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: February 26, 2024
Presenters: Mikel Morales

ADEQ
Arizona Department of Environmental Quality
Clean Air, Safe Water, Healthy Land for Everyone

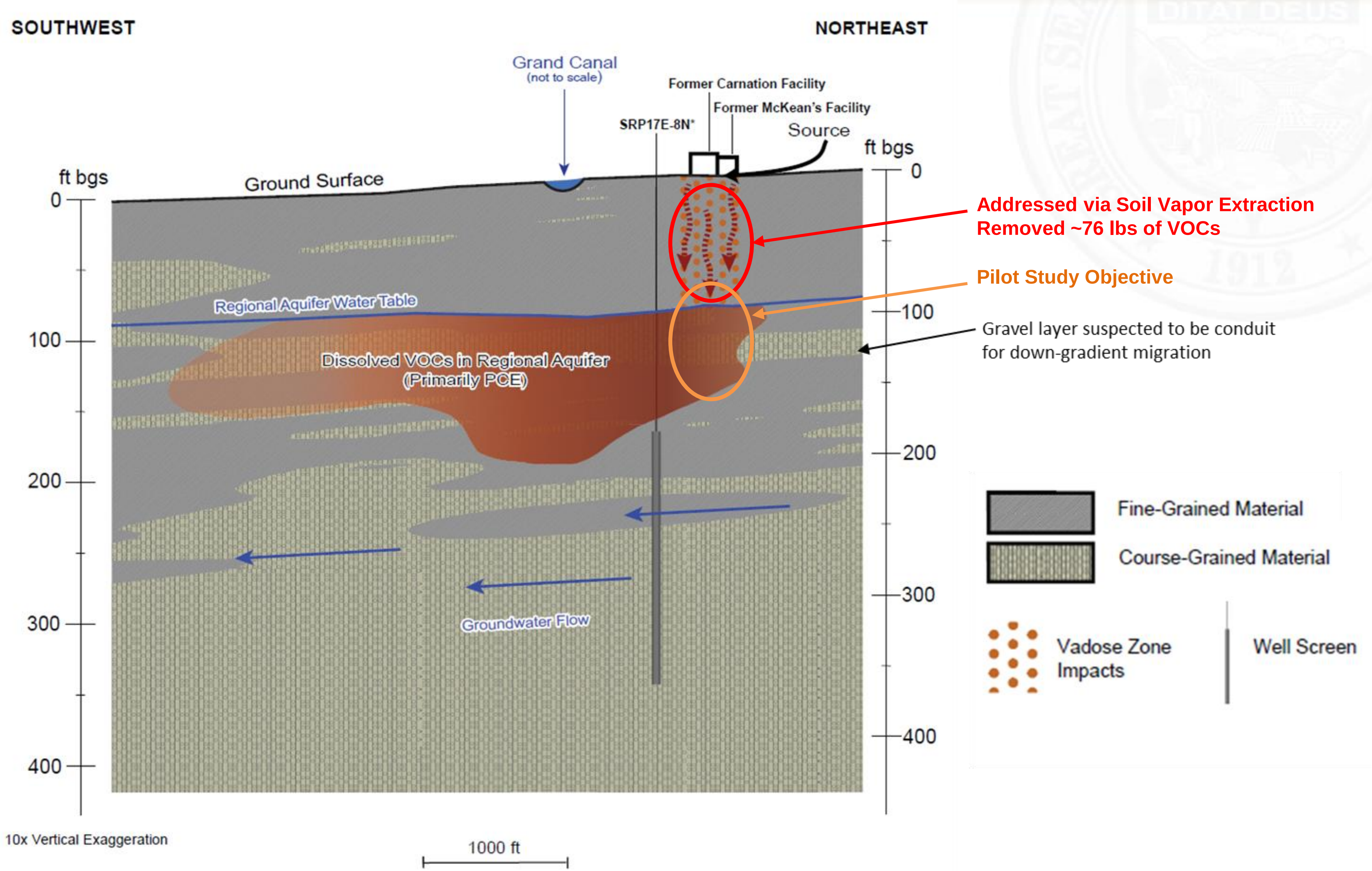
Site Background

- Registry Placement Date: May 18, 2000
- Contaminant of Concern: Tetrachloroethene (PCE)
- Source of Contamination: Multiple former dry-cleaning facilities
- Current Impacted Media: Groundwater
- Early Response Action: Soil contamination remediated by soil vapor extraction (SVE) technology
- Potential Receptors: Salt River Project (SRP) water supply wells

Site Map

Thomas Rd.
16th St.
AZ-51
24th St.
Grand Canal
0
1,500
3,000
Feet
24th and Grand Canal Plume Contour
Groundwater Flow Direction
Source Area Property
SRP Well
N

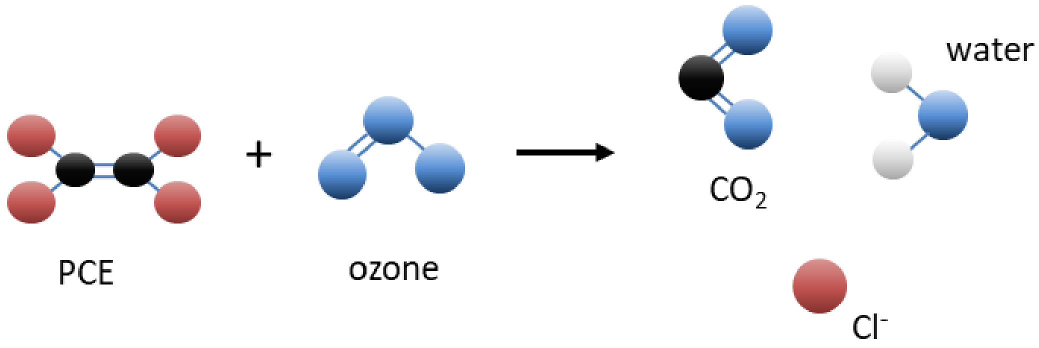
Conceptual Site Model



Source: Remedial Investigation, Figure 9 (Geosyntec, 2019)

Ozone (O_3) Sparge Pilot Study

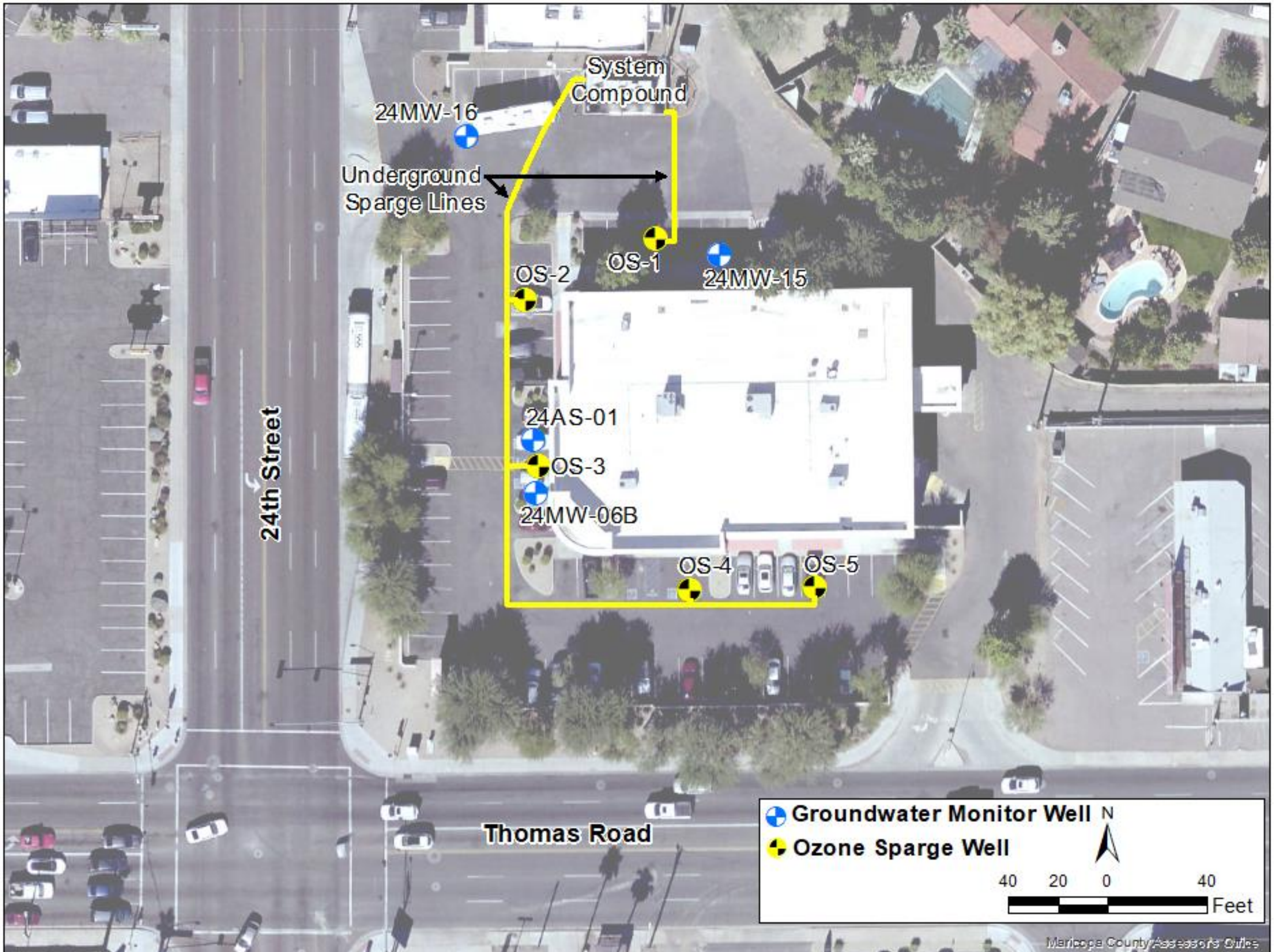
- Pilot Study Objectives:
  - Assess remedy proposed in Feasibility Study
  - Map distribution of O_3 treatment
  - Evaluate cost-effectiveness
  - Remediate residual source area (~1/2-acre former dry cleaner site) below 5 micrograms per liter (ug/L) PCE



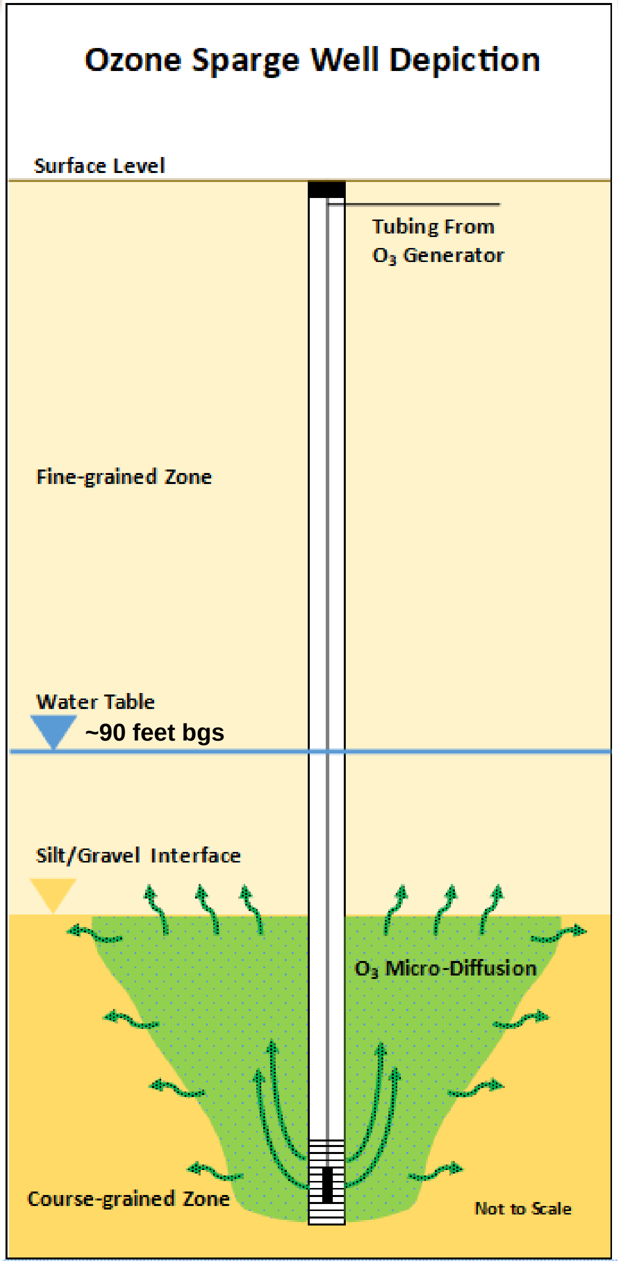
Ozone (O_3) Injection System Installation

- System installed February/March 2020
- Five injection wells equipped with 20-micron O_3 diffusers
- Two 23 lb/day O_3 generators (46 lbs/day max capacity)

O_3 Injection System Layout



O_3 Injection Well Design



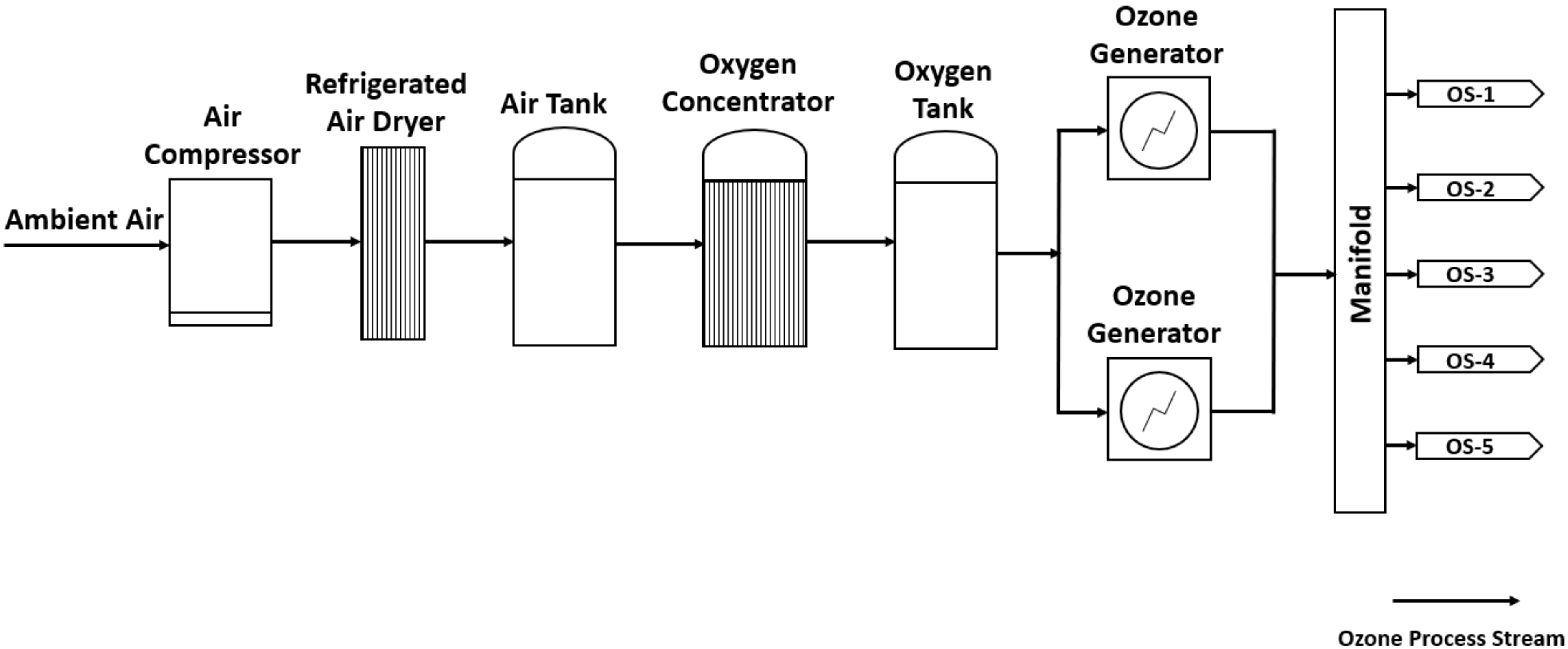
Well Construction Details:

- 4-inch Schedule 80 PVC Casing
- 4-inch 0.020 Slotted Schedule 80 PVC Screen
- 5-foot Screen from ~120-125 feet below ground surface (bgs)

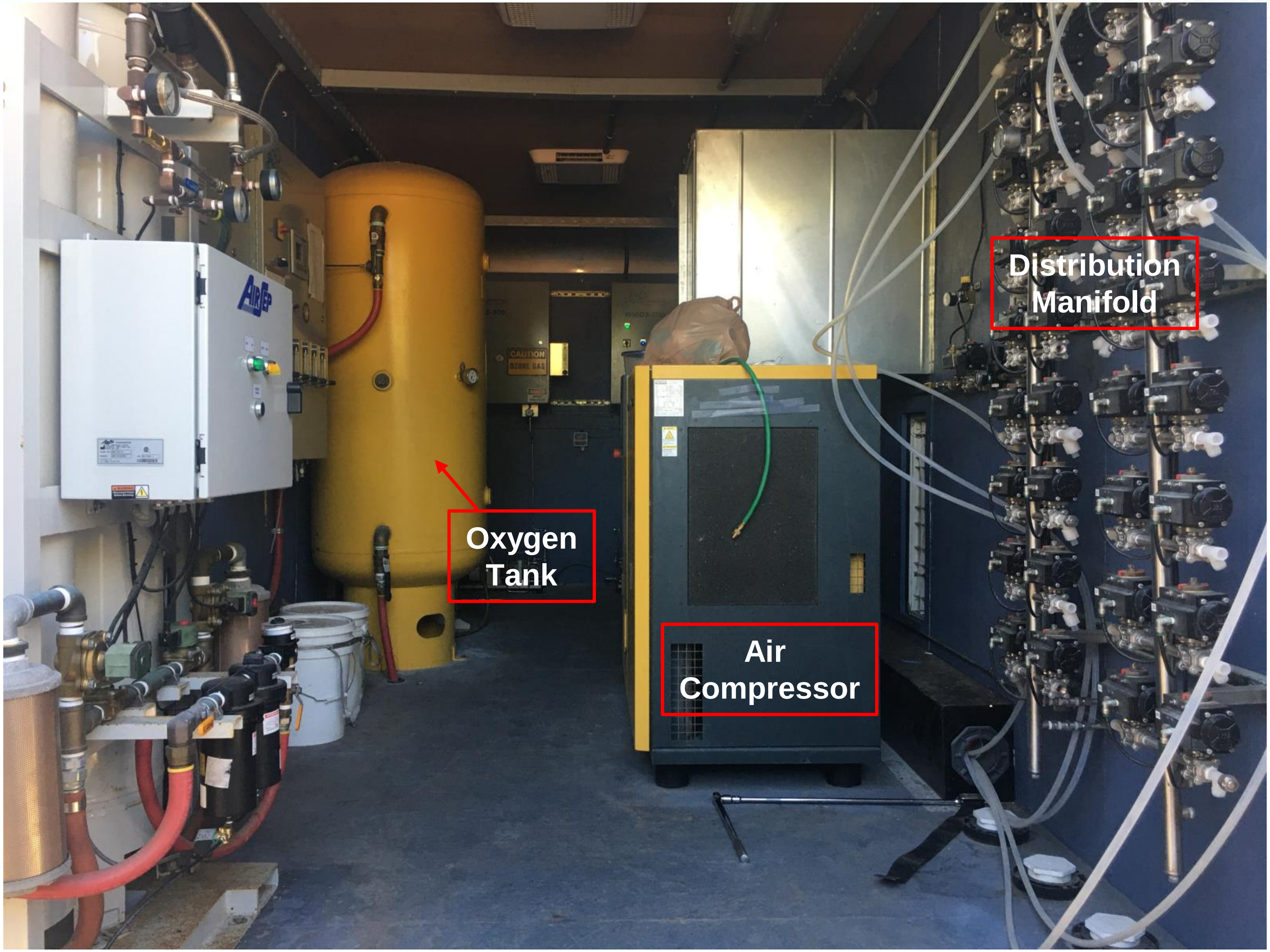
O_3 Injection System Process Flow Diagram

ADEQ Arizona Department of Environmental Quality

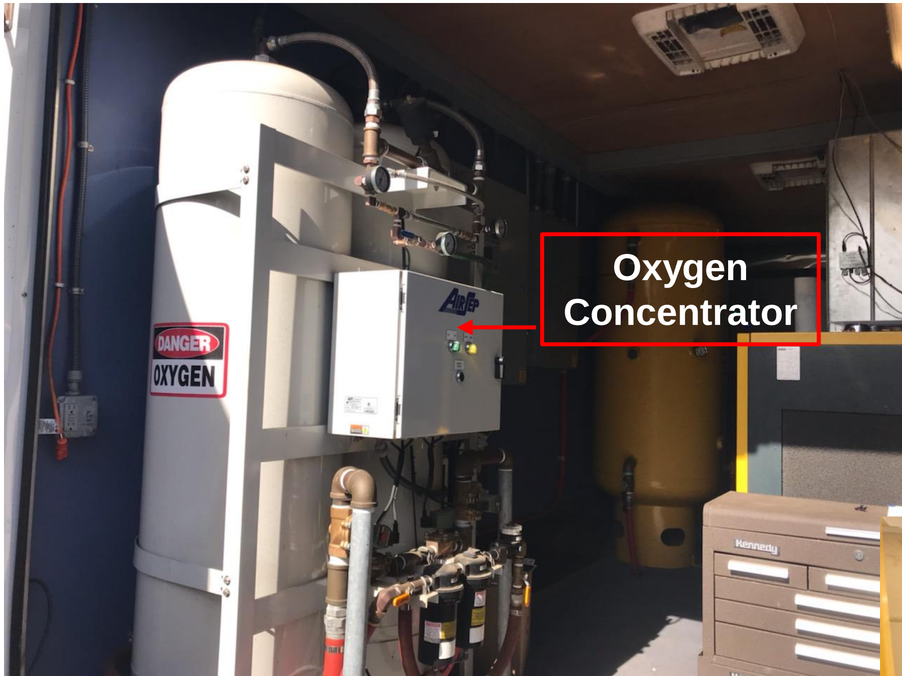
Ozone Sparge Process Flow Diagram

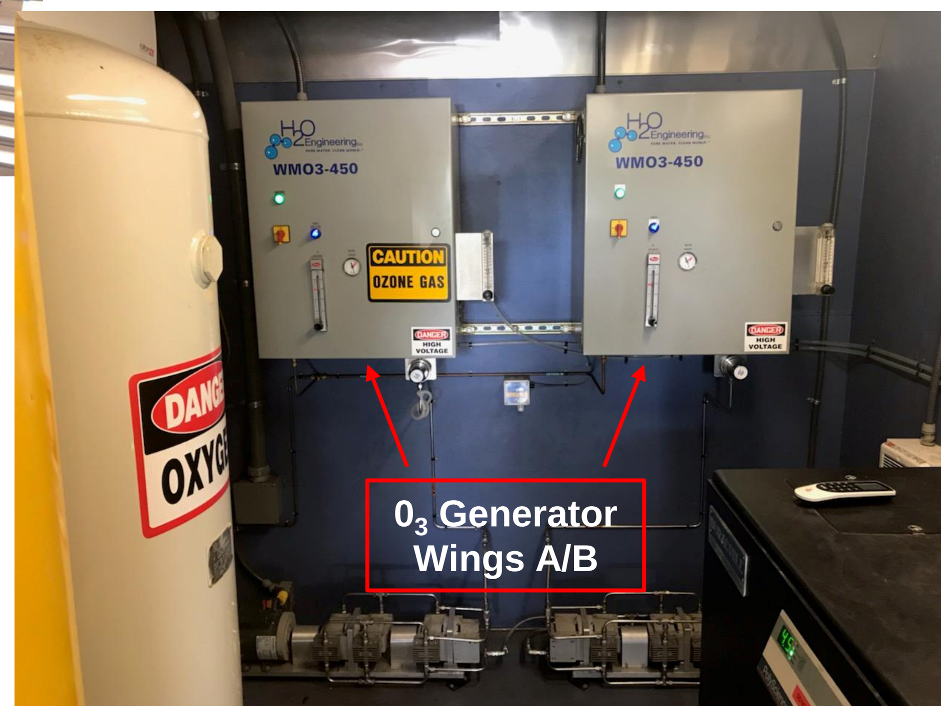


O_3 Injection System

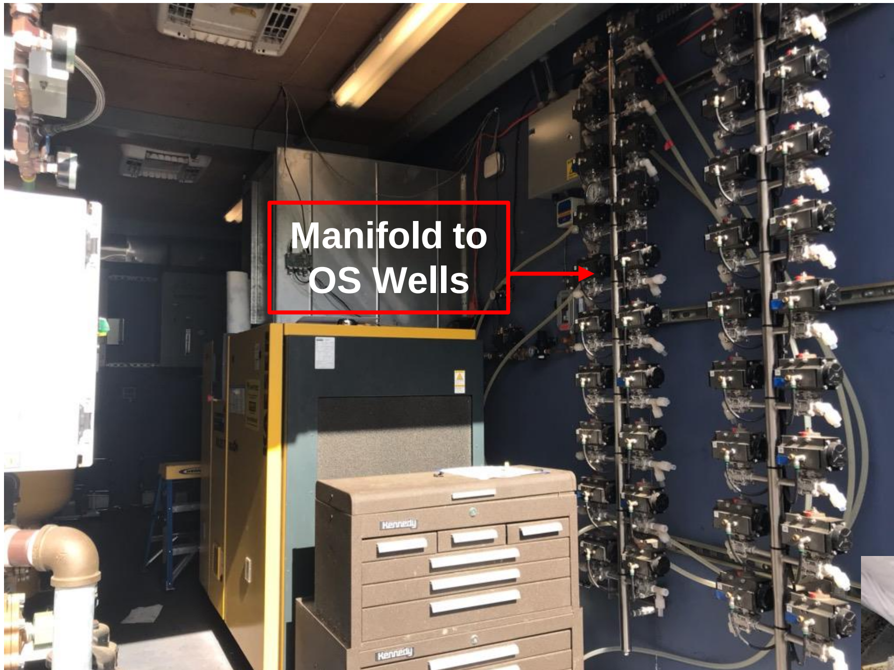


O_3 Injection System (cont.)





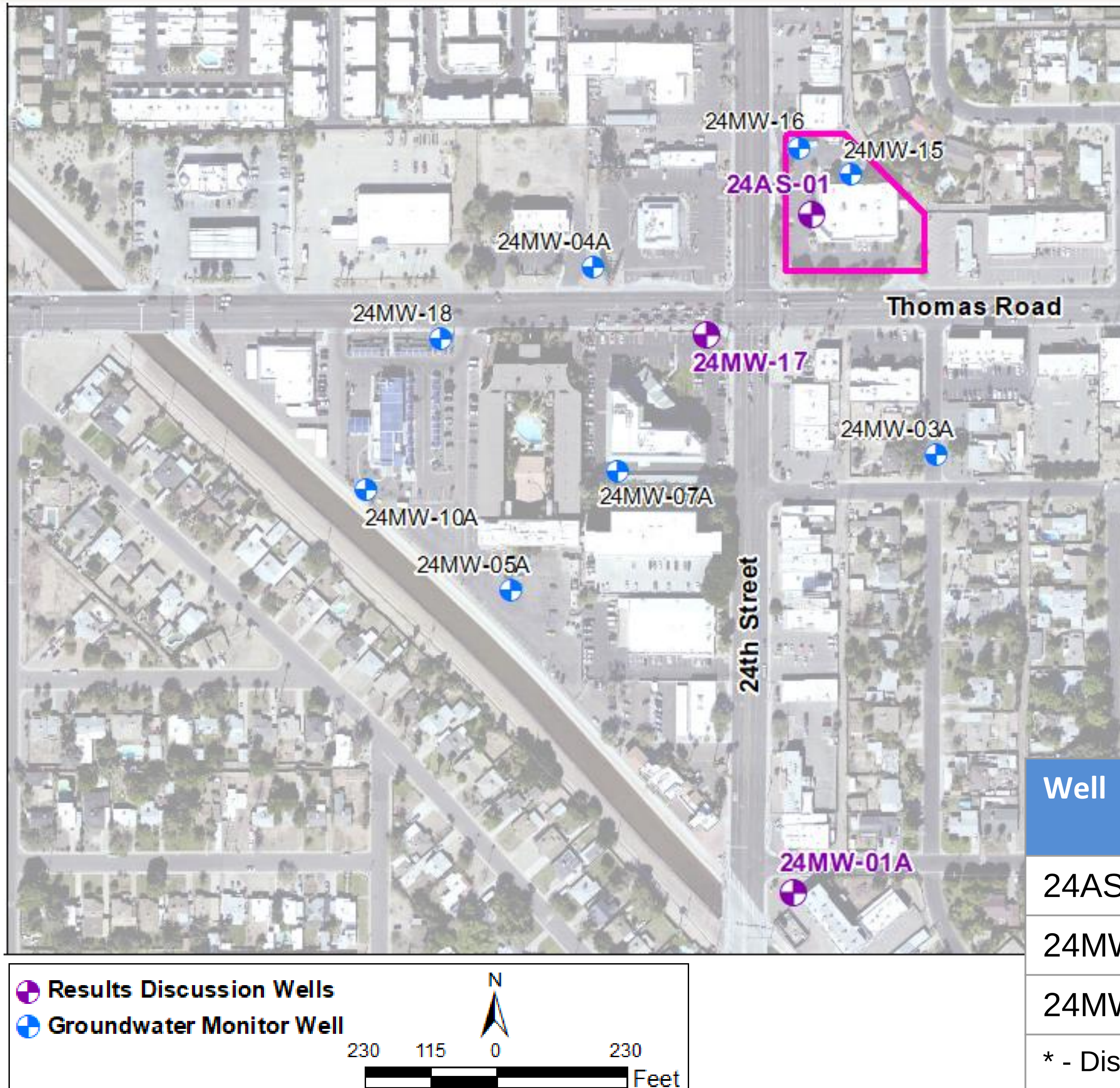
O_3 Injection System (cont.)



Sparge System Helium Test

- Map helium migration pathway and flow direction
- Helium fed to air compressor intake for distribution to injection well network
- Conducted prior to O_3 injection
- Test work scope:
  - Helium gas delivered to sparge wells at flow of 1 liter per minute for ~72 hours
  - Screened system equipment, tubing, and well fittings using handheld helium gas detector (senses extremely low concentrations)
  - Screened headspace at 11 monitor wells
  - Screened cracks in onsite asphalt pavement

Helium Test Results



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

O_3 Injection System Operation

ADEQ Arizona Department of Environmental Quality

- Intermittent operation between April 2020 and June 2022
- Cycled O_3 injections on 5-minute intervals
- System operated for a total of 9,300 hours (388 days)
- Downtime due to ambient heat and geochemical issues (sediment accumulation in wells and on diffusers)
- System delivered 13,500 lbs of O_3 into the aquifer

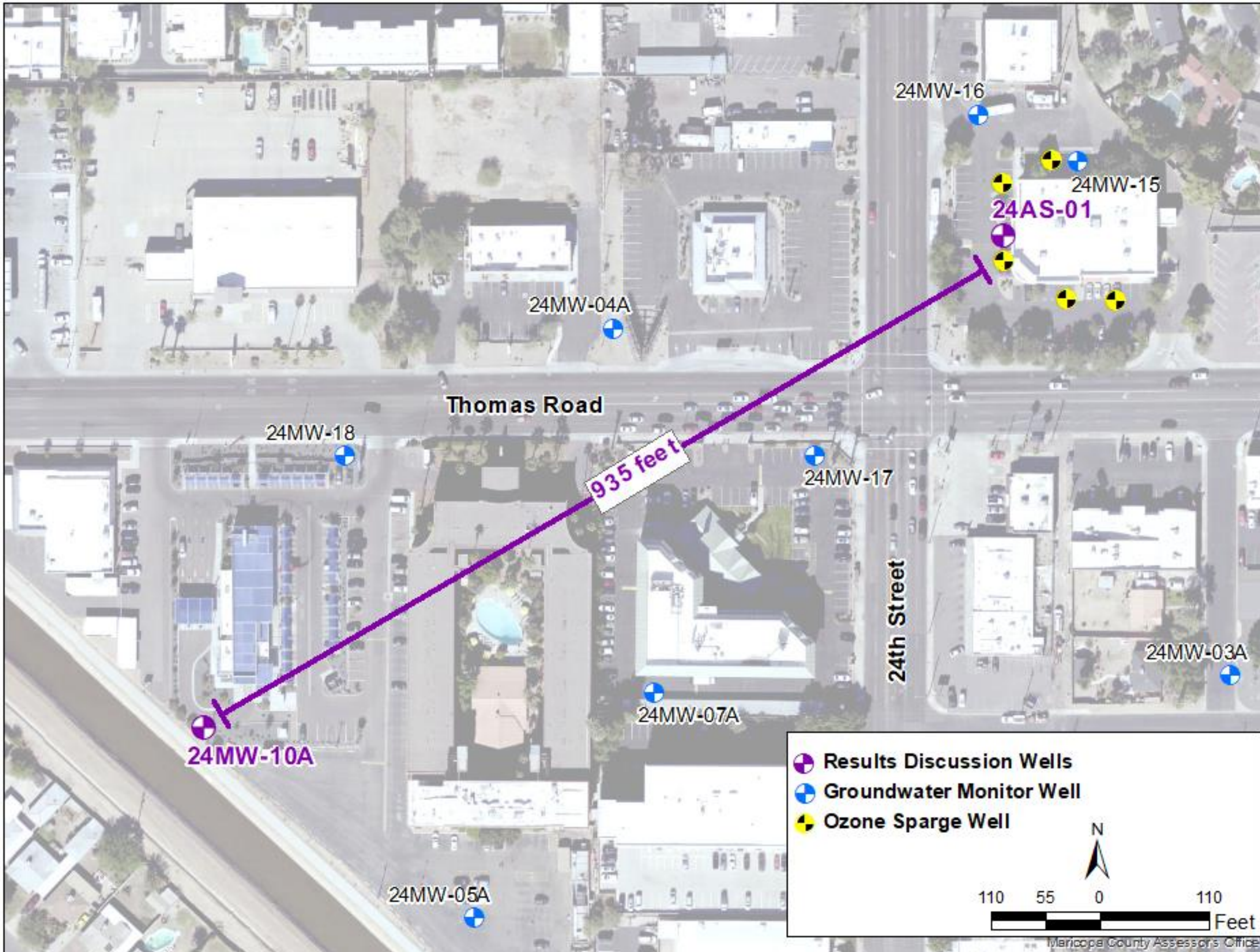
O_3 Injection Operation Maintenance & Monitoring

- Daily remote monitoring via telemetry
- Weekly site visits to monitor O_3 injection pressures and flow rates
- Monitoring wellheads for potential O_3 gas leaks
- As-needed trouble-shooting/repair upon system alarm notifications

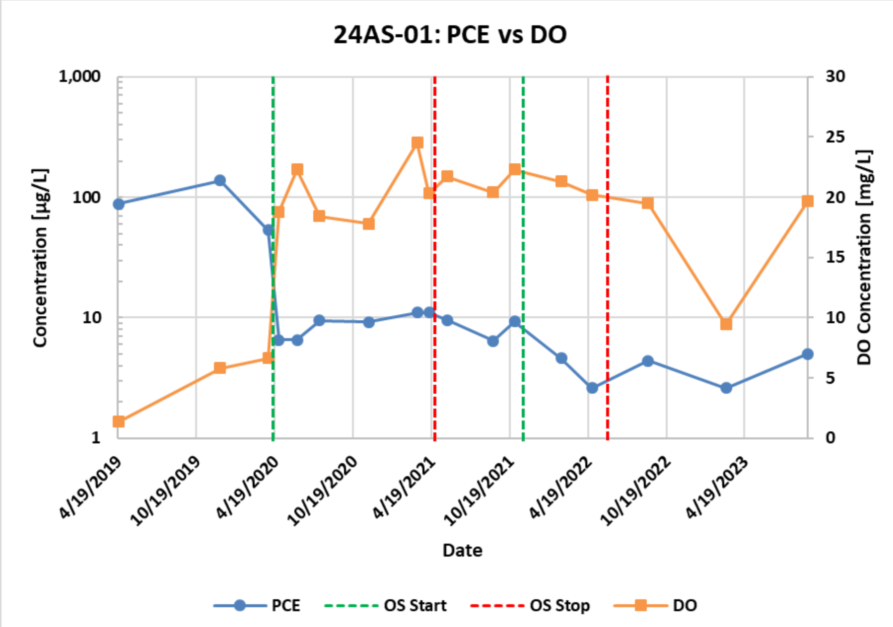
O_3 Injection System Performance Monitoring

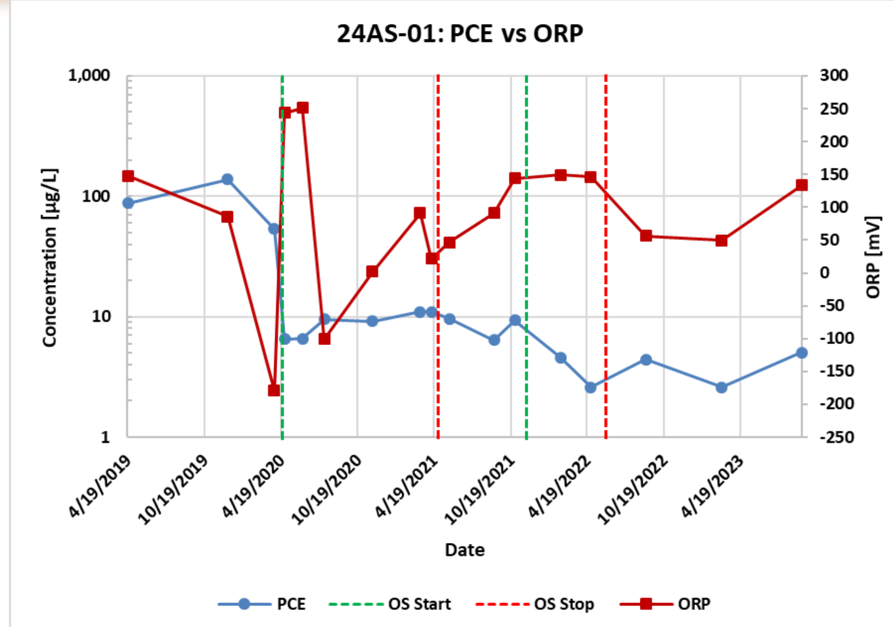
- Groundwater:
  - Sampling/analyzing for VOCs and dissolved metals
  - Sampling for field Redox parameters (oxidative reduction potential [ORP] dissolved oxygen [DO], conductivity, pH)
- Distribution of O_3 (zone of influence):
  - Field gas meter at wellheads (O_3 in headspace)
  - Colorimetric test strips (O_3 in groundwater)

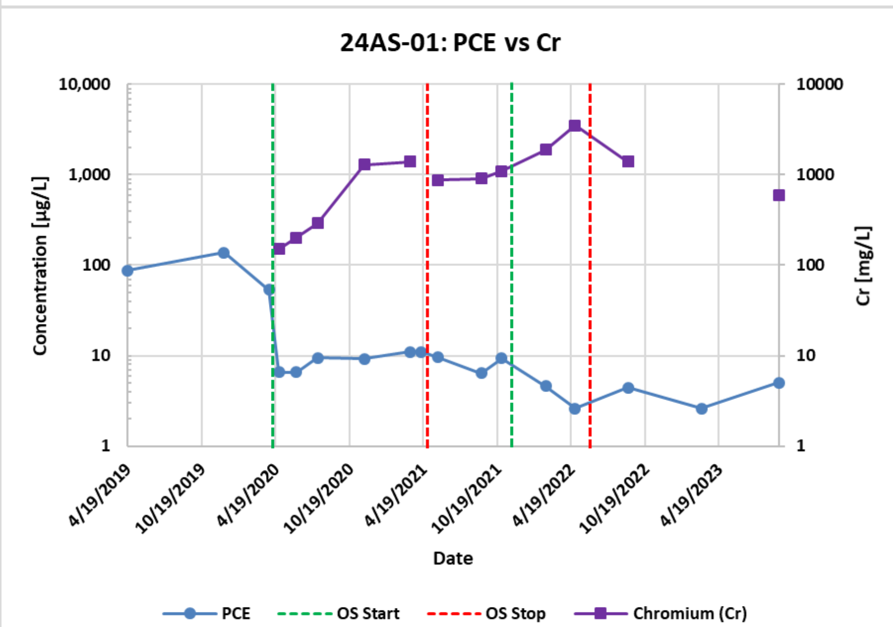
Performance Monitoring Well Locations



Concentration Plots - 24AS-01

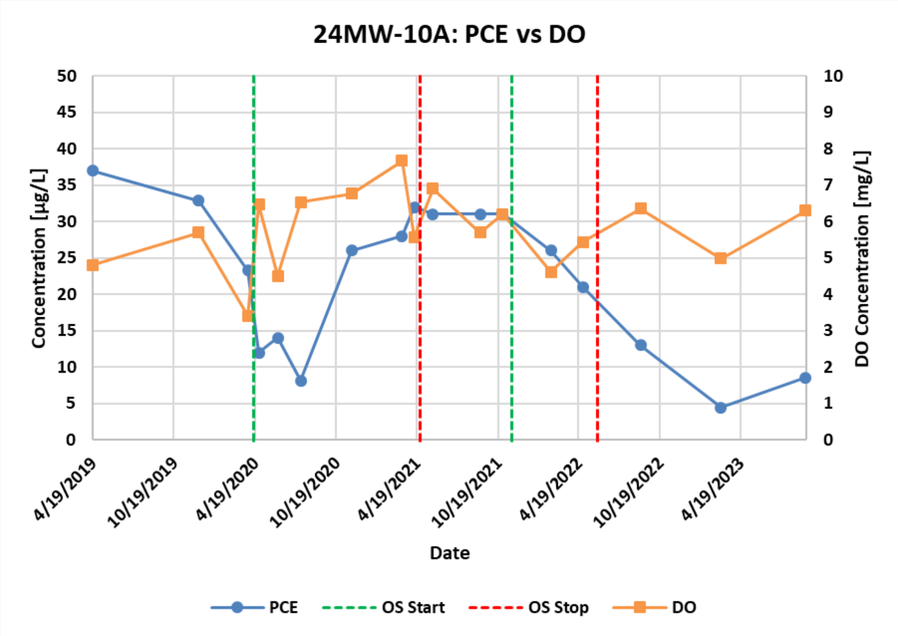


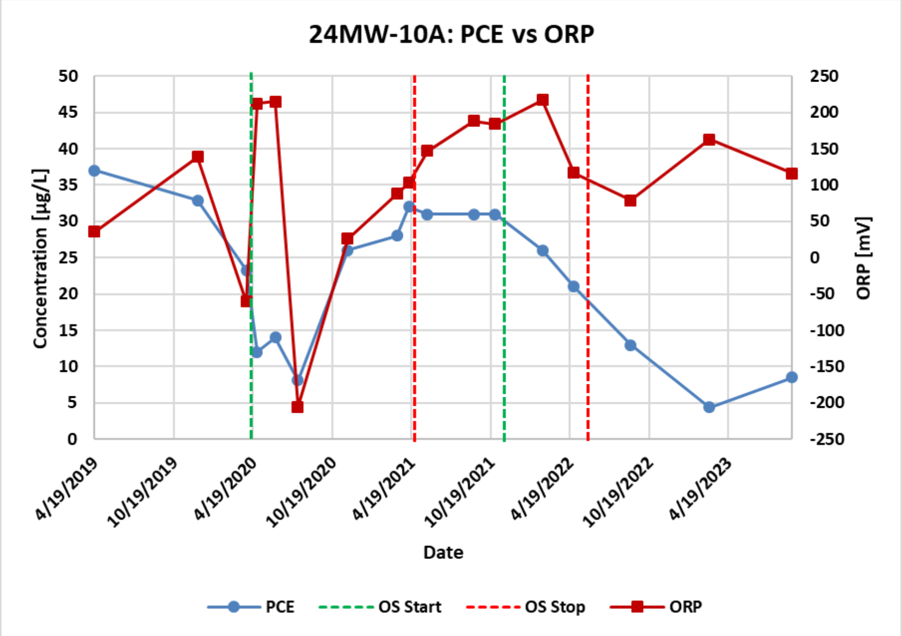


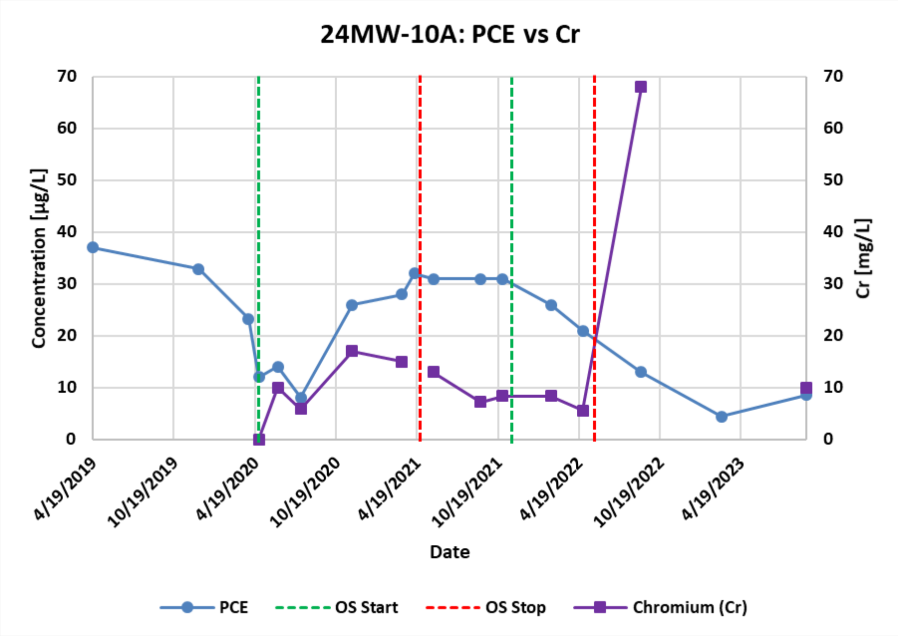


- Located ~12 feet from OS-3
- Baseline Concentration: 53 µg/L
- 95% reduction of PCE from start of pilot study
- PCE detected at concentration of 5.03 ug/L in September 2023

Concentration Plots – 24MW-10A

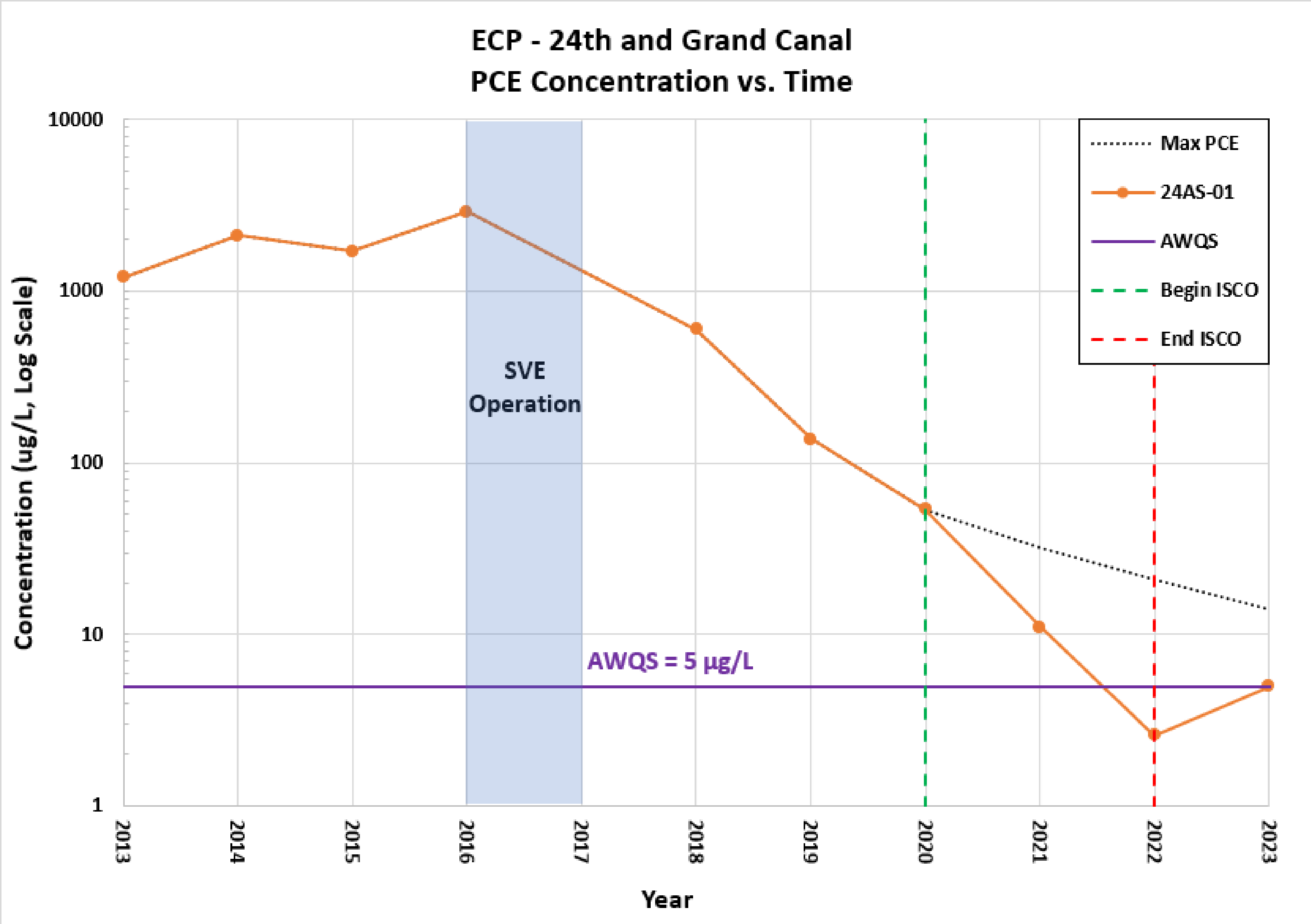






- Located ~935 feet down-gradient from nearest injection well
- Baseline Concentration: 23 µg/L
- PCE detected at concentration of 8.52 ug/L in September 2023

Historical PCE Concentration Plot



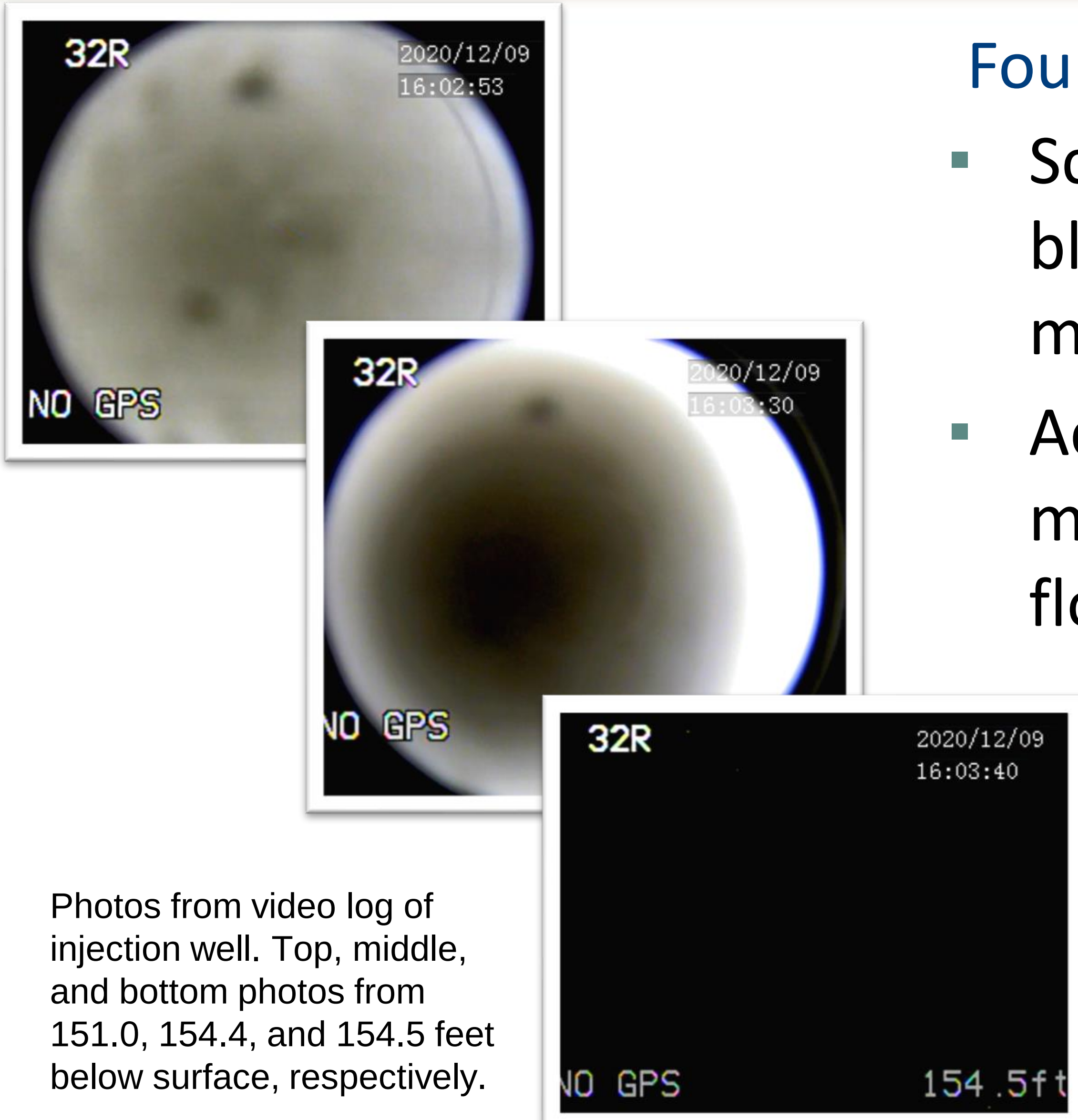
Extreme Heat

- Modified system operation schedule was needed during summer (shutdown system when outside temperatures exceeded 110 °F)

Well Siltation Issues/Solutions

- Redeveloped by standard techniques at a relatively low cost

Lessons Learned



Photos from video log of injection well. Top, middle, and bottom photos from 151.0, 154.4, and 154.5 feet below surface, respectively.

Fouling Issues / Solutions

- Screens clogged with black deposits (iron / manganese).
- Acid treated wells with muriatic acid to restore flow.

ADEQ Arizona Department of Environmental Quality

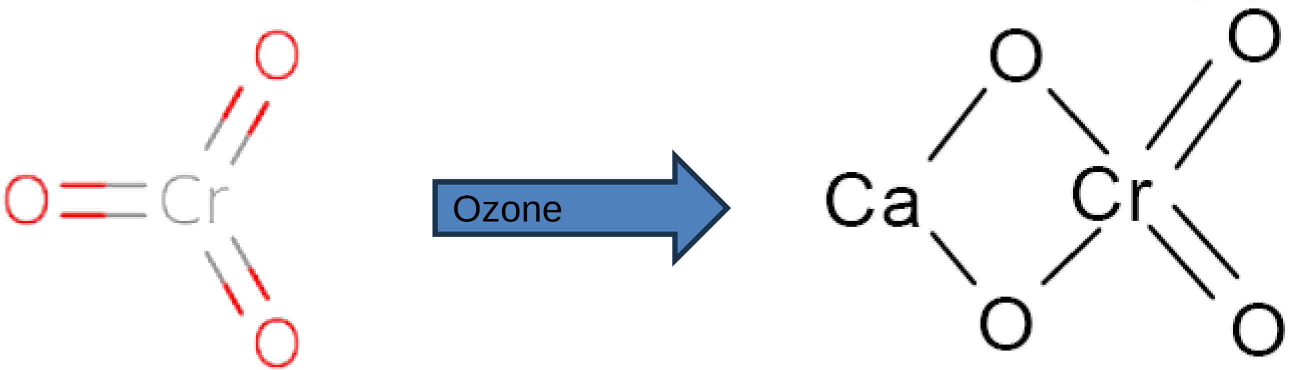
Ozone Diffuser Fouling – Iron and Manganese Deposits

Before Diffuser Cleaning

After Diffuser Cleaning

Lessons Learned

Some dissolved chromium was liberated proximal to select injection wells



Over long periods of time, ozone can oxidize metals such as chromium

Project Cost

Project Item	Cost
System Design	$34,000
System Construction[1]	$84,000
OS Well Installation[2]	$153,000
System O&M[3]	$437,000
Subtotal[4]	**$708,000**

Notes:

1 - Utilized existing SVE infrastructure (fenced compound, power supply, etc.)

2 - Five OS wells drilled via hollow stem auger

3 - Includes rental cost for O_3 generator

4 - PRAP projected cost of $1.2M for OS remedy

Findings/Observations

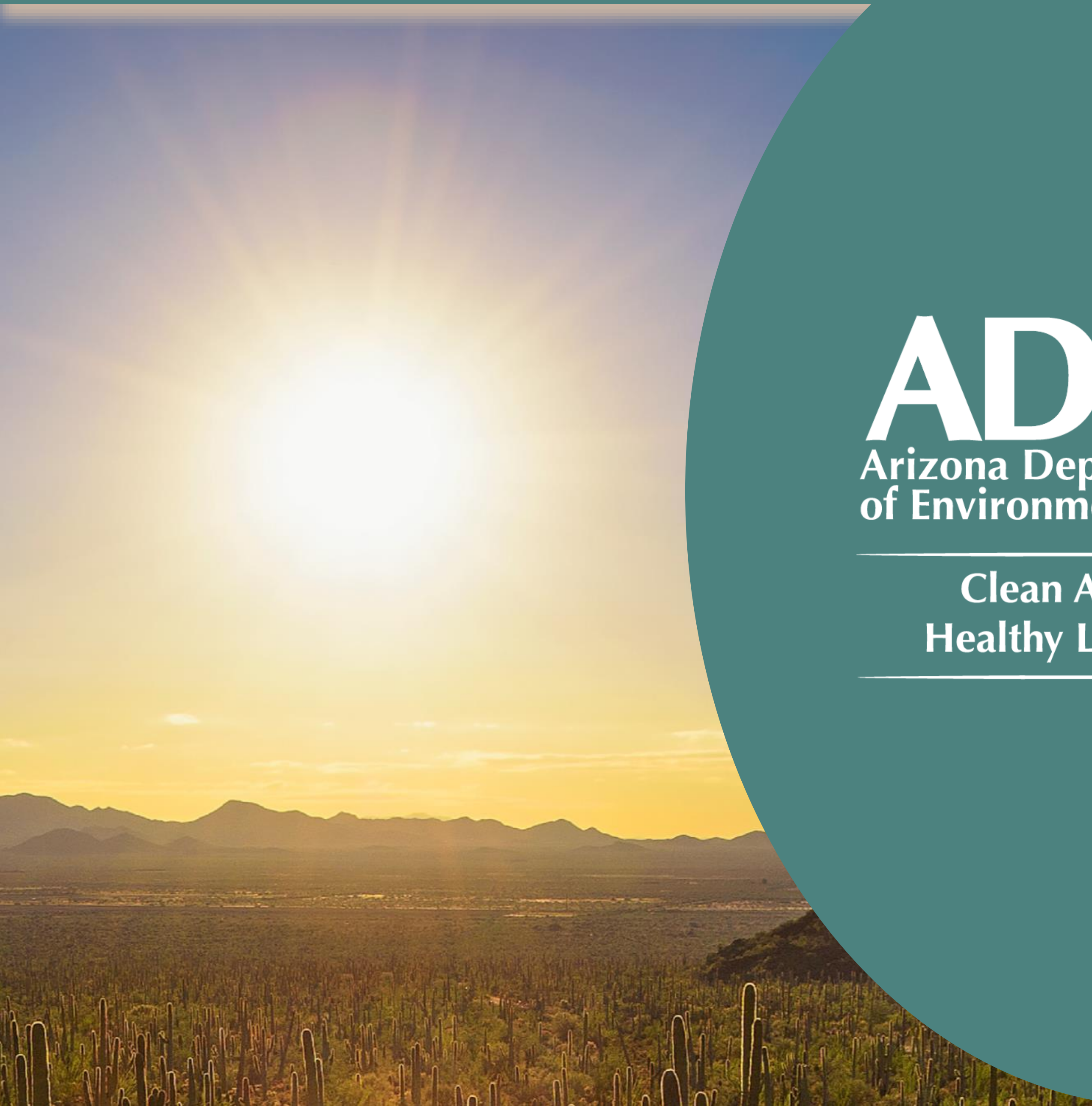
- PCE destruction occurred in close vicinity to treatment wells with evidence of treatment further downgradient (~250 feet)
- There is a concern for liberation of metals
- Technology did provide a feasible option for source area treatment
- Consideration should be given on remediation goals (e.g. How 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 addressing the residual source area was an objective in an area where groundwater resources are highly valued

Next Steps

- Routine groundwater monitoring program*
  - Annual monitoring for VOCs and MNA parameters
  - Semiannual monitoring for VOCs at select wells
- Groundwater sampling for metals to assess post-injection conditions
- No further O_3 treatment needed

*Routine monitoring performed in accordance with groundwater monitoring frequency optimization schedule

Thank You! Questions?



ADEQ
Arizona Department
of Environmental Quality

Clean Air, Safe Water,
Healthy Land for Everyone

Questions/Contact Information

ADEQ Project Manager

Mikel Morales

Morales.Mikel@azdeq.gov

602.771.4182

Geosyntec Senior Principal

Trevor Carlson, B.Sc.

tcarlson@geosyntec.com

657.331.5944