



Federal Remedial Technology Roundtable

**Richard Mach
Naval Facilities Engineering Command**

9 June 04



Nanoscale Particle Treatment of Groundwater

Naval Air Engineering Station
Lakehurst, NJ

Location and Site Conditions



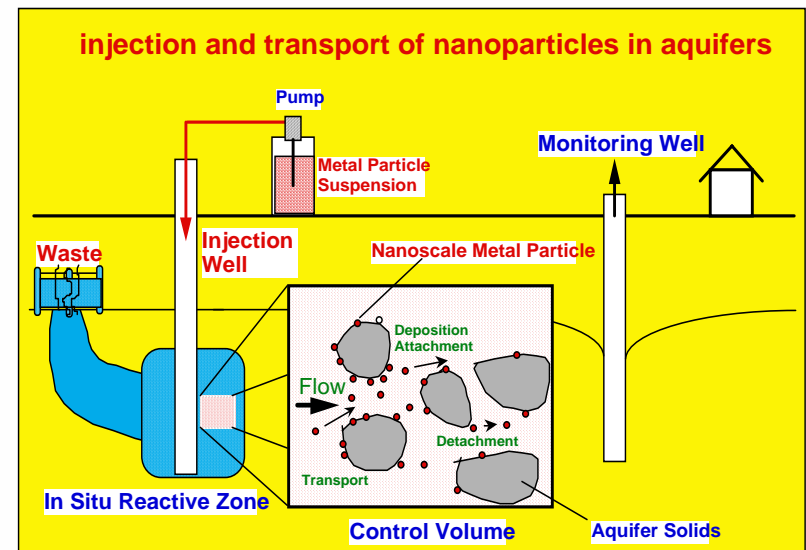
- Site of Hindenburg Crash in 1933
- Result from testing of aircraft launching activities
- Soil type = Coastal plain aquifer – mostly Sand and gravel
- Targeted treatment depth was 50' – 70'
- Water table 15' BGS
- TCE present in GW up to 56 ug/L, avg. ~ 15 ug/L
- Two plumes treated with nanoscale iron with palladium catalyst
- Natural Attenuation was initially chosen, Regulators required more aggressive treatment
- >\$1M spent on MNA



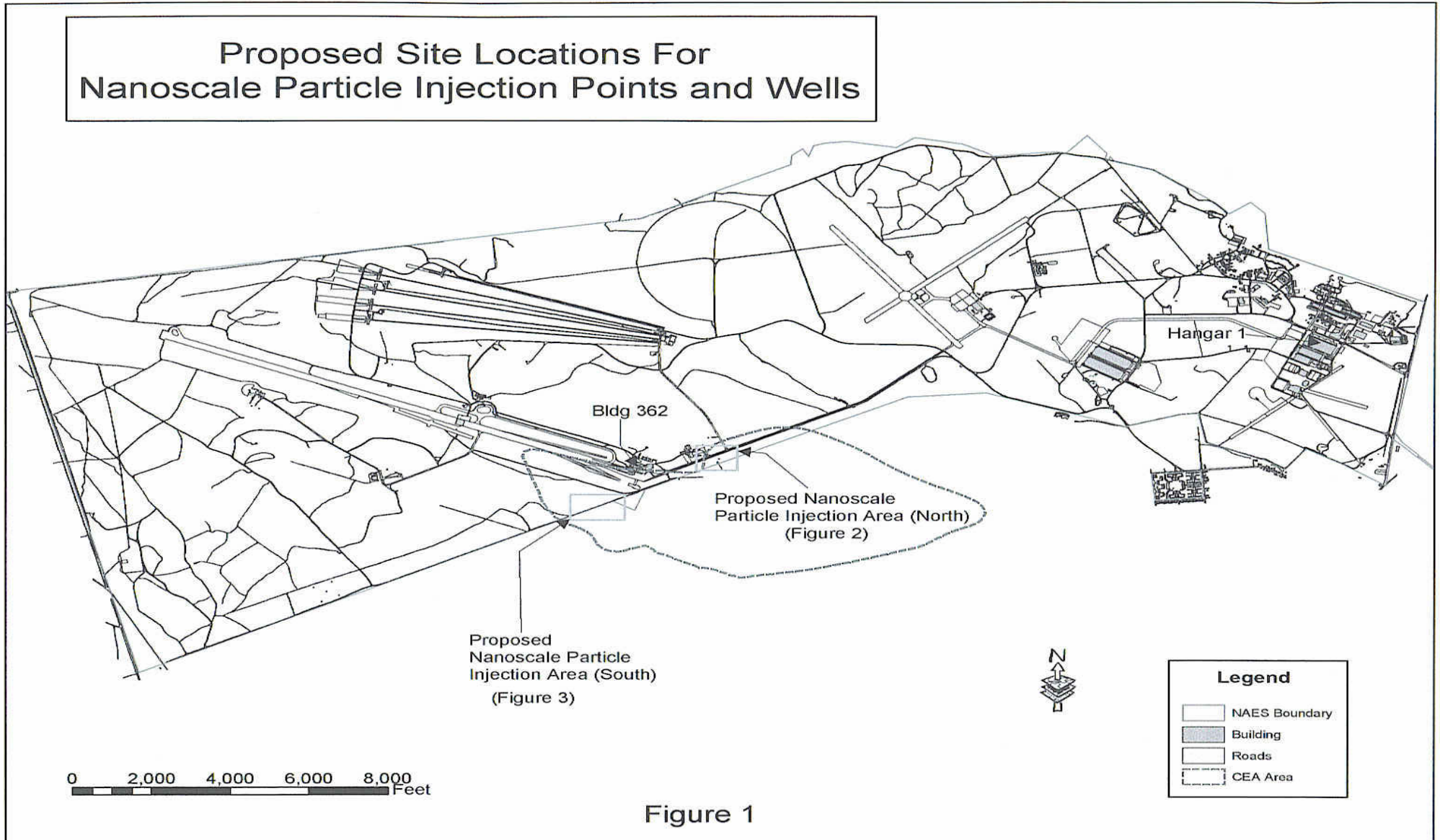
Treatment Details



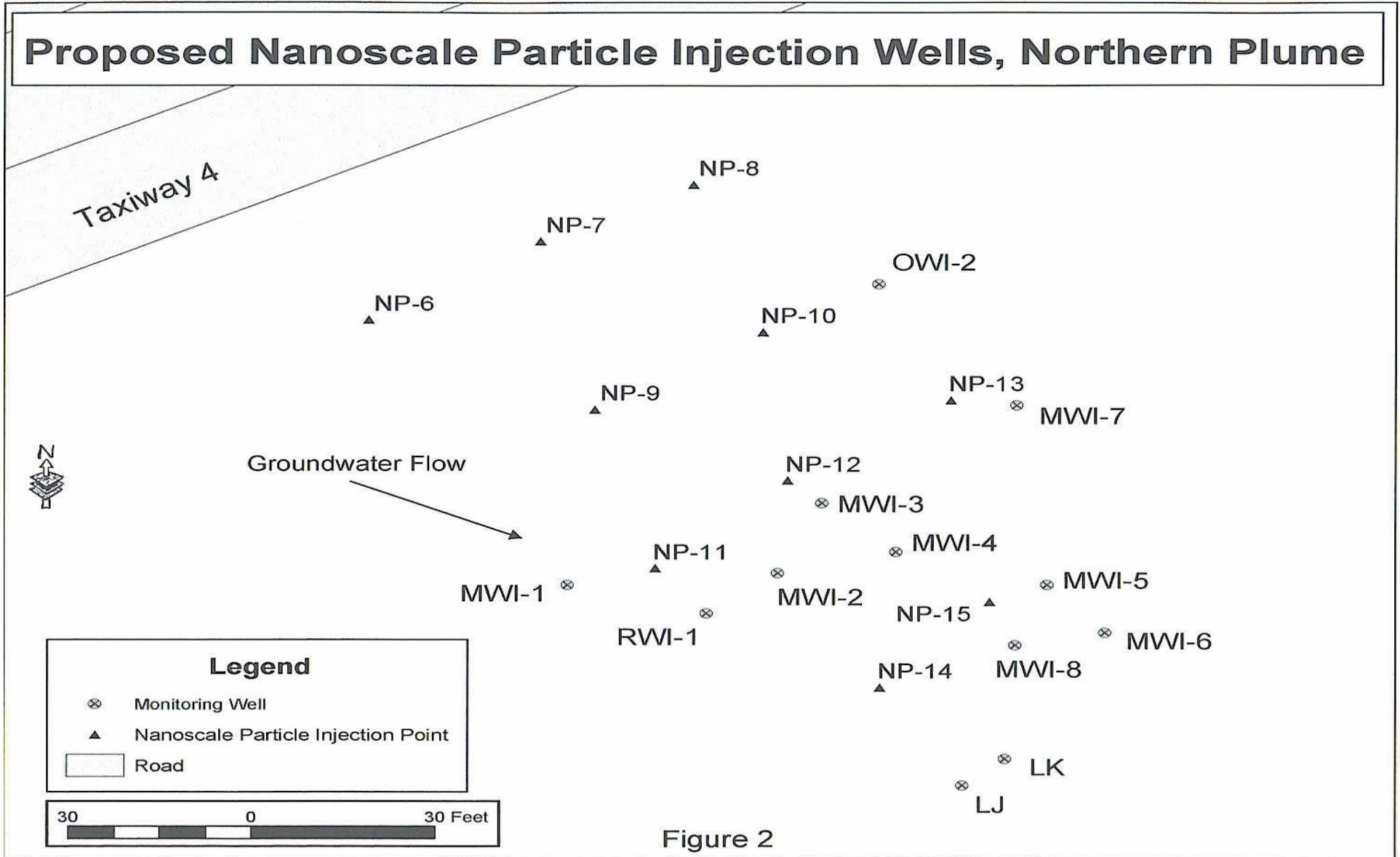
- Used 20 lbs nanoFe/1200 gal water in each of 15 Geoprobe injection points
- Solution injected over a 20-foot interval (50'-70'), in equal 2-ft lifts
- Used GW from nearby extraction well
- A total of 300 lbs NanoFe injected
- TCE levels reduced up to 50% in single injection – additional injection anticipated
- NanoFe = nanoscale iron with a Pd⁰ coating (catalyst)
- 1.7 lbs Palladium used in Phase I;
3.75 lbs used in Phase II



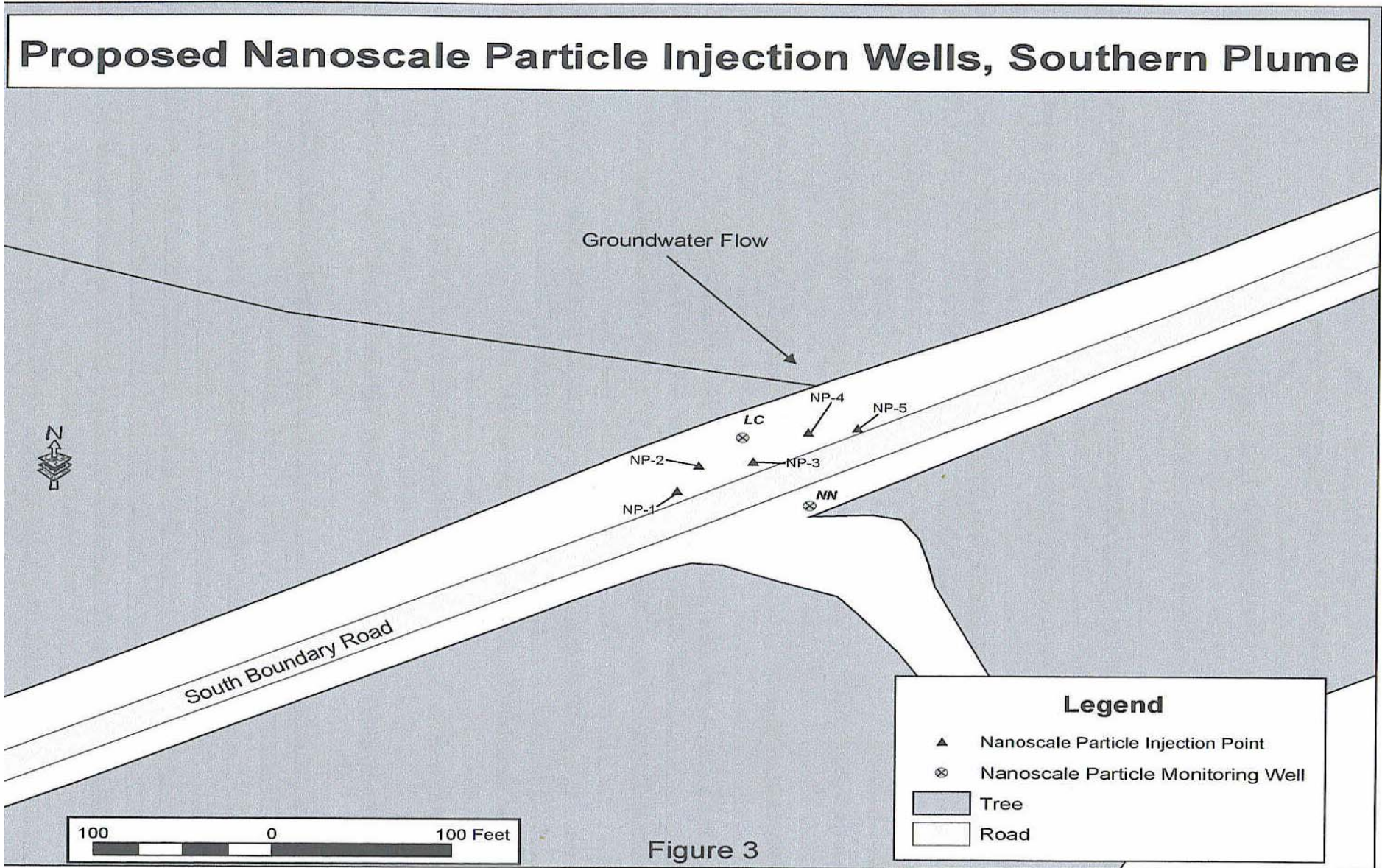
NAES Lakehurst Site Locations



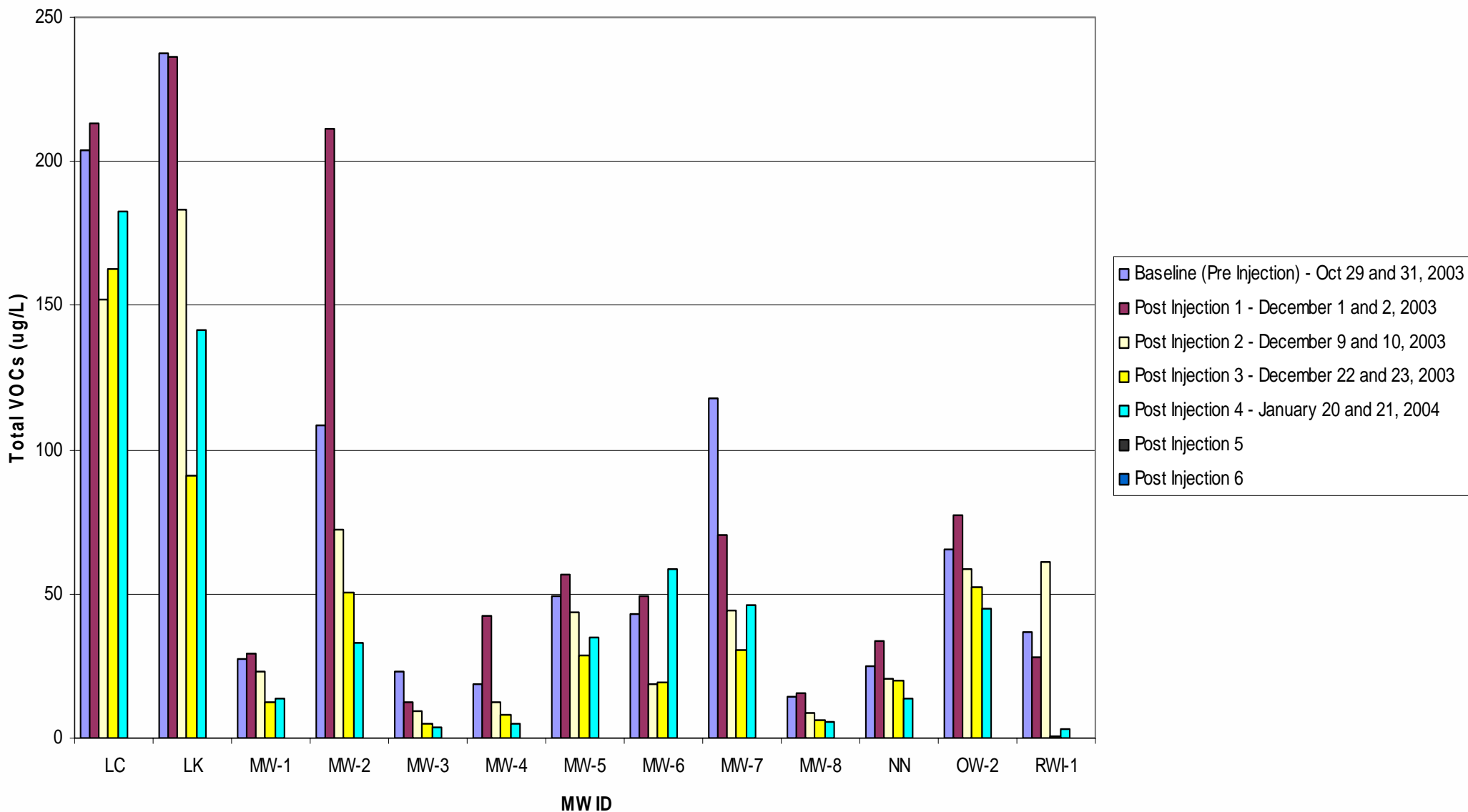
NAES Lakehurst Northern Plume



NAES Lakehurst Southern Plume



Total VOCs Sampling Results





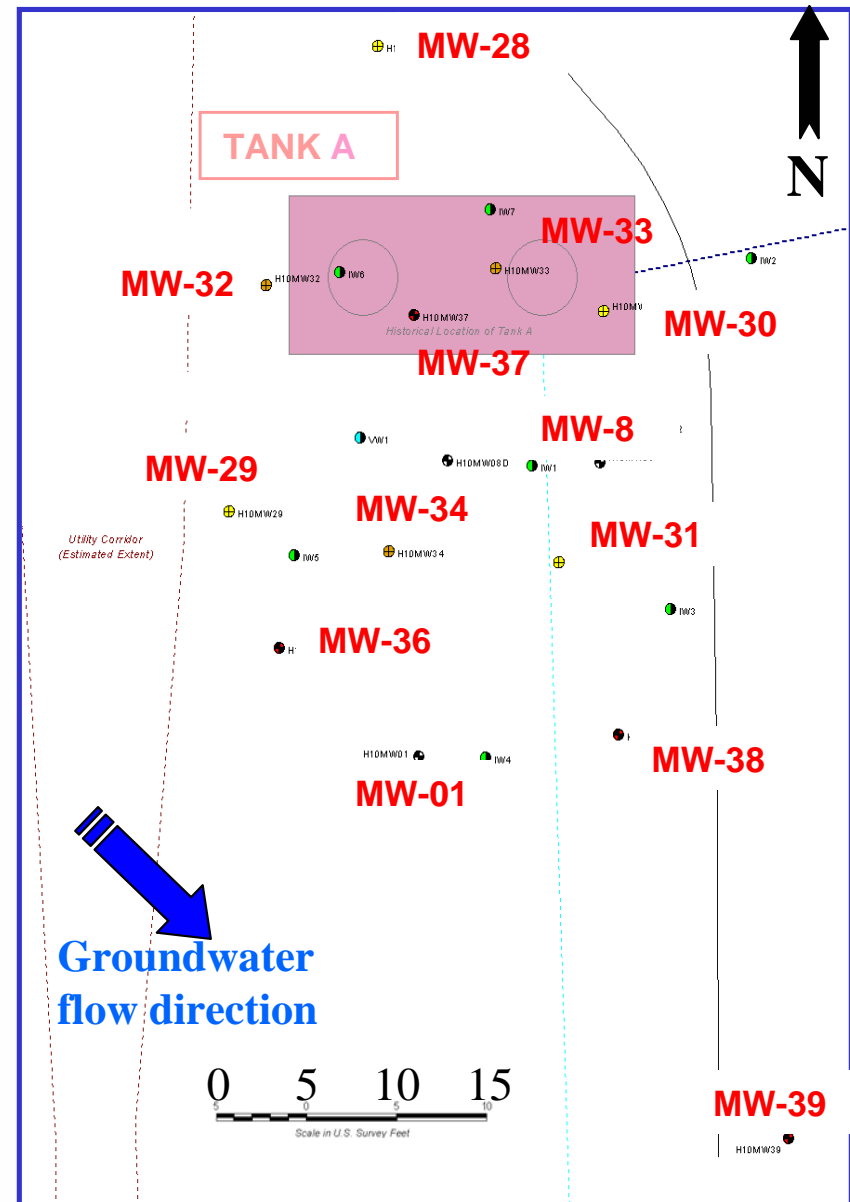
Source Area Treatment with Nanoscale Particles

Naval Air Station
Jacksonville, FL

Location and Site Conditions



- Hanger 1000
- Tank A removed in 1994
- Soil
 - Fine to medium sand from 0 to 24 feet bgs
 - Dense clay from 24 to 54 ft bgs
 - TCA = 337 mg/kg
 - TCE = 224 mg/kg
 - PCE = 139 mg/kg
- Groundwater
 - Flow toward southeast
 - Water table at 7 feet bgs
 - TVOCs => 50mg/l
- Not expected to reach MCLs
- MNA anticipated as next step



Treatment Details



- **Nanoscale Iron**
 - Food grade Polymer Supported w/Palladium Catalyst
 - Purchased from PARS Environmental
 - CVOC mass estimated: 40 to 125 lbs
 - 300 lbs of iron was injected
 - Prior to 2003, nanoscale iron was not commercially available
 - Costs for the nanoscale iron has dropped 2 times



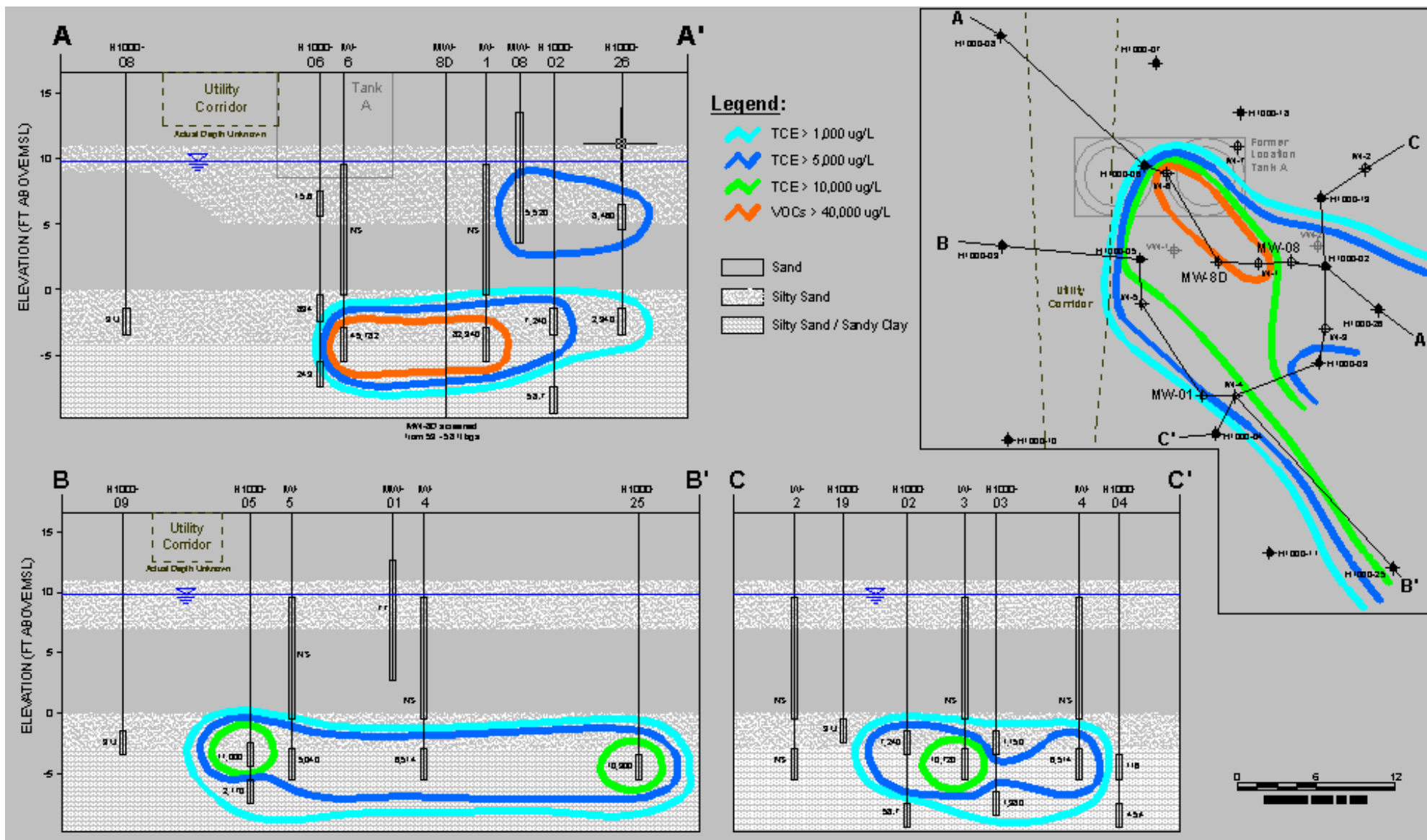
Treatment Details (con't)



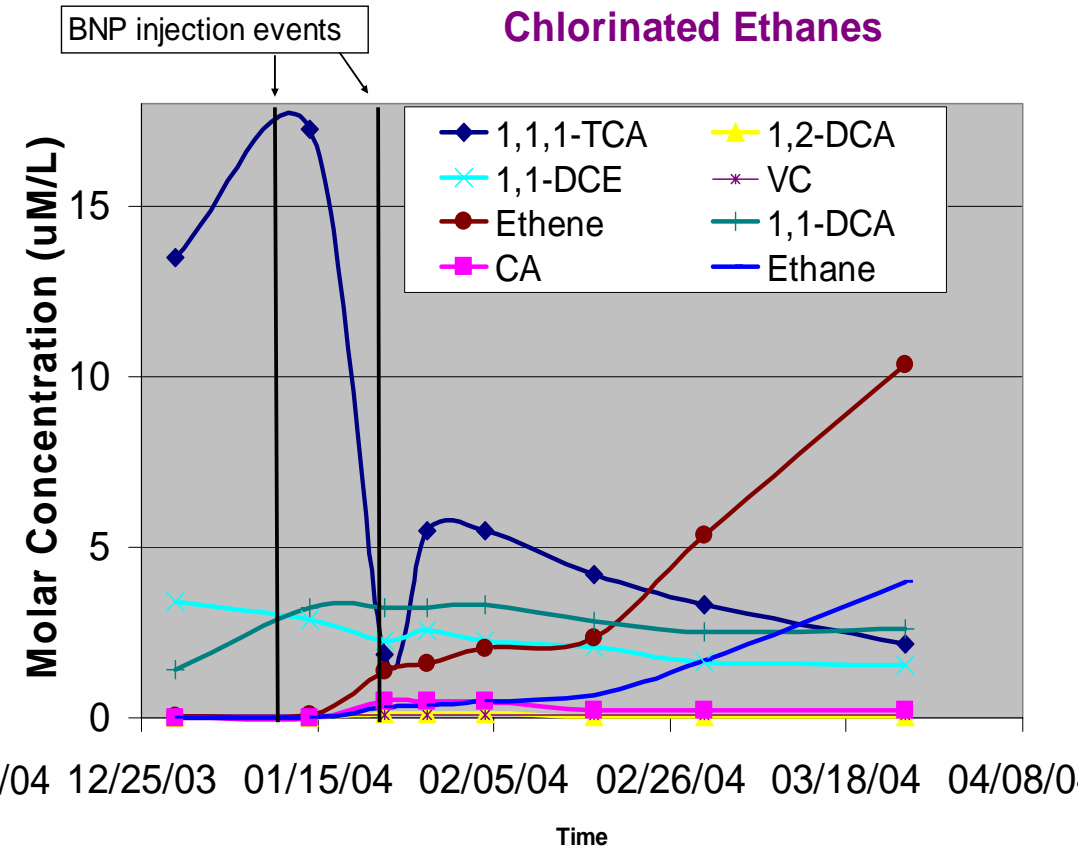
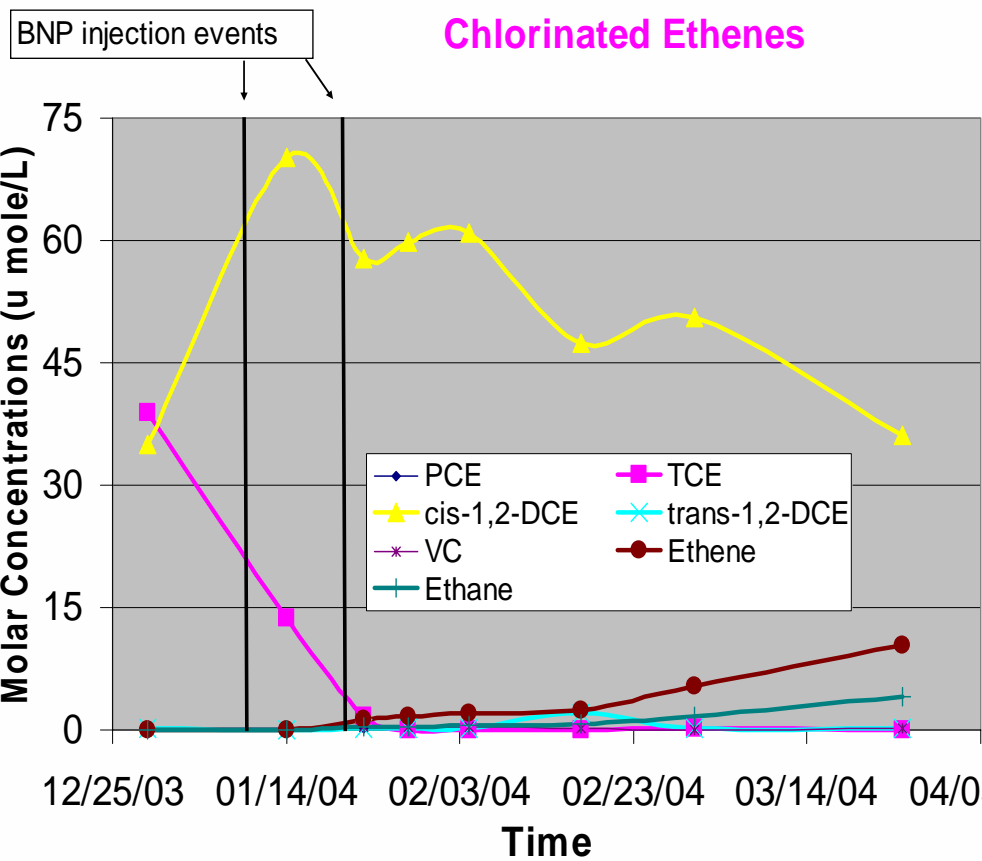
- **Two injection methods:**
 - Strategic DPT injections
 - Recirculation Process
- **More work is yet to be done:**
 - Groundwater sampling for 3 remaining quarters
 - Confirmation soil sampling
- **Cost estimates**
 - Current is \$300-350/yd³
 - Excavation estimated to be \$400-500/yd³
 - Estimate with less sampling and lower iron costs is \$215-265/yd³



NAS Jacksonville TCE in Groundwater



Source Well MW-37 Results



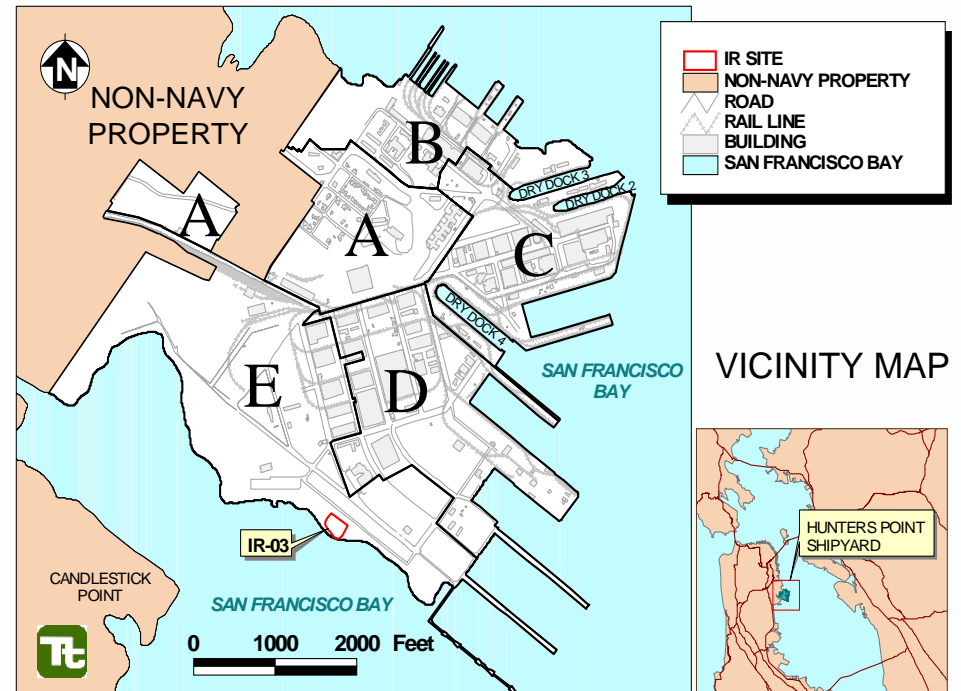
Micro-Scale ZVI Treatment of Groundwater

Hunter's Point Shipyard
San Francisco, CA

Location and Site Conditions



- Remedial Unit C4
- Pneumatic fracturing to inject micro-scale ZVI
- Soil type = 10ft layer of artificial fill over fractured bedrock
- Targeted depth is 7ft bgs to 32 ft bgs
- Water table is 7 ft bgs
- TCE present in GW up to 88 $\mu\text{g/l}$
- Removed 99.1% of total chlorinated solvents
- Project cost estimate was \$117/ yd^3



Hunter's Point
Shipyard

Micro-scale ZVI and Hydrofracturing

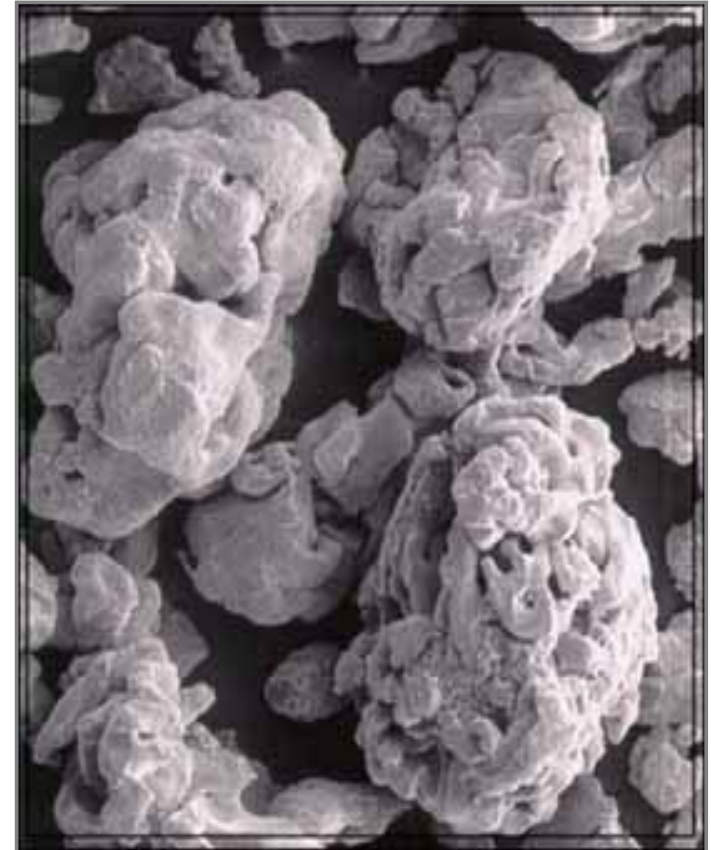


ZVI

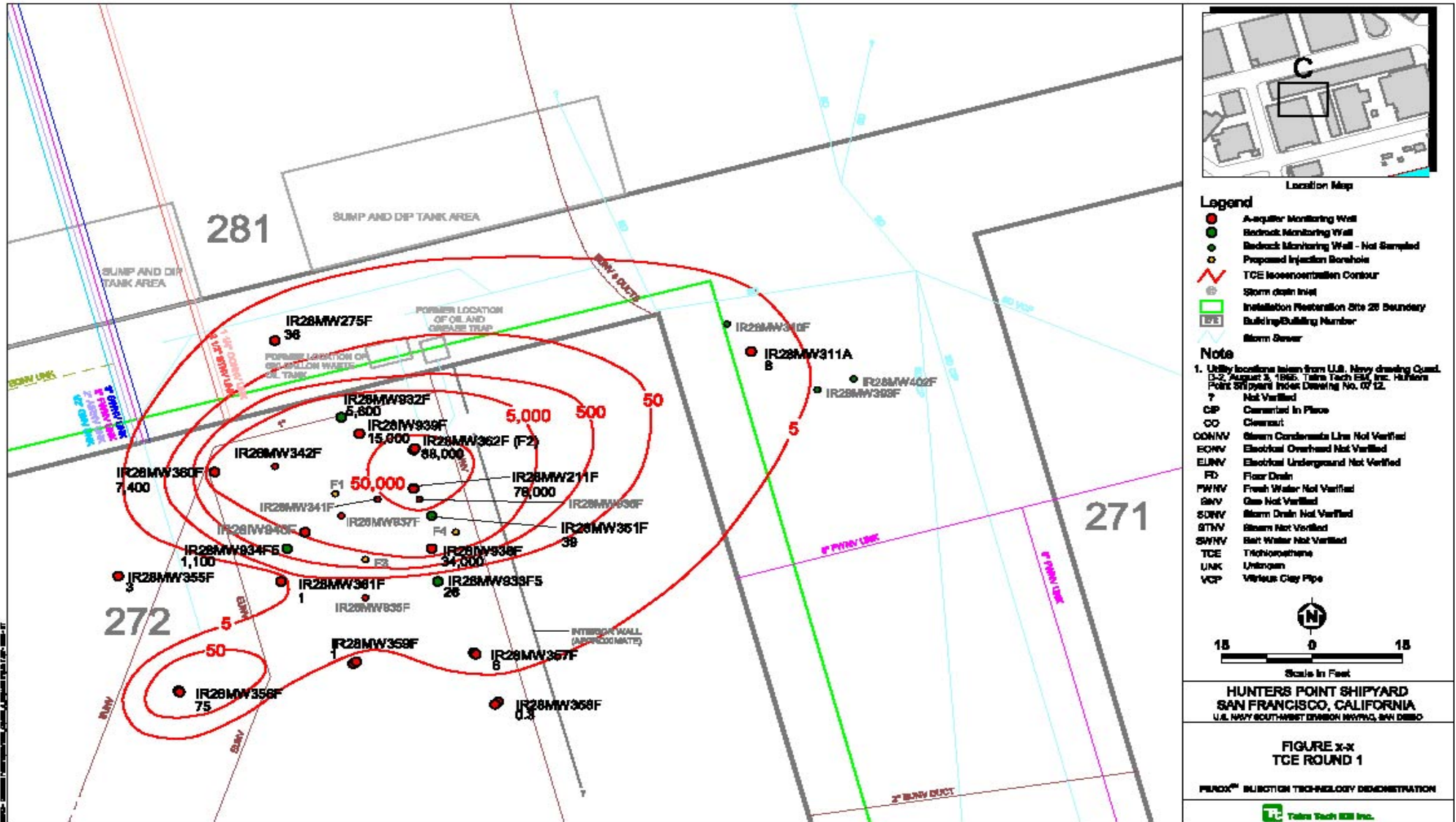
- ~40 um particles
- High Purity Iron (95%+) with trace carbon within the particle structure

Hydrofracturing

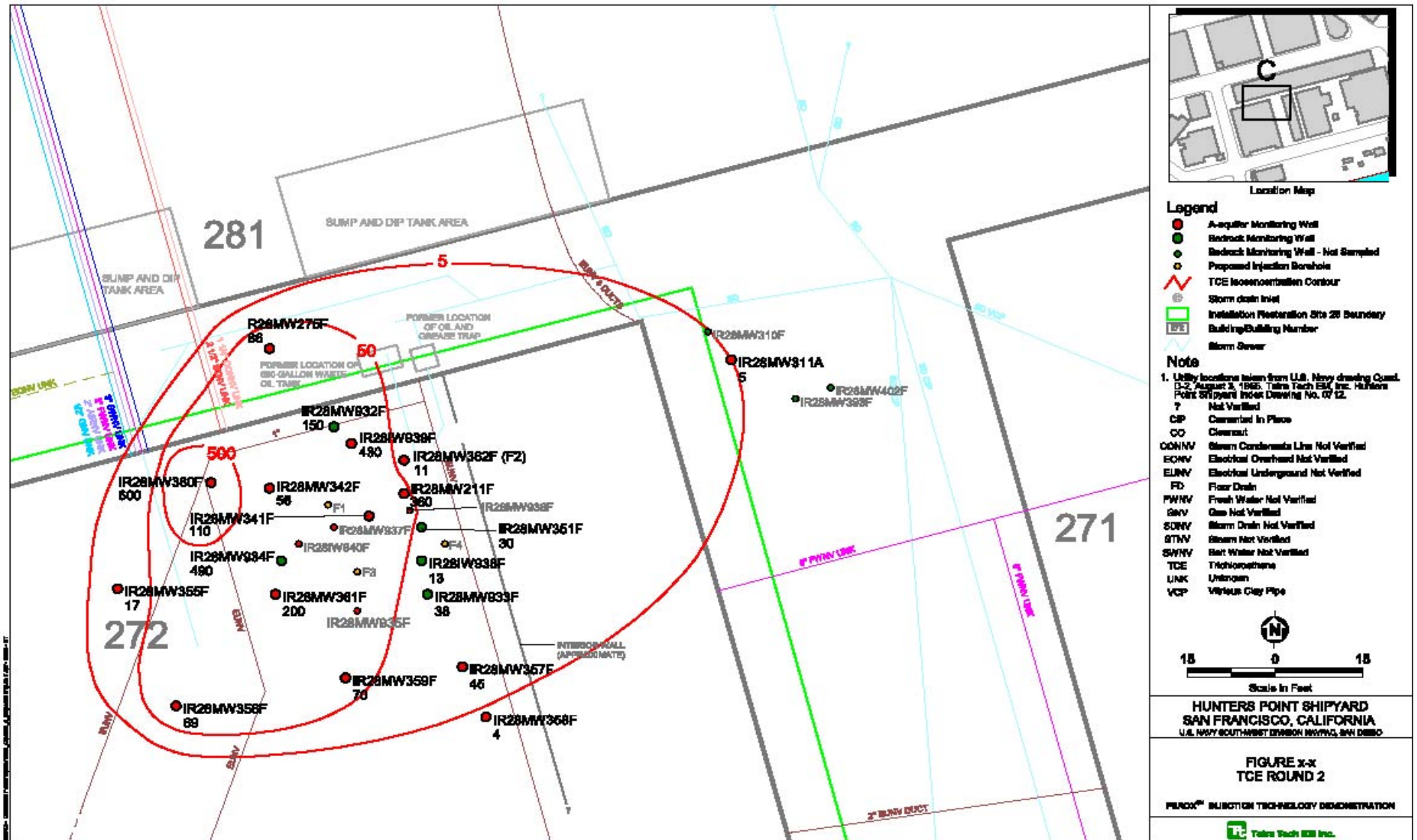
- Inject nitrogen gas for 10 – 15 seconds to fill pore spaces (and open new pore spaces)
- Following initial nitrogen injection, ZVI-water slurry is introduced to the gas stream
- Nitrogen acts as carrier fluid to atomize and disperse slurry into the formation
- Liquid atomized injection of ZVI slurry increases contact with contaminants
- 4 injection boreholes with 15 ft radius



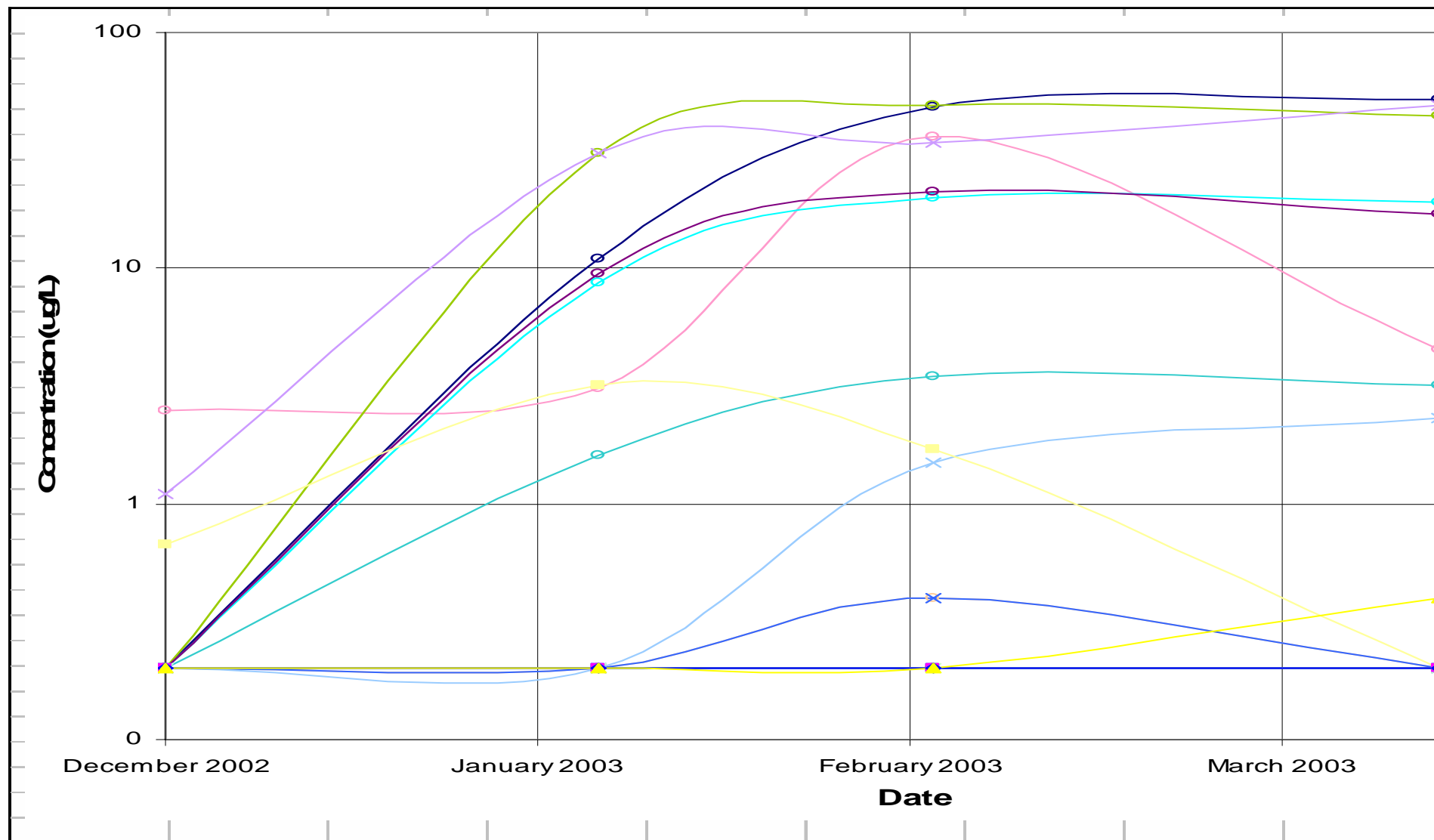
Hunter's Point Pre-ZVI Injection



Hunter's Point Post-ZVI Injection



Hunter's Point Ethene in Groundwater vs. Time



Hunter's Point Conclusions

- TCE in groundwater was reduced 99.2% in 3 weeks
- Project cost estimate was \$117/yd³
- Plume displacement not significant
- Mn and As not mobilized during treatment
- Radius of influence ranges from about 15 to 20 feet
- Applied to additional sites
- Evaluating applicability to another site with concentrations close to MCLs