Injection & Re-circulation of Sodium Permanganate to Treat Chlorinated Solvent Impacted Groundwater in Fractured Bedrock

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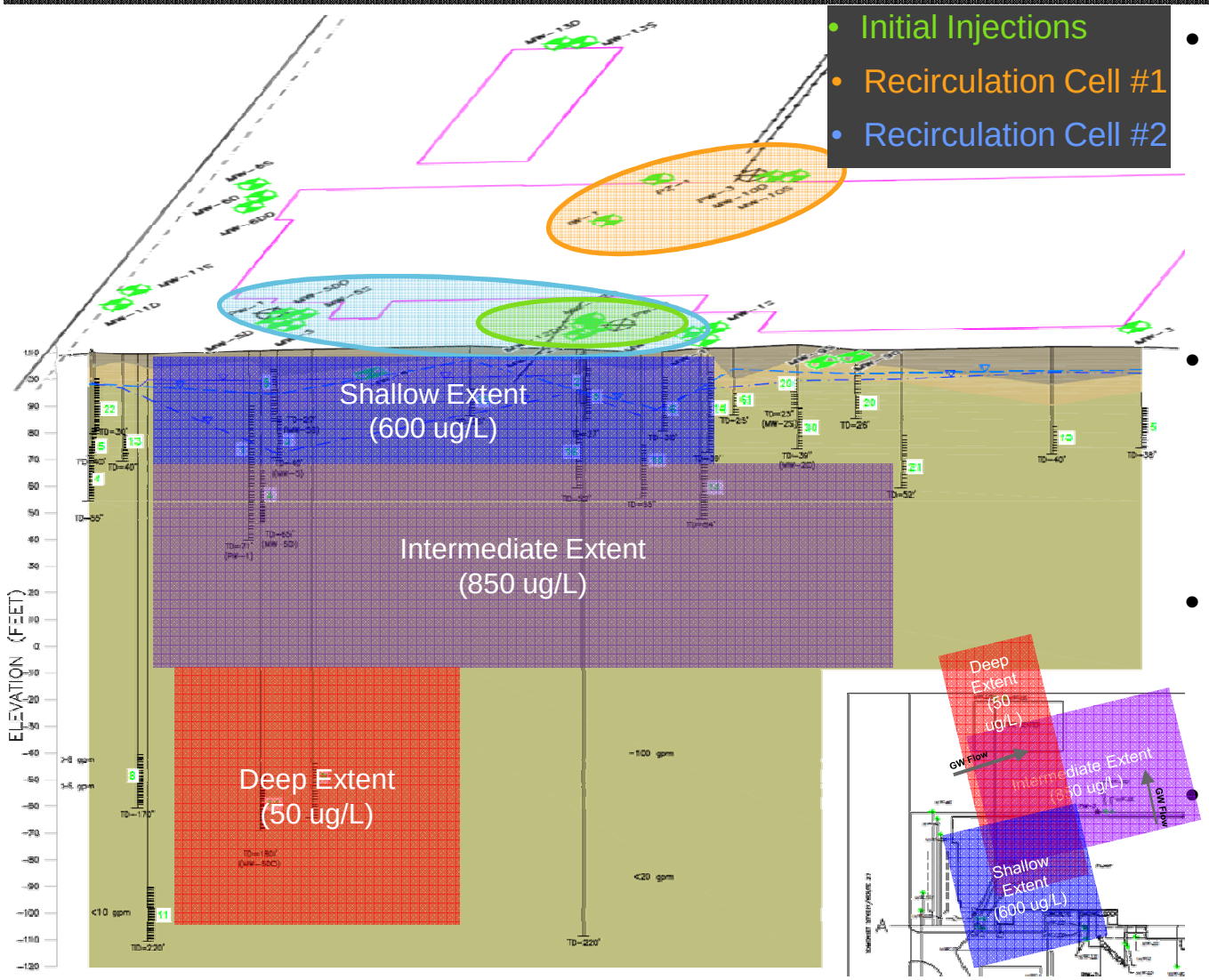
Site History

- Confidential Site in NJ
- Site History
  - 10 leaking solvent USTs
- Remedial Action to-date
  - USTs and impacted soil removed
  - P&T for onsite GW impacts and MNA for off-site GW impacts
- Status of P&T System
  - Over 1,900 lbs. of total CVOCs recovered in 14 years
  - Recovery slowed down to 2-3 lbs per month
- Revaluation of Technology
  - Modify/optimize existing P&T – long remedial time frame
  - In-situ bioremediation – no control on contaminant migration
  - ISCO – Recirculation to provide plume control & effective oxidant distribution

Difficulties Injecting in Bedrock Aquifers

- Unknown preferential pathways and heterogeneities
- Residual contamination trapped in matrix pore spaces
- Inadequate contact time for oxidants

Conceptual Site Model

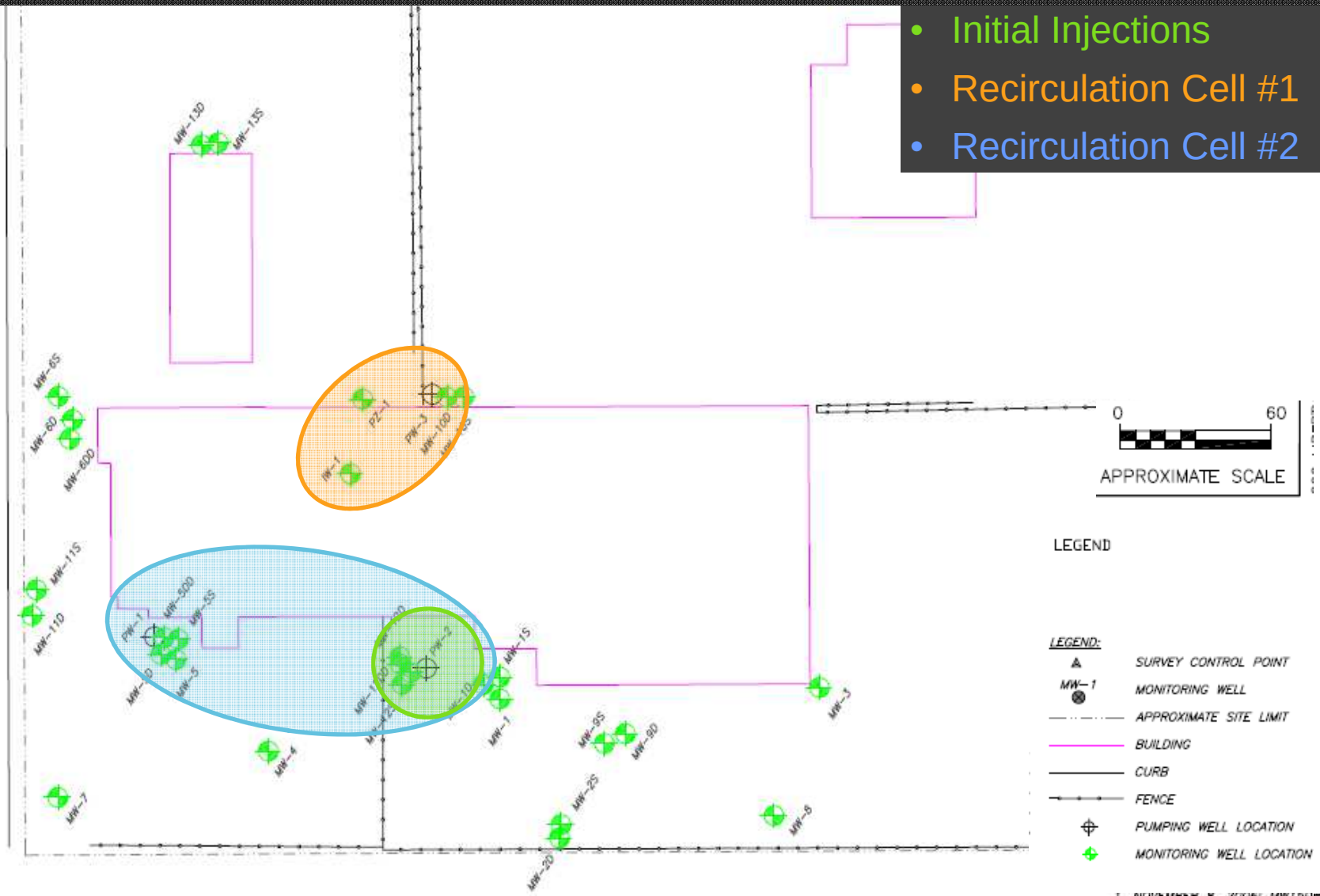


- Geology (in ft bgs)
  - 0-15: Fill
  - 15-90: Shale (discontinuous horizontal fractures). Fracture dip NW from 6 to 15 degrees.
  - 90-220: Shale (less fractures)
- Three zones:
  - Shallow (<40 ft bgs)
  - Intermediate (40-120)
  - Deep (>120 ft bgs)
- GW Flow Direction
  - Shallow: NE, NNE
  - Intermediate: NNE
- Hydraulic Conductivity
  - Shallow: 18 ft/day
  - Intermediate: 10 ft/day
  - Deep: 9 ft/day

AECOM

Recirculation Cell Locations

- Initial Injections
- Recirculation Cell #1
- Recirculation Cell #2



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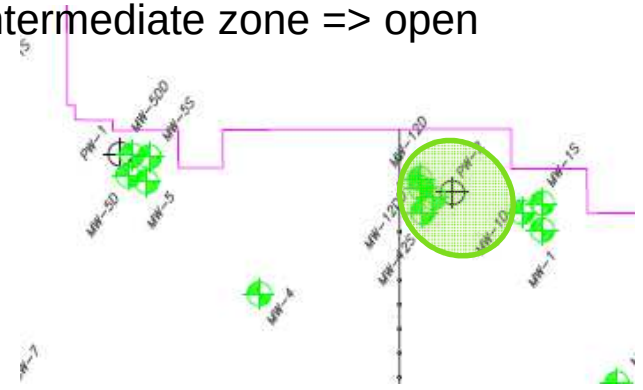
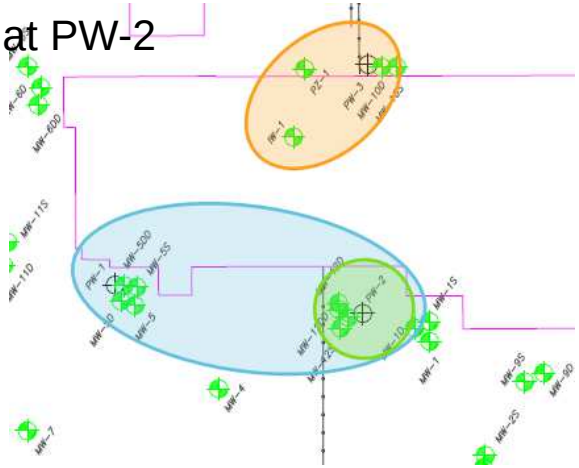
Summary of Pilot Study (Round 1)

- **Round 1 Pilot Study - Oxidant Injection (Initially Performed at Site on 12/21/11)**
  - ***Objective:*** Estimate ROI, injection pressures, groundwater displacement
  - ***Injection Summary:***
    - Injected 1,100-gallon of 5% by mass sodium permanganate at PW-2
    - 20-40 ft bgs packered interval: gravity fed at up to 2 gpm
    - 40-70 bgs packered interval: could not inject even at 30 psi
  - ***Findings:***
    - Localized mounding of up to 7.8’ => risk of day lighting
    - ROI of around 40 ft
    - Higher hydraulic conductivity in shallow zone than intermediate zone => open borehole injection recommended



Summary of Pilot Study (Round 2)

- **Round 2 pilot Study - Oxidant recirculation (Two injections performed: 10/31/11 and 11/14/11)**
  - ***Objective:*** Evaluate the efficacy of recirculation cell
  - ***Recirculation Cell (between IW-1 and PW-3) Injection Summary:***
    - Injected 1,122-gallon of 3% by mass sodium permanganate at IW-1
    - Steady state flow rate of 2 gpm achieved at 12 psi
      - Performed pulse injections
    - Recirculation cell established in 3.5 hours
  - ***Recirculation Cell (between PW-2 and PW-1) Injection Summary:***
    - Injected 726-gallon of 3% by mass sodium permanganate at PW-2
    - Steady state flow rate of 1-2 gpm achieved at 12 psi
      - Performed pulse injections
    - Recirculation cell established in 1 day



Injection System Setup

- The water from the extraction well collected in 200-Gallon poly tank
- Passed through 40 micron bag filters to precipitate any MnO2
- Pushed to the injection line via a 1.5HP pump (110V, single phase)
- NaMnO4 dosed via in-line Dosatron pump (Model D14MZ10)