

ADEQ Experience with Remediation of PCE Plume Using *In Situ* Micro-Diffusion Ozone Treatment

East Central Phoenix –
24th Street and Grand Canal
Phoenix, AZ

Date: June 4, 2024

Presenter: Mikel Morales



Clean Air, Safe Water,
Healthy Land for Everyone



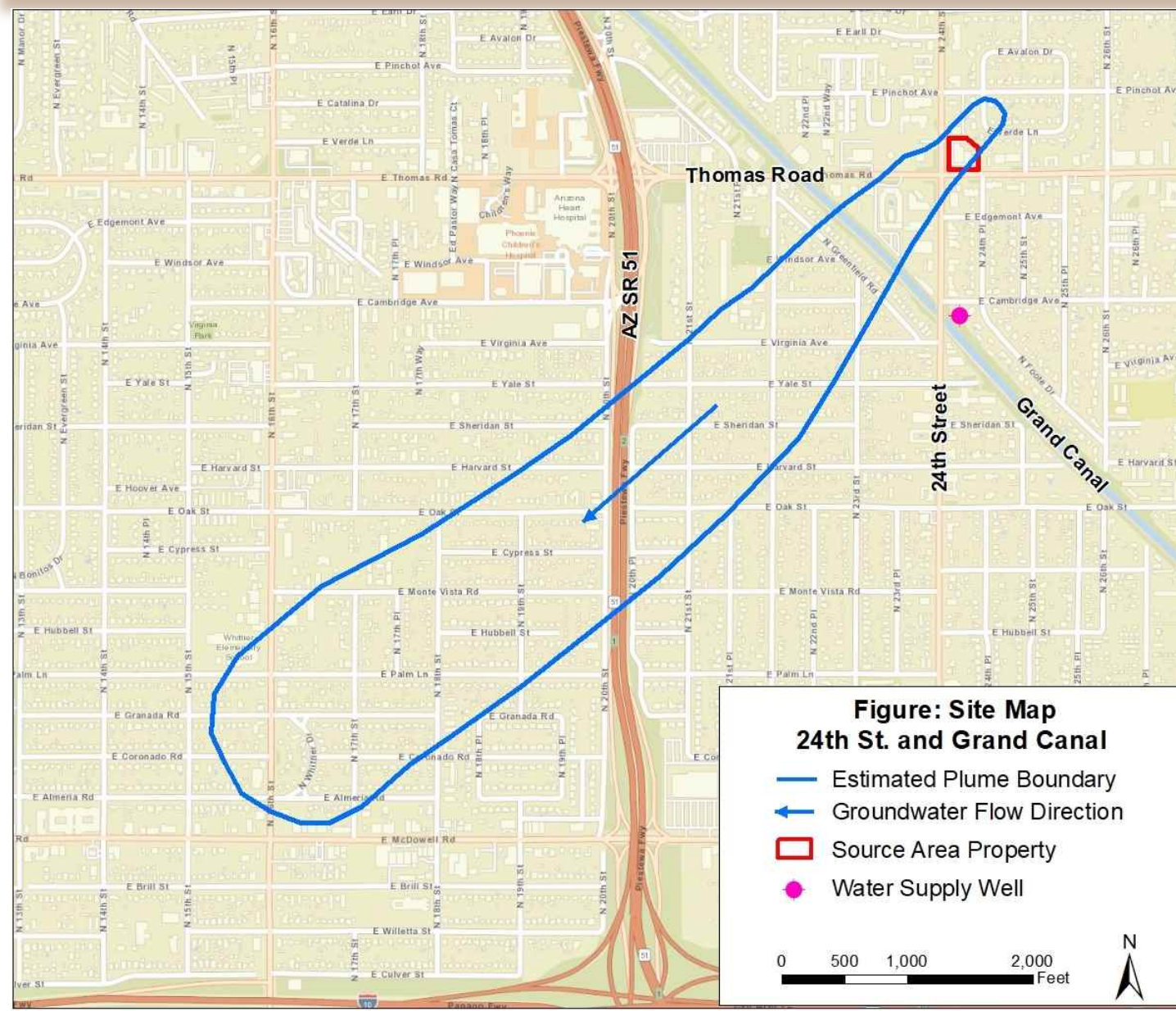
- Jeff Rackow, PE, Principal Engineer, ADEQ
- Daniel Sola, Principal Hydrogeologist, ADEQ
- Trevor Carlson, B.Sc, Senior Principal, Geosyntec Consultants



Site Background

- Location: Phoenix Metro Area, Deep Alluvial Aquifers
- Water Quality Assurance Revolving Fund (**WQARF**) Registry
Placement Date: May 18, 2000 (“Arizona State Superfund”)
- Source of Contamination: Multiple former dry-cleaning facilities -Tetrachloroethene (PCE) Groundwater Plume
- Early Response Action: Source area soil contamination remediated by soil vapor extraction (SVE)
- Potential Municipal Use (yield >1000 gallon per minute)

Site Map

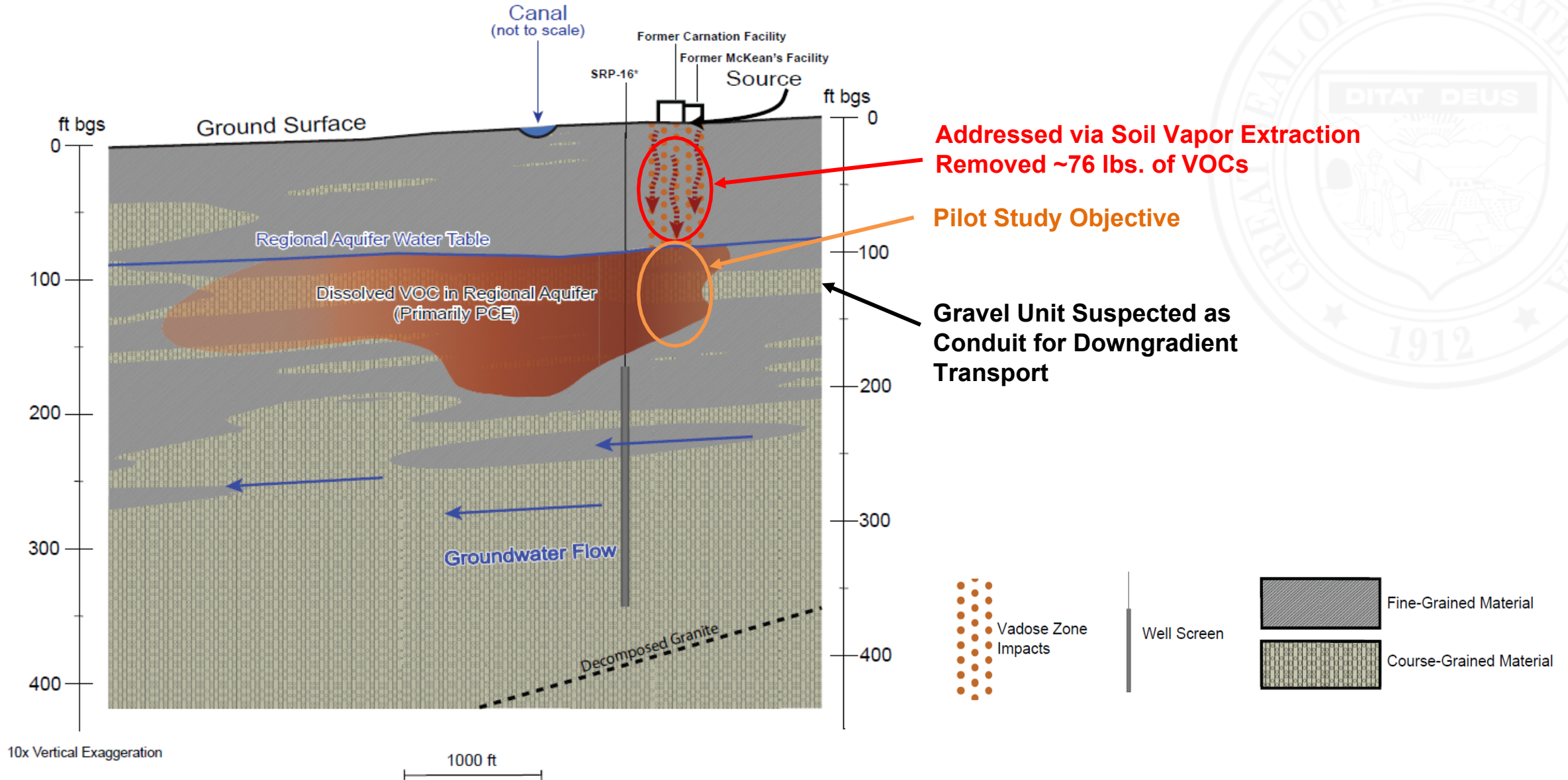


- Estimated plume boundary: PCE in groundwater exceeding the Arizona Aquifer Water Quality Standard of 5 micrograms per liter ($\mu\text{g/L}$)
- Groundwater flow to southwest
- Plume extends ~1.5 miles downgradient of source area
- Plume depth ranges from ~90 to 130 feet below ground surface (ft bgs)

Conceptual Site Model

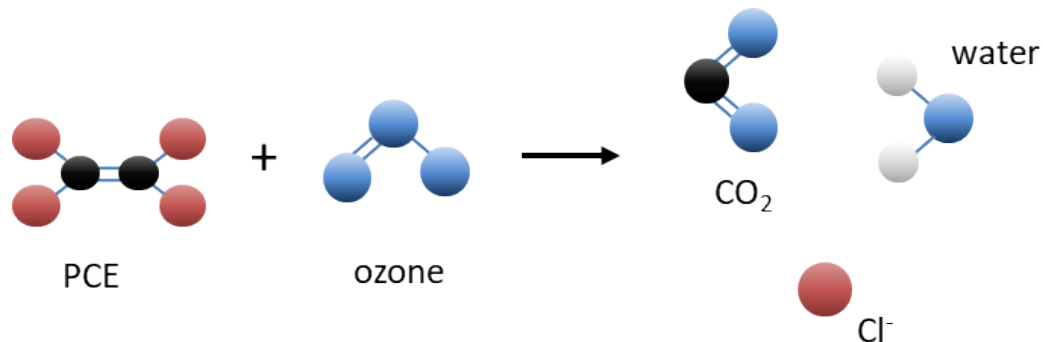
SOUTHWEST

NORTHEAST

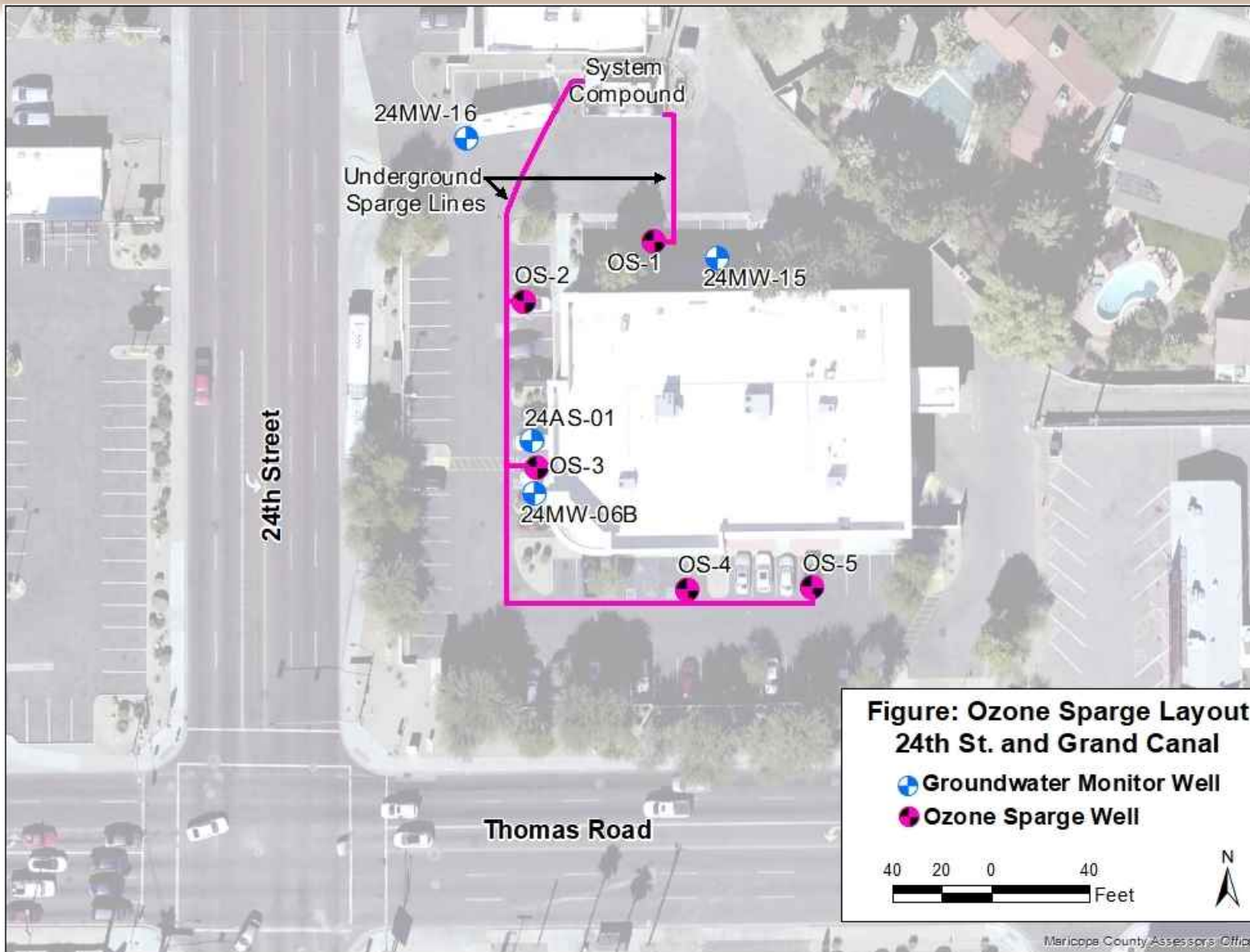


Ozone (O₃) Treatment Pilot Study

- Pilot Study Objectives:
 - Assess full-scale design parameters
 - Map distribution of O₃ treatment
 - Evaluate cost-effectiveness
 - Remediate source area (~1/2-acre former dry cleaner site) PCE concentrations to below 5 ug/L

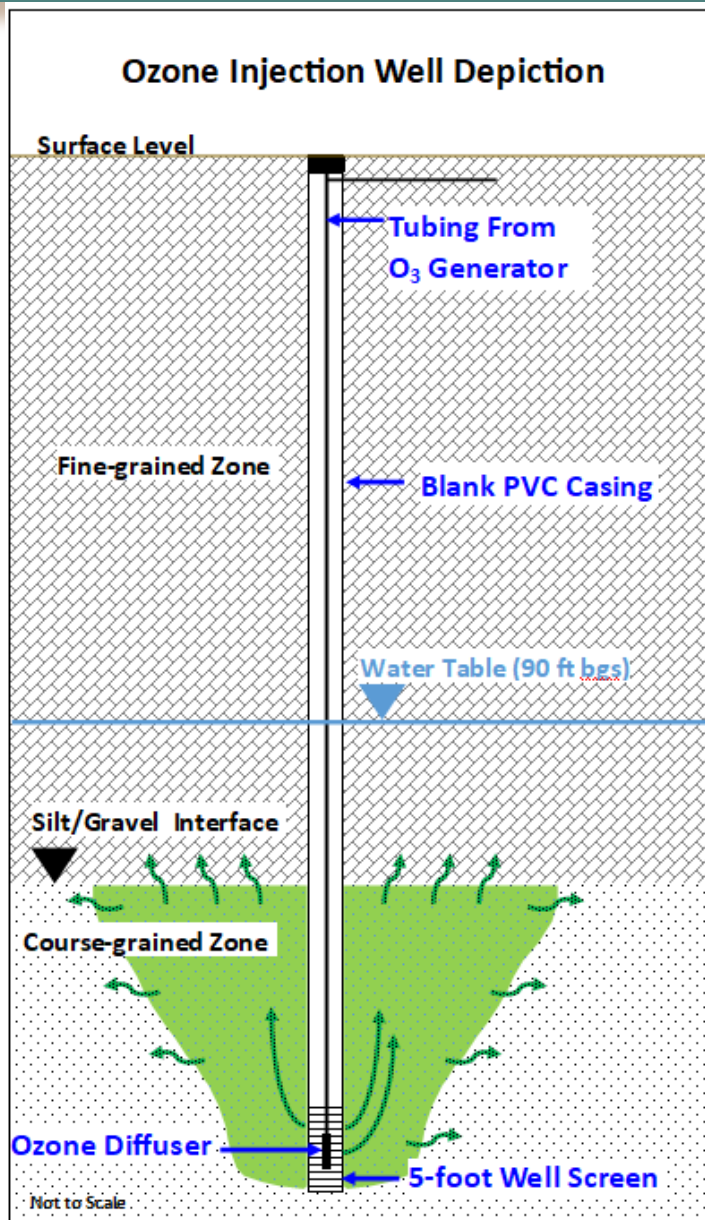


O₃ Injection System Layout



- System installed February/March 2020
- Five injection wells each equipped with 20-micron O₃ diffusers
- Two 23 lb/day O₃ generators (46 lbs/day max capacity)

O₃ Injection Well Design



Well Construction Details:

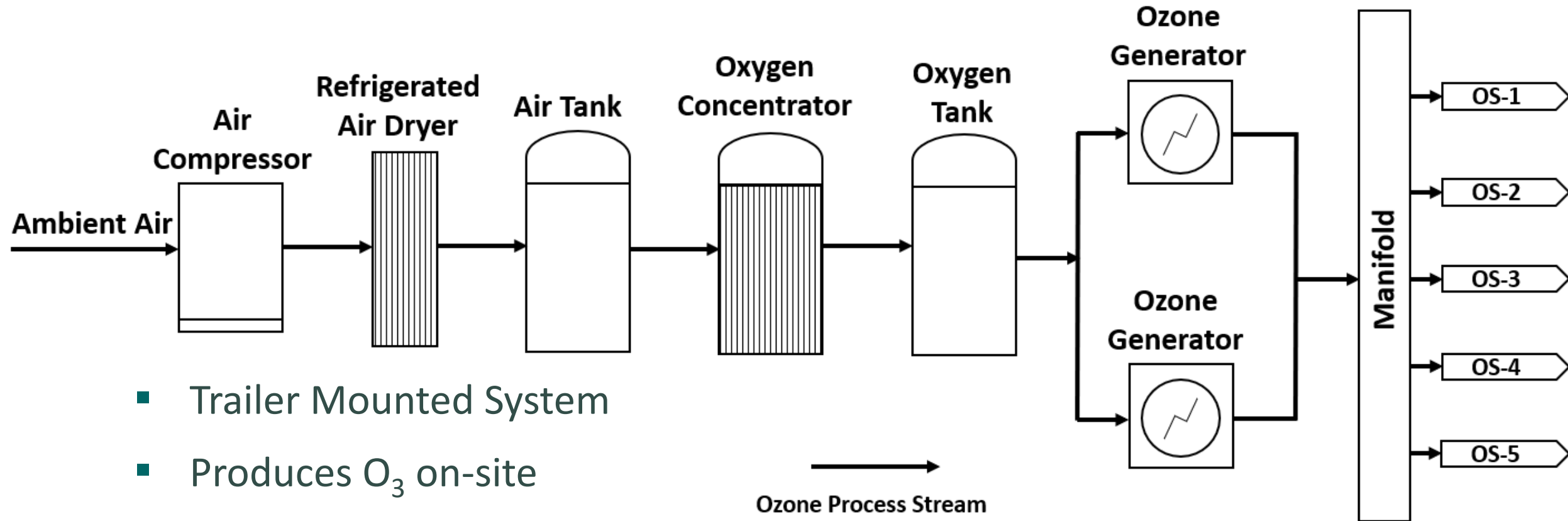
- 4-inch Schedule 80 PVC Casing
- 4-inch 0.020 Slotted Schedule 80 PVC Screen
- 5-foot Screen from ~120-125 ft bgs
- Equipped with 6-inch 20-micron O₃ diffusers in screen
- 3/8-inch diameter perfluoroalkyl conveyance tubing

Micro-diffusion:

- Enhance oxidant contact area
- More efficient gas dissolution into groundwater

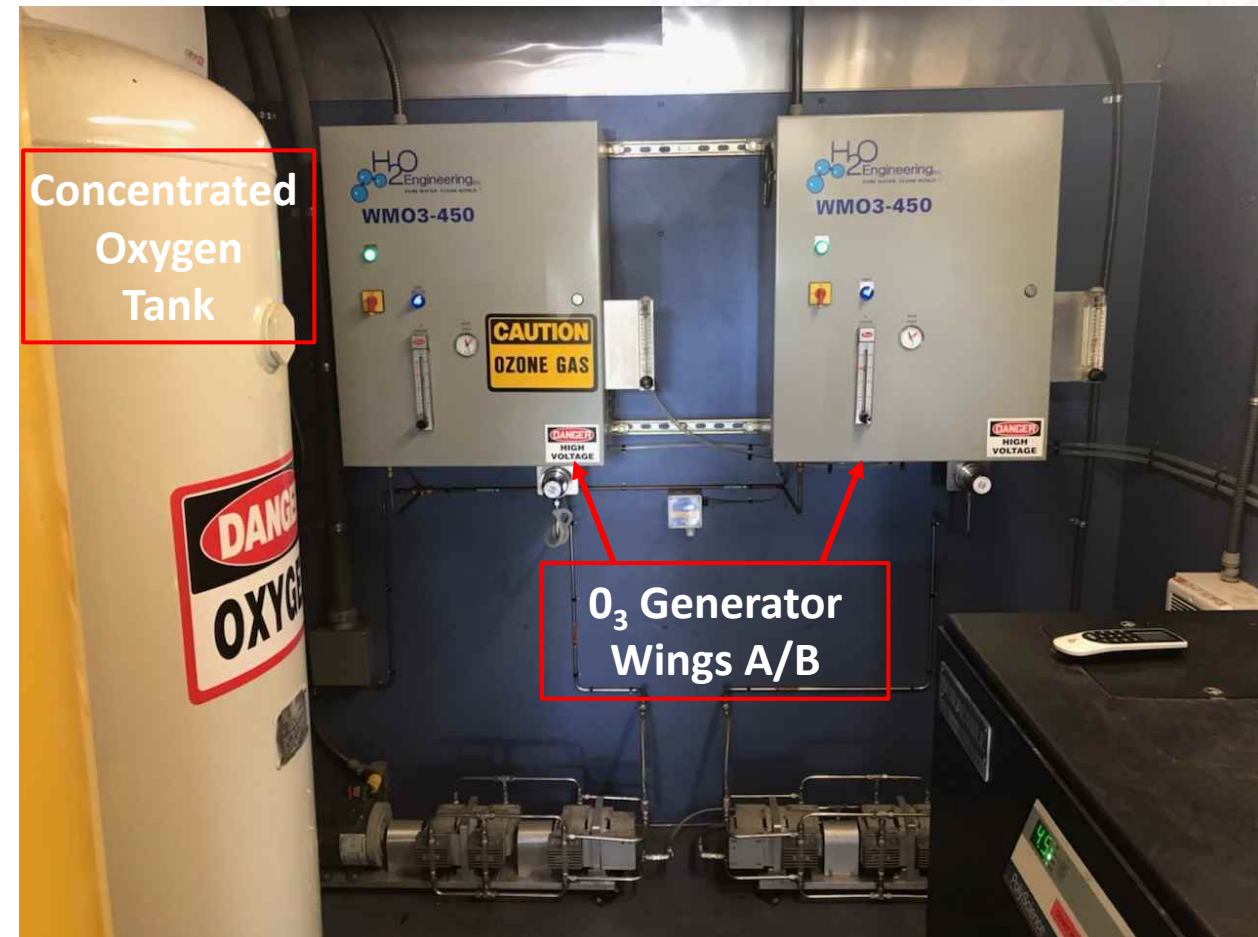
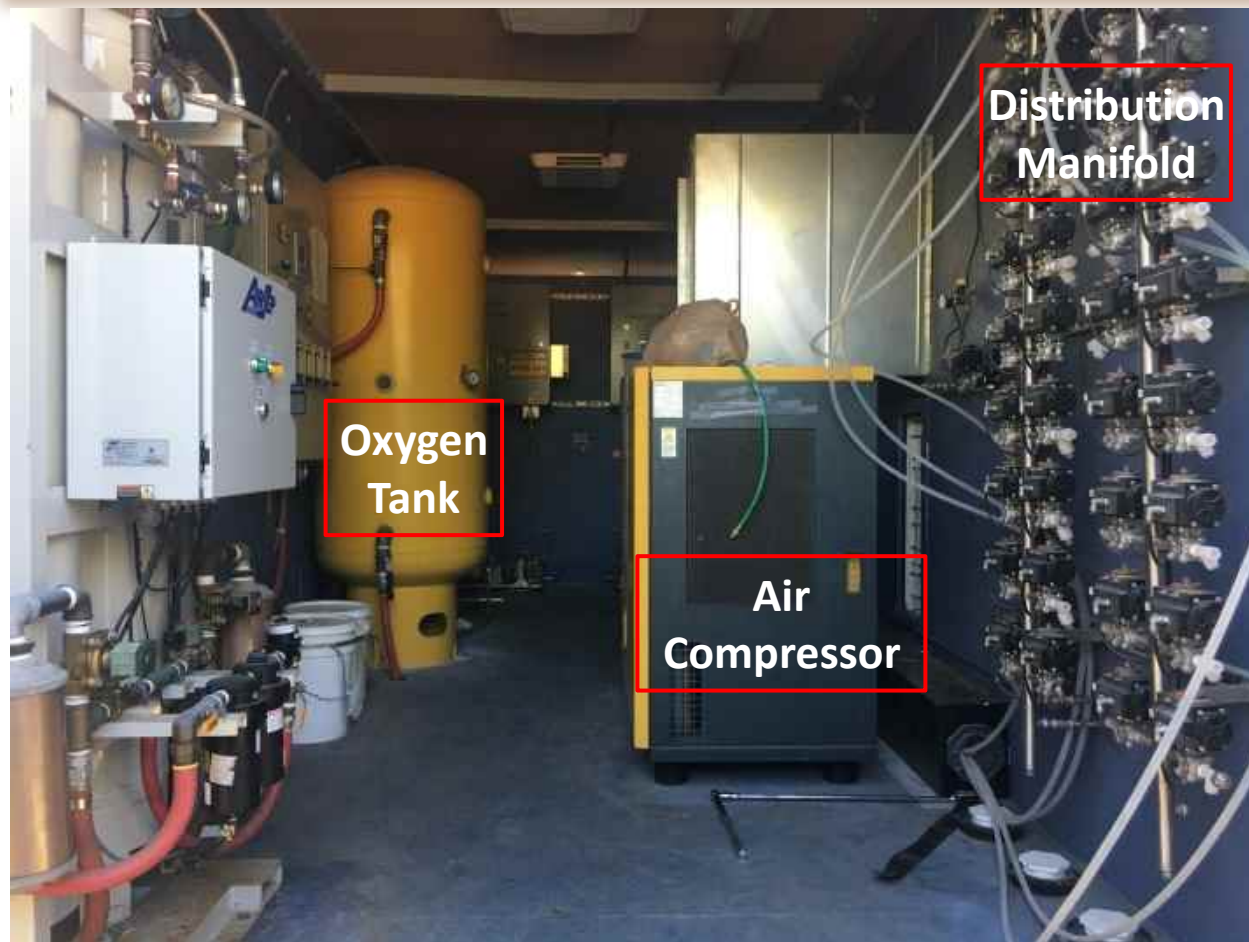
O₃ Injection System Process Flow Diagram

Ozone Injection Process Flow Diagram

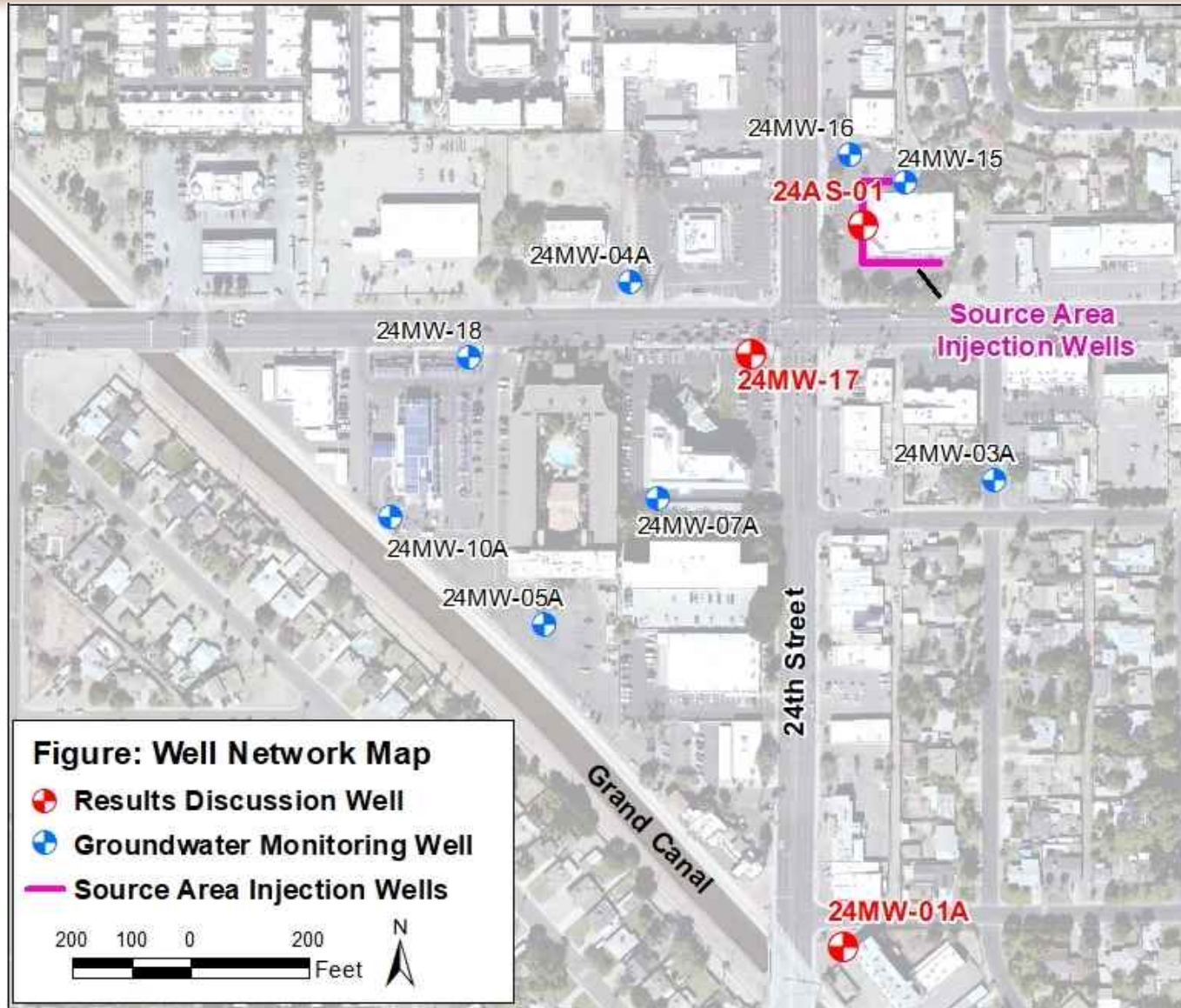


- Trailer Mounted System
- Produces O₃ on-site
- Two 23 lb/day O₃ generators

O₃ Injection System Photos



Injection System Helium Test



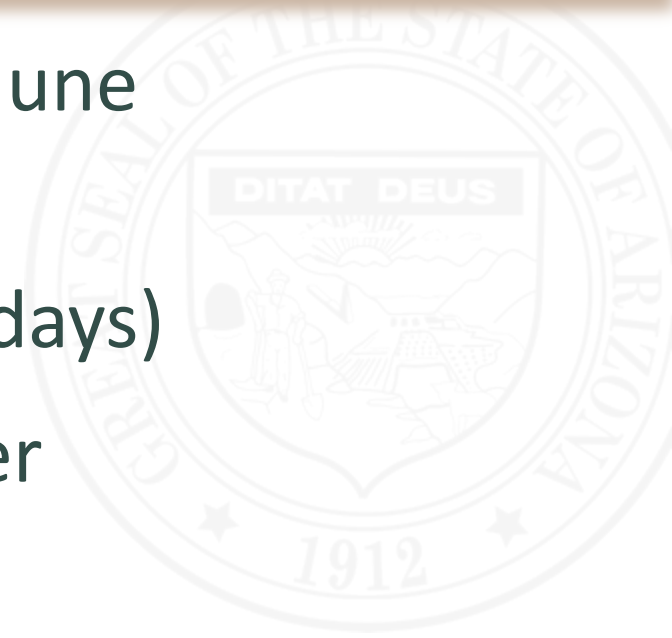
- 72-hour test conducted prior to O₃ injections
- Helium fed to system intake and distributed to sparge wells
- Map migration pathway and flow direction
- Field screened equipment, tubing, well fittings, and surface features

Well	Day 2 [ppmv]	Day 3 [ppmv]	Distance [feet]*
24AS-01	8,600	9,800	12
24MW-17	1,175	1,700	282
24MW-01A	125	225	1,200

* - Distance from nearest injection well
ppmv - parts per million by volume

O₃ Injection System Operation Overview

- Intermittent operation between April 2020 and June 2022
- System operated for a total of 9,300 hours (388 days)
- System delivered 13,500 lbs of O₃ into the aquifer
- Cycled O₃ injections on 5-minute intervals
- Downtime due to ambient heat and geochemical issues (sediment accumulation in wells and on diffusers)

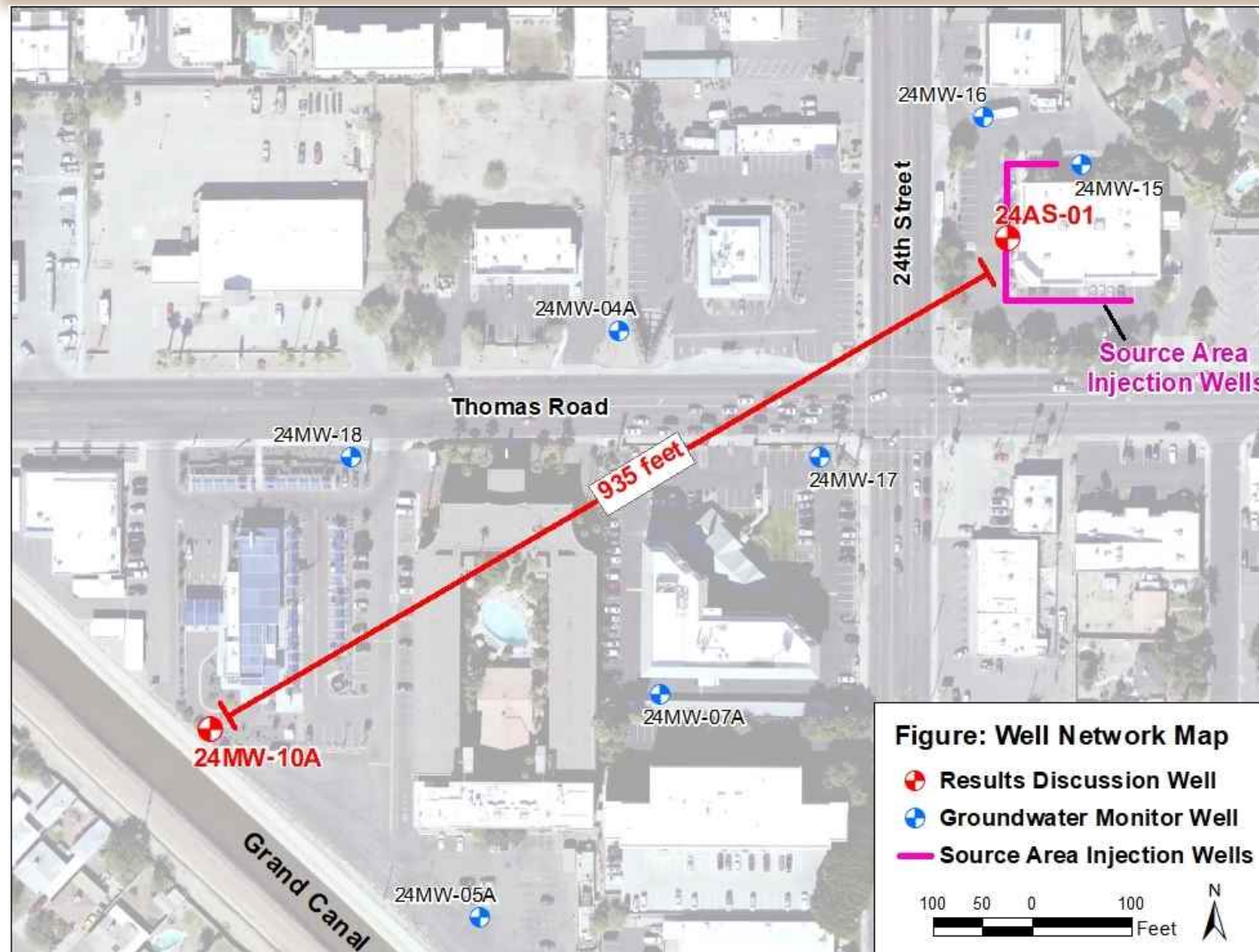


O₃ Injection Operation Maintenance & Monitoring

- Daily remote monitoring via telemetry
- Weekly site visits to monitor O₃ injection pressures and flow rates
- Monitoring wellheads for potential O₃ gas leaks
- As-neededed trouble-shooting/repair upon system alarm notifications



O₃ Injection System Performance Monitoring

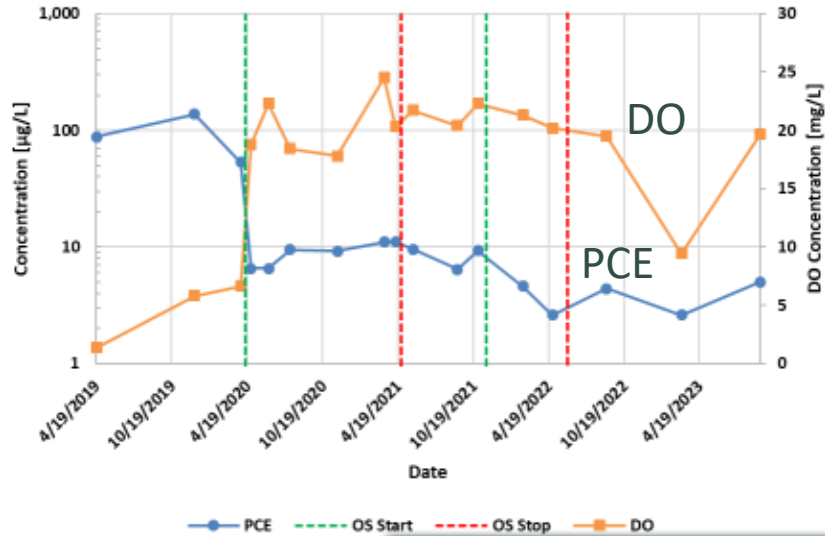


- Groundwater:
 - VOCs and dissolved metals
 - Redox parameters
- Distribution of O₃:
 - Field gas meter at wellheads (O₃ in headspace)
 - Colorimetric test strips (O₃ in groundwater)

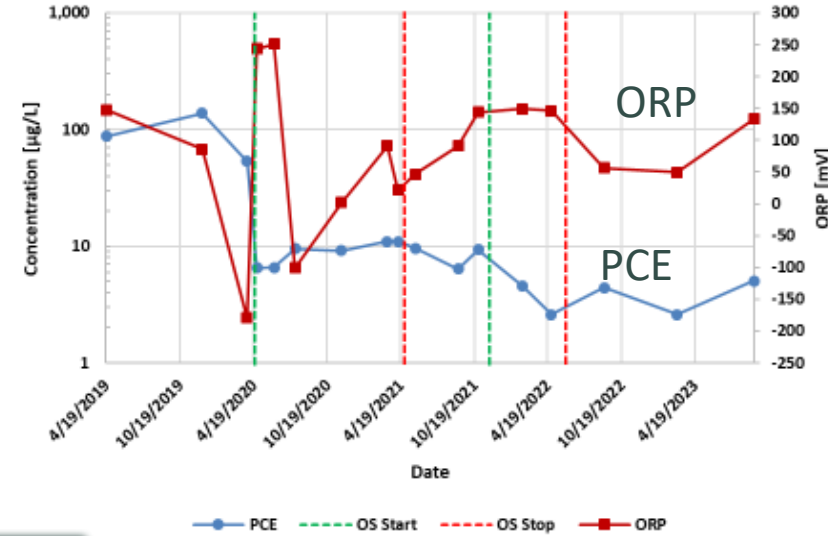
24AS-01 and 24MW-10 results presented on next two slides

Concentration Plots - 24AS-01

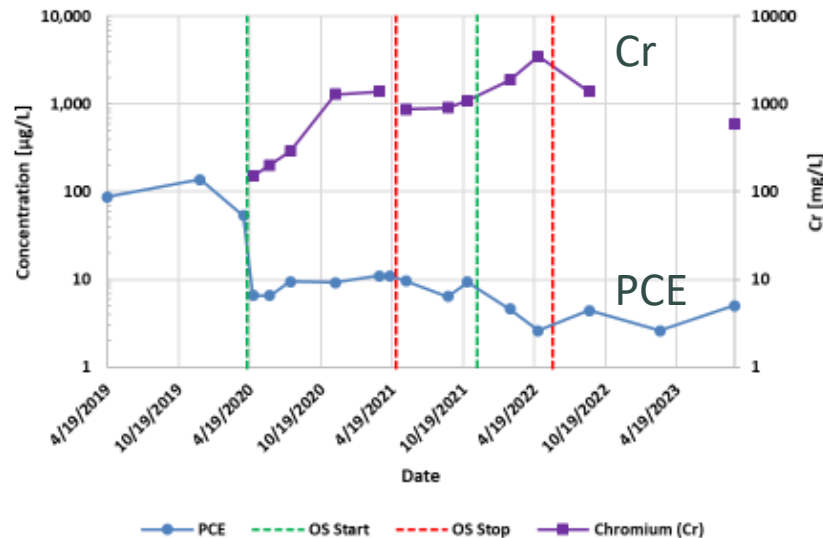
24AS-01: PCE vs DO



24AS-01: PCE vs ORP

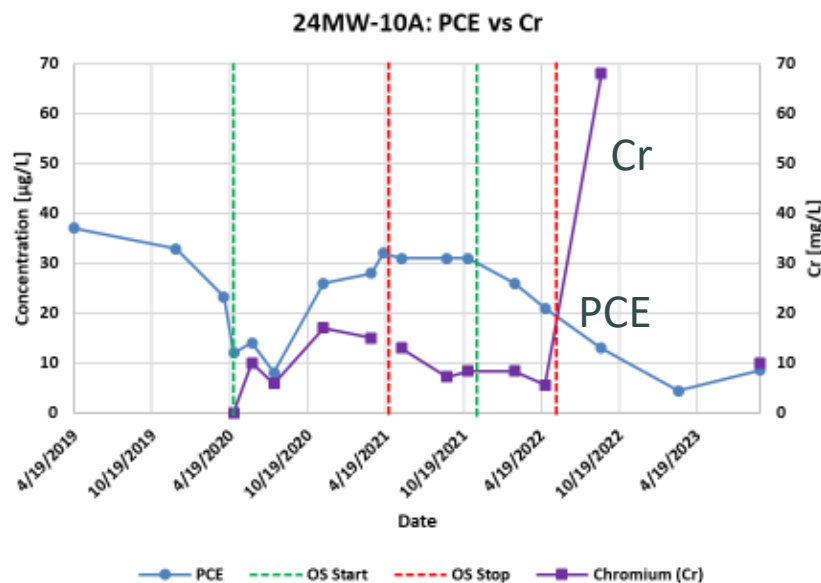
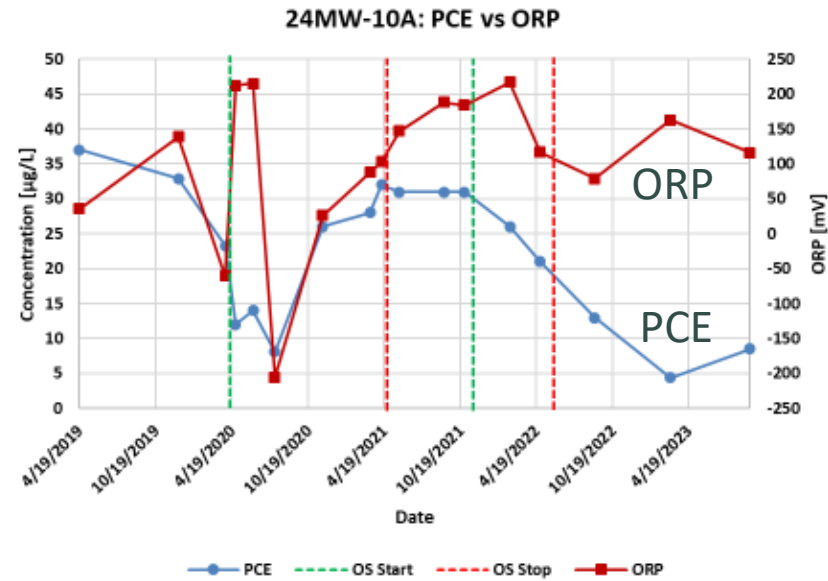
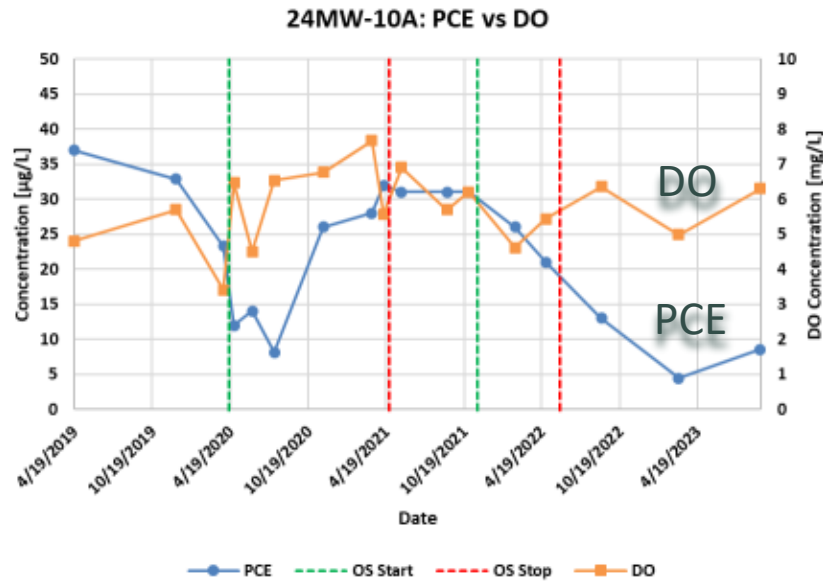


24AS-01: PCE vs Cr



- Located ~12 feet from OS-3
- Baseline concentration: 53 µg/L
- 95% reduction of PCE from start of pilot study
- PCE detected at concentration of 5.03 ug/L in September 2023

Concentration Plots – 24MW-10A



- Located ~935 feet down-gradient from nearest injection well
- Baseline concentration: 23 µg/L
- PCE detected at concentration of 8.52 µg/L in September 2023

Extreme Heat

- Various equipment issues and downtime due to hot ambient temperatures
- Treatment trailer modifications for additional cooling and insulation
- Solution was modified operation schedule (shutdown system when outside temperatures exceeded 110 °F)



Lessons Learned

Ozone Diffuser and Well Screen Fouling – Iron and Manganese Deposits

Before Diffuser Cleaning

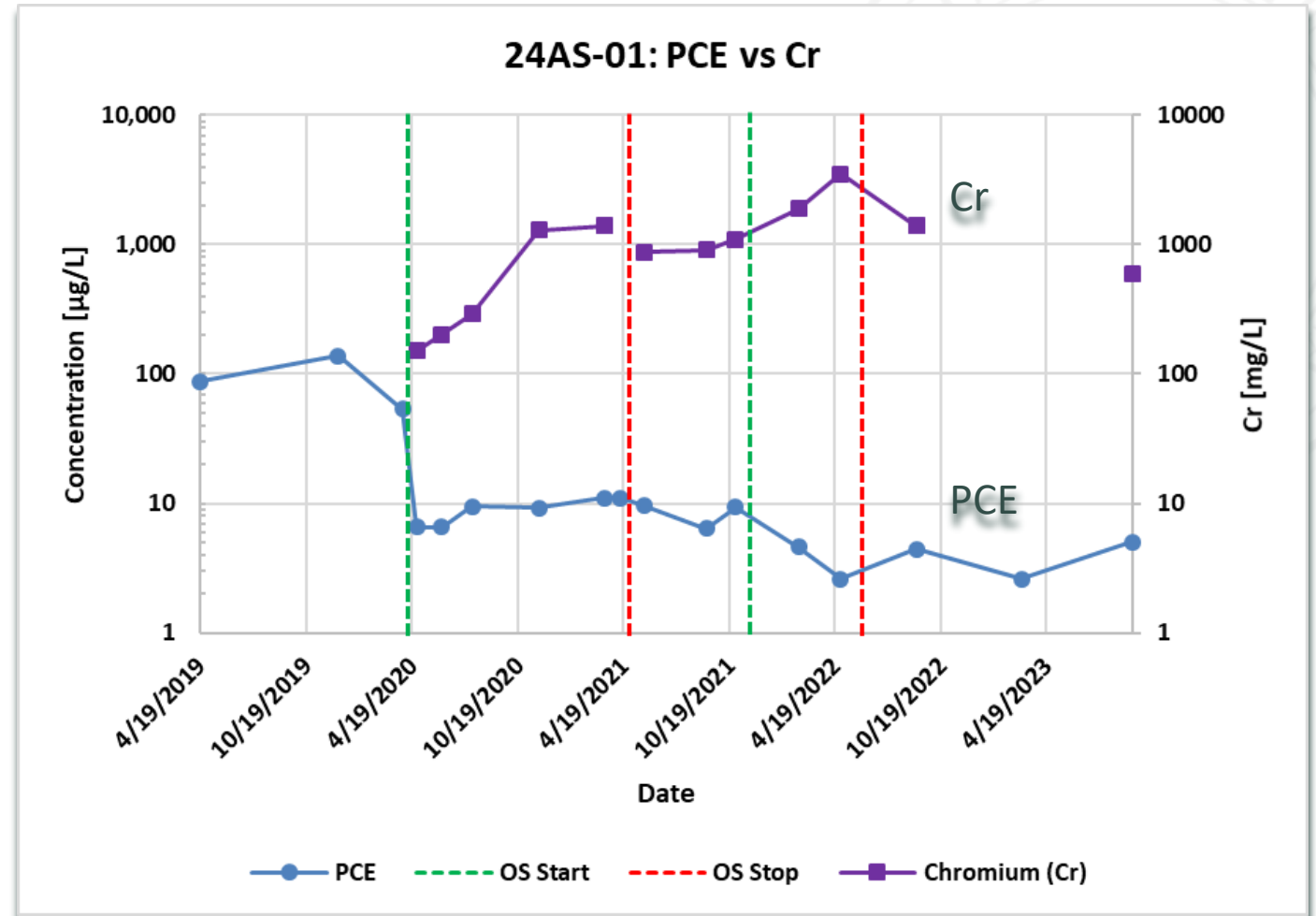


After Diffuser Cleaning



Lessons Learned / Observations

- Some dissolved chromium was liberated proximal to select injection wells
- Concentrations declining toward ambient conditions since turning system off



Graphic duplicate from Concentration Plots - 24AS-01 slide

Project Cost

Project Item	Cost
System Design	\$34,000
System Construction ¹	\$84,000
Injection Well Installation ²	\$153,000
System O&M ³	\$437,000
Subtotal⁴	\$708,000
Notes:	
1 - Utilized existing SVE infrastructure (fenced compound, power supply, etc.)	
2 - Five injection wells drilled via hollow stem auger	
3 - Includes rental cost for O ₃ generator	
4 - PRAP projected cost of \$1.2M for O ₃ treatment remedy	

- PCE destruction occurred in close vicinity to treatment wells with evidence of treatment further downgradient (~250 feet)
- There is a concern for liberation of metals
- Technology did provide a feasible option for source area treatment
- Consideration should be given on remediation goals (e.g. How long does it take to achieve asymptotic levels? Operate system beyond asymptotic levels?)
- The costs were relatively high compared to the mass of PCE treated, but treatment addressed the residual source in a high-value aquifer area with potential municipal use

Questions?



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Healthy Land for Everyone**

Questions/Contact Information

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