

# Enhanced In-Situ Bioremediation and Solar-Irrigated Phytoremediation to Treat a High Salinity PCE Plume

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# Agenda

- Site Background
- Pilot Studies
- Full-scale Remedy Implementations
- Lessons Learned/Summary



# Site Map

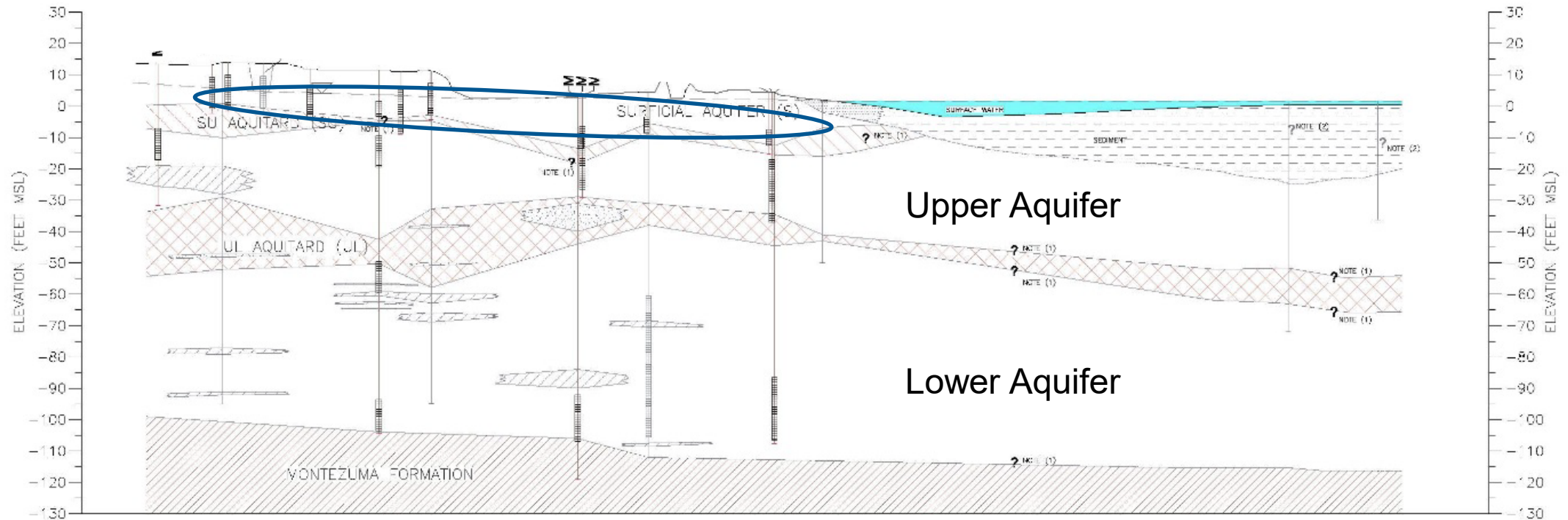
- Shallow Water Table
  - 8 - 12 ft bgs
- High TDS
  - 1,000 - 2,000 mg/L
  - Salty
- Tidal Effect
- Main COCs
  - CFCs
  - $\text{CCl}_4$
  - Organo-lead
  - 1,2-DCA
  - PCE





# Geologic Cross Section

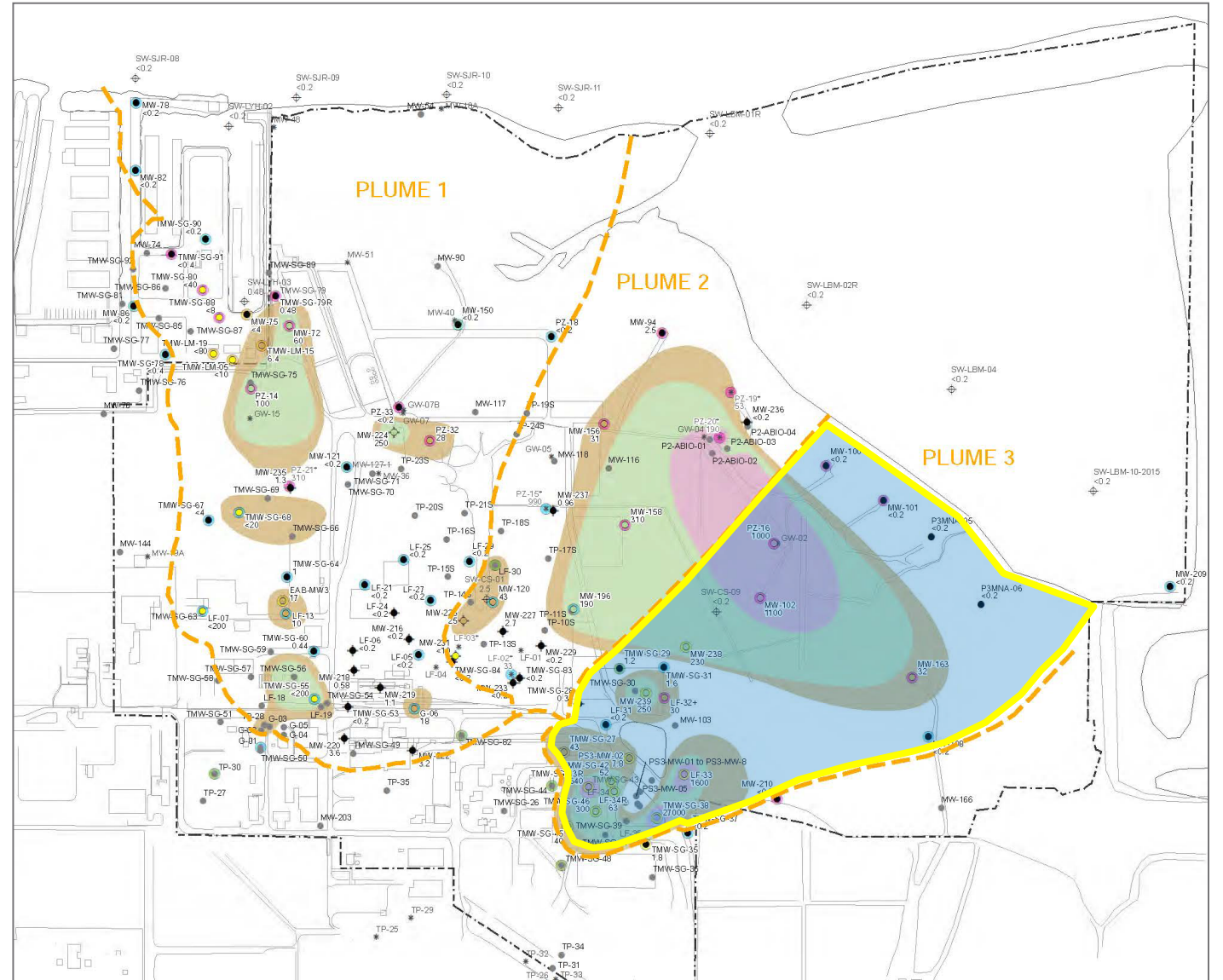
- Surficial Aquifer
- Upper Aquifer
- Lower Aquifer





# PCE Concentrations – Plume 3 Surficial Aquifer

- Plume 1
- Plume 2
- **Plume 3**



# Pilot Test: Phytoremediation

- Plant Tissue Sampling and Analyses

- Collected 36 eucalyptus and willow tree tissue samples
- Data indicated PCE uptake occurs in eucalyptus trees, but willow uptake may require further study



*Eucalyptus globulus*



*Tree core sample collection*

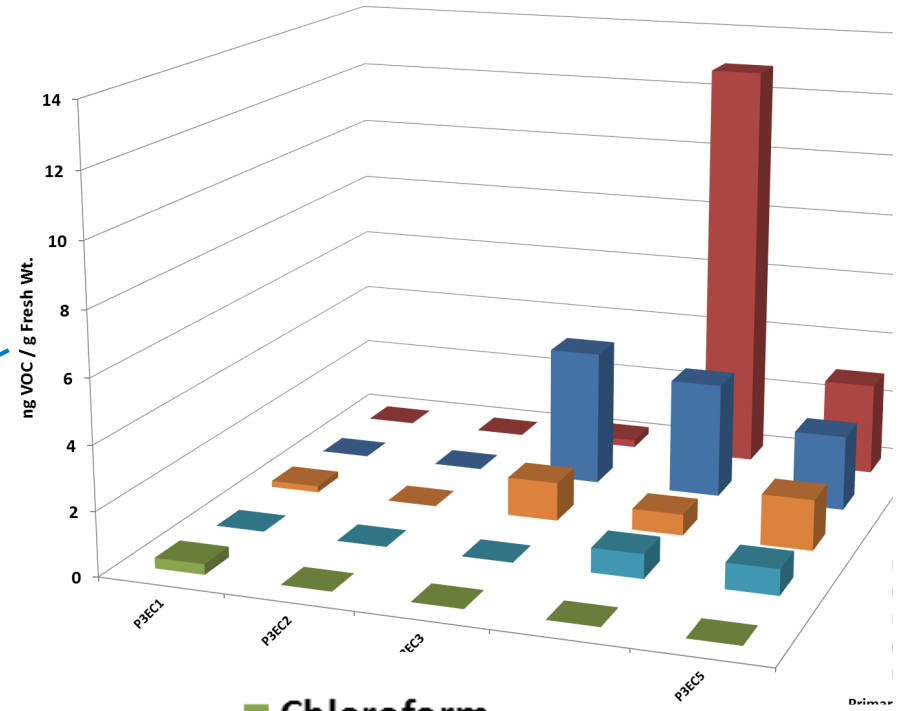
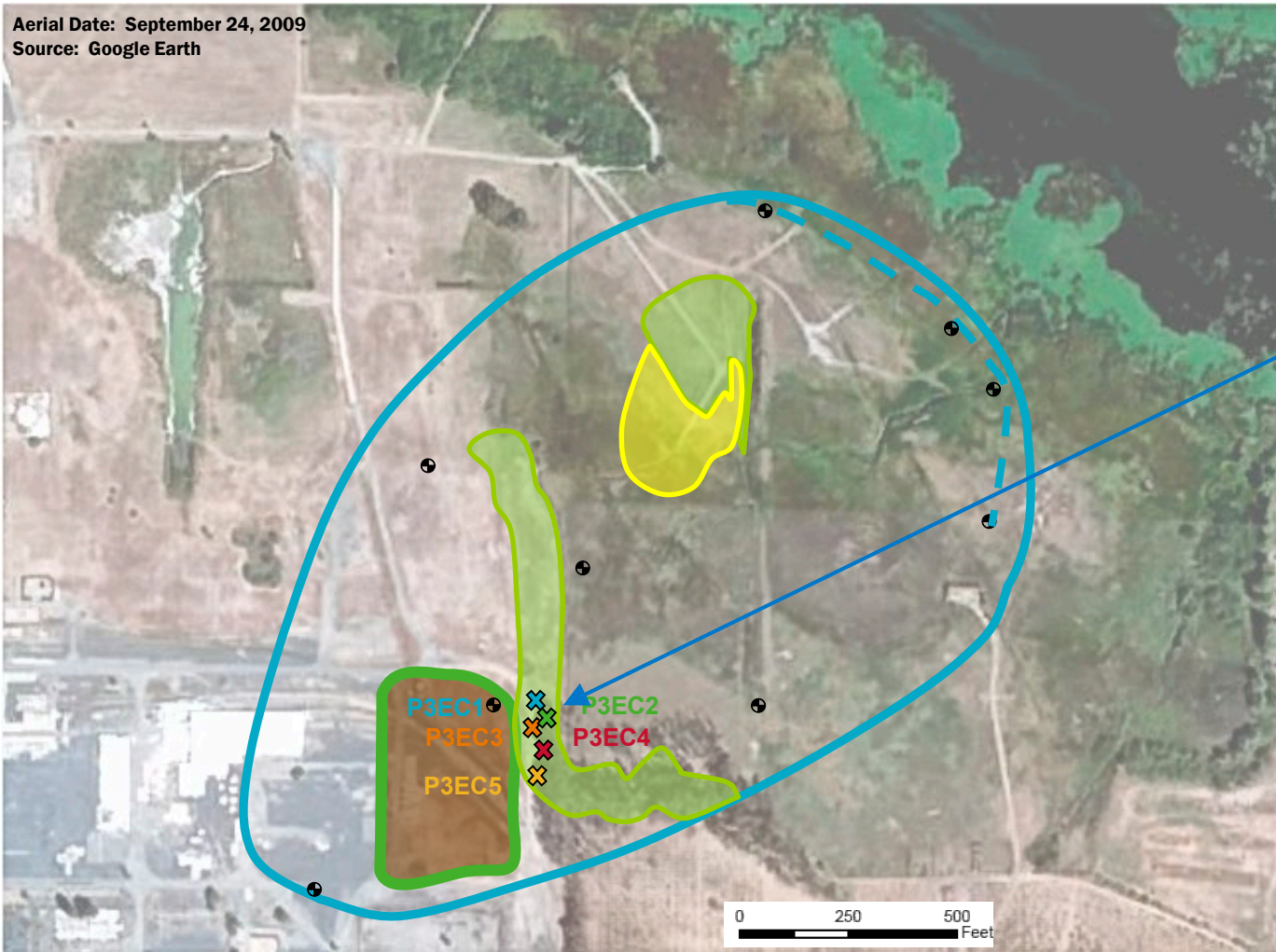


*Wood analyzed for VOCs*



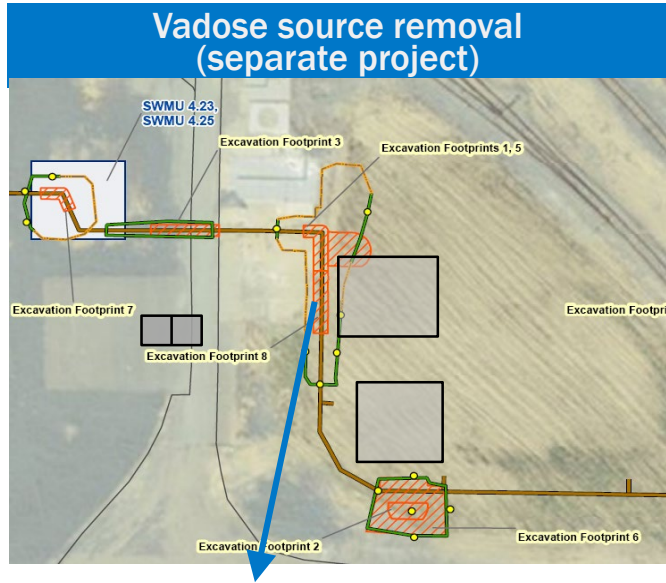
# Pilot Test: Phytoremediation

Aerial Date: September 24, 2009  
Source: Google Earth



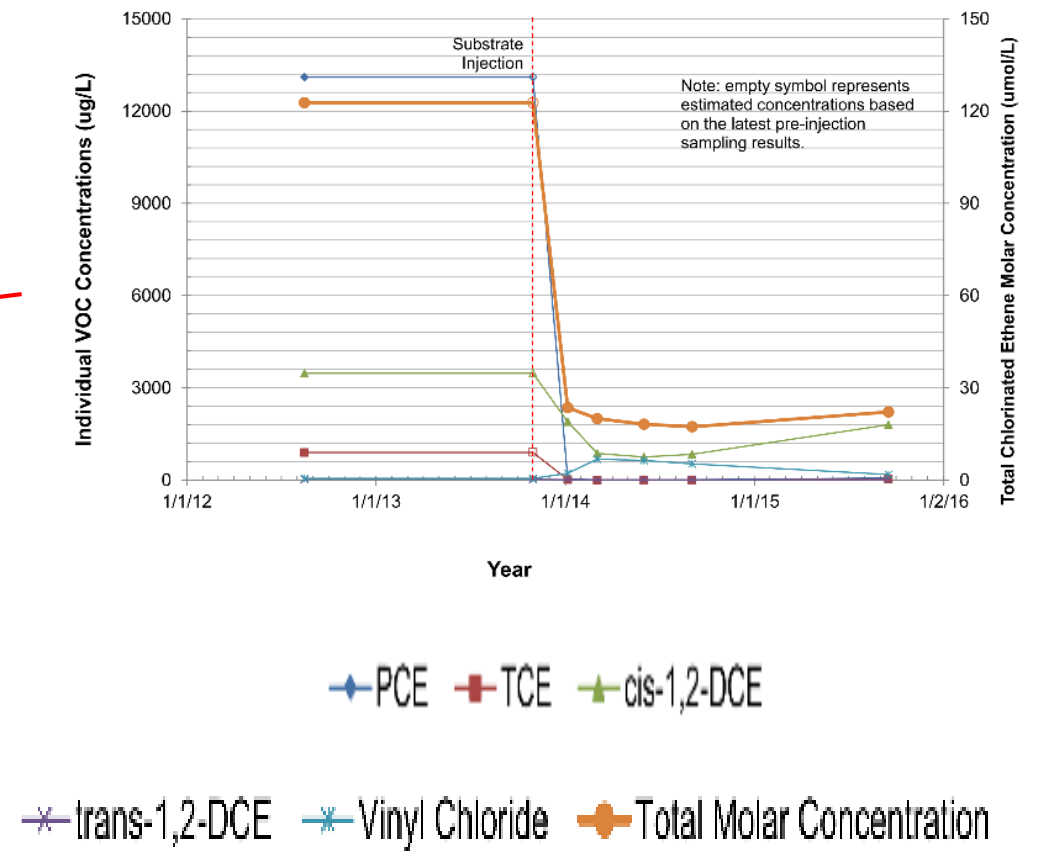
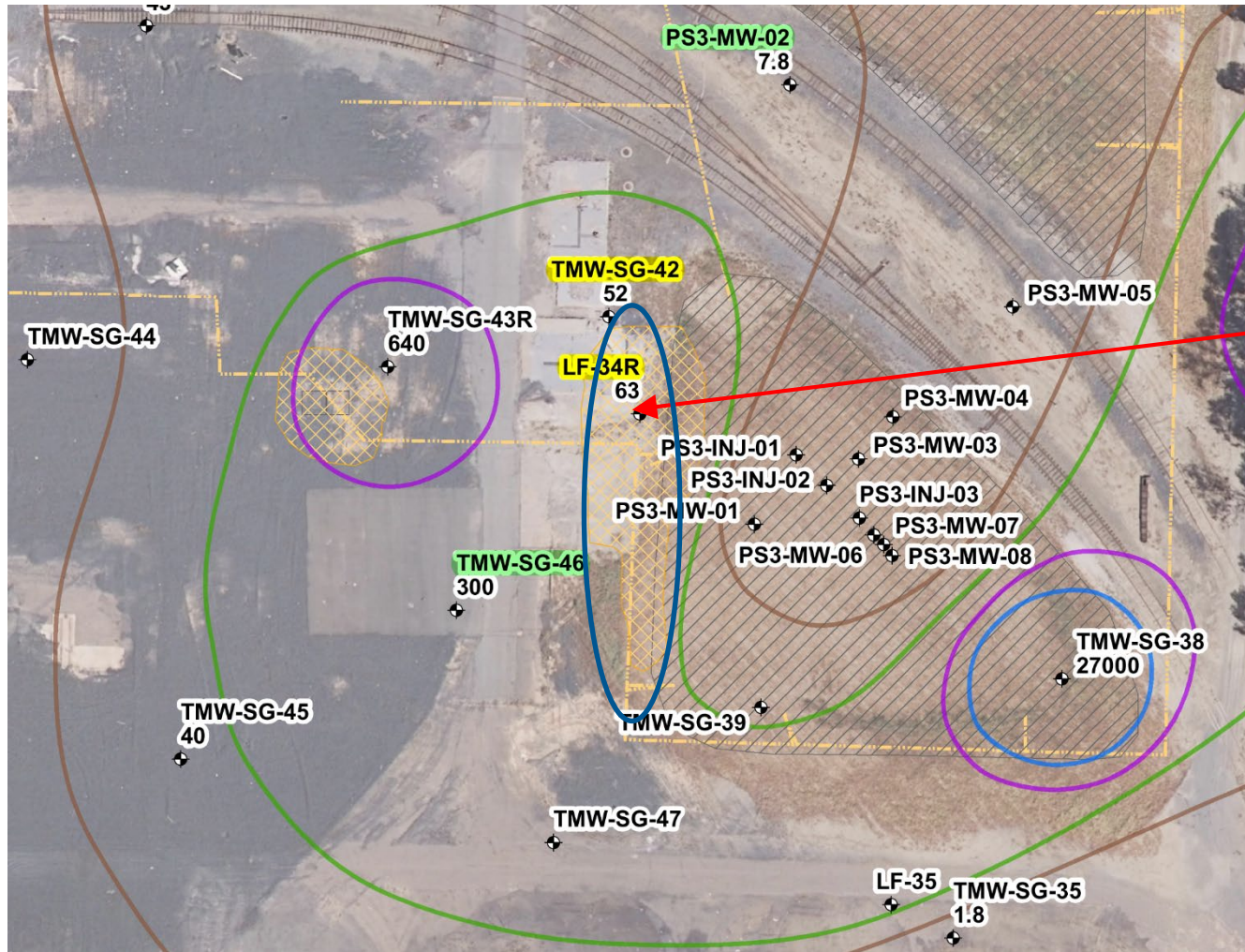


# Pilot Test: Enhanced Bioremediation

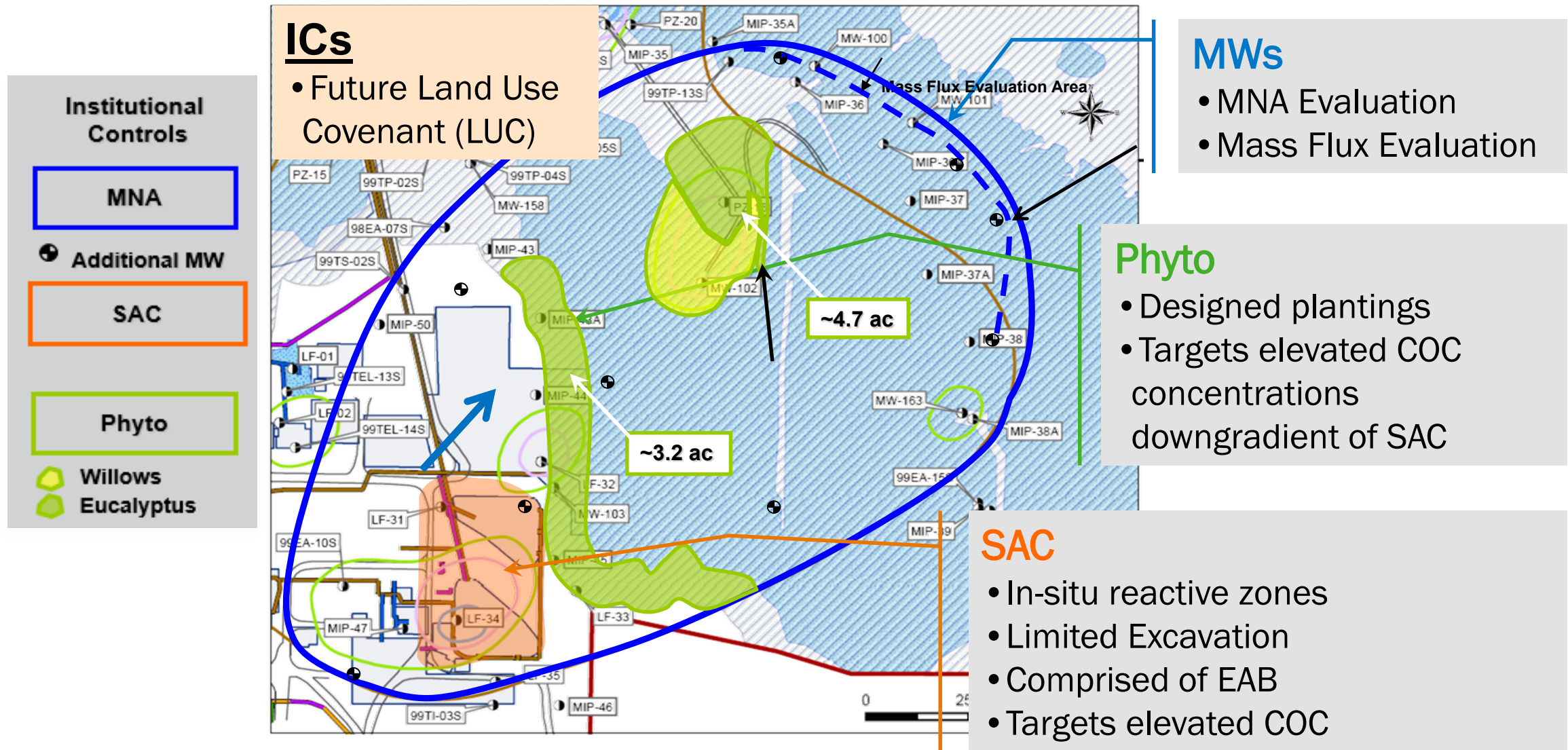




# Pilot Test Results

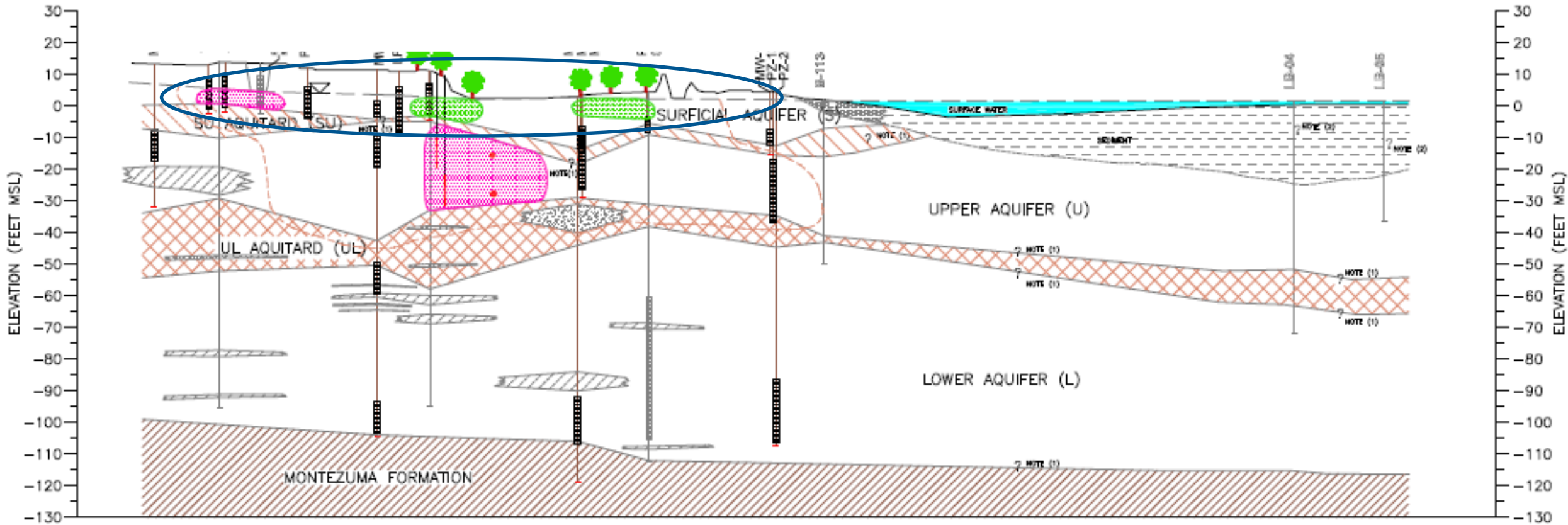


# Full Scale: Remedy Selection – Plume 3 Surficial Aquifer



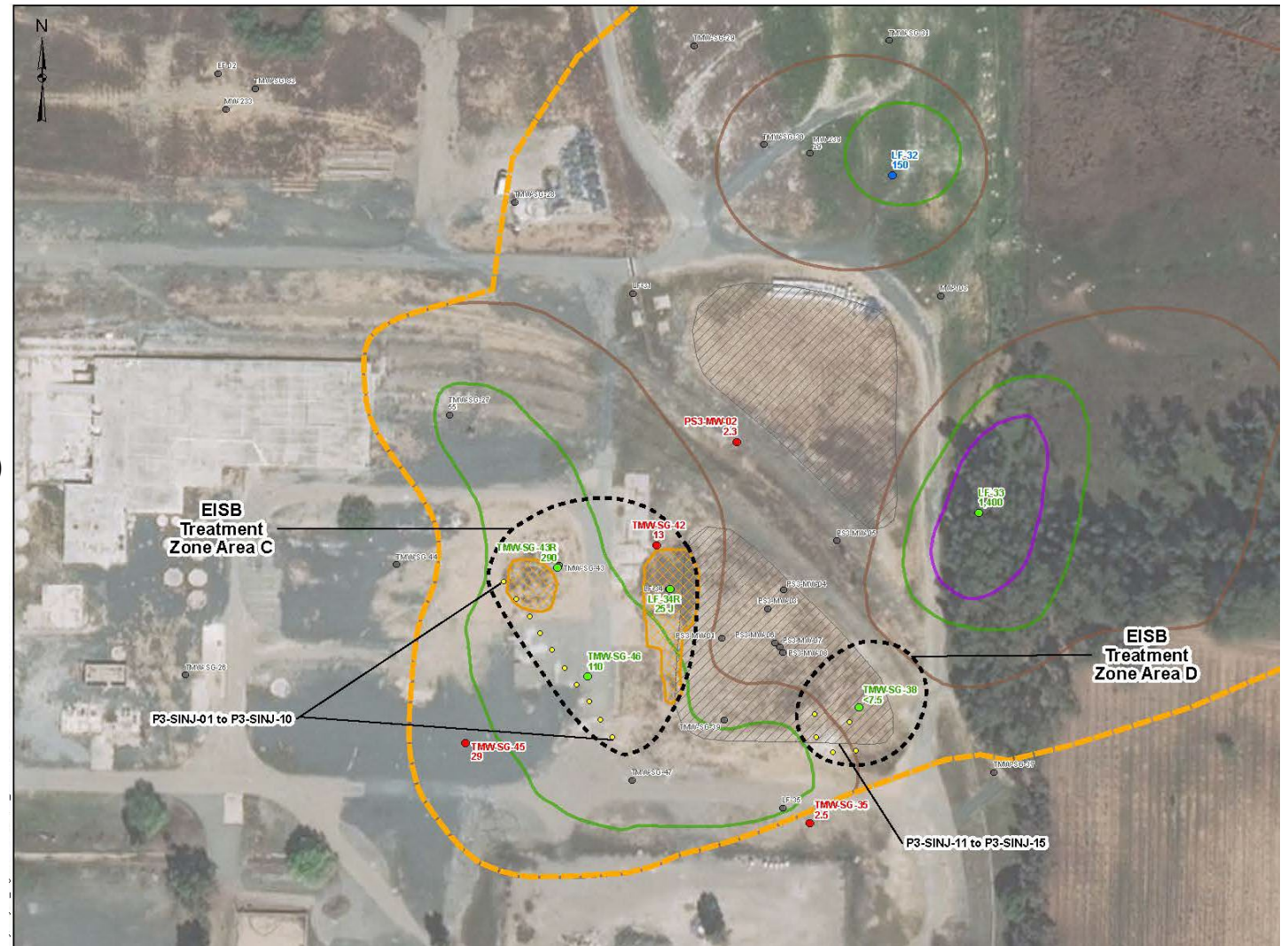


# Full Scale: Remedy Selection



# Substrate/Bioaugmentation Injection

- 15 injection wells
  - Treatment Area C – 10 injection wells
  - Treatment Area D – 5 injection wells
- Substrate Injection – 37,770 gallons
  - Newman Zone HRO – 1,860 gallons
  - Newman Zone QR – 310 gallons
  - Neutral Zone pH Buffer – 1,350 gallons
  - Makeup water – 34,250 gallons (MW-31)
- Bioaugmentation Injection
  - KB-1 Culture – 1 liter/well
  - Makeup water – 1 gallon (MW-31)
  - Push water – 30 gallons (MW-31)
  - Anaerobic conditions – 30 days later
    - DO < 1 mg/L
    - Negative ORP
    - Neutral pH





# Substrate Injection



*Totes of Substrate*



*Injection Trailer and Manifold*

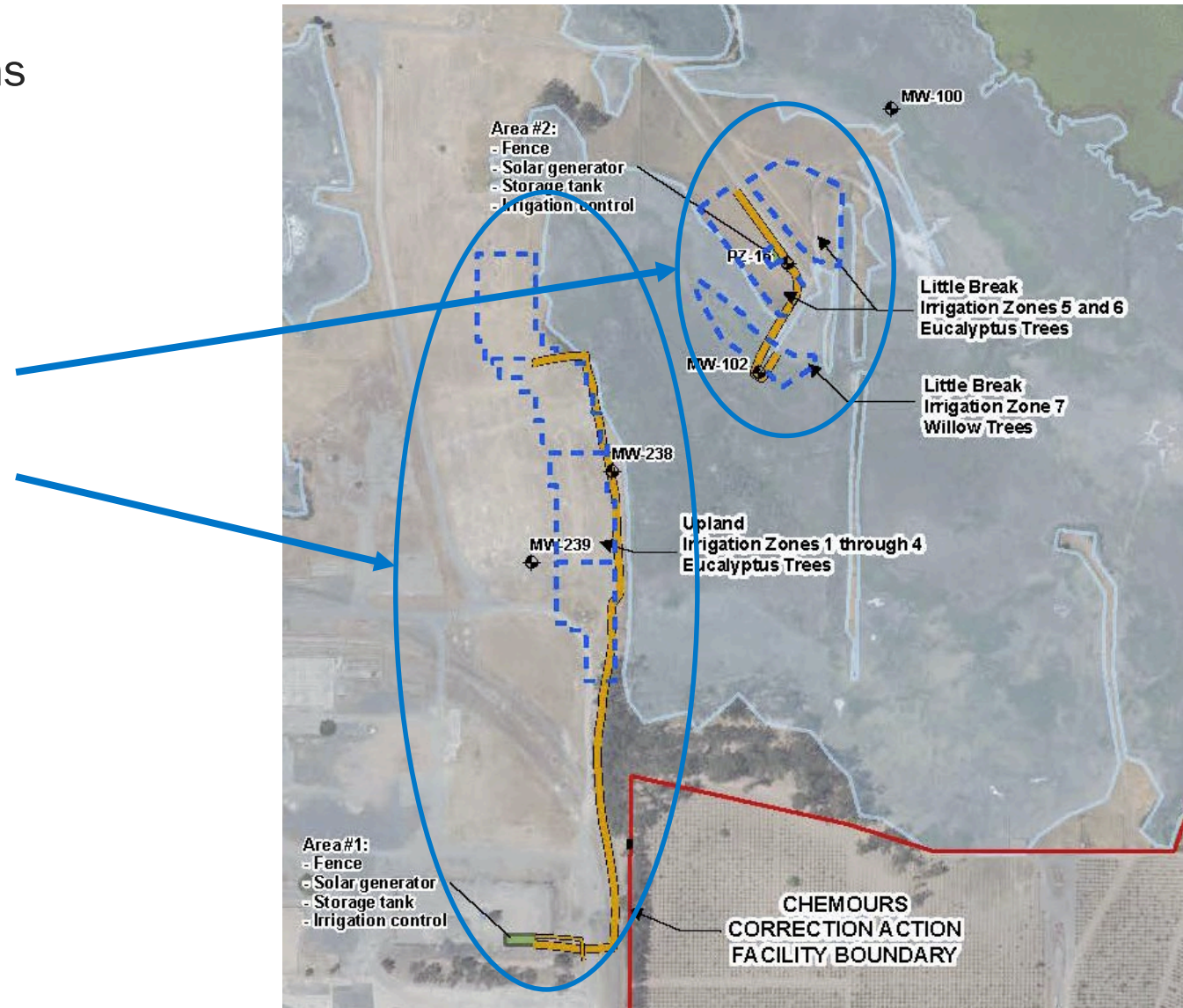


*Well Injection*



# Phytoremediation Layout

- Two solar-powered irrigation stations
  - Wetland irrigation station
  - Upland irrigation station
- Seven zones phytoremediation
  - Wetland – 2 zones of eucalyptus trees  
1 zone of willow trees
  - Upland – 4 zones of eucalyptus trees



# Full Scale: Phytoremediation

Five type of eucalyptus trees planted

- Salt tolerant species
- Propagated from seeds by Cal Poly
- Delivered to the site for planting



*Upland Debris Area*

Planting Spec

- Grid – 15ft x 15ft
- Depth – 10 ft Upland  
3 ft for Wetland
- Diameter – 1.5 ft
- Import Soil with 10% Municipal Compost





# Solar-Powered Irrigation Station



*Wetland Irrigation Station and Drip Emitters*

- Upland Irrigation Station
  - 1,100 gal storage tank – MW-32 groundwater
  - Power submersible pump in MW-32 and transfer pump to irrigation network
- Wetland Irrigation Station
  - 2,600 gal storage tank – import water due to salty GW
  - Power transfer pump to irrigation network



*Upland Irrigation Station Setup*



# Phytoremediation 2015 - 2018

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2015



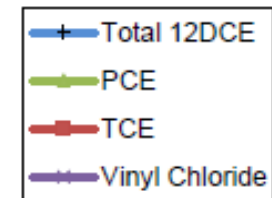
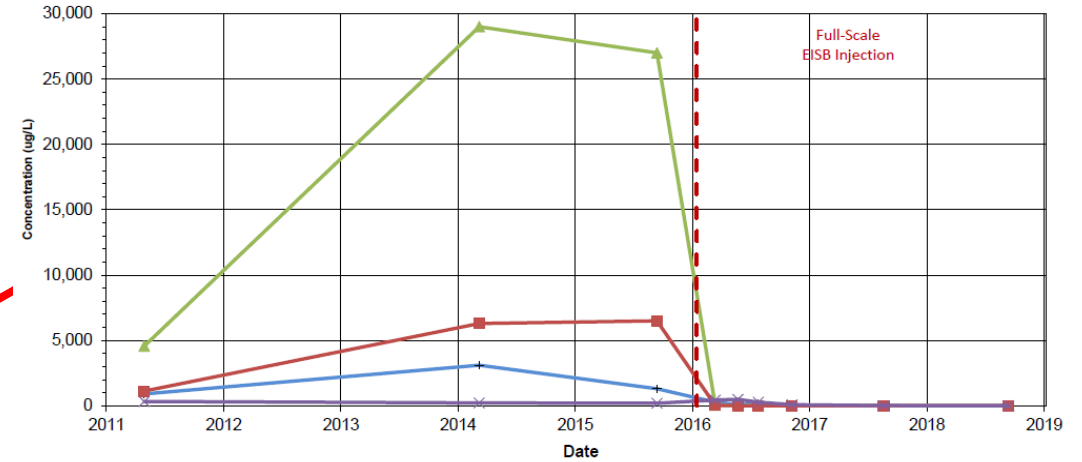
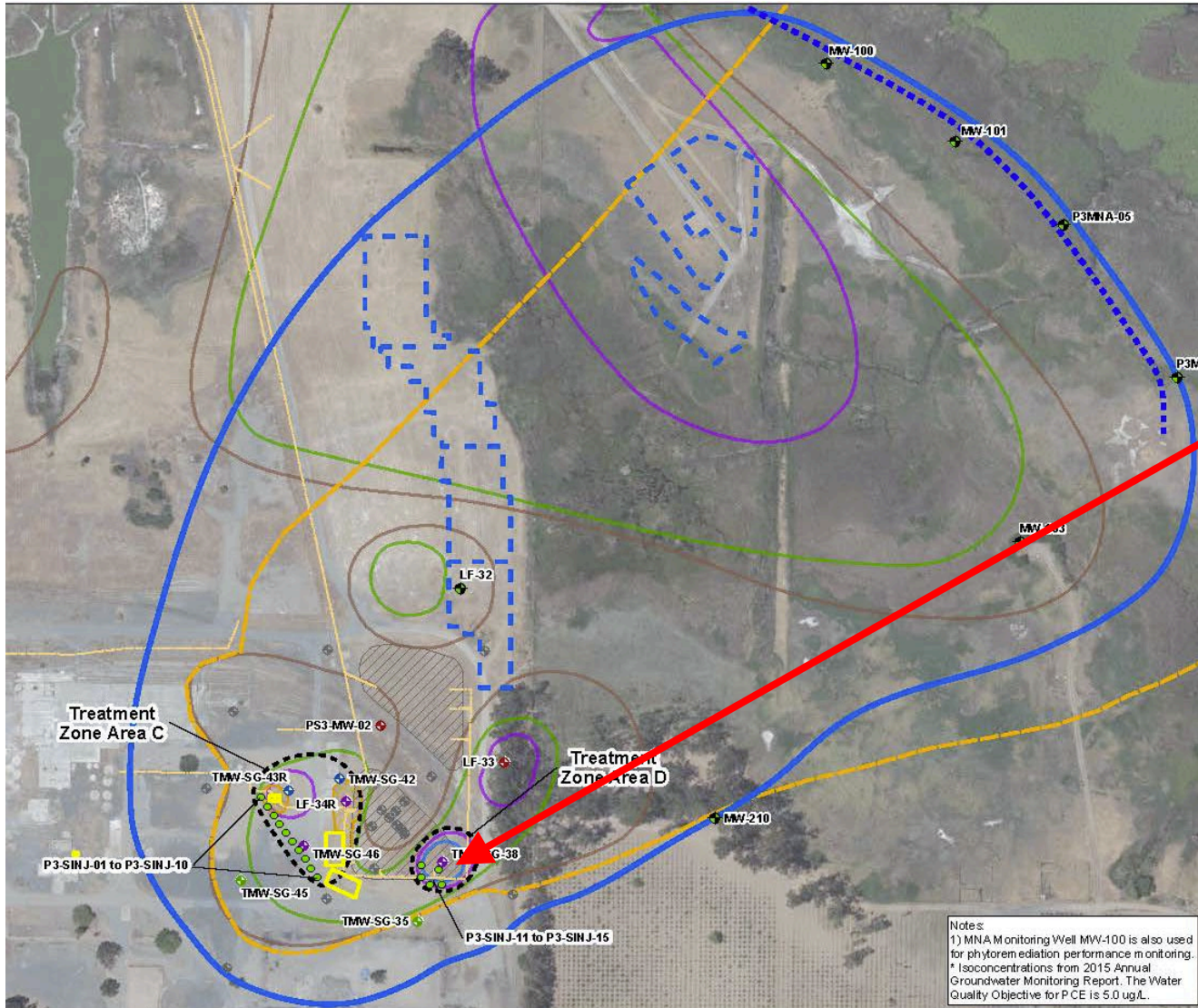
2017



2018

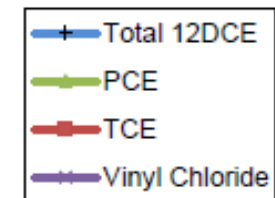
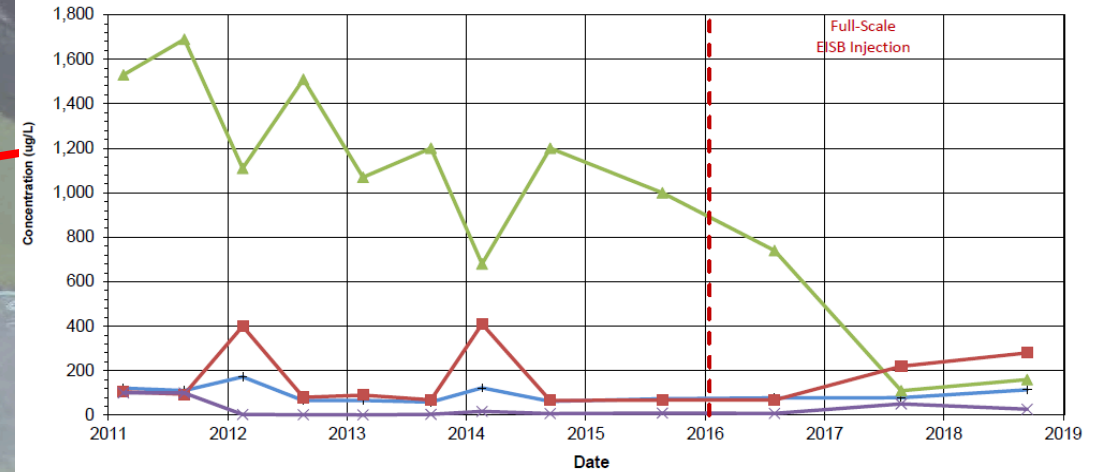
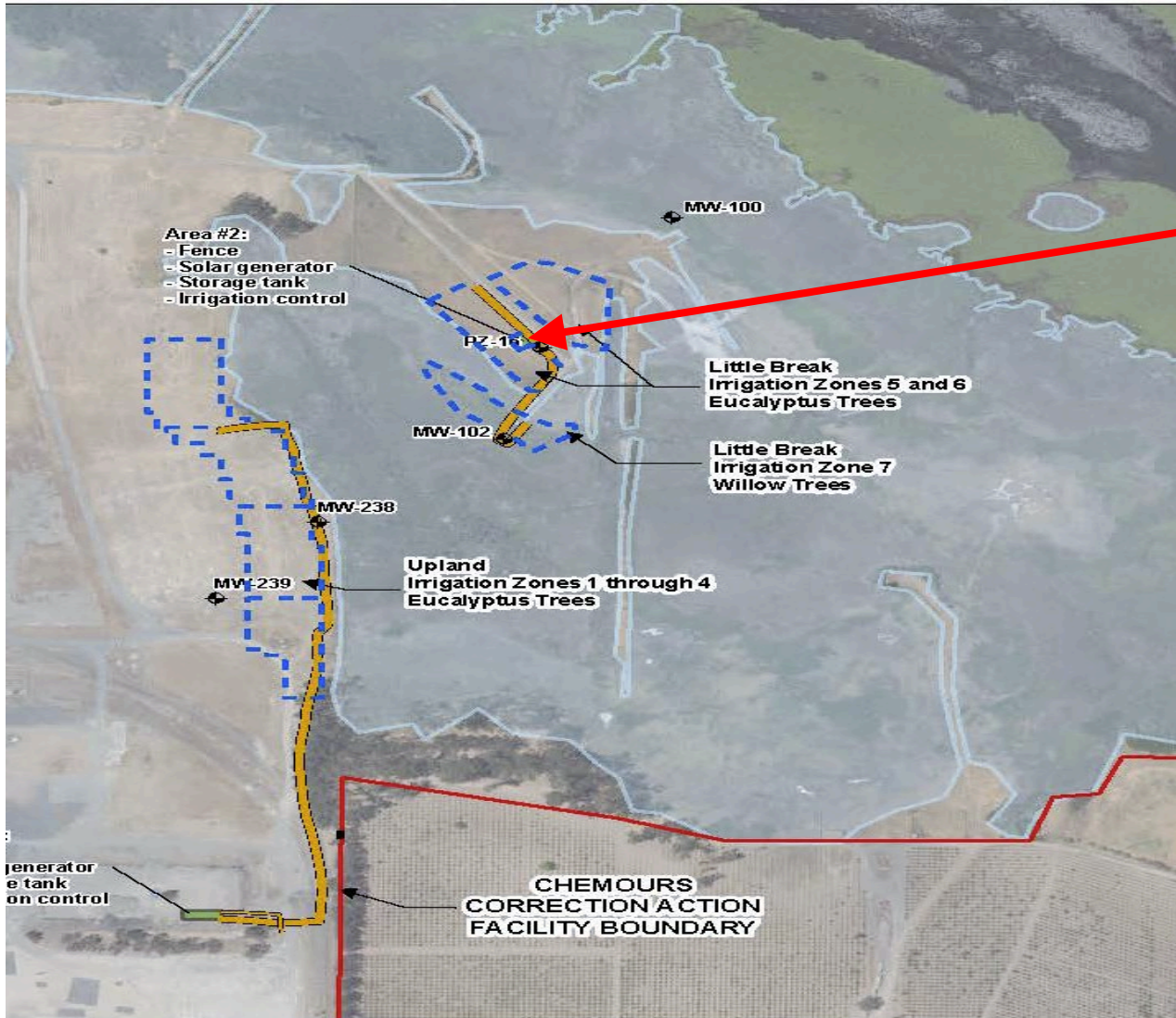


# EISB Performance Monitoring Well Results

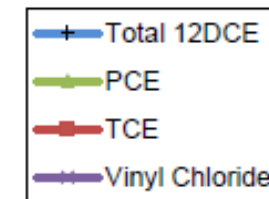
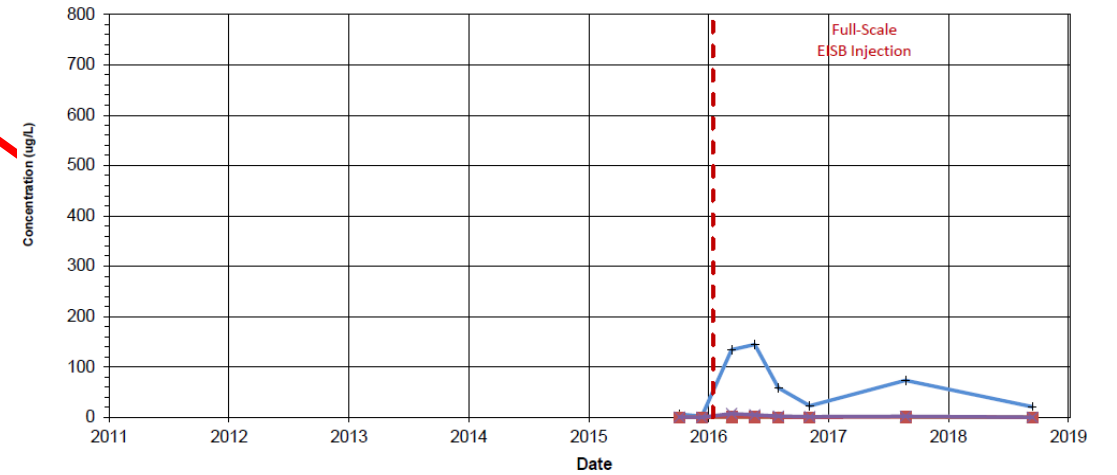
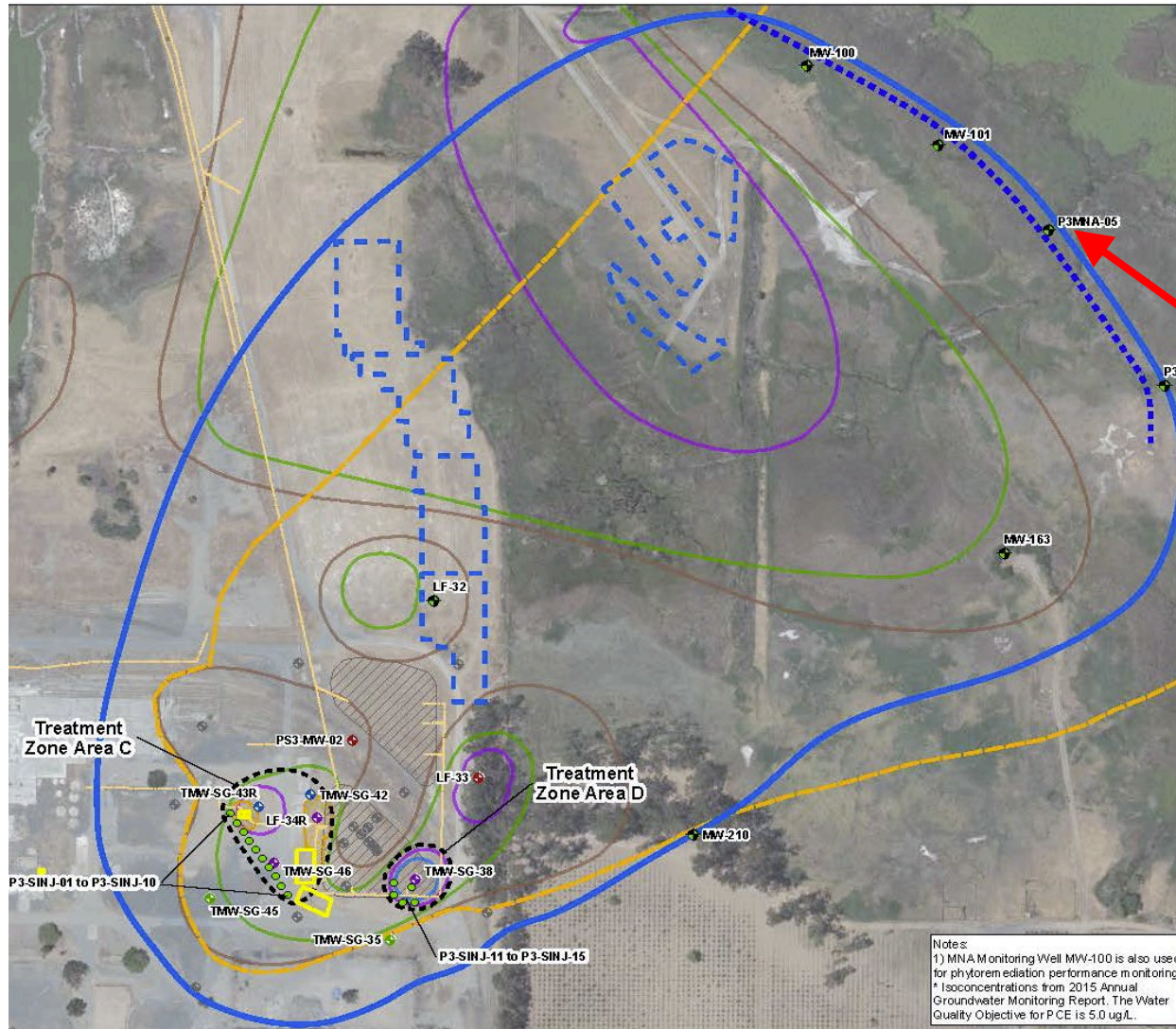




# Phytoremediation Performance Monitoring Well Results



# MNA Performance Monitoring Well Results





## EISB Injection Challenges/Lessons Learned

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- Slower than expected injection rates resulted in minor substrate spoilage and lower injection efficiency
  - Shallow groundwater level
  - Less permeable
- Expand manifold to maintain minimal (~4 gpm) injection rate required for injection pump to maintain prime.
- High pressure direct injection

## Phytoremediation Challenges/Lessons Learned

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- Hand watering required weekly before full-scale implementation
- More effort involved in weeding and mowing than anticipated
- Salinity of one onsite well was high - elected to truck in water
- Salt tolerant eucalyptus trees – E. Robusta and E. Occidentalis
- Solar panel attracts vandalism
- Irrigation stops after two years of operation
- High tree survival rate



# Summary

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- Successfully applied pilot studies to demonstrate sustainable technologies worked
- Phytoremediation was successfully installed and enhanced by solar power and site groundwater irrigation system
- High tree survival rate
- EISB successfully implemented with lessons learned
- COCs reduced significantly in treatment zone wells
- Microbes and volatile fatty acid concentrations still high in certain wells 3 years after the injection



# Q&A

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