Site Remediation with Iron NanoParticles

Interagency Workshop: Nanotechnology and the Environment: Applications and Implications
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Nanotechnology holds great promise for meeting environmental challenges

- Improve environmental technologies (treatment, remediation, sensing, etc.)
- Improve manufacturing processes (efficiency, waste reduction, etc.)
- Dematerialization

Environmental Technologies *at the* Nanoscale

Nanotechnology could substantially enhance environmental quality and sustainability through pollution prevention, treatment, and remediation.

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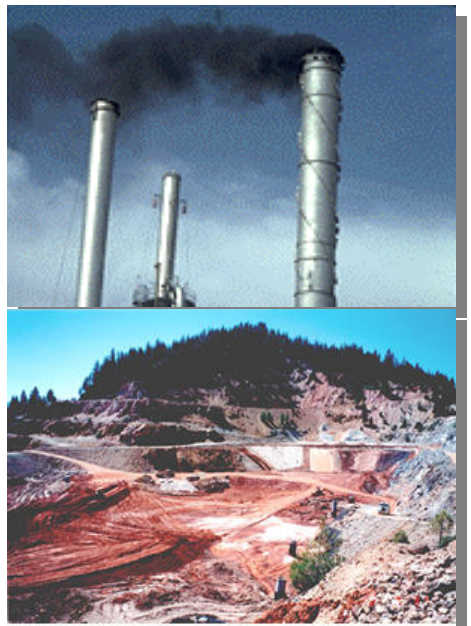
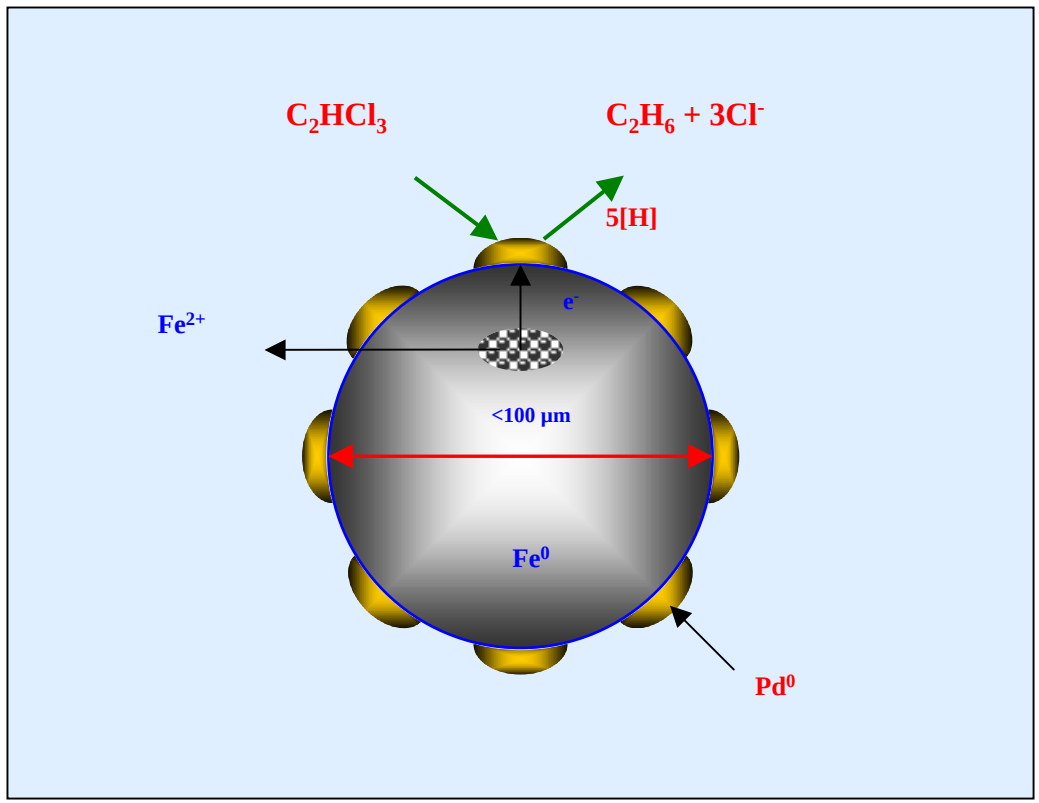
Site Remediation
Industrial Waste Treatment



Brick Flat Pit Sludge Disposal Cell at Iron Mountain Mine

Environmental Remediation with Nanoscale Iron Particles

Lab and Field Experience



Why Nanoparticles?

- **Small size for easy subsurface injection**
- **Large surface area**
- **Extremely high reaction rates**
- **Low temperature reaction**
- **Added Catalytical functions**

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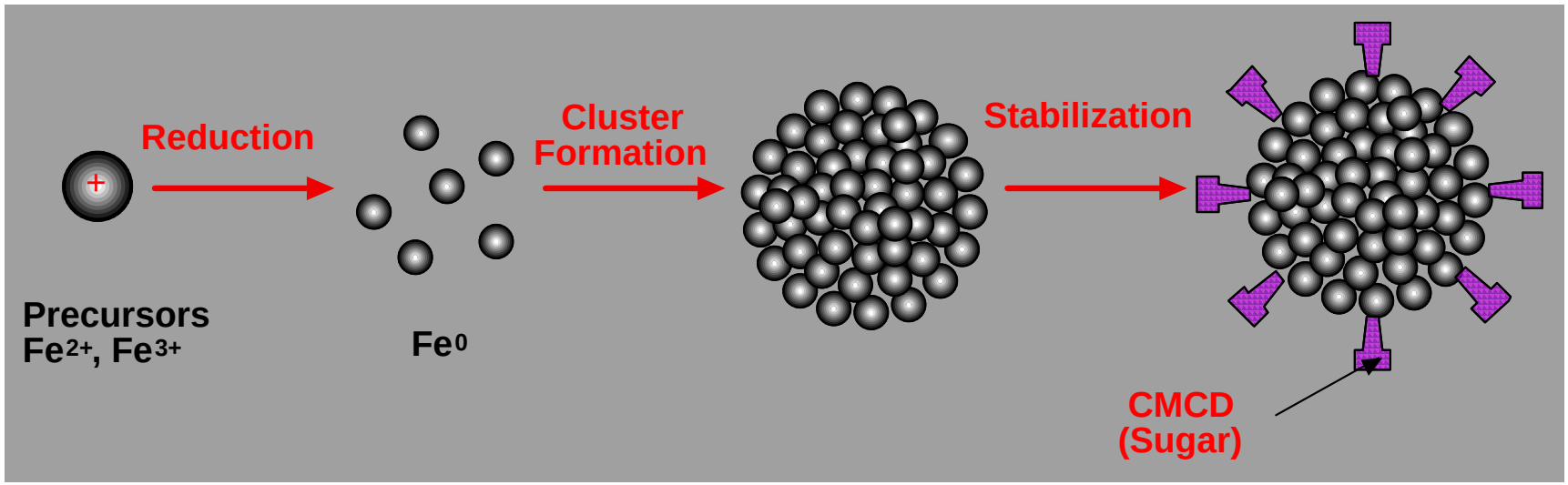
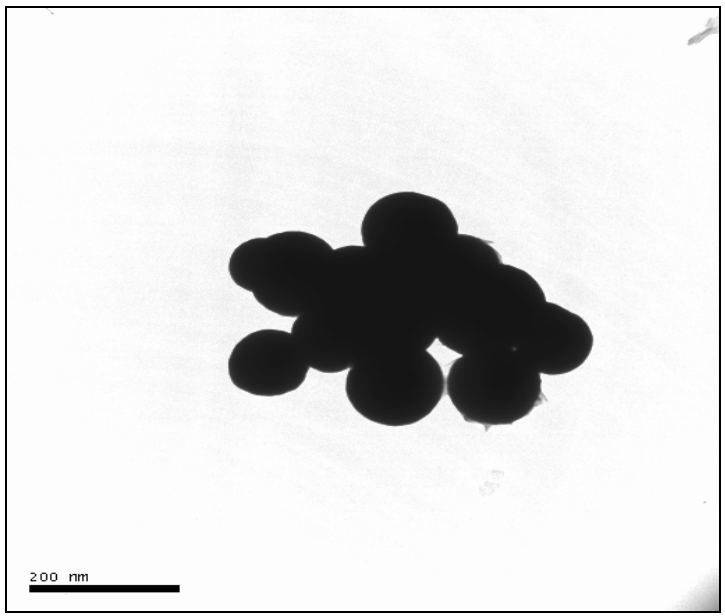
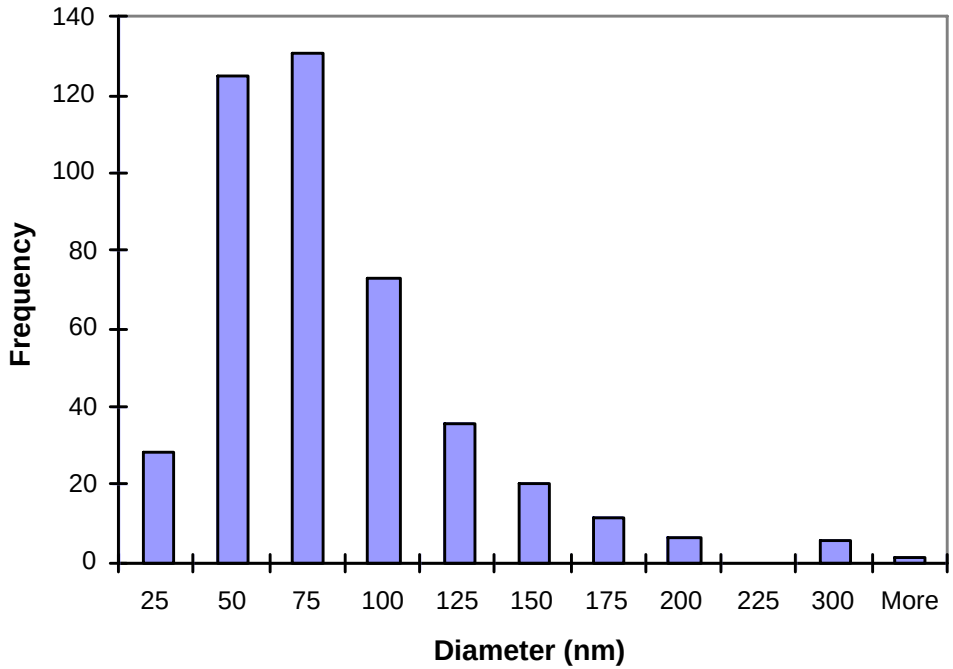
Methods of Synthesis



Size (50-100 nm)





50 nm nanoparticle

QuickTime™ and a TIFF (Uncompressed) decompressor are needed to see this picture.

Iron particles (100-200 nm)

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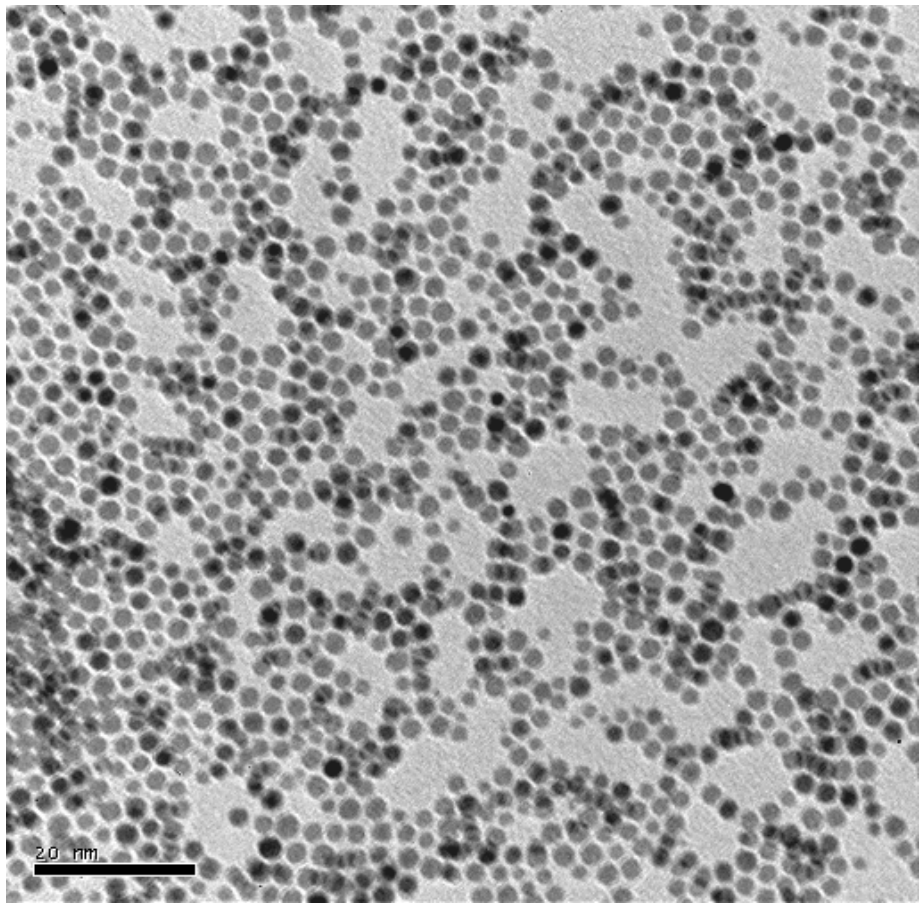
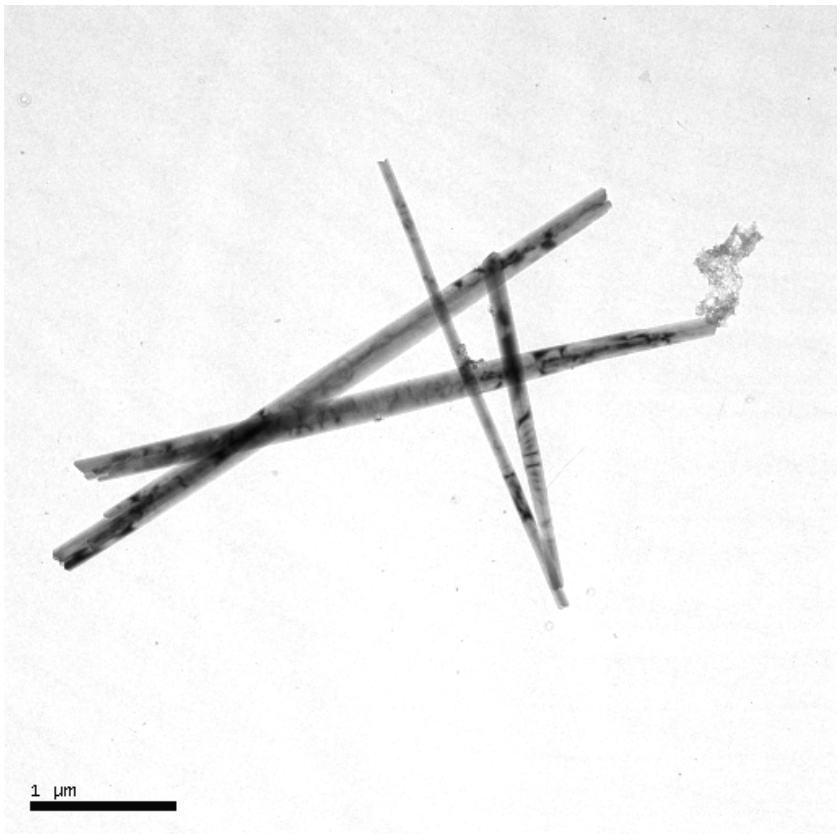
Iron particles (3-5 nm)



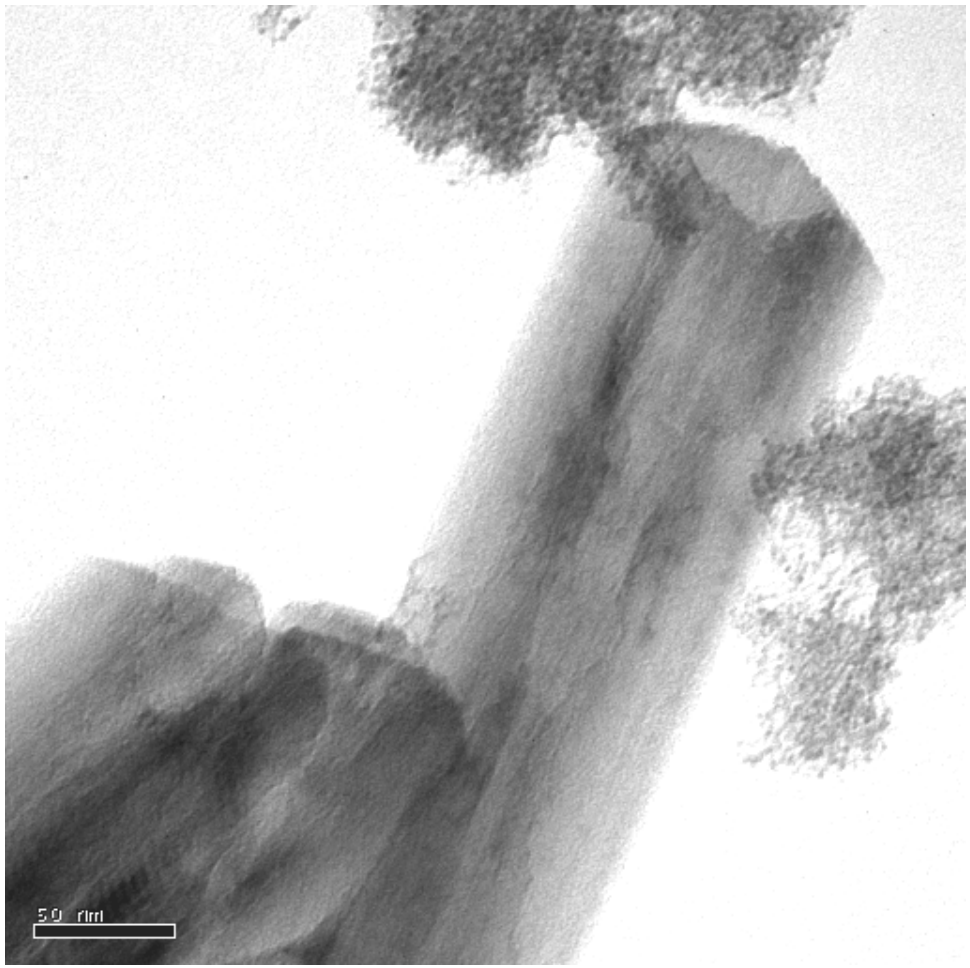
Nano Iron Wire
(dia 50-75 nm,10-20 μm long)

QuickTime™ and a TIFF (Uncompressed) decompressor are needed to see this picture.

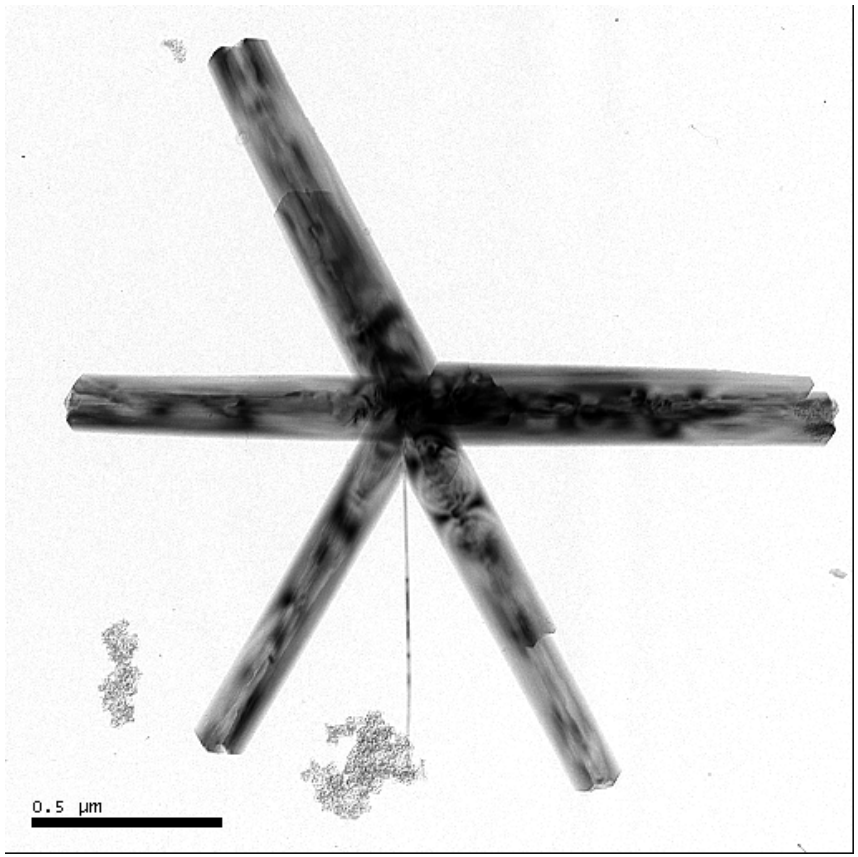
Iron Rod (dia ~50 nm)



Iron Tube (~ 50 nm)



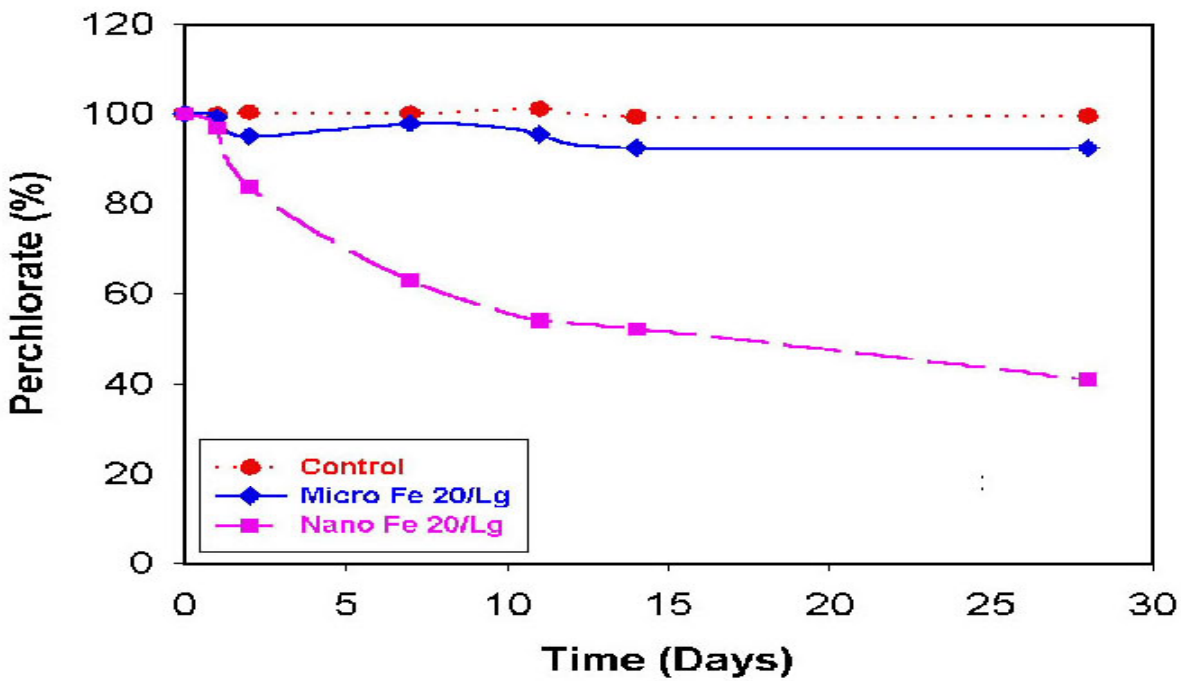
Nano Iron Antenna (~50 nm)



Contaminant Transformation With Reactive Iron Nanoparticles

Organic solvents (TCE, PCE)
Pesticides (DDT, lindane)
Fertilizers (nitrate)
Heavy metals (Pb, Hg, Cr, As)
Explosives (TNT, RDX)
Radioactive materials (U)
Perchlorate (ClO_4^-)

Perchlorate Reduction



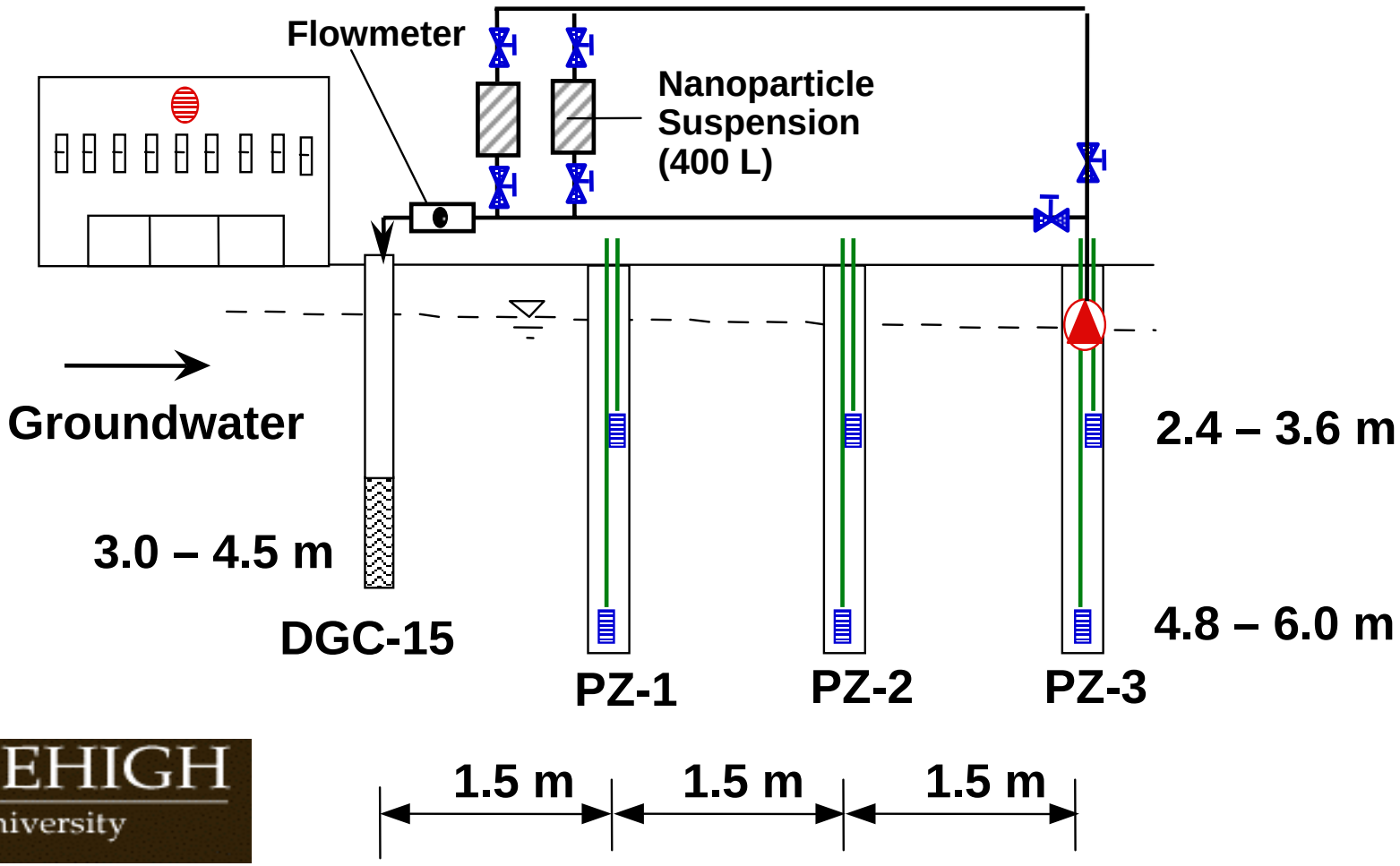
Initial perchlorate concentration 200 mg/L

Most effective Eh regulator

Field Test -1
(1.7 kg nanoFe applied, 2000)

- A 27-acre NJ manufacturing site
- Continuous production since 1930s
- C_2HCl_3 (TCE), CCl_4 (CT), etc.
- >$1.0 million has been spent on the site
- Active remedy is needed

Test Area Schematic



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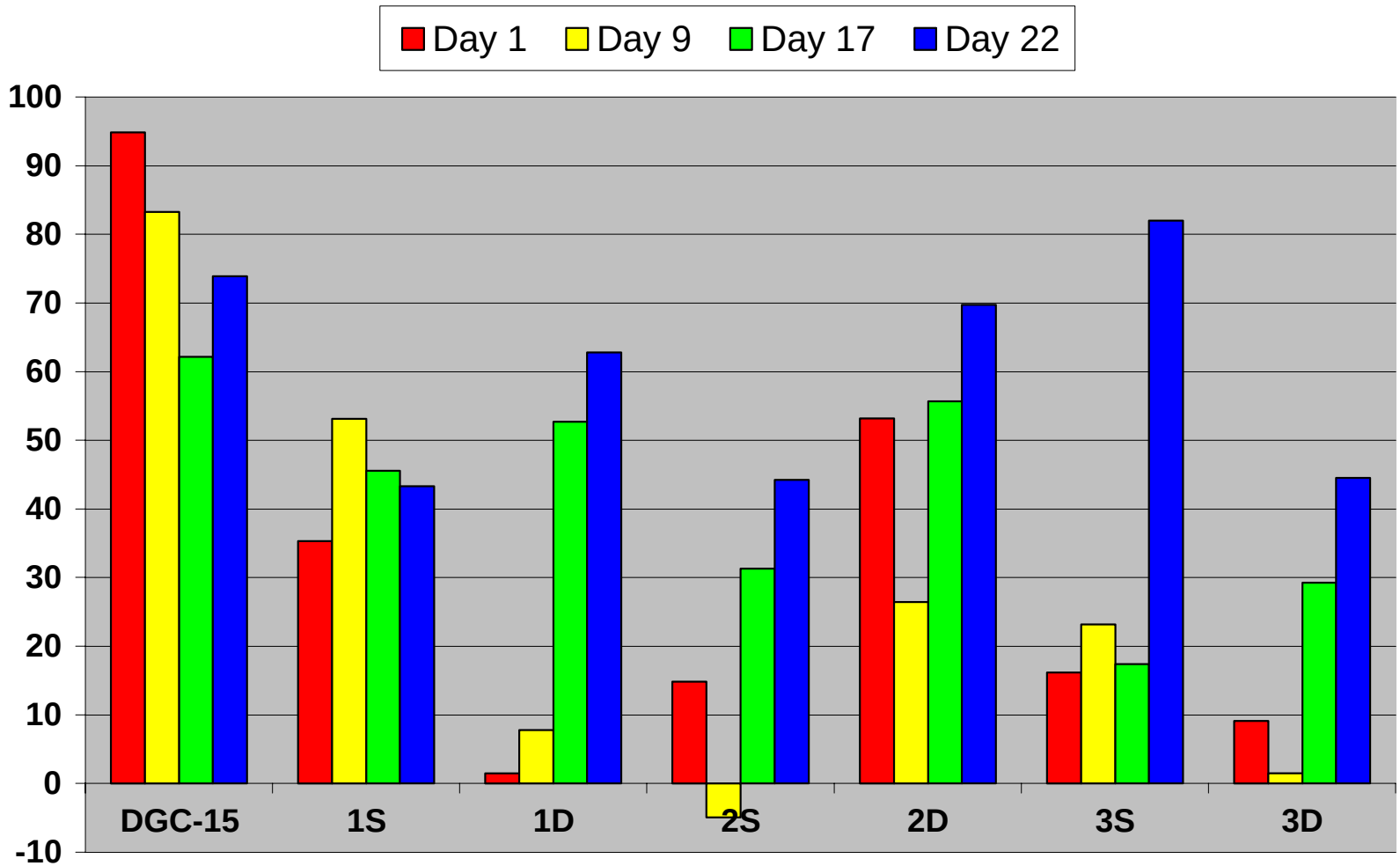
Setting Up!

- 2-165 gal tanks
- Recirculation from PZ-3S, 3D to DGC-15 or storage tank
- Dedicated low-flow pumps in each well
- Goal = Gravity Feed!

The Nano Fe Slurry

TCE Reduction %



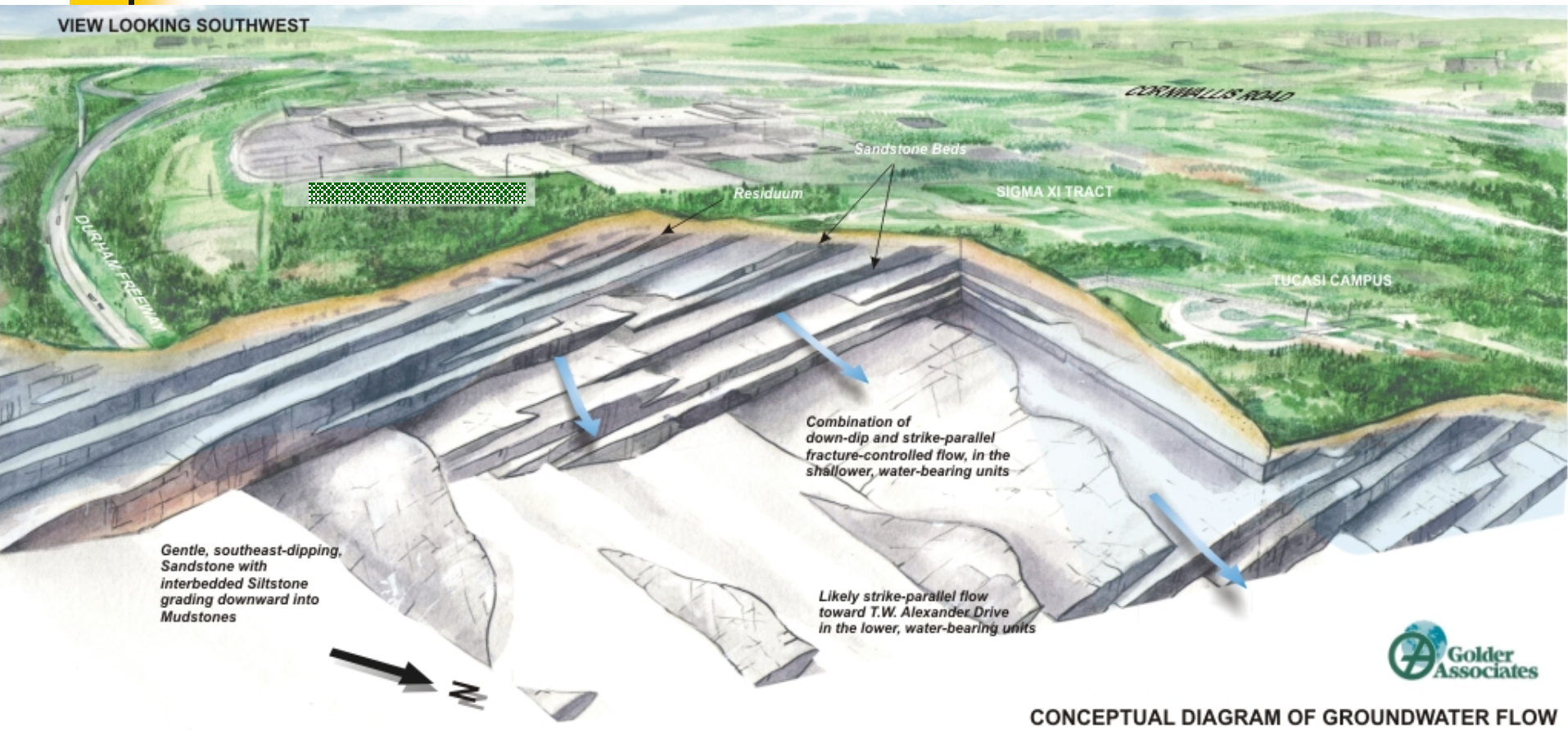
Field Test - 2
(Nano Fe 10 kg, 2002)

Total volume injected = 1,600 gallons (6,056 L)
Nano Fe concentration = 1.9 g/l
Average injection rate = 0.6 gpm

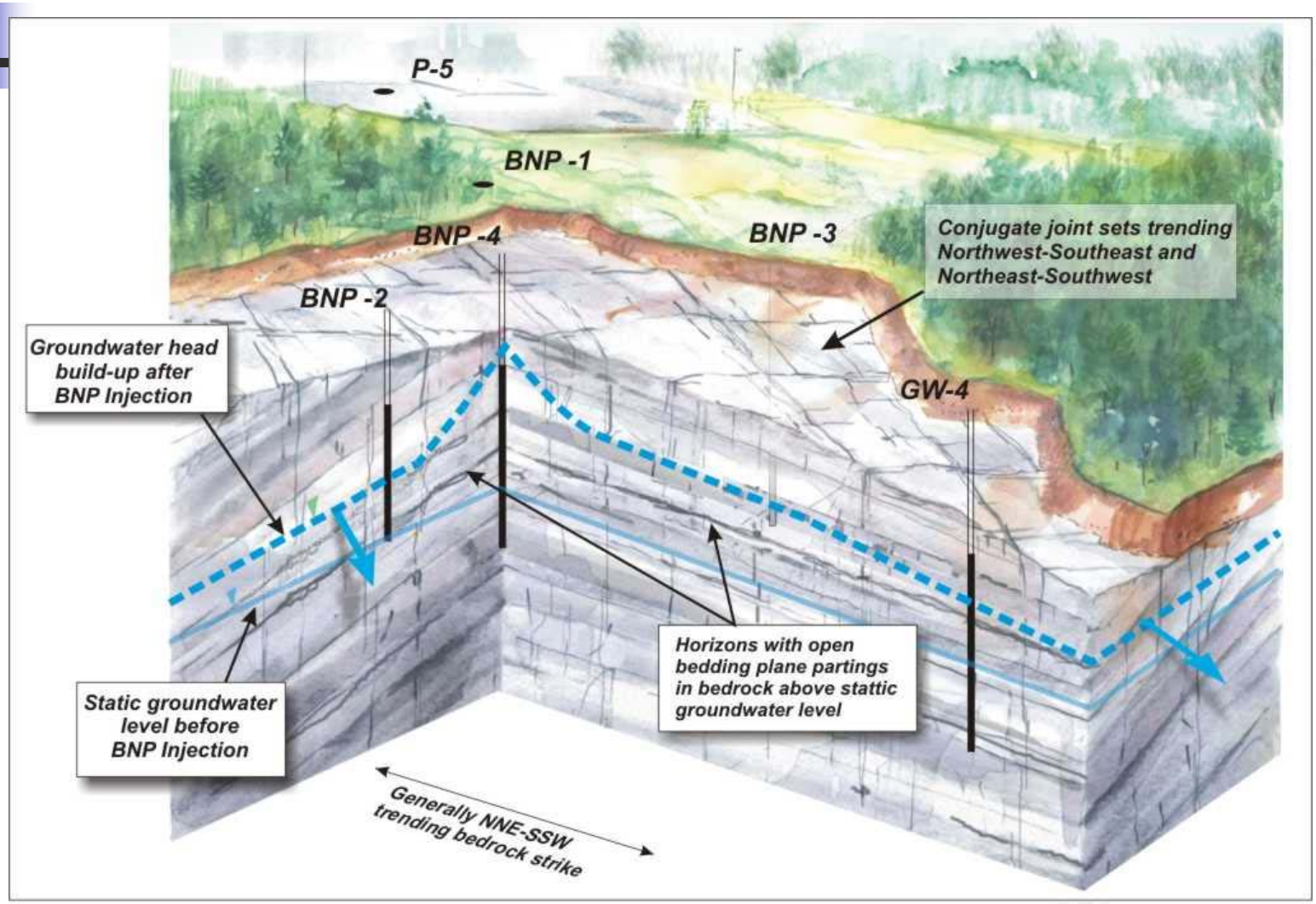
Injection Well B-4
Monitoring Wells

- **B-3: 20 feet north of B-4**
- **B-2: 40 feet northeast of B-4**
- **GW-4: 63 feet north-northeast of B-4**

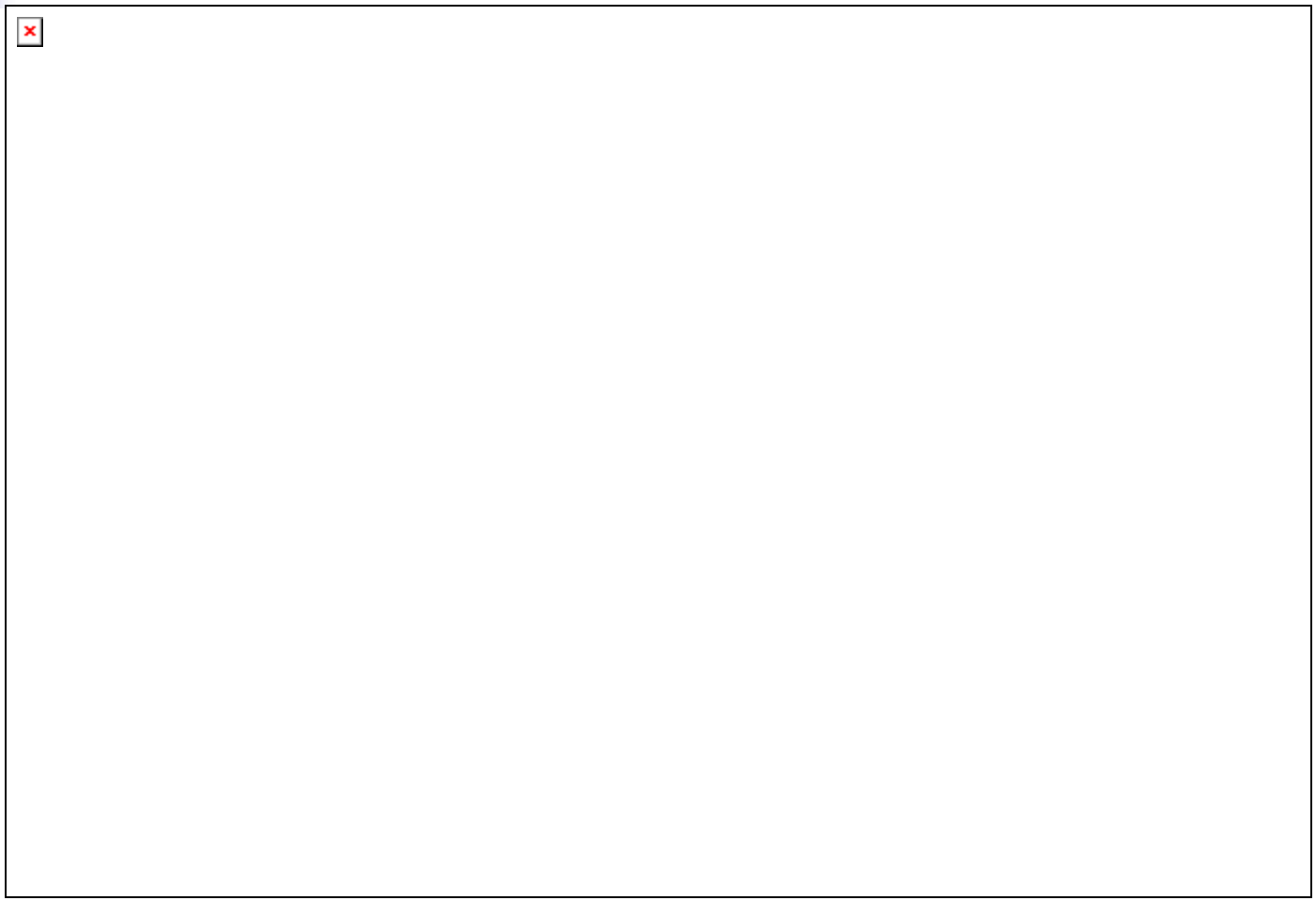
Conceptual Geologic/Hydrogeologic Model



Conceptual Model - Injection Area



Field Test - 2 (10 kg Nano Fe)



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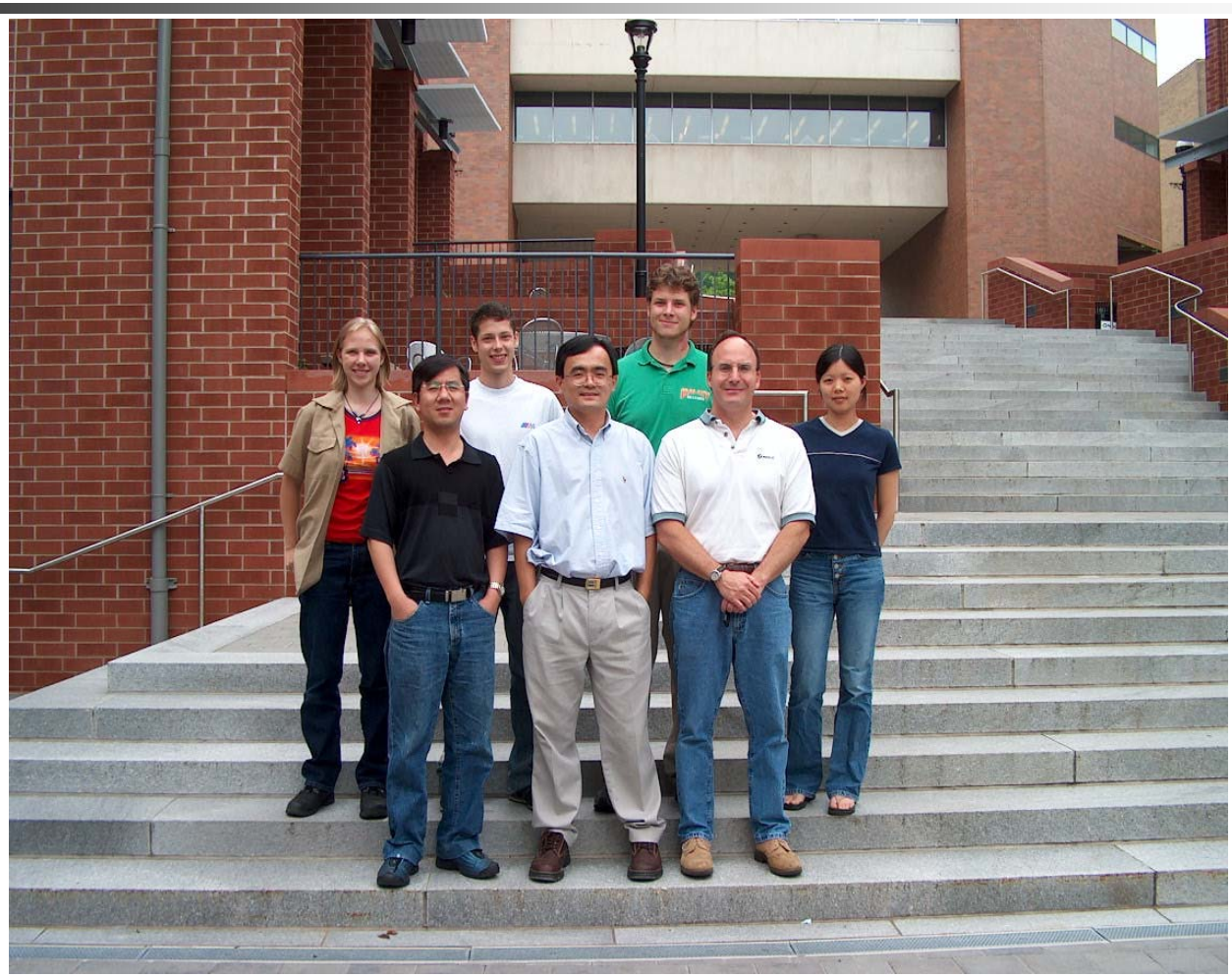
Research Group