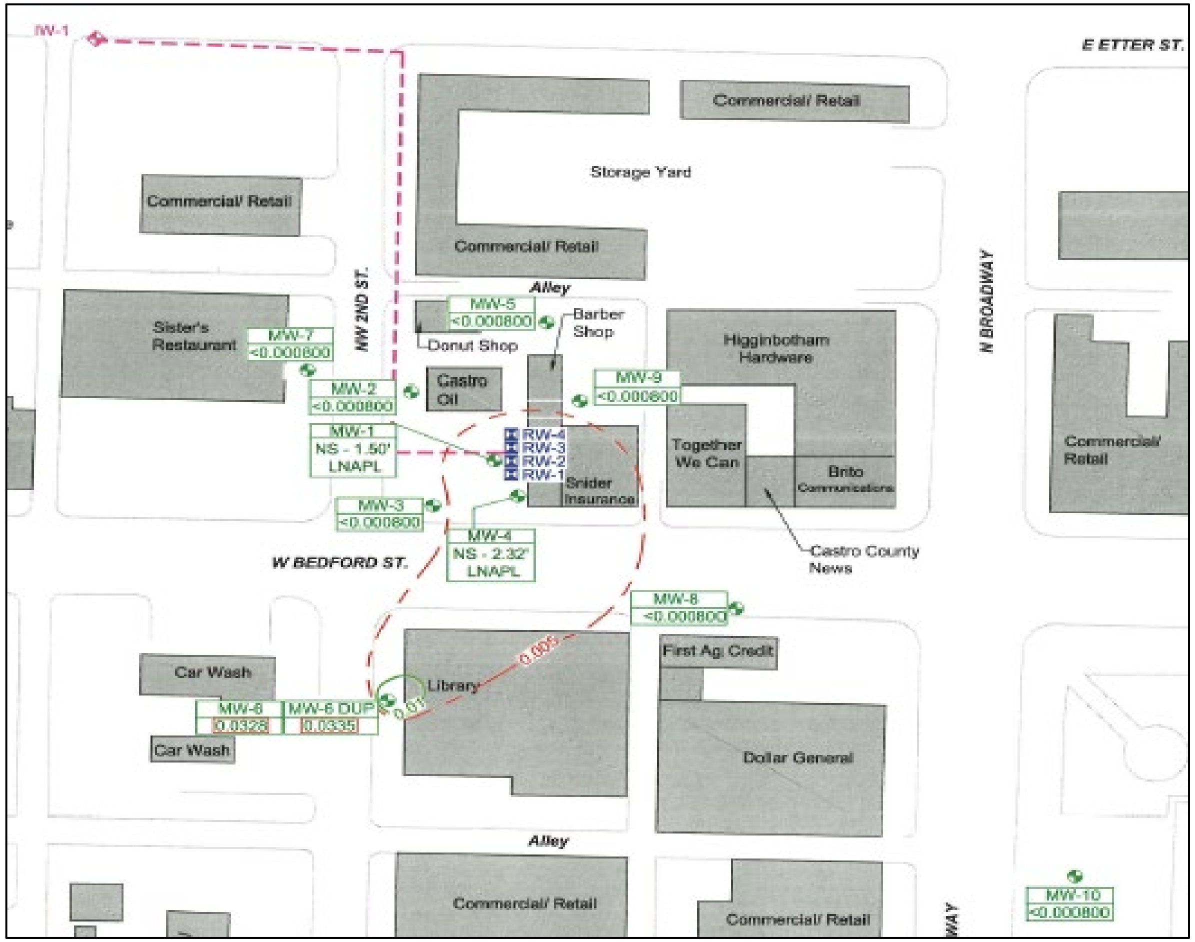
GWSDAT Output – Mar/Apr 2024



Current Status – Case Study 1



Benzene isoconcentration map – July 2024

- Turned off remediation system in 2023
  - Groundwater COCs met target levels
- Observe for rebound (LNAPL reappearance, increase in concentrations)
  - Adjust pumping depth or install larger diameter well
  - Consider eligibility for closure

Case Study 1 Takeaways

Evaluate site data to understand plume changes over space and time

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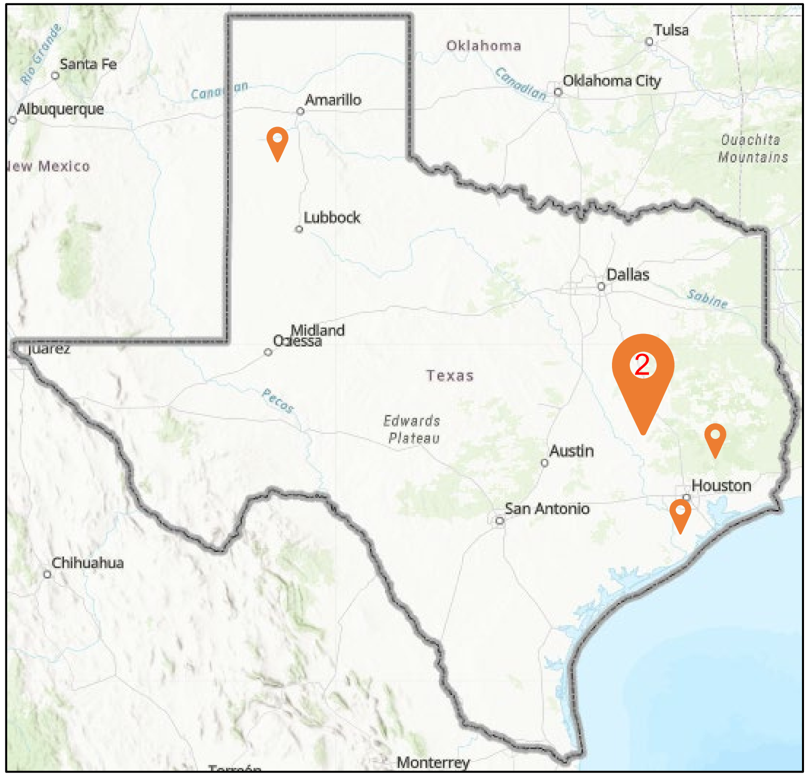
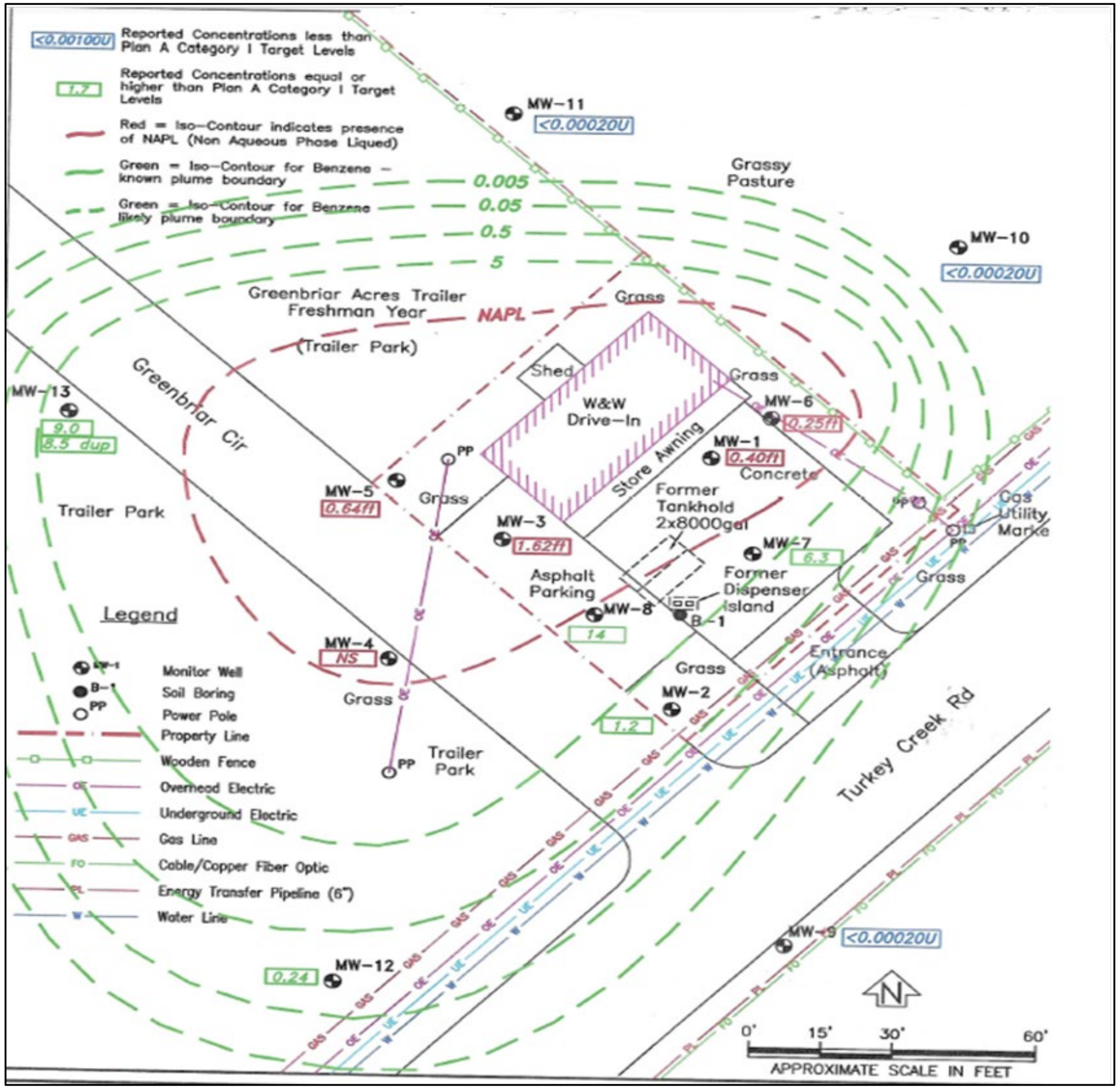
Use understanding to

Adjust remedial strategy, especially when site conditions change considerably over time	Evaluate eligibility for case closure • Is the plume stable? • Are receptors protected?

Case Study 2

Bryan, Texas





Case Study 2 Background

Former UST facility - USTs removed in 2011
Entered State Lead Program in 2021
Commercial/industrial use

Predominant soil type: sandy clay
Depth to groundwater: ~16’ bgs
Carrizo-Wilcox Aquifer

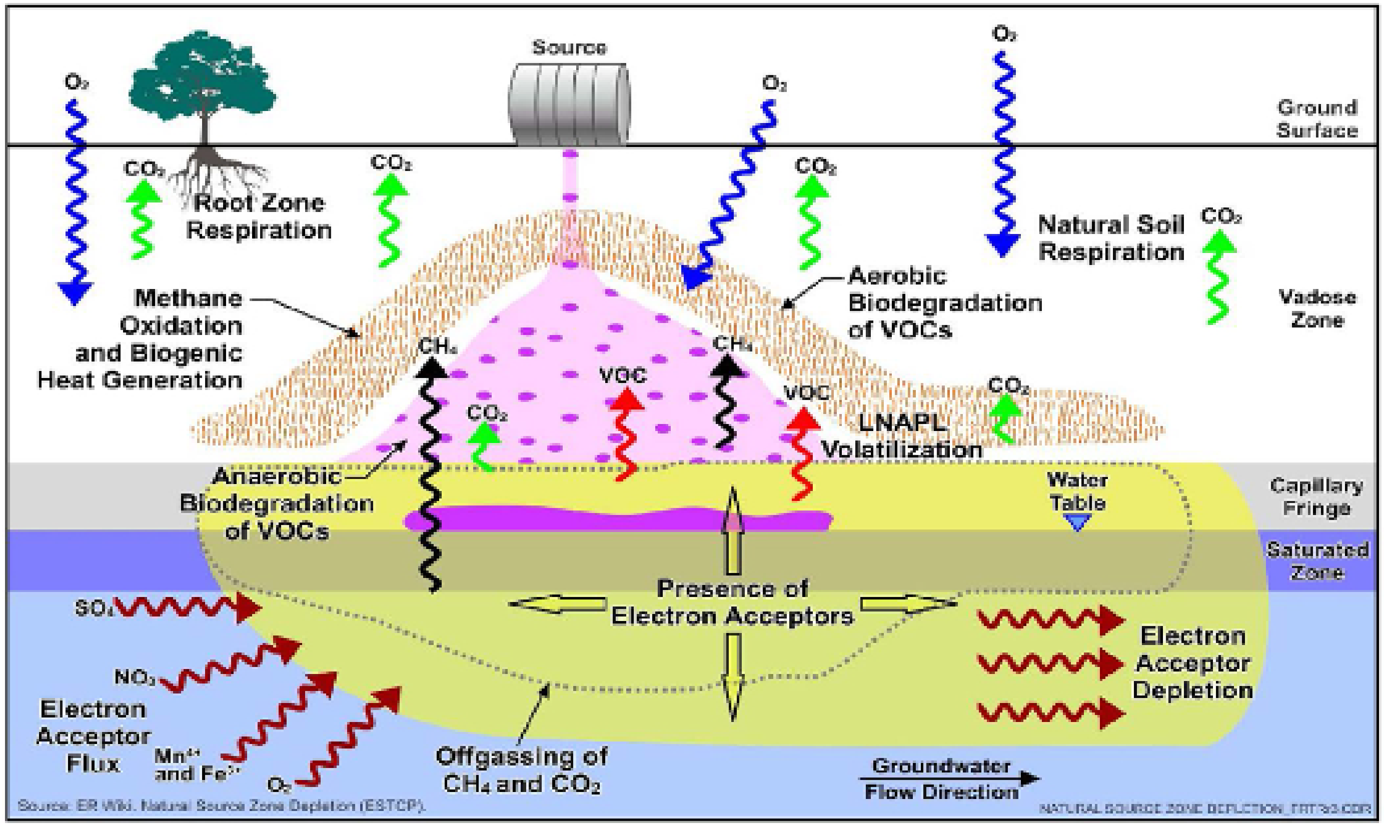
No public/drinking water well within ½-mile radius of site

Issues: LNAPL and dissolved phase COCs

- Mobile dual phase extraction (MDPE) events conducted since November 2022 to recover LNAPL

Natural Source Zone Depletion (NSZD)

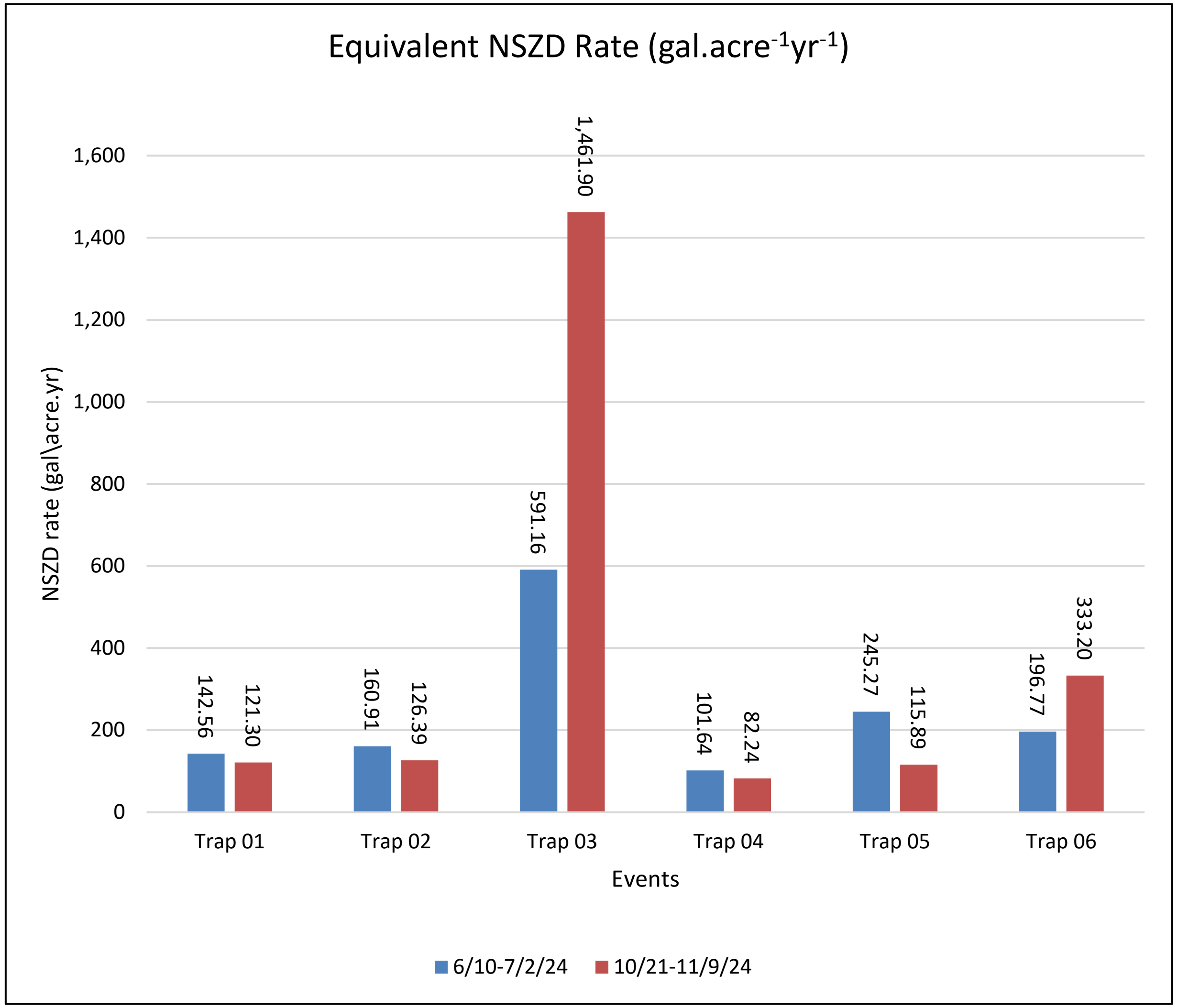
- Naturally occurring processes that facilitate LNAPL attenuation
  - Biodegradation
  - Dissolution
  - Volatilization
- Used to assess LNAPL attenuation rates
- Can be estimated using several field methods



Source: FRTR 2020

NSZD Sampling Locations & Photograph of Equipment

Current Status – Case Study 2



- NSZD rates measured at 6 locations to observe spatial and seasonal patterns
  - Date range = 6/10 - 7/2/24
  - Date range 2 = 10/21 - 11/9/24
  - Date range 3 (pending)
- Quantification of LNAPL attenuation to be used as line of evidence for leaving LNAPL in-place

Case Study 2 Takeaways

Measuring NSZD rates for an LNAPL plume site provides several key insights:

Effectiveness of Natural Attenuation: NSZD rates help determine how effectively natural processes are reducing mass and toxicity of LNAPL contaminants without human intervention.

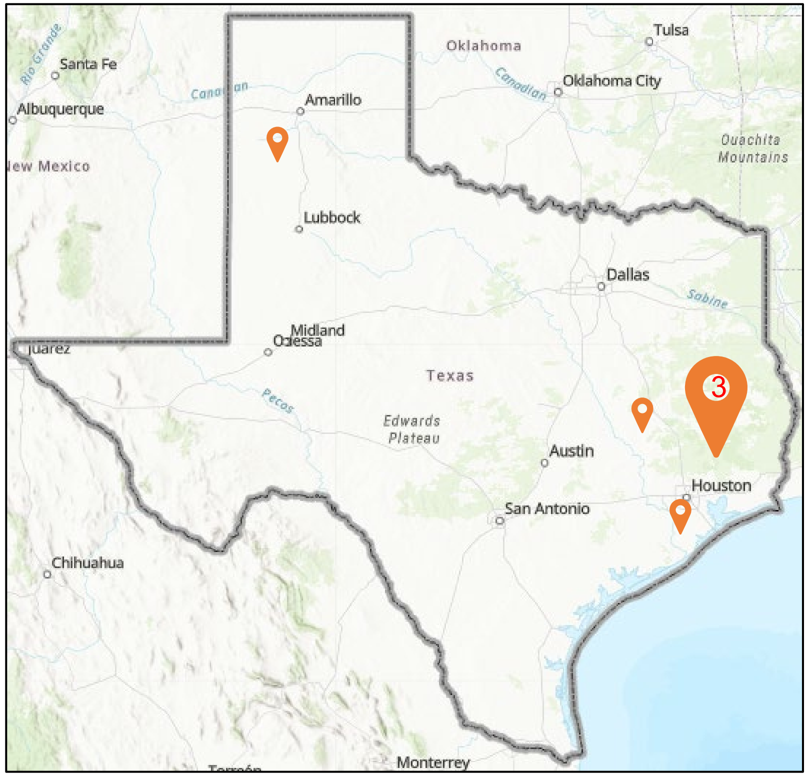
Remediation Planning: Understanding NSZD rates can guide decisions on whether additional remediation efforts are needed or if natural attenuation is sufficient.

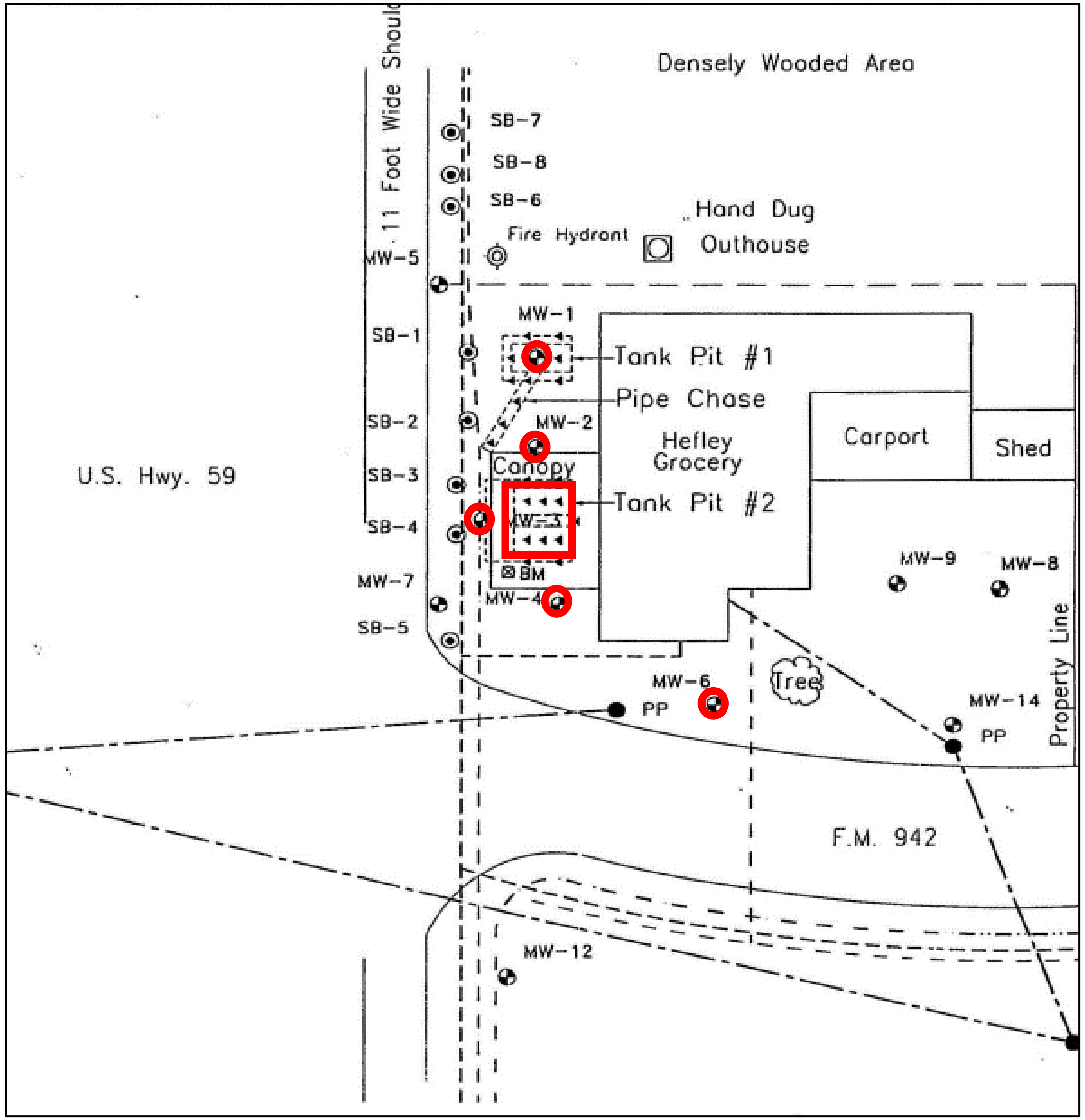
Environmental Impact: By quantifying biodegradation rates, NSZD measurements can assess long-term environmental impact and contaminated site recovery.

Cost Efficiency: Using NSZD can be more cost-effective compared to engineered remediation techniques, especially for mature LNAPL bodies.

Case Study 3

Leggett, Texas





Case Study 3 Background

Former UST facility
USTs removed in 1994 (release discovered)
Little impermeable surface cover
Commercial/industrial use
No zoning restrictions

Predominant soil types: sandy clay & clayey sand
Depth to groundwater: 8 to 14’ below top of casing
Gulf Coast Aquifer

By 2021, all exposure pathways addressed except SOIL

- Residential health-based
- Commercial/industrial health-based
- Construction worker health-based

Soil Data Exceeding Plan A Target Levels

Sample Location	Sample Date	Depth (ft)	Benzene (mg/kg)	Total Xylene (mg/kg)	Naphthalene (mg/kg)
Tank Pit #2 – Composite Floor Tank #2	1/25/94	10	13.3	203	
Tank Pit #2 – Wall Composite	1/25/94	8	2.6	315	
MW-1	2/17/98	14-15	66.9	347	
MW-2	2/17/98	13-14	16.71	213.44	
MW-3	2/17/98	12-13	185	1,013	85.3
MW-4	2/18/98	13-14	38.59	210.92	
MW-6	1/14/99	10-11	10.1	45.5	
Plan A Target Levels (Health-Based)					
Residential			7.14	1,870	112
Commercial/Industrial			9.62	9,280	531
Construction Worker			21.9	202	11.5

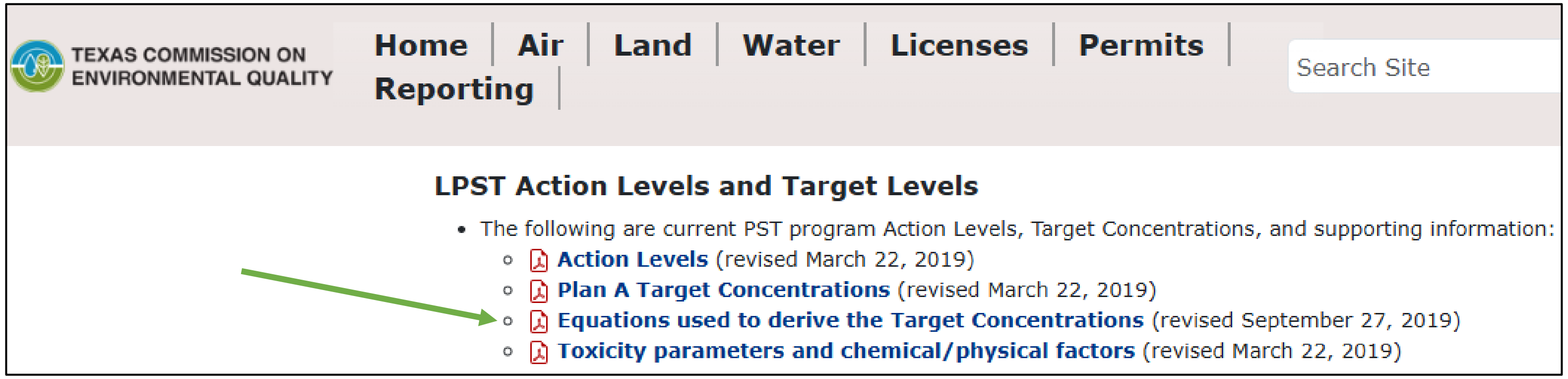
Approach

Calculate site-specific soil target levels (Limited Plan B Assessment)

Drill confirmatory soil borings adjacent to sampling locations with Plan B exceedances

Limited Plan B Assessment

Calculate Plan B numbers for COCs with Plan A exceedances



https://www.tceq.texas.gov/remediation/pst_rp/downloads.html#targetlevels

Site-specific geotechnical soil values

- Total porosity (0.406; 0.35 default)
- Fraction organic carbon (0.011; default 0.002)

Soil Data Exceeding Plan B Target Levels

Sample Location	Sample Date	Depth (ft)	Benzene (mg/kg)	Total Xylene (mg/kg)	Naphthalene (mg/kg)
Tank Pit #2 – Composite Floor Tank #2	1/25/94	10	13.3	203	
Tank Pit #2 – Wall Composite	1/25/94	8	2.6	315	
MW-1	2/17/98	14-15	66.9	347	
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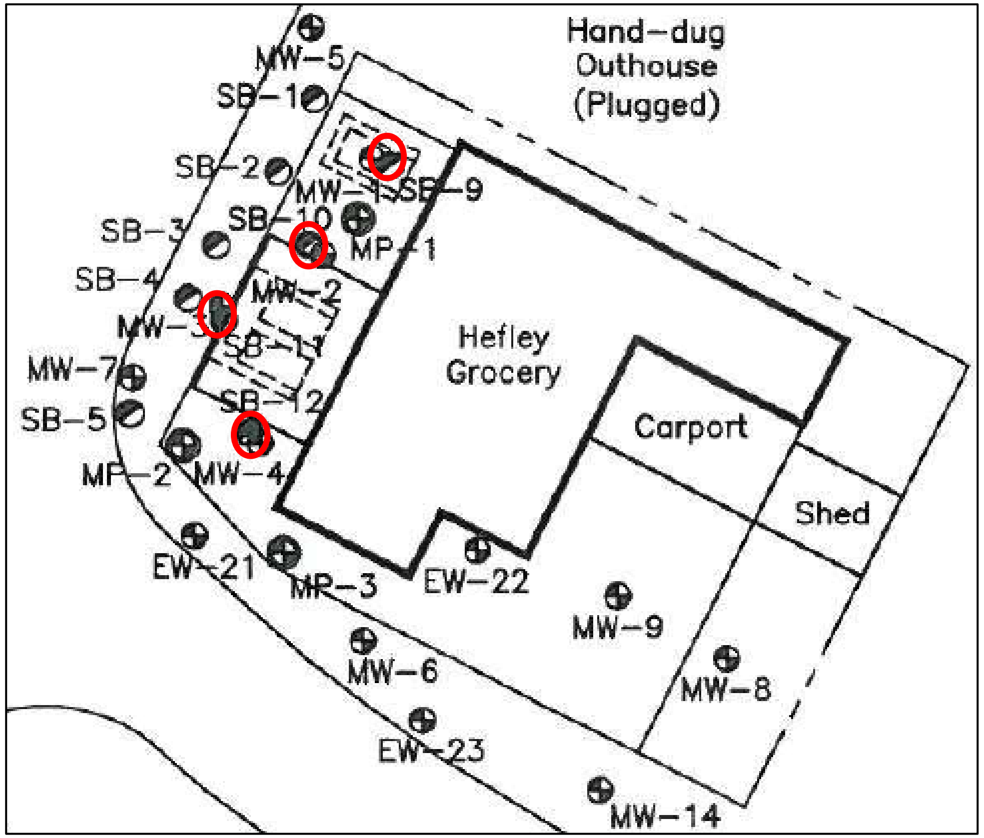
MW-4	2/18/98	13-14	38.59	210.92	
MW-6	1/14/99	10-11	10.1	45.5	
Plan ~~A~~ Target Levels Health-Based					
Plan B Residential			14.22 ~~7.14~~	3,747 ~~1,870~~	~~112~~
Commercial/Industrial			22.97 ~~9.62~~	20,860 ~~9,280~~	~~531~~
Construction Worker			53.9 ~~21.9~~	466 ~~202~~	25.4 ~~11.5~~

At least one Plan B exceedance

Confirmatory Soil Borings



No Plan B Exceedances
Final closure letter issued June 2022

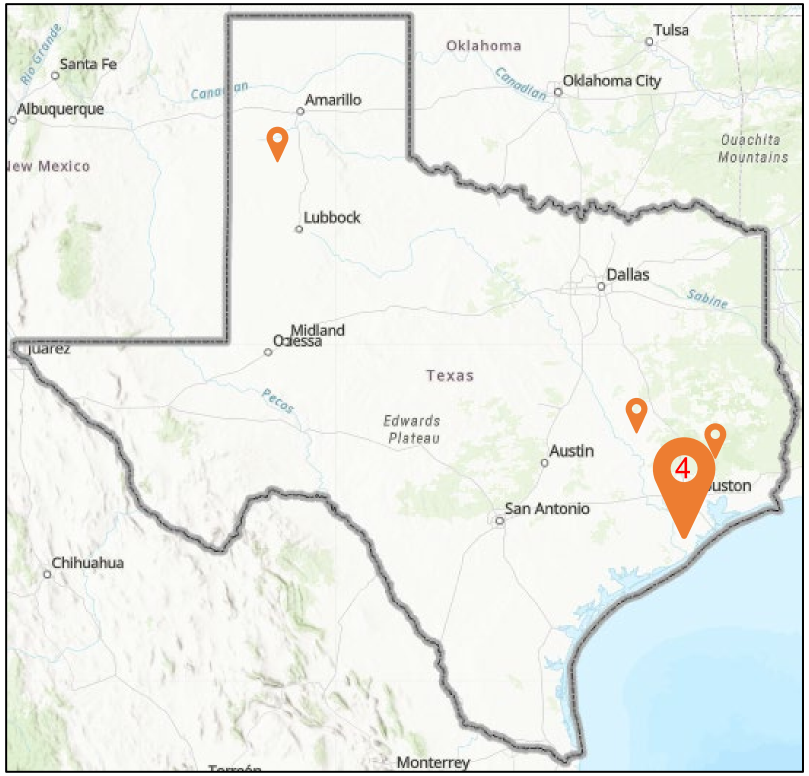
Sample Location	Depth (ft)	Benzene (mg/kg)	Total Xylene (mg/kg)	Naphthalene (mg/kg)
SB-9	13-14	0.00837	9.76	
	14-15	0.144	253	
SB-10	13-14	0.128	123	
	14-12	0.939	158	
SB-11	12-13	0.176	105	
	14-15	3.27	407	
SB-12	13-14	0.0717	24.6	
	14-15	0.256	75.8	15.3
Plan B Target Levels (Health-Based)				
	Residential	14.22	3,747	
	Commercial/Industrial	22.97	20,860	
	Construction Worker	53.9	466	25.4

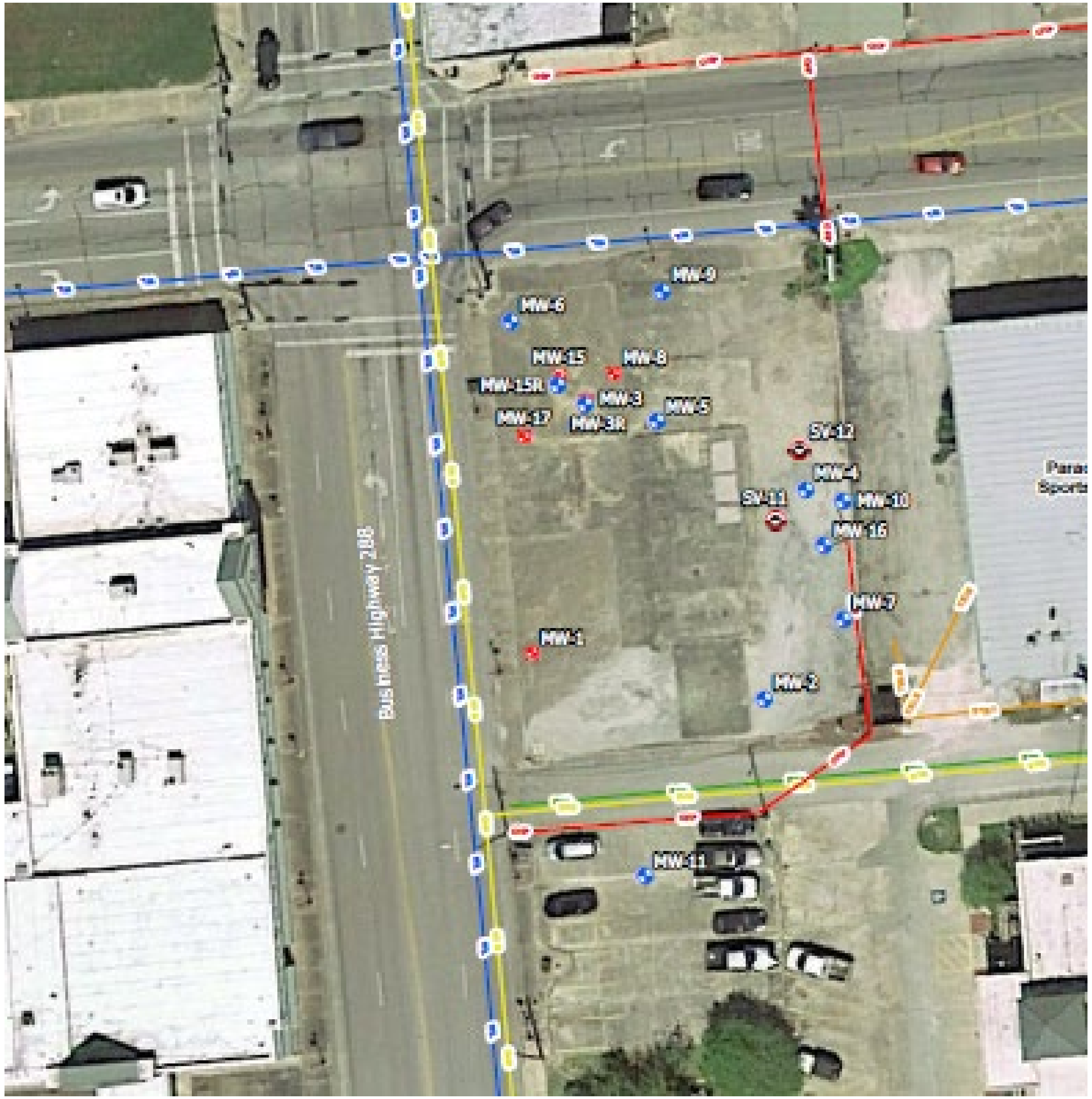
Case Study 3 Takeaways

- Calculate site-specific target levels if Plan A exceedances
- Collect confirmatory samples
- Consider addressing soil pathways earlier

Case Study 4

Angleton, Texas





Case Study 4 Background

Former UST facility
USTs removed in 1990 (release discovered)
Vacant with no buildings
Commercial/industrial use
No continuous impervious cover

Predominant soil types: sandy clay, sand
Depth to groundwater: 5 to 8' bgs
Gulf Coast Aquifer

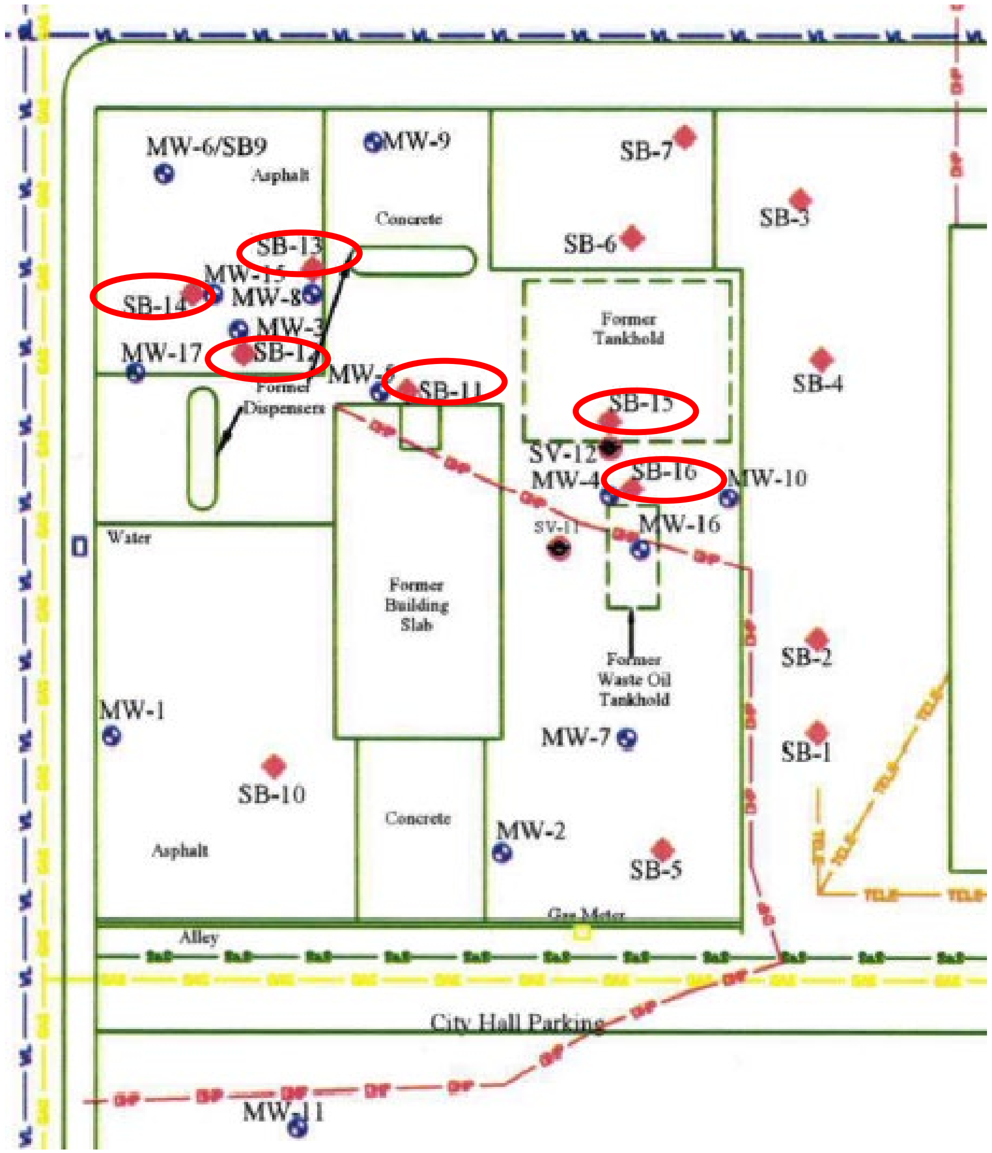
Potential receptors: 3 irrigation wells located 0.25-0.5' mi from site

By 2018, all exposure pathways addressed except SOIL

- Commercial/industrial (C/I) health-based
- Construction worker (CW) health-based

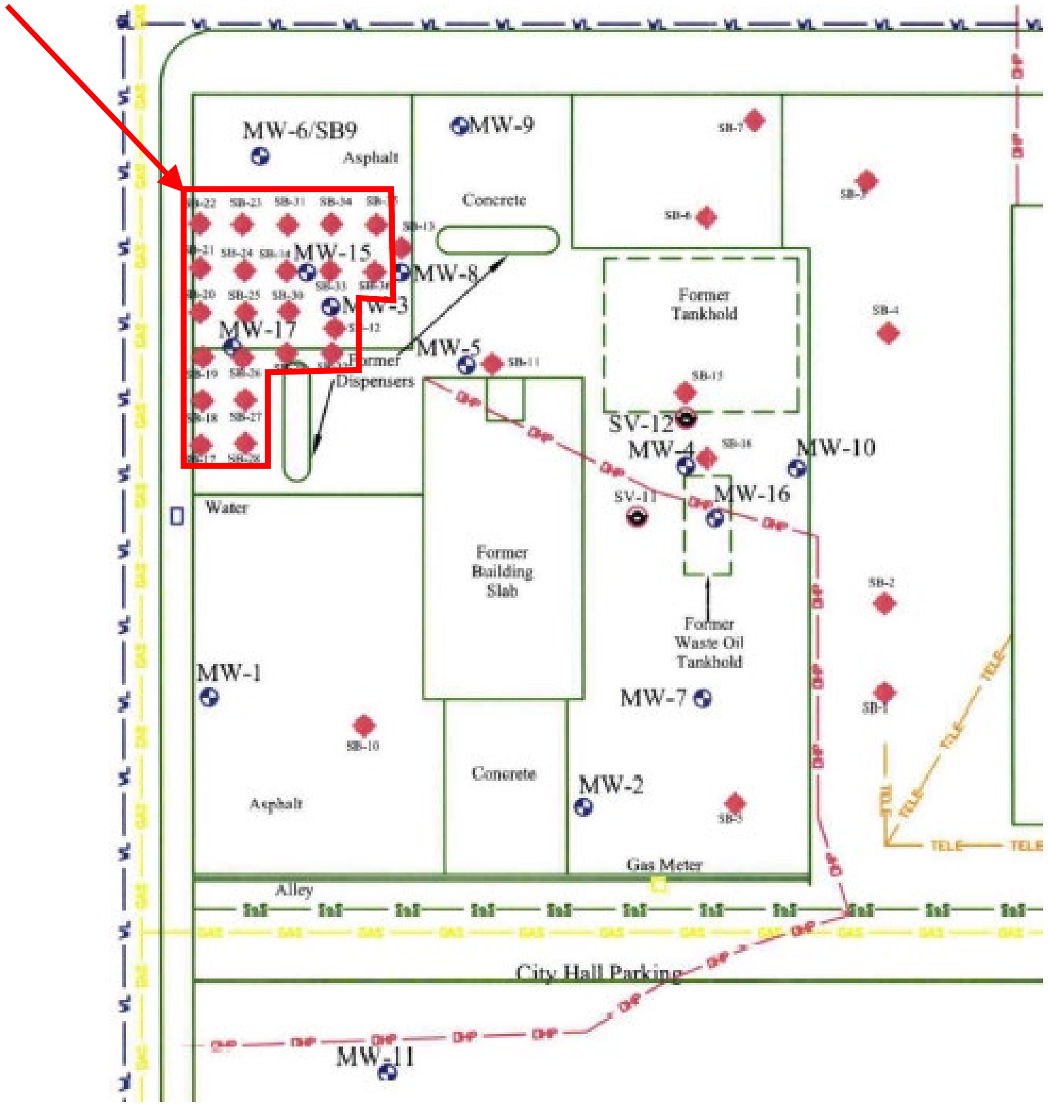
Need for Excavation

- Dec 2018: 18 soil samples from 6 borings
  - Drilled next to select monitoring wells
- Findings
  - Benzene > C/I & CW health-based target levels in most samples
  - High TPH in some borings (potentially indicating LNAPL)



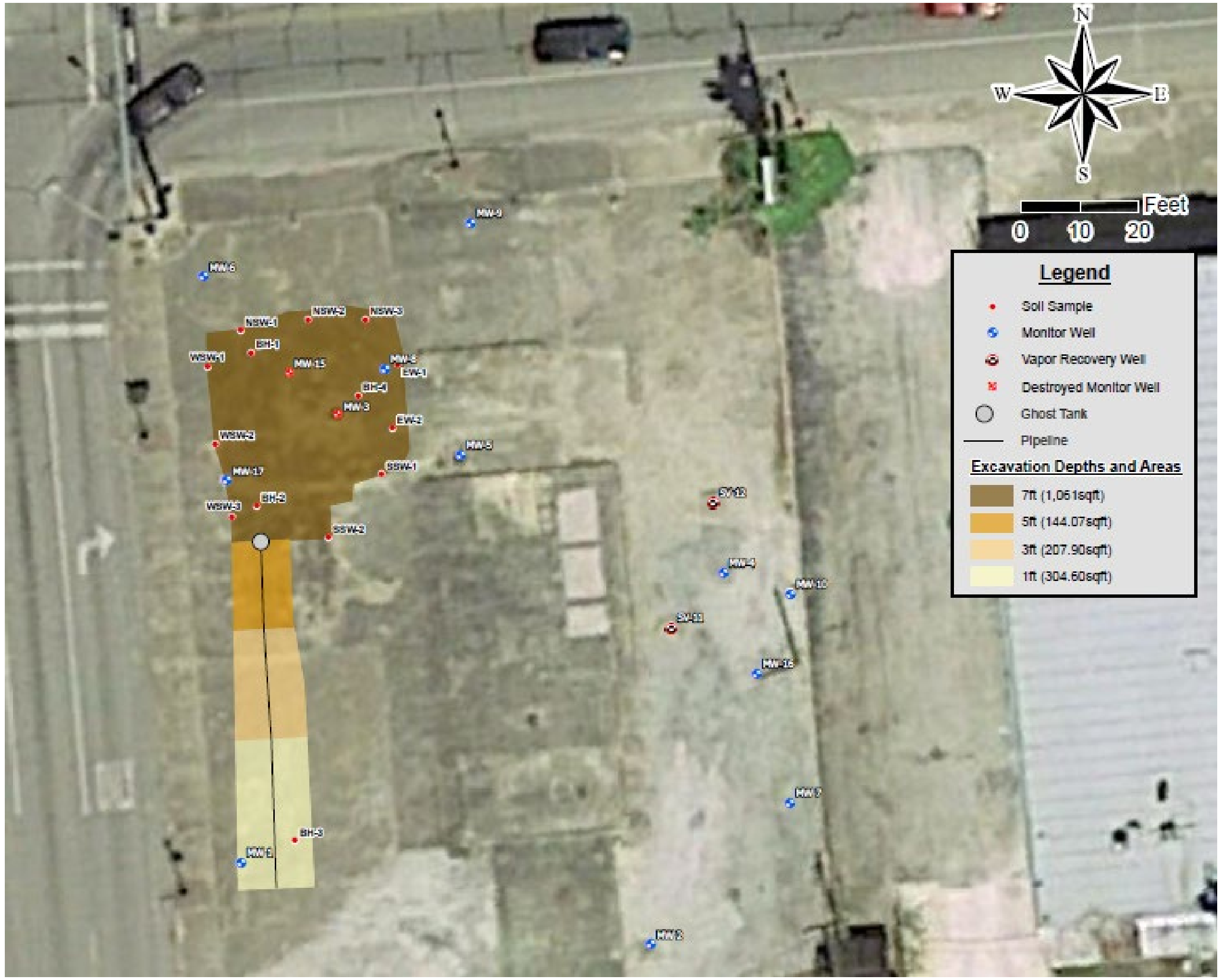
Excavation Extent

- Aug 2019: 57 soil samples from 20 borings
  - Drilled in grid pattern ~8' apart
- Similar findings as Dec 2018
- COC data used to inform excavation extent laterally and vertically



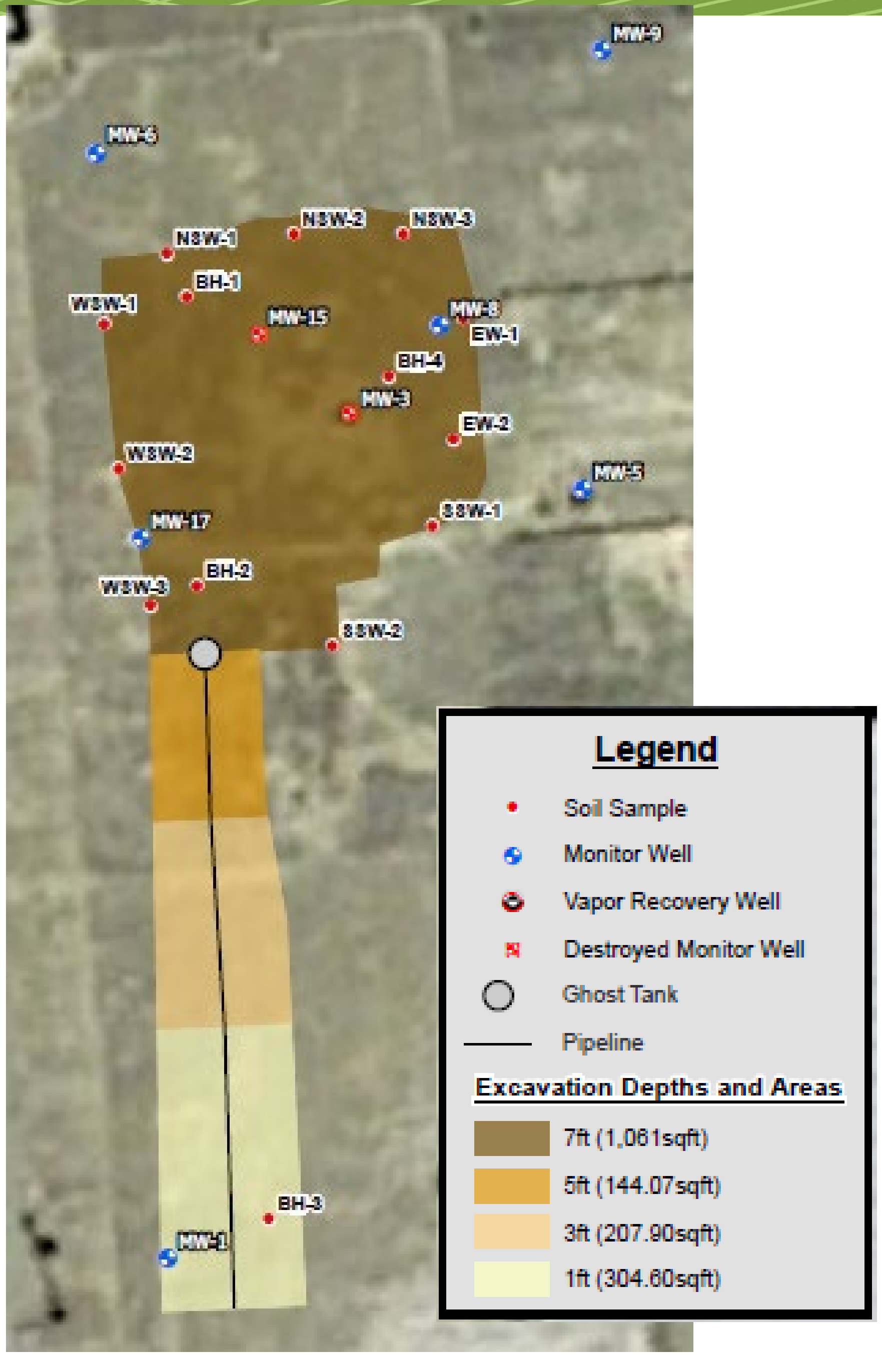
Excavation and Chemical Treatment

- Excavation
  - 1,890 square feet; 336 cubic yards
  - Depths ranging from 1 to 7’ bgs
  - 500 gallon UST found during excavation
- Chemical treatment of excavated soil
  - Sodium hydroxide solution
  - Chemical surfactant and sodium persulfate solution
- PID used prior to and following chemical treatment



Confirmation Samples

- Confirmation soil samples collected during excavation and chemical treatment process
  - 10 sidewall, 4 bottom hole, and 7 stockpile samples



Site Restoration and Follow-Up

- Site restoration
  - Backfilled with treated soils, following receipt of lab results
  - Impervious cover replaced
- Groundwater monitoring event in May 2023
  - Decreasing groundwater COCs with distance from source
  - Groundwater delineated to target levels protective of receptors
- Final closure letter issued July 2023

Case Study 4 Takeaways

- Consider addressing soil pathways sooner
- Define lateral and vertical extent of excavation by grid sampling
- Treat and backfill with excavated soils to reduce costs
- Follow-up with groundwater sampling for additional line of evidence

Summary

Challenging LPST cases

- Re-evaluate remedial technologies and/or risk
- Case studies showed benefits of
  - Use of data analysis tools to understand site
  - Quantifying natural attenuation rates to guide decisions
  - Calculation of site-specific soil target levels
  - Reduction of contaminants in source area

Case studies presented for demonstrative purposes only

- Discuss specifics with TCEQ Project Manager for your site

Questions?

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