RECLAIMING GROUNDWATER CONTAMINATED BY VOCS AND PERCHLORATE

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INTRODUCTION

- A pump & treat (P&T) system built at an industrial facility in Northern VA in late 1980s
- P&T system designed to extract and treat chlorinated VOCs from a deep bedrock aquifer
- P&T system operated at 60-80 gpm for over 12 years

HISTORICAL DESIGN

- Original P&T system:
  - 2 extraction wells
  - 40 ft air stripper tower
  - 2, 8000-lb GAC vessels
- System designed to treat VOCs only (99.9% removal efficiency)
- Approx. 25% of treated water used onsite for facility non-contact water; rest discharged to surface water under permit

PERCHLORATE

- In 2001, ongoing investigations at facility detected perchlorate in deep bedrock aquifer; as a result, P&T system shut down – not designed to treat perchlorate
- Perchlorate (ClO_4^-) is anion of ammonium perchlorate (NH_4ClO_4) = primary solid rocket propellant in military and NASA propulsion systems
- Perchlorate does not degrade readily under ambient environmental conditions

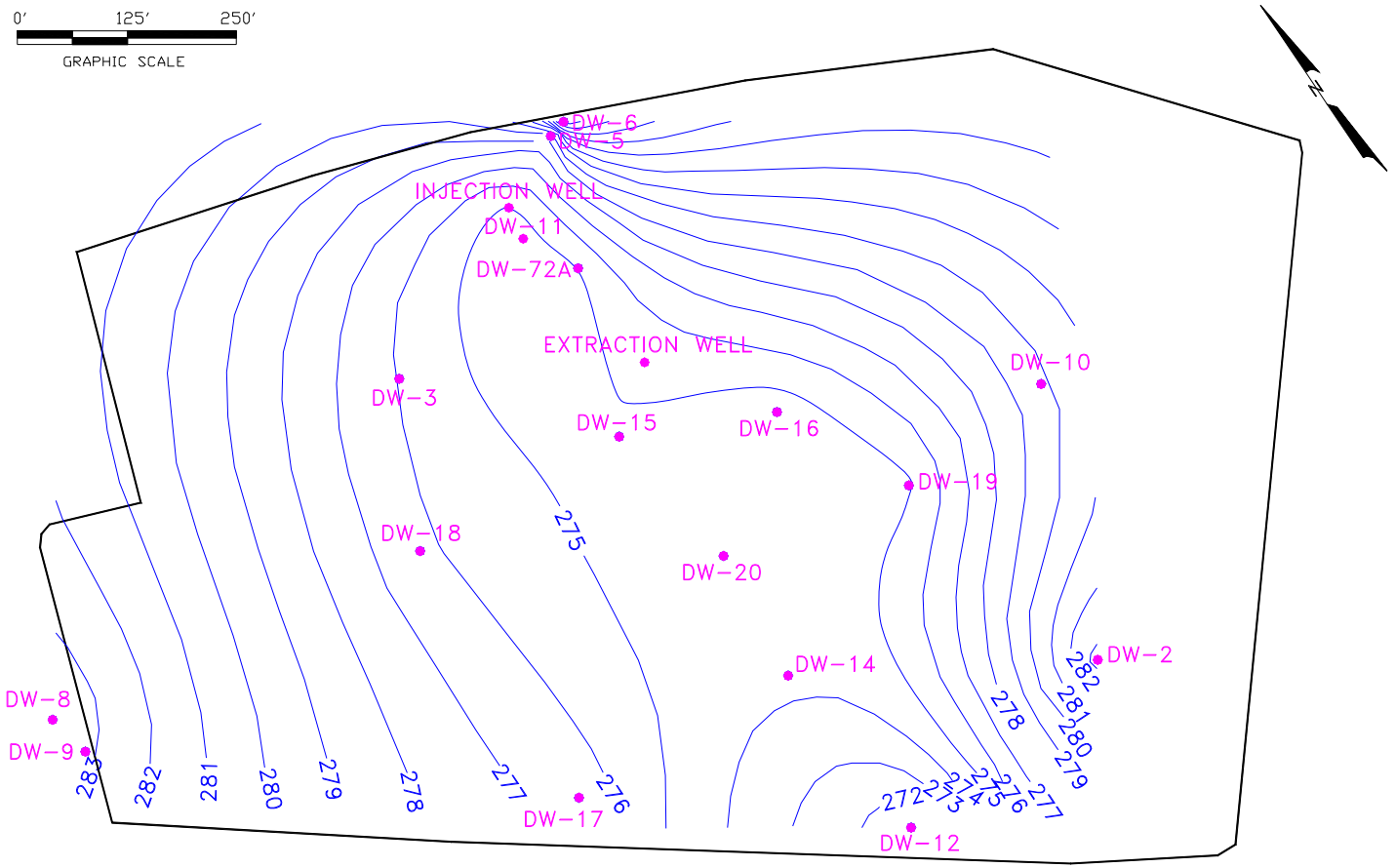
IN-SITU ANAEROBIC BIOREMEDIATION

- Naturally-occurring bacteria can degrade both perchlorate and chlorinated VOCs under anaerobic conditions
- Stimulating anaerobic degradation requires introduction of electron donor substrate (e.g., acetate, vegetable oil, methanol) = ***In Situ* Anaerobic Bioremediation**

PILOT SYSTEM DESIGN GOALS

1. Utilize existing wells and treatment equipment
2. One system capable of treating both chlorinated VOCs and perchlorate
3. Hydraulic control of perchlorate and chlorinated VOCs plumes
4. Minimize or eliminate surface water discharge requirements

STATIC (NON-PUMPING) CONDITIONS



NOTES:

1) VALUES INTERPOLATED USING A KRIGING ALGORITHM
2) STATIC (NON-PUMPING) CONDITIONS
3) CONTOUR INTERVAL = 1 FOOT

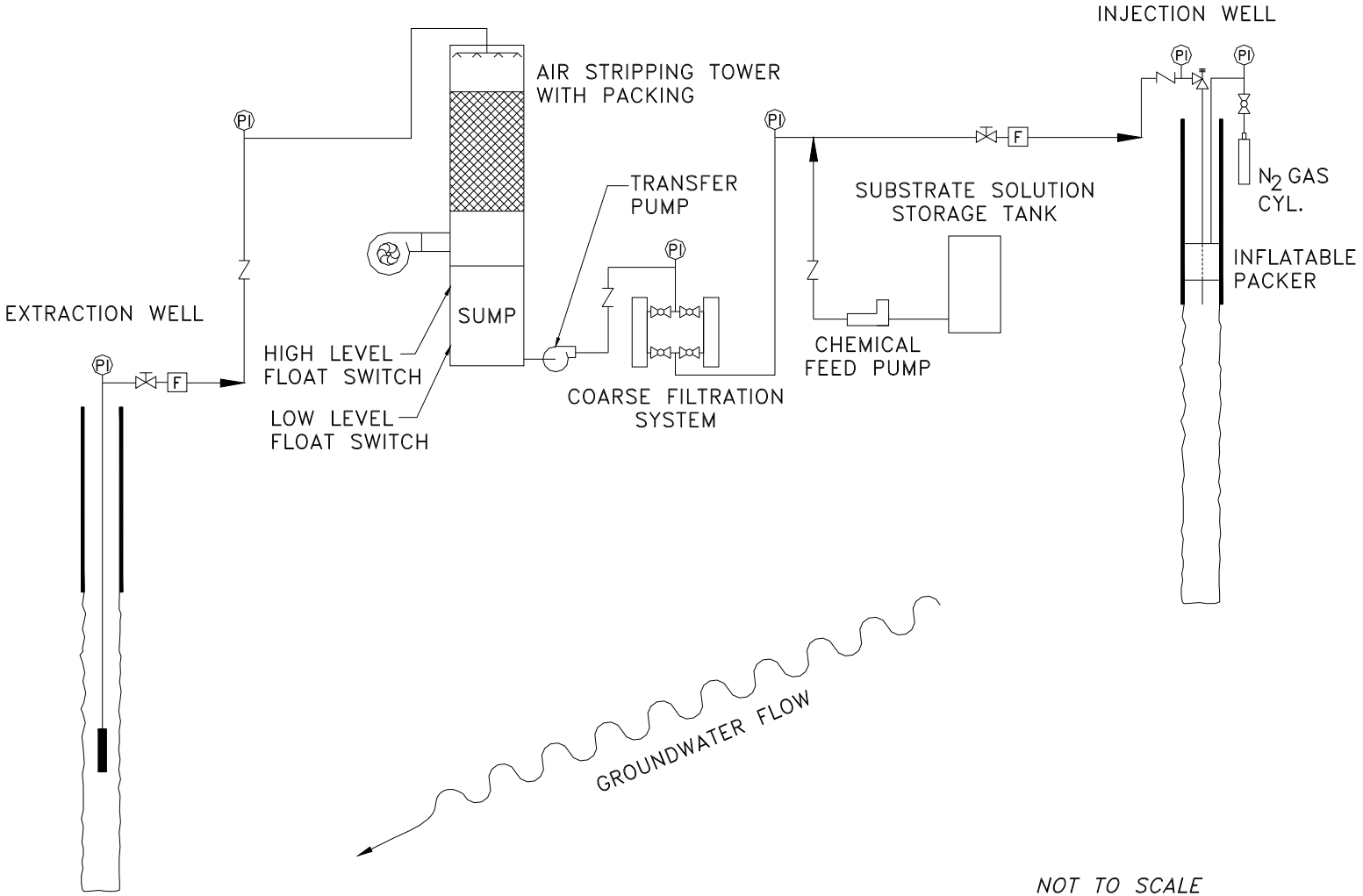
• DEEP GROUNDWATER WELL

290 INTERPOLATED EQUIPOTENTIAL LINE (FEET AMSL)

PILOT SYSTEM DESIGN

- Recirculating Anaerobic Bioremediation (RAB) System
  - Extract GW
  - Treat GW for VOCs
  - Amend treated GW with electron donor substrate
  - Reinject treated and amended GW

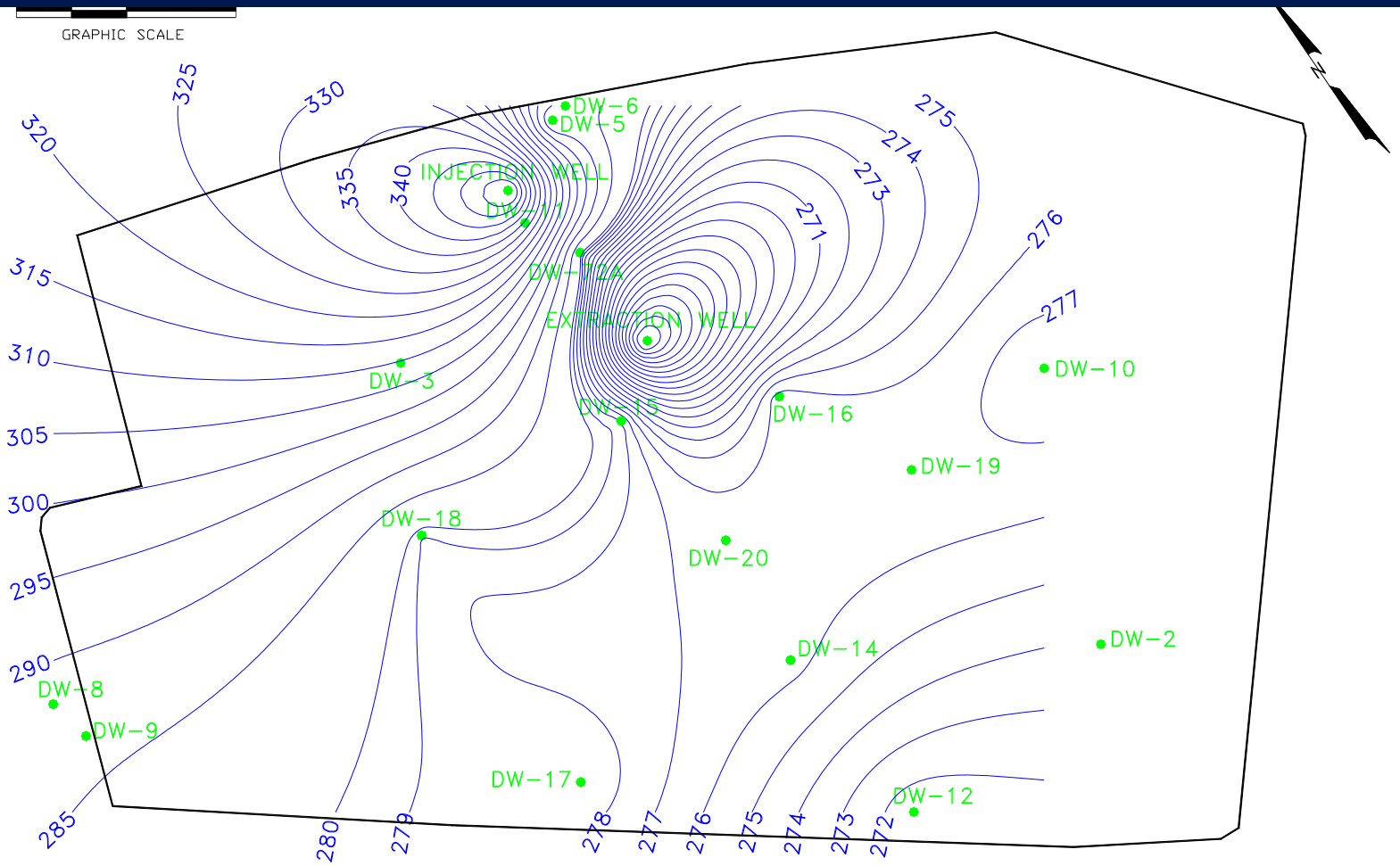
PILOT SYSTEM DESIGN (cont.)



PILOT SYSTEM O&M

- Pilot test conducted from Oct. 2002 to May 2003
- Approx. 6 weeks downtime for system repairs
- Extraction/injection between 20 and 30 gpm
- Approx. 3 million gallons of water treated, amended, & reinjected

RECIRCULATION CONDITIONS



NOTES:

1) VALUES INTERPOLATED USING A KRIGING ALGORITHM
2) EXTRACTION RATE SET AT 30 GPM
3) MAXIMUM CYCLED INJECTION RATE SET AT 60 GPM
4) CONTOUR INTERVAL = 1 FOOT

DEEP GROUNDWATER WELL

290 INTERPOLATED EQUIPOTENTIAL LINE (FEET AMSL)

PILOT TEST RESULTS

- Buildup of backpressure at the injection well due to mineral scaling (supersaturation of Ca-Mg-CO3 and Ca/Fe-O minerals with CMA and air stripping)
- Extensive cone of depression capable of providing hydraulic capture of both perchlorate and VOCs plumes at Q = -40 gpm (compared to P&T 60 to 80gpm)
- 71% reduction in perchlorate concentrations (6.24 mg/L Oct 2002 to 1.84 mg/L May 2003)

PILOT TEST RESULTS (cont.)

- Iodide tracer not detected in influent = low concentration (100mg/L) and short duration of CMA/iodide injection
- Acetate detected at 1.02 mg/L in November 2002:
  - Hydraulic connection between extraction/injection wells
  - Acetate substrate distributed within the targeted treatment zone

FUTURE STUDIES

- New RAB system design:
  - Utilize existing extraction/injection wells
  - Allow for system expansion to additional extraction/injection wells (decrease cleanup time)
  - Avoid aeration and mineral scaling:
    - Utilize GAC instead of air-stripping
    - Utilize more soluble substrate (MeOH) instead of CMA

CONCLUSIONS

- Overall effectiveness of P&T system converted to in-situ RAB technology in treating perchlorate/VOCs in GW
- Three-fold benefits in this design:
  1. Retro-fitting existing equipment = saves $$$
  2. Reduces contaminating concentrations & controls plume migration = protects human health & environment
  3. Compared to typical P&T systems, RAB replaces 100% of extracted GW back to aquifer storage = conserves increasingly precious resource