

Lessons Learned from Combined Injection and Groundwater Recirculation Trench Pilot Test

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Safety Moment (Lessons Learned)

If it looks, sounds, and smells like construction...

Treat it as a construction project!

- Vibration, Noise, Air Monitoring
- Clean fill testing
- Safety: EM 385-1-1
- HAZOP-type analysis
- Activity Hazard Analyses
- Construction oversight



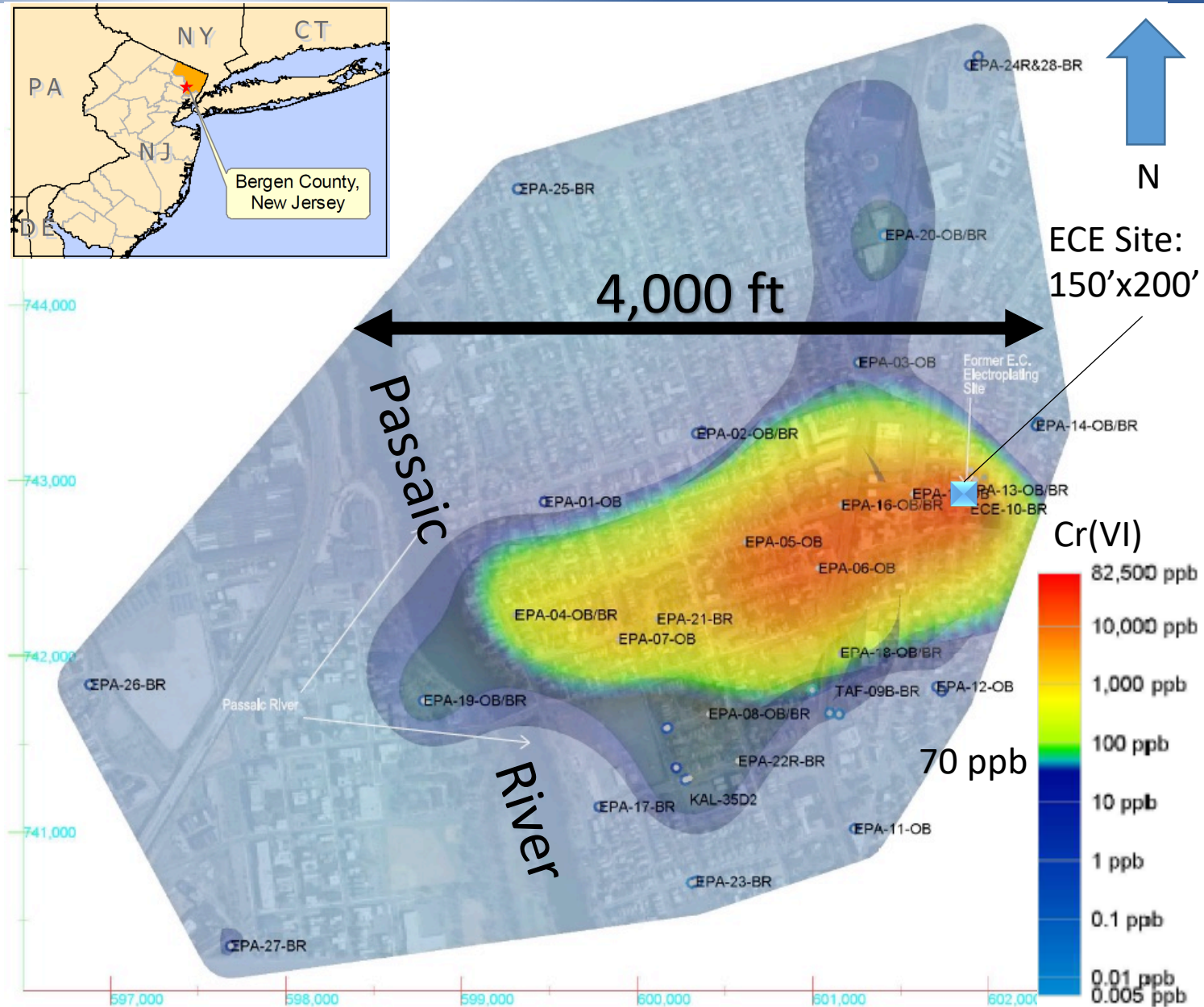
Agenda

- Site History
- PDI/Pilot Study
- Interim Results
- Lessons Learned
- Summary

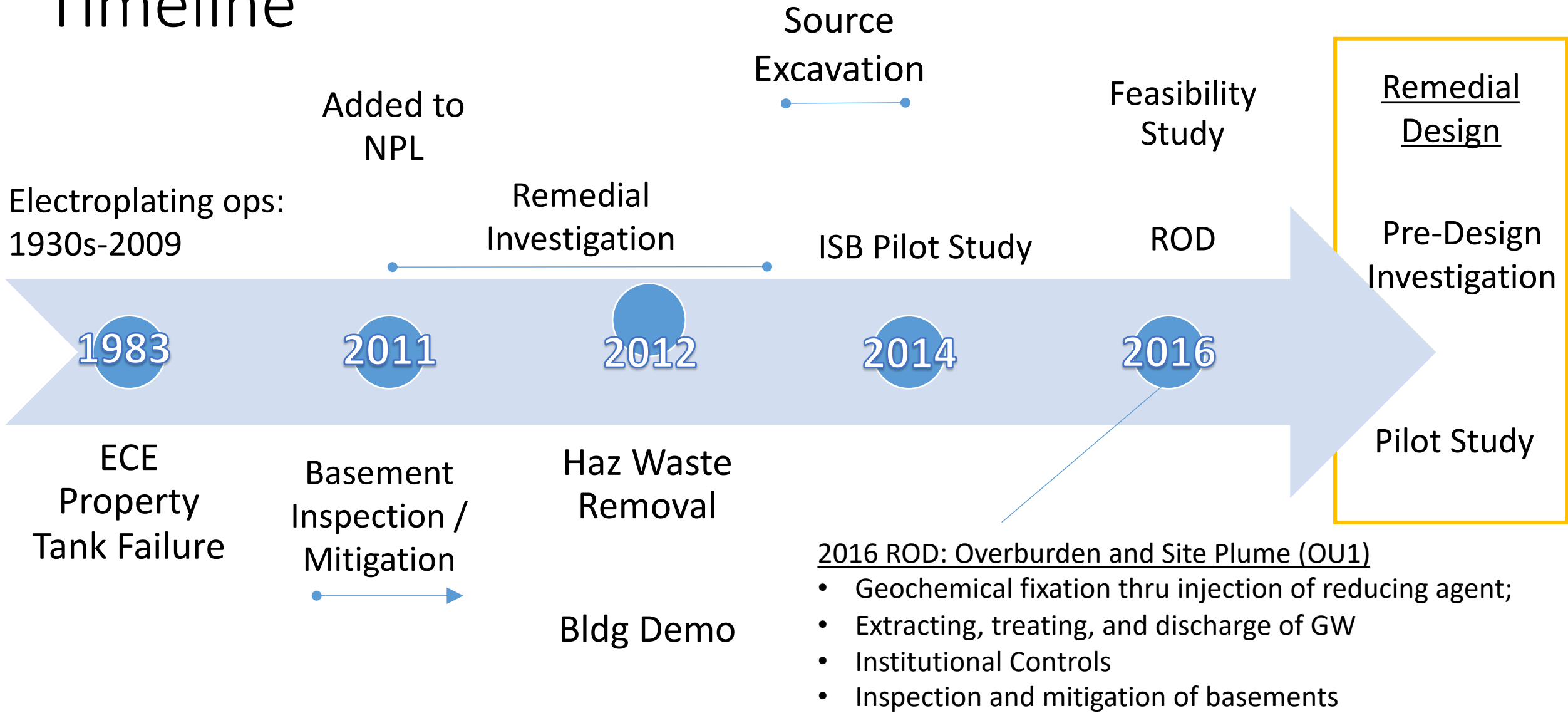


Site History

- Former Electroplating facility
- Chromic acid spills:
 - Mass under buildings
 - Migration to bedrock
 - Large GW Plume
 - Infiltration of basements



Timeline



2016 ROD: Overburden and Site Plume (OU1)

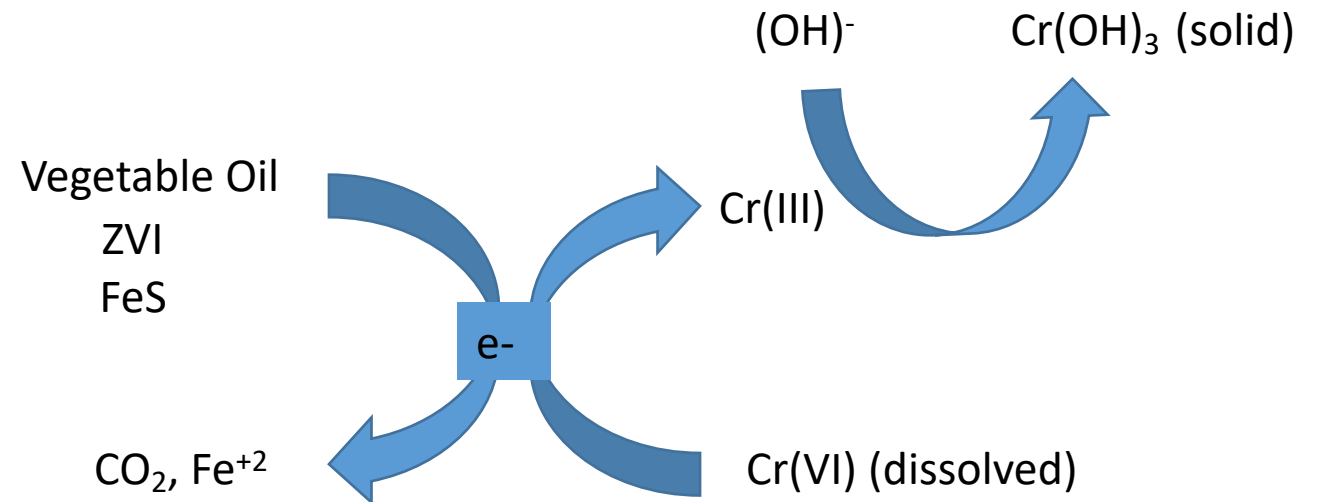
- Geochemical fixation thru injection of reducing agent;
- Extracting, treating, and discharge of GW
- Institutional Controls
- Inspection and mitigation of basements

Remedial Design Timeline

- Pre-Design Investigation Activities (PDI)
 - Nov 2017- Mar 2018: Well Install, sampling to refine the source extent
 - Oct 2018: Injections
 - Oct-May 2018: Injection Performance Monitoring
 - May 2019: ZVI Trench Installation
 - July 2019: ZVI Trench Startup
 - June 2020: ZVI Trench Shutdown
 - July 2020: Installation of 4 new monitoring wells
 - Sept 2020: Last performance monitoring event
- Design underway: 2020 through 2021

Chromium Treatment

- Reduce Cr(VI) to Cr(III) thru
 - Biologically supplied electrons
 - Iron oxides (ZVI)
 - Iron sulfides
- Cr(III) precipitates



Goal: Total Chromium < 70 ug/L

Pre-Design Investigation

Pre-Design Investigation

13 new monitoring wells

Baseline Sampling Event

Step Testing – 6 wells

1 offsite well

4 new wells

Pilot Study

21 Injection Wells
(20' on center)

Reagents: EVO, lactate, MicroZVI, NaOH, bromide tracer, ~30% pore volume

ZVI Trench: 44'x5'x15'
Ops: ~11 months

3 extraction wells, 1-2 gpm each

Monitoring Events (~14):
Metals, geochemistry, WLs



- ◆ Bedrock Monitoring Well
- ◆ Excavation Fill Monitoring Well
- ▼ Injection Well (EVO with Lactate + Buffer)
- ▼ Injection Well (EVO with Lactate + MicroZVI)
- ▲ Overburden Extraction Well
- ◆ Overburden Monitoring Well
- ★ Soil Gas Monitoring Point
- ZVI Trench Piezometer

Operations Summary

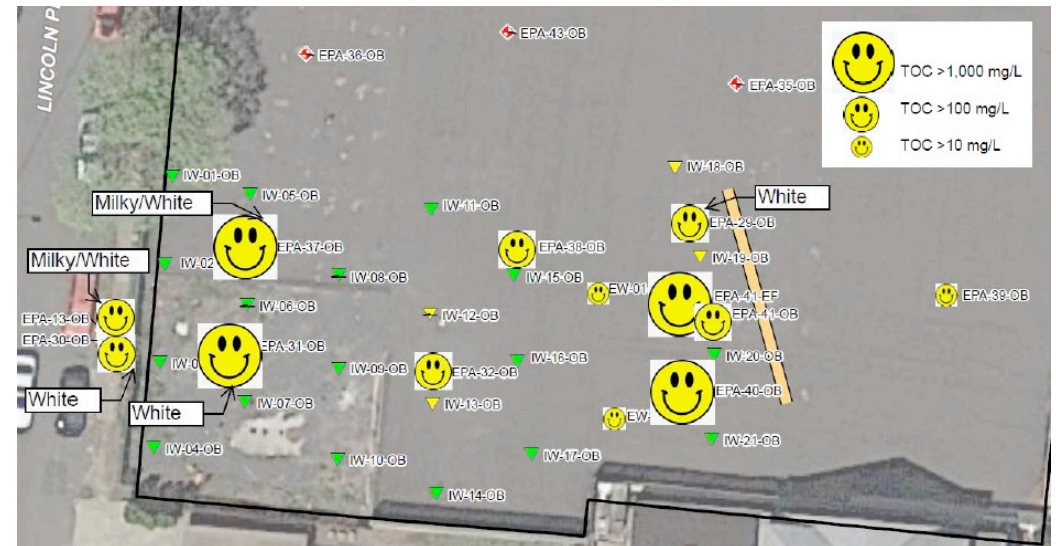
Injections

Let's do the numbers...

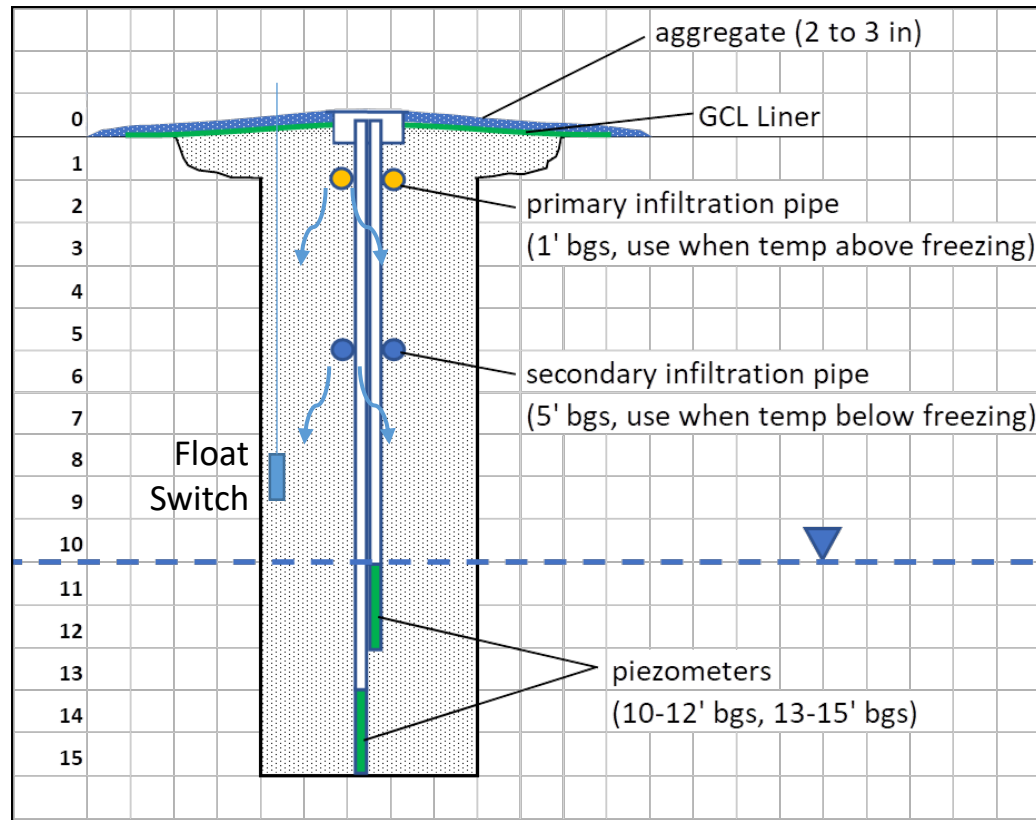
	Total (Per Well)	Design Basis
Volume (gal)	48,000 (2,200)	30% pore volume
Microscale ZVI (lbs)	1,500 (375)	0.3 lb / lb of EVO 4 wells
EVO (gal)	3,300 (160)	6.9% by vol 21 wells
Lactate (gal)	420 (20)	0.9% by vol 21 wells
NaOH (gal)	510 (10-52)	17 wells Step-wise
Bromide tracer	120 lbs (24 lbs)	5 wells, front end slug 1,000 mg/L ave. /440 g/L

Observations:

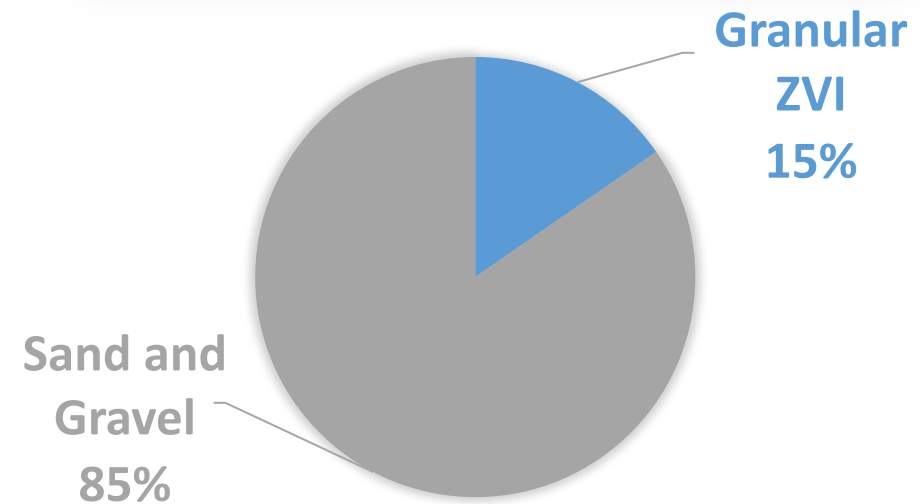
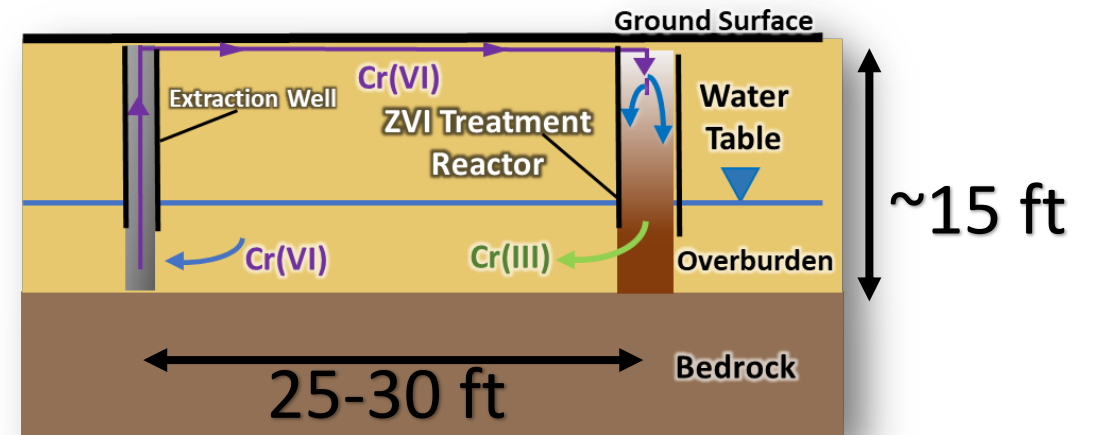
- Generally good distribution - lines of evidence: Br, TOC, diss iron, visual, mounding
- NaOH use 23% of predicted by soil titration test -> step-wise introduction
- Radius of Influence: 10-20 ft



ZVI Trench Design



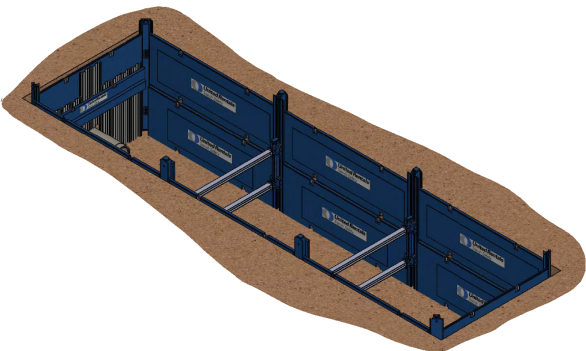
Conceptual x-section



Design Hydraulic Residence Time: ~ 50 minutes

Construction Lessons Learned

- Trench Installation Method Revised
 - Trench box unsuccessful in saturated soils
 - Custom Slide Rail system added time, but...
 - No dewatering (GW = haz waste)
 - No upwelling of soils or bowing of sides
 - No vibrational impacts 20-25' ft from slide rail
- Trench was 3 ft shallower than expected
 - Why??



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Treat it like construction!*



Trench Box

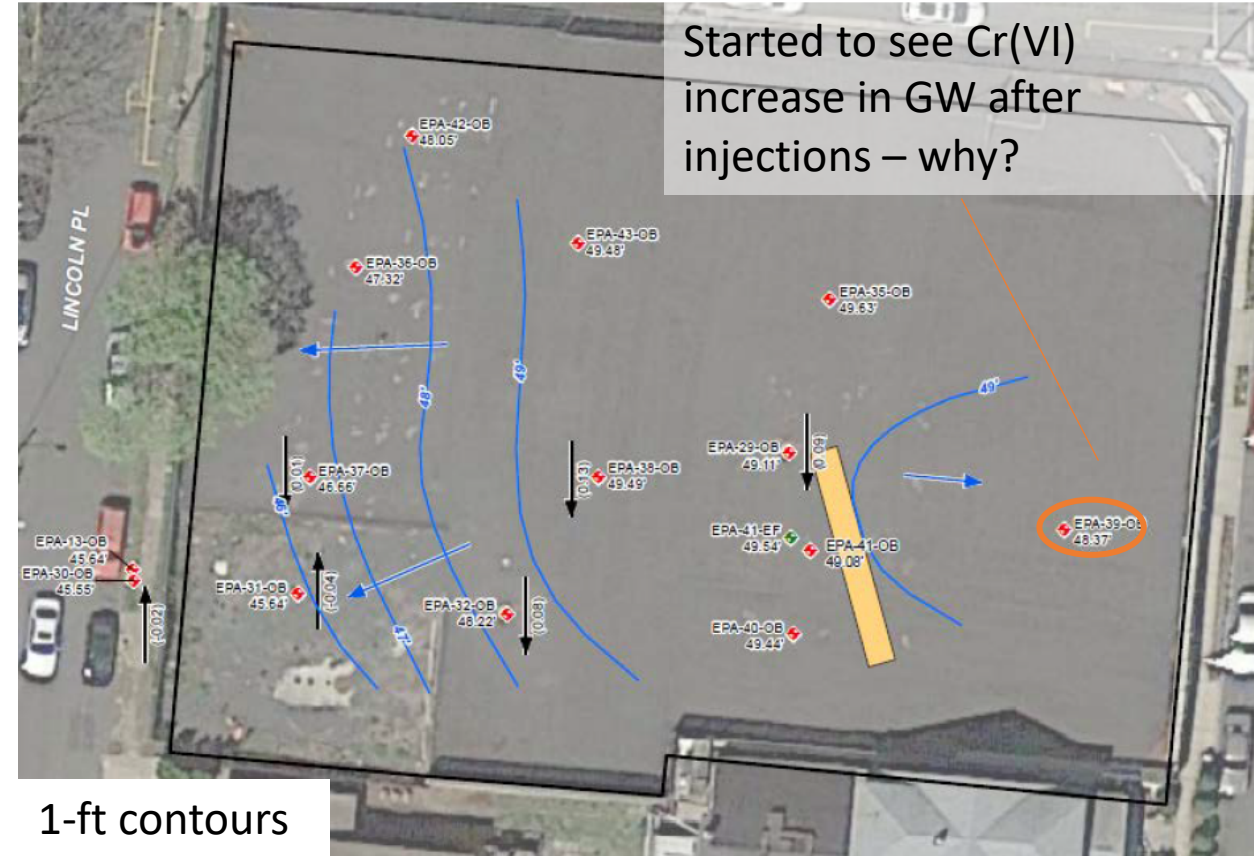
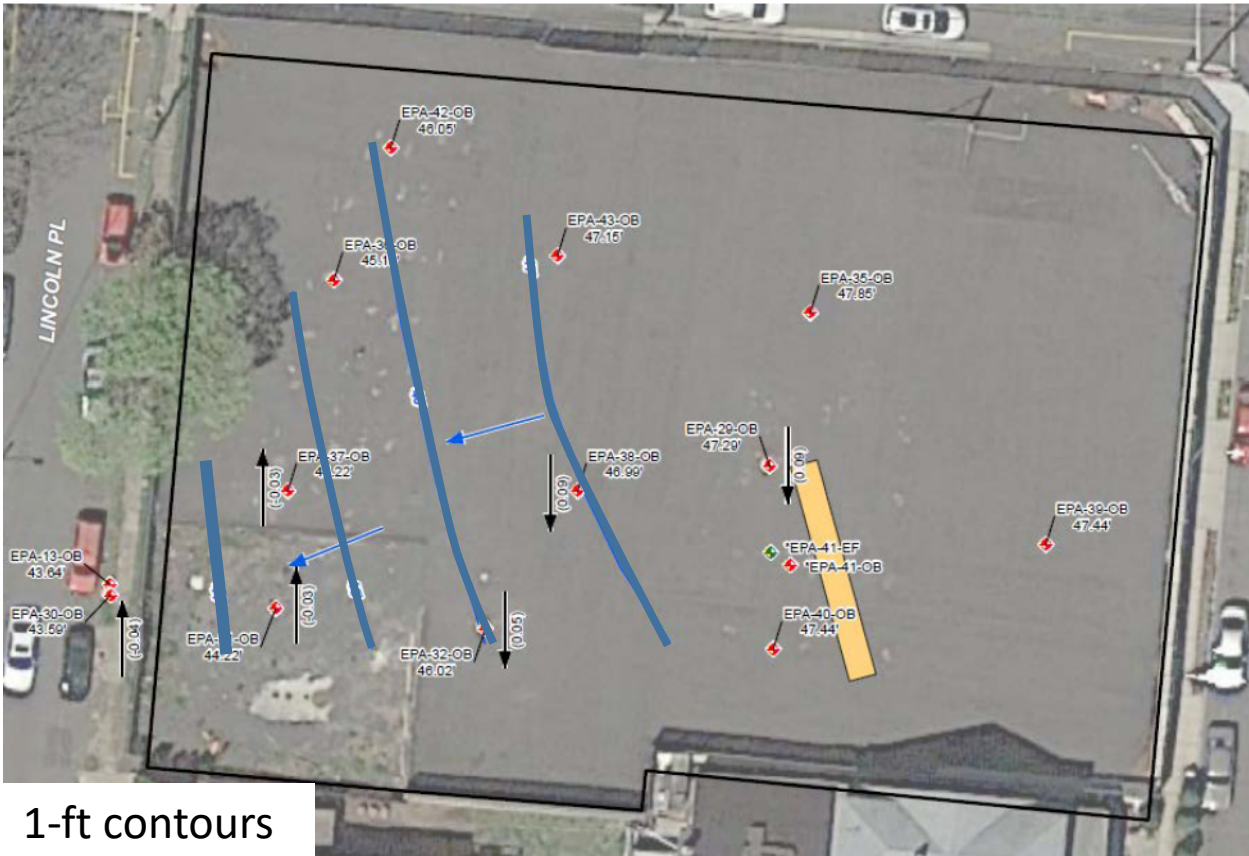


Slide Rail System

Groundwater Elevation – Overburden

Pre-Injection, Pre-ZVI Trench
Mar 2018

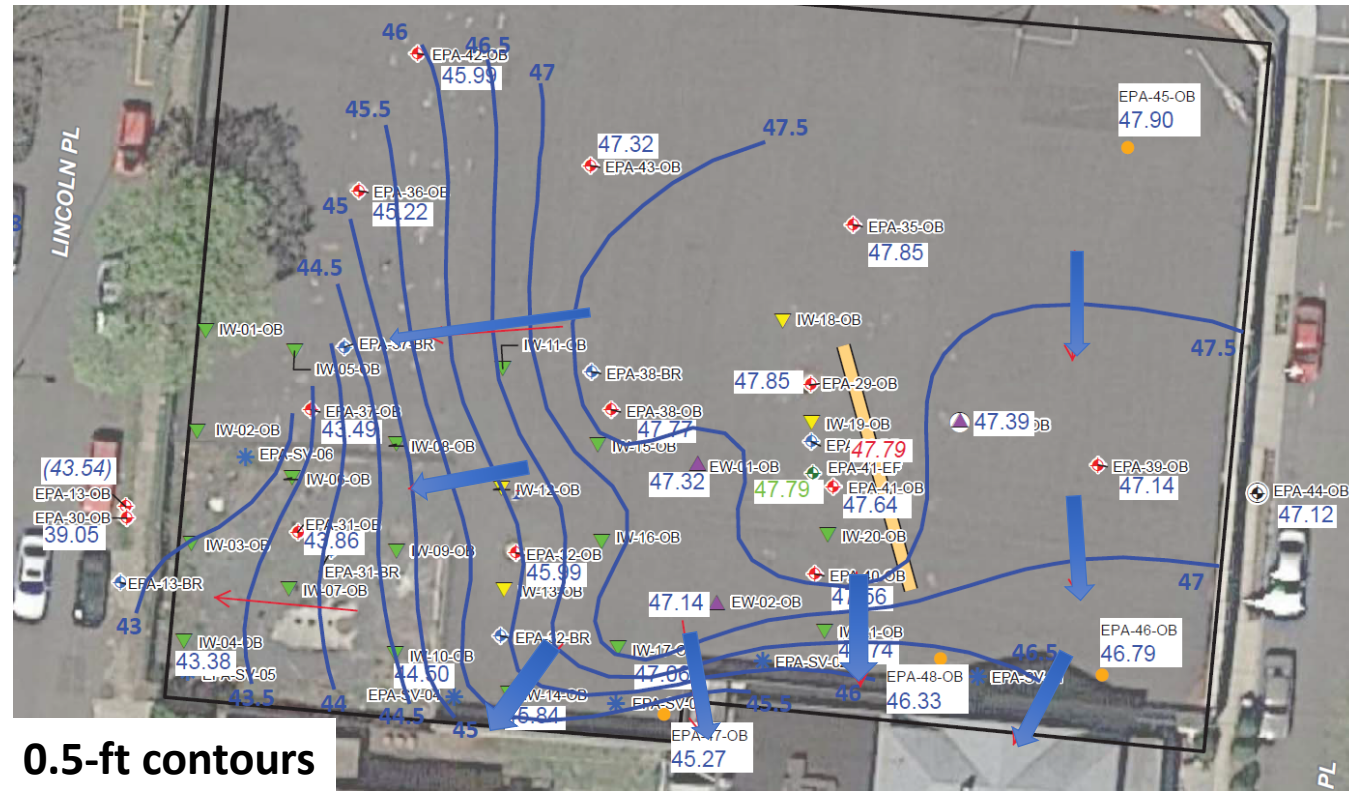
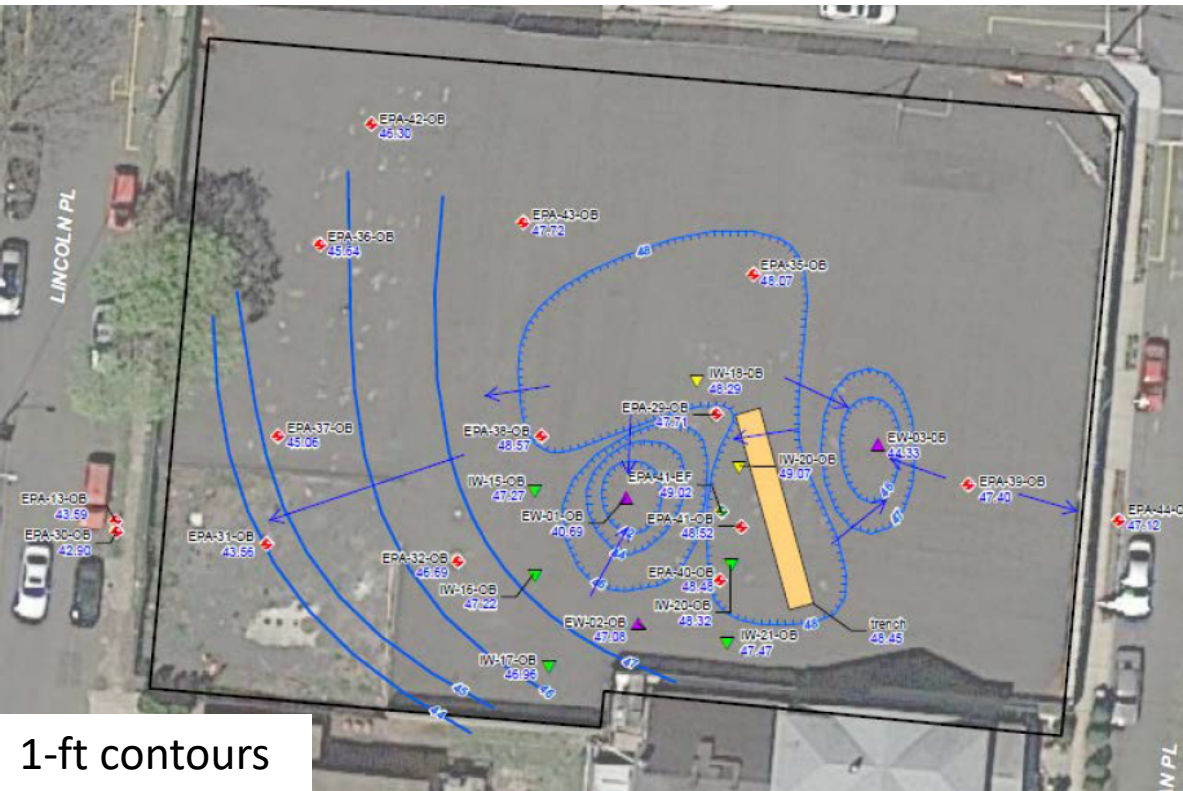
~5 months after Injections, Pre-ZVI Trench
Mar 2019



Groundwater Elevation – Overburden, cont'd

Post-ZVI Trench Install, 7 months of ops
Feb 2020

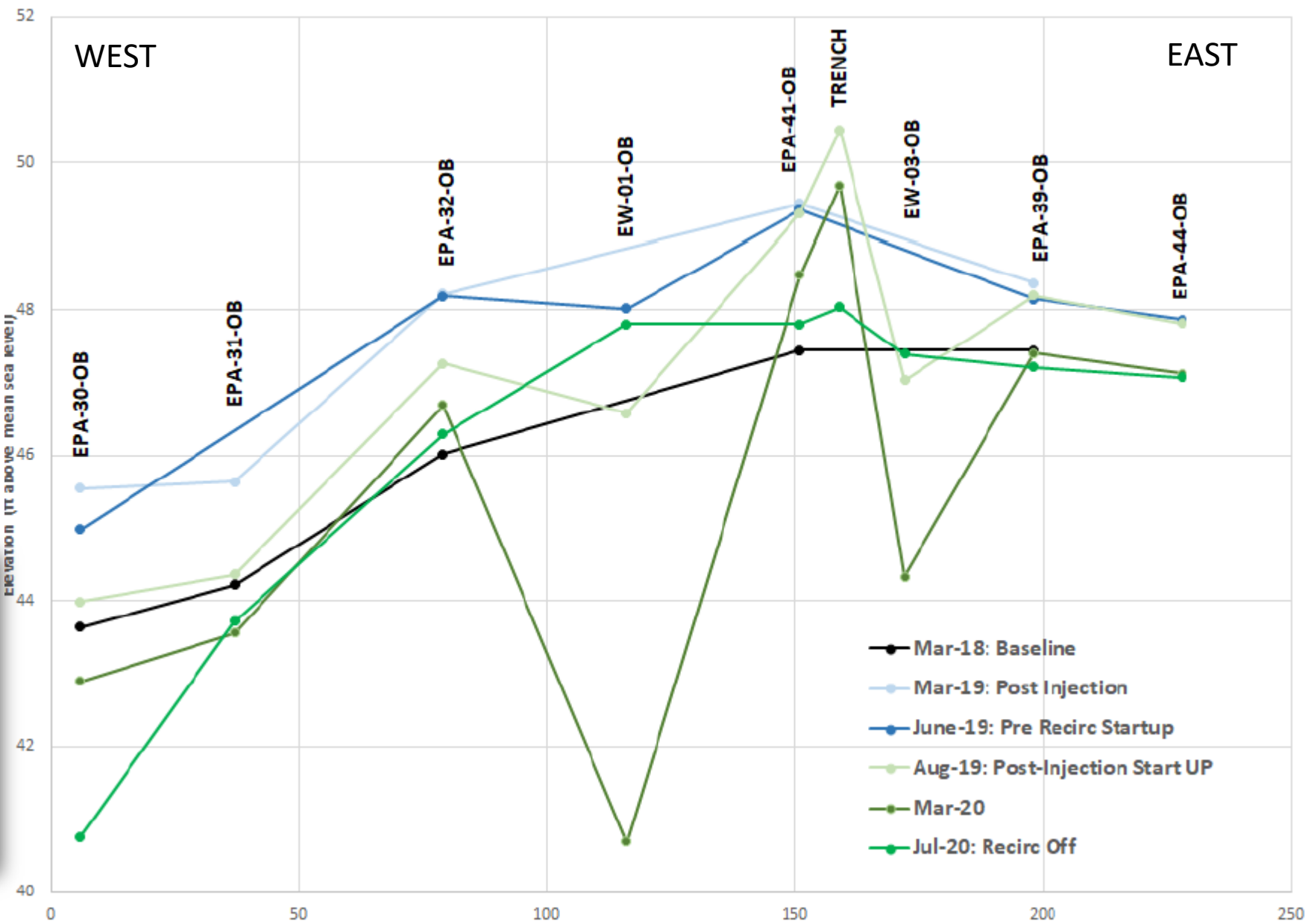
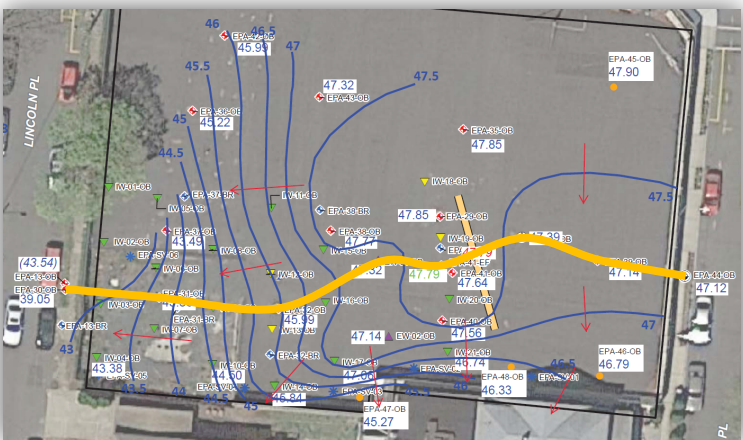
After ZVI Trench Shutdown + new wells
Aug 2020



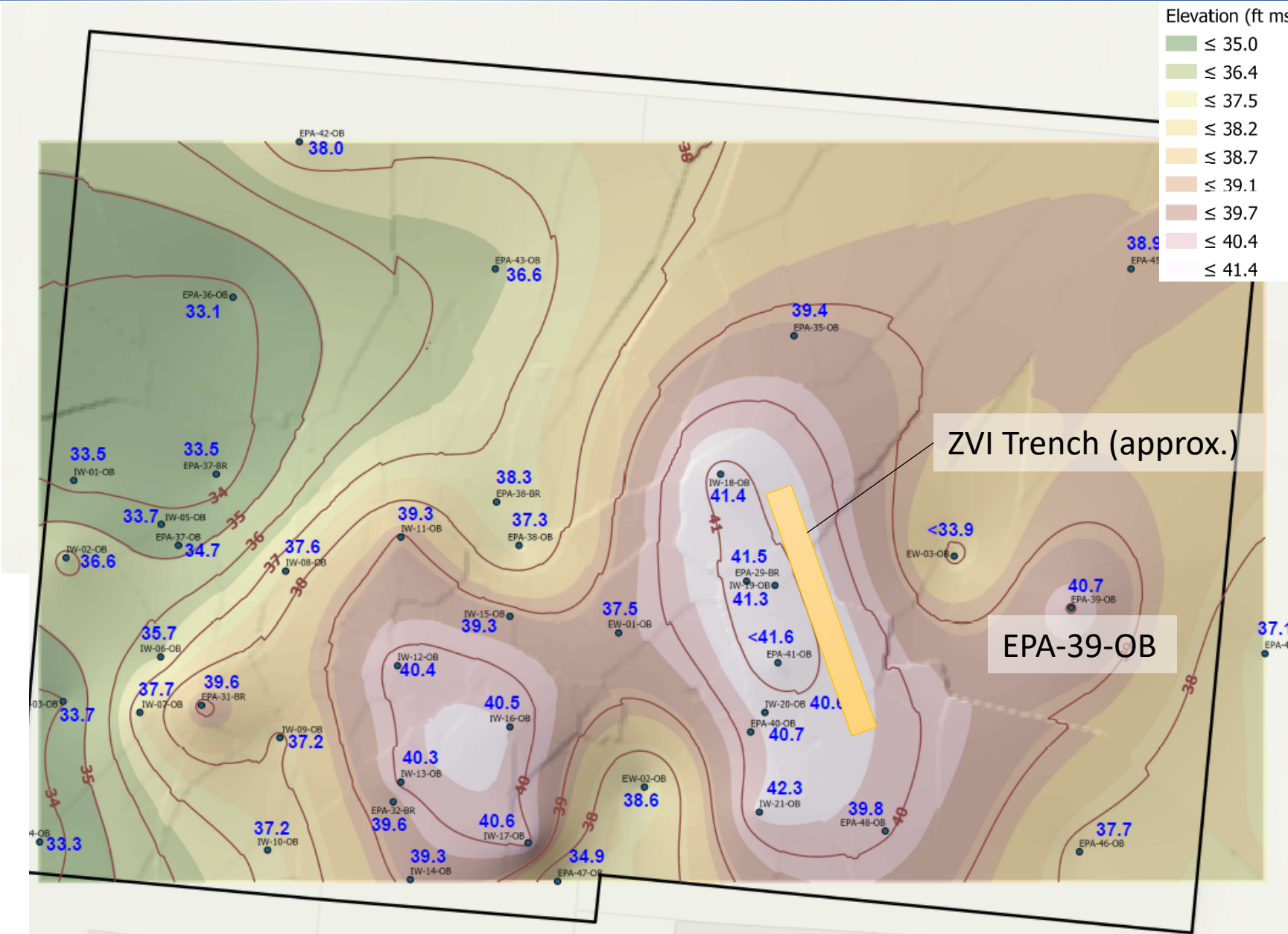
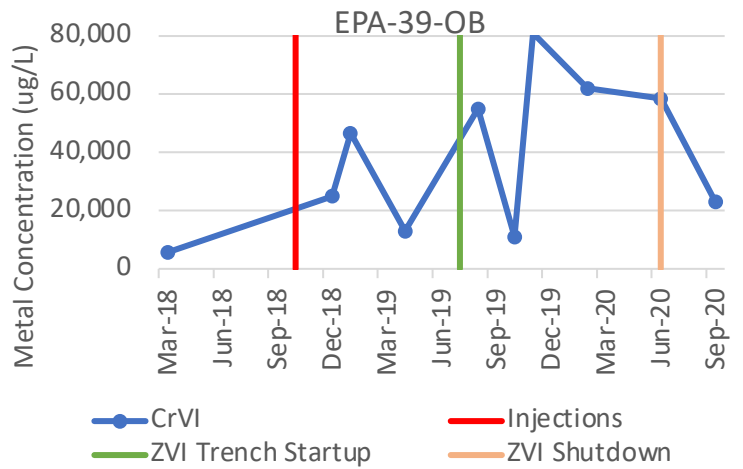
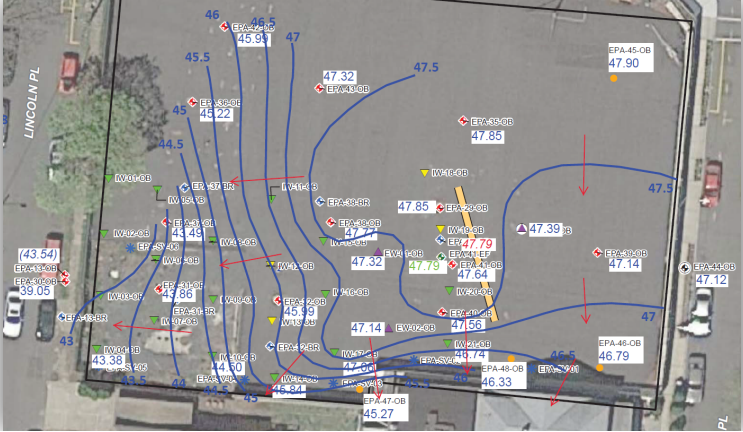
1-ft contours

0.5-ft contours

Groundwater Elevation Profile



Bedrock Surface Map



Operations Summary

ZVI Trench

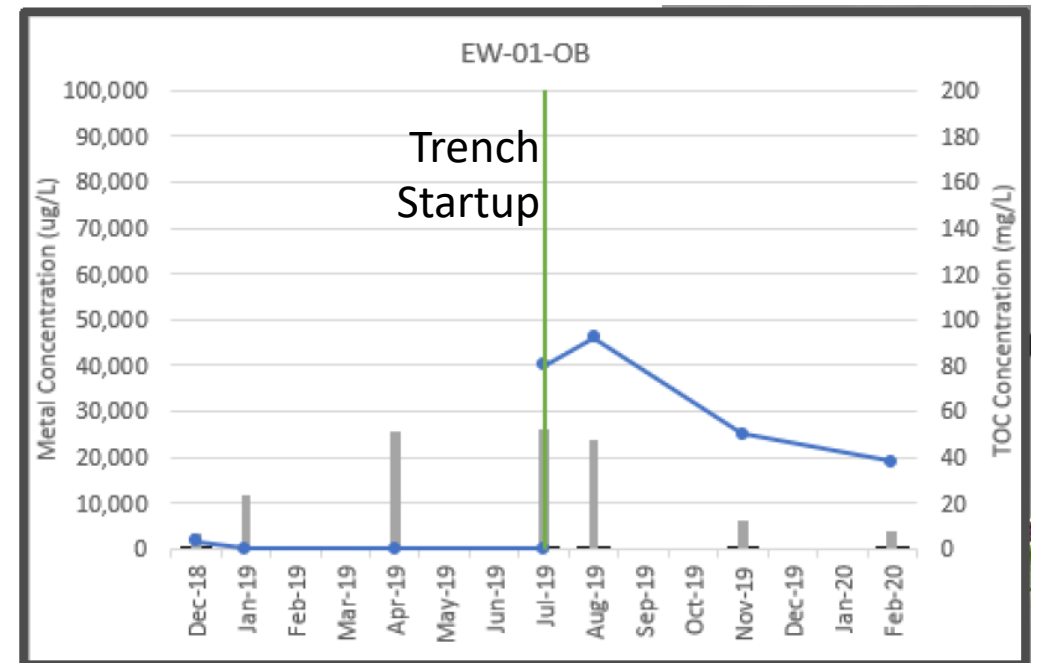
Data through Mar 2020

Location	Flow Rate (gpm)	Total Gal	Mass Extracted (grams)	Max concentration (ug/L)
EW-1	0.3-1.7	107,000	8,000	~45,000
EW-2	0.2-2.2	85,000	16,000	~60,000
EW-3	0.2-1.7	87,000	19,000	~80,000
Trench		279,000	43,000	

~ 20 lbs

Estimated 2-2.5 pore flushes over 8 months of ops

EW-3 Pump

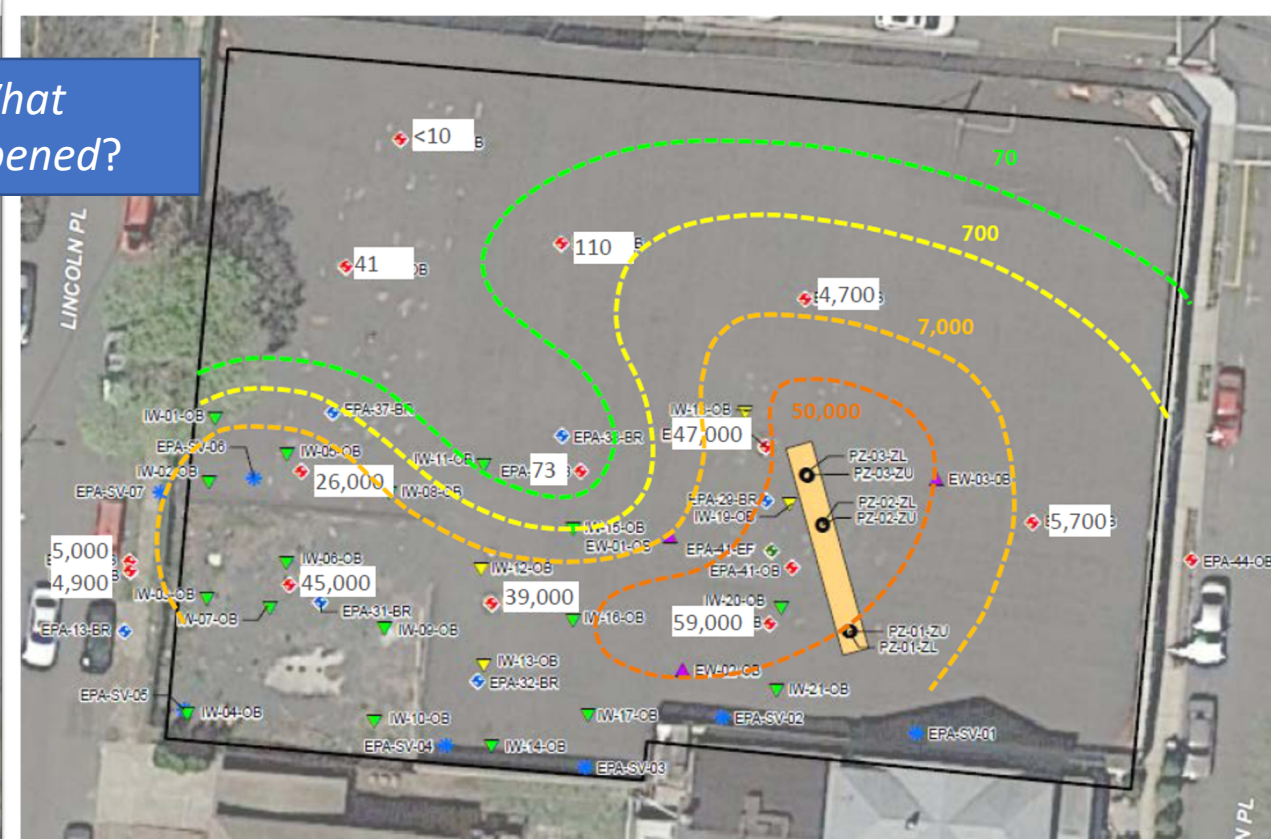
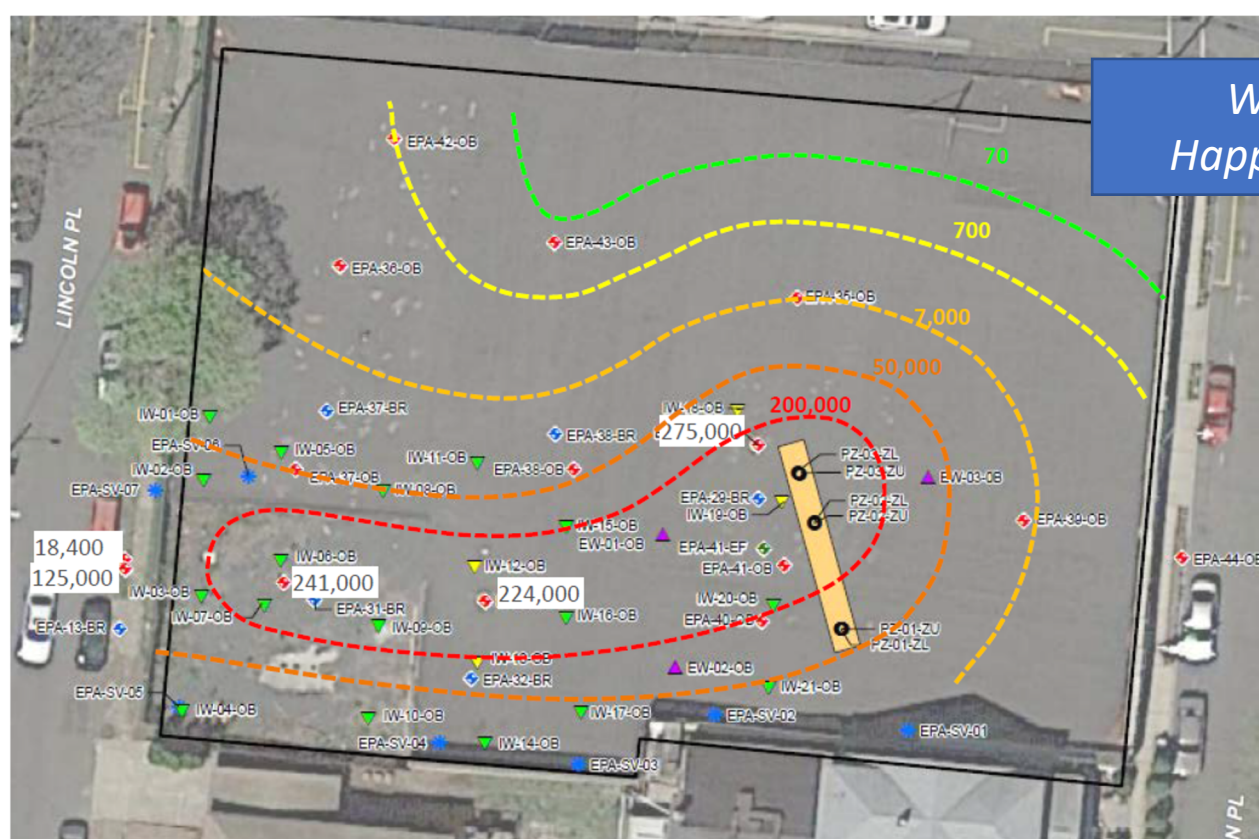


Prelim Sept 2020: <10 ug/L

Cr(VI) Overburden Plume

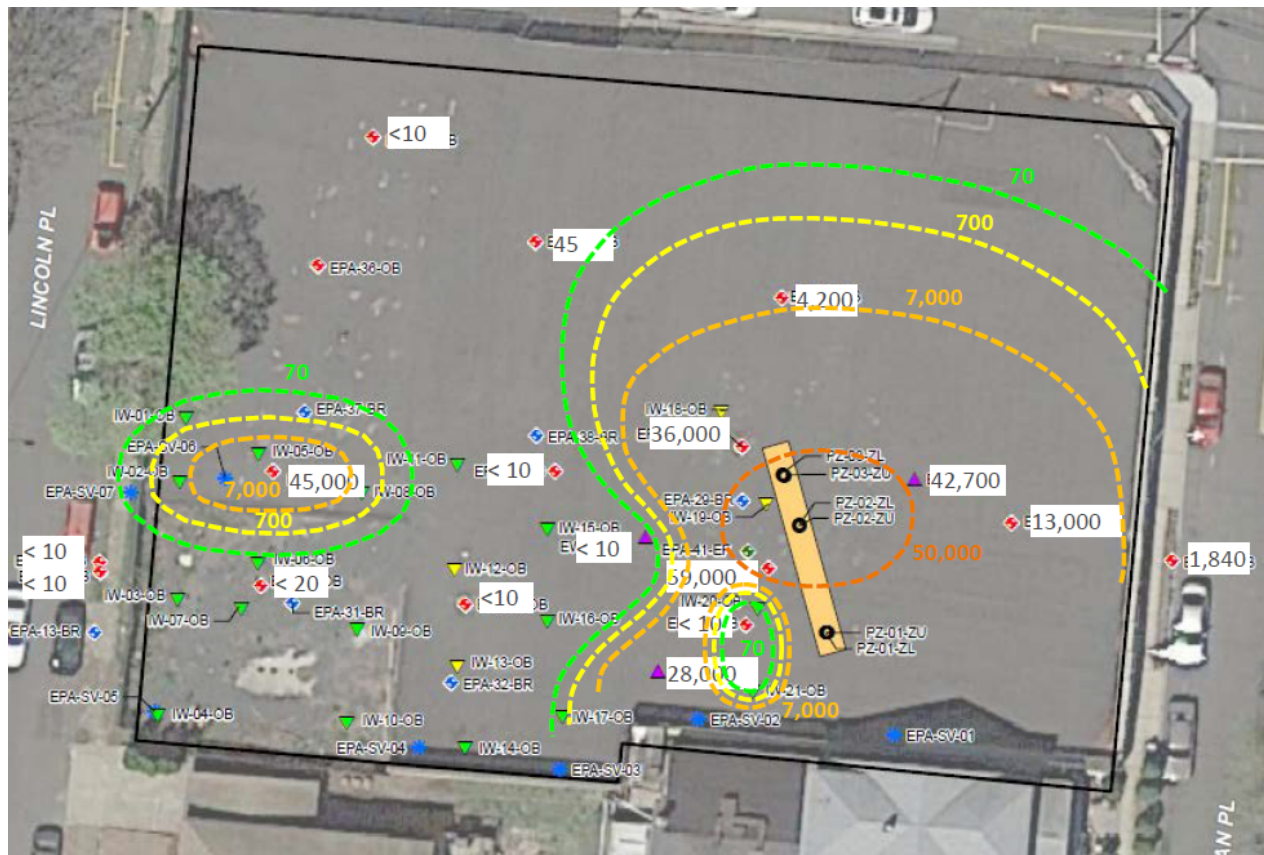
Cr(VI) Overburden Plume – Baseline 2014

Cr(VI) Overburden Plume – Mar 2018
Pre-Injection, Pre-ZVI Trench Baseline

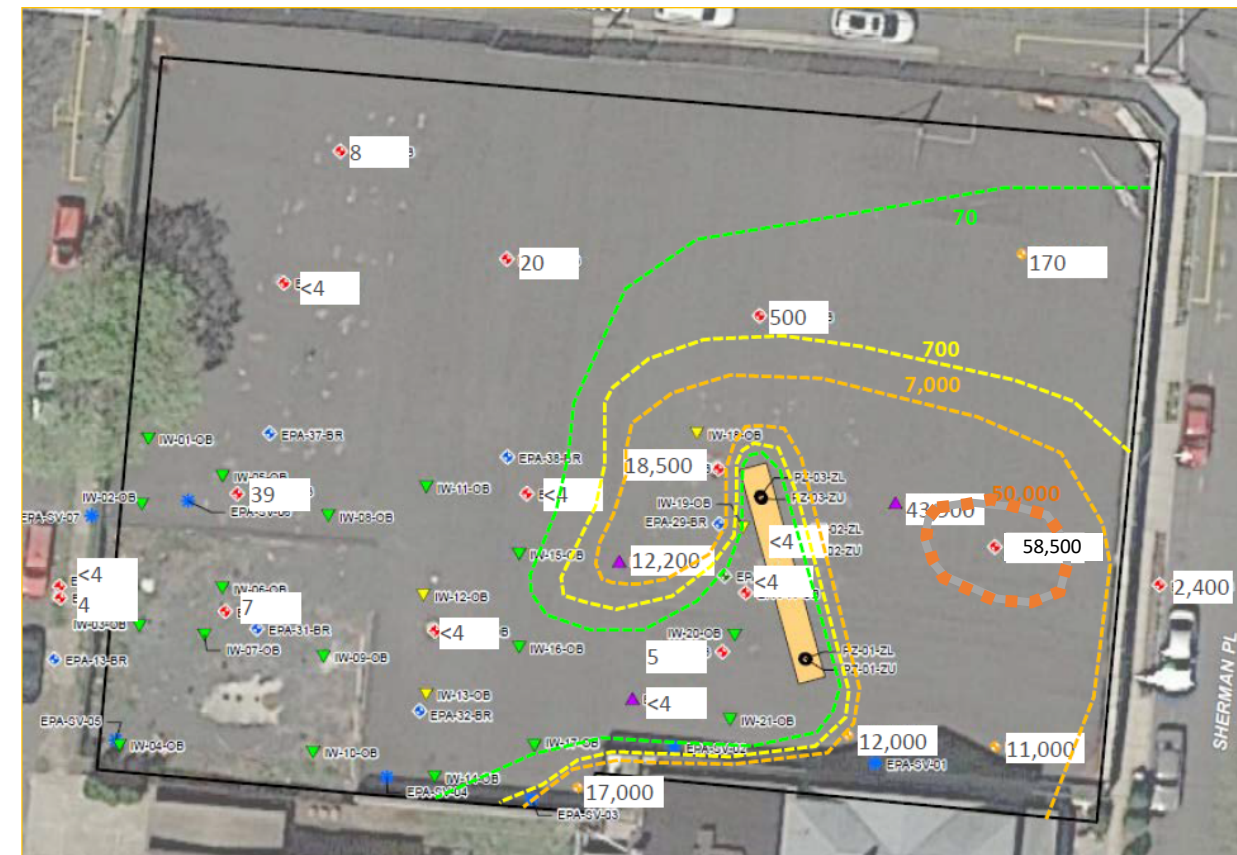


Cr(VI) Overburden Plume, cont'd

Cr(VI) Overburden Plume – Apr 2019
Post-Injection (~7-months)



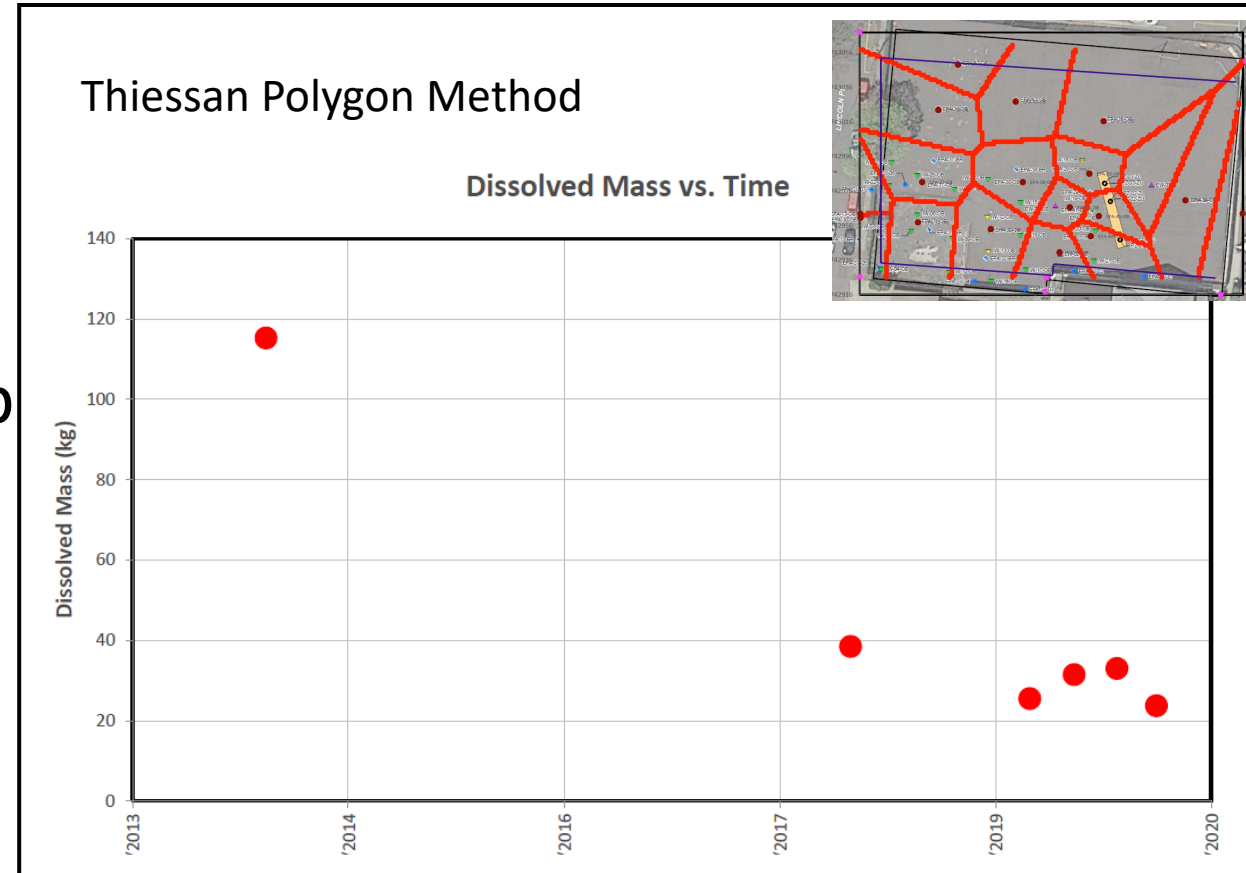
Cr(VI) Overburden Plume – June/July 2020
Post-Injection (~22-mo) + Recirc Trench (~10 months)



Mass Reduction

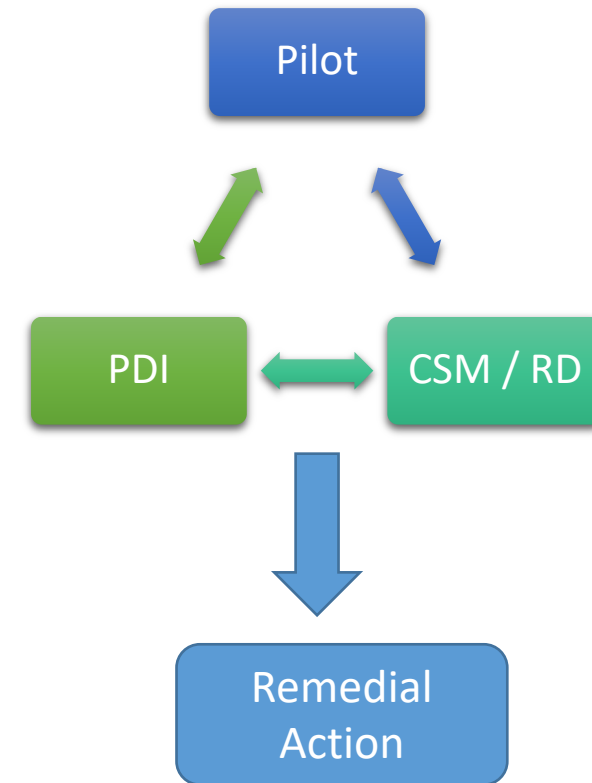
Dissolved Phase

- Cr(VI) reduced by 80% since 2014
- Temporary increase after ZVI Startup
- Center of mass shifted to east (EPA-39-OB)
- Limited effect on shallow bedrock
- Significant reducing capacity on western half of site may limit mass flux for years



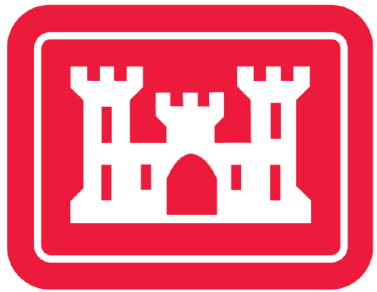
Summary

- Significant reduction of Cr(VI) onsite since 2014, particularly on western half
- Bedrock surface map and extra wells revealed portion of onsite groundwater flows to the south
- Construction mindset needed regardless of phase of work
- Flexibility to adjust PDI/Pilot crucial for this project
- Lessons Learned contributed to a much stronger basis of design and more effective and informed remedial action





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