# Site Remediation with Iron NanoParticles

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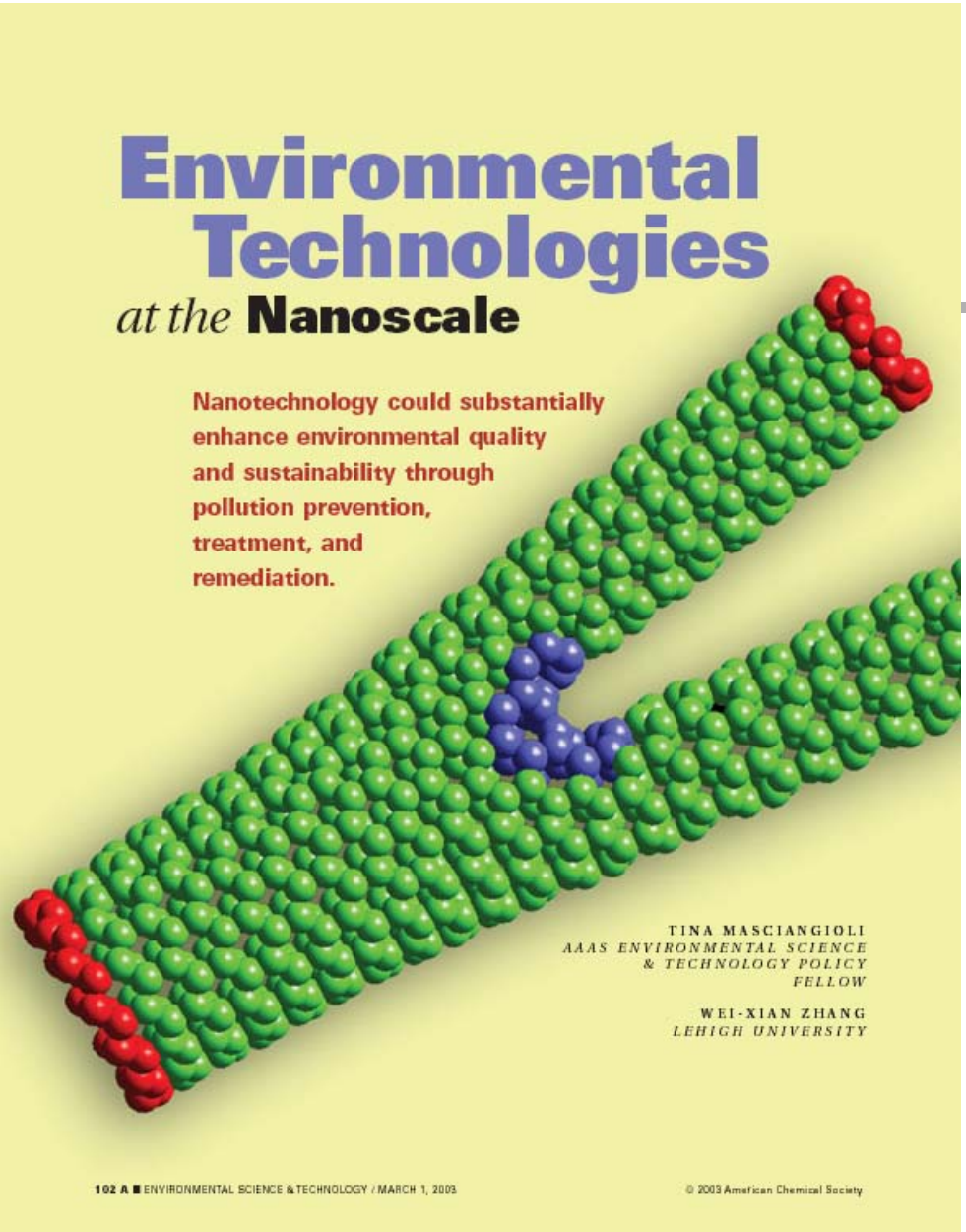
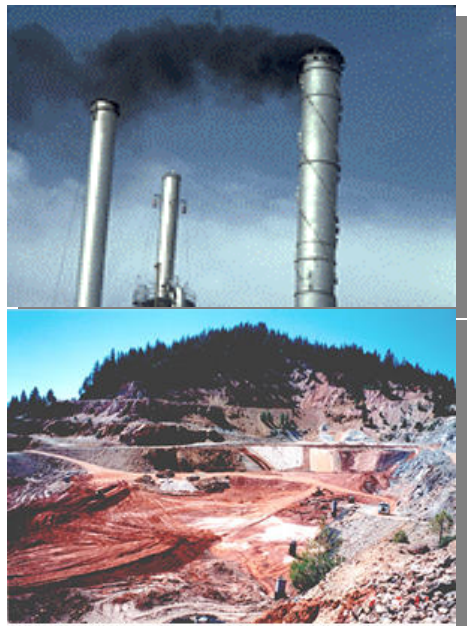
# Nanotechnology holds great promise for meeting environmental challenges


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

# Site Remediation
# Industrial Waste Treatment

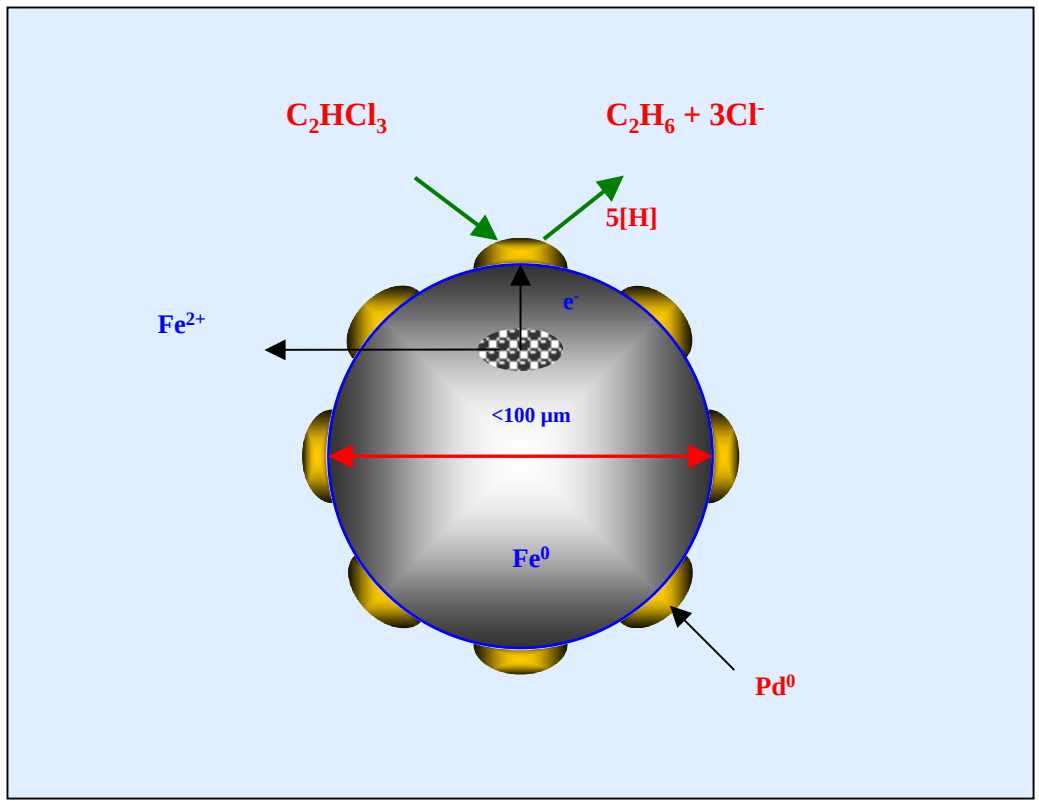


Brick Flat Pit Sludge Disposal Cell at Iron Mountain Mine

# Environmental Remediation with Nanoscale Iron Particles

## Lab and Field Experience

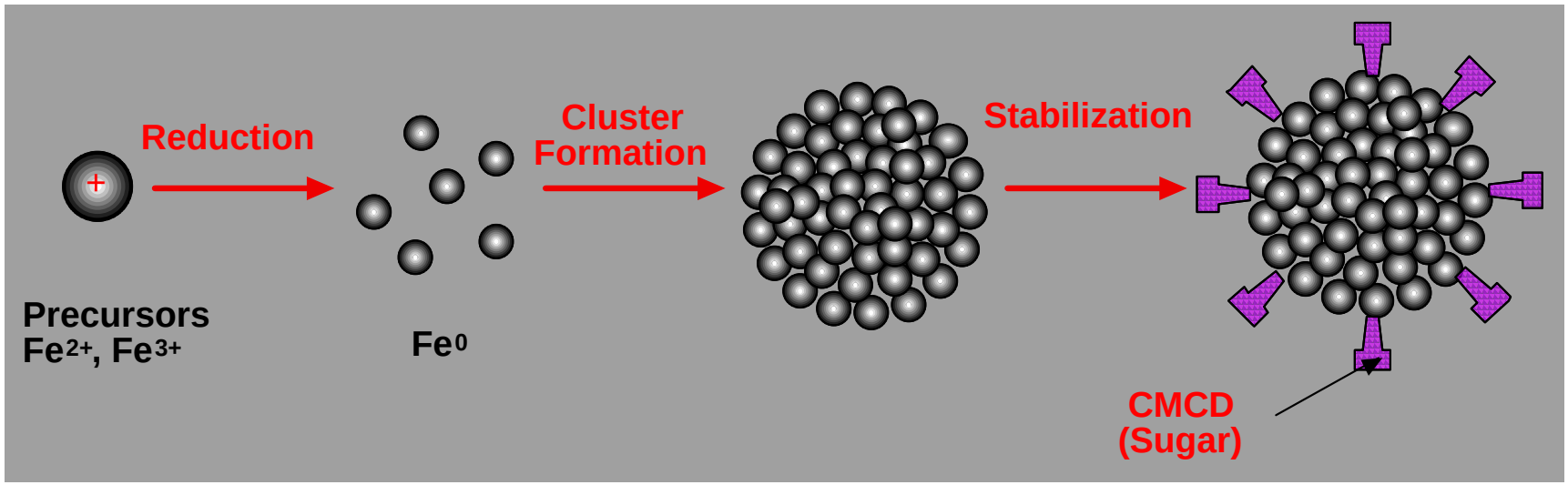


# Why Nanoparticles?

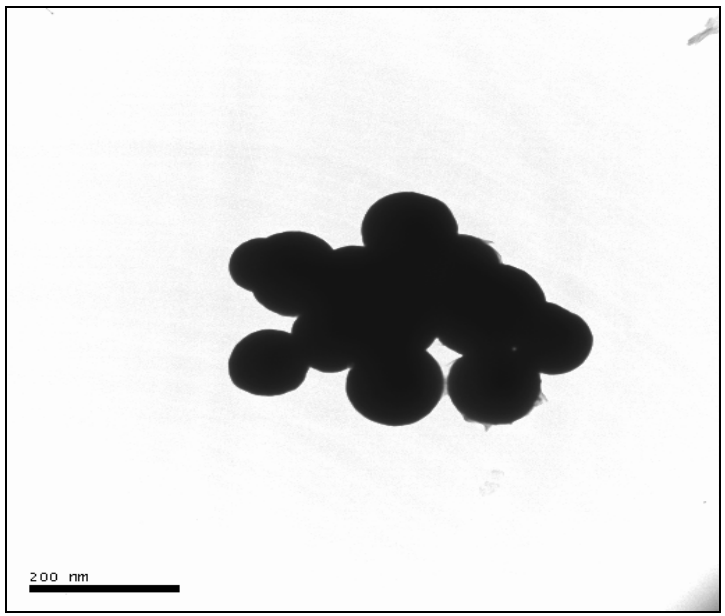
- **Small size for easy subsurface injection**
- **Large surface area**
- **Extremely high reaction rates**
- **Low temperature reaction**
- **Added Catalytical functions**

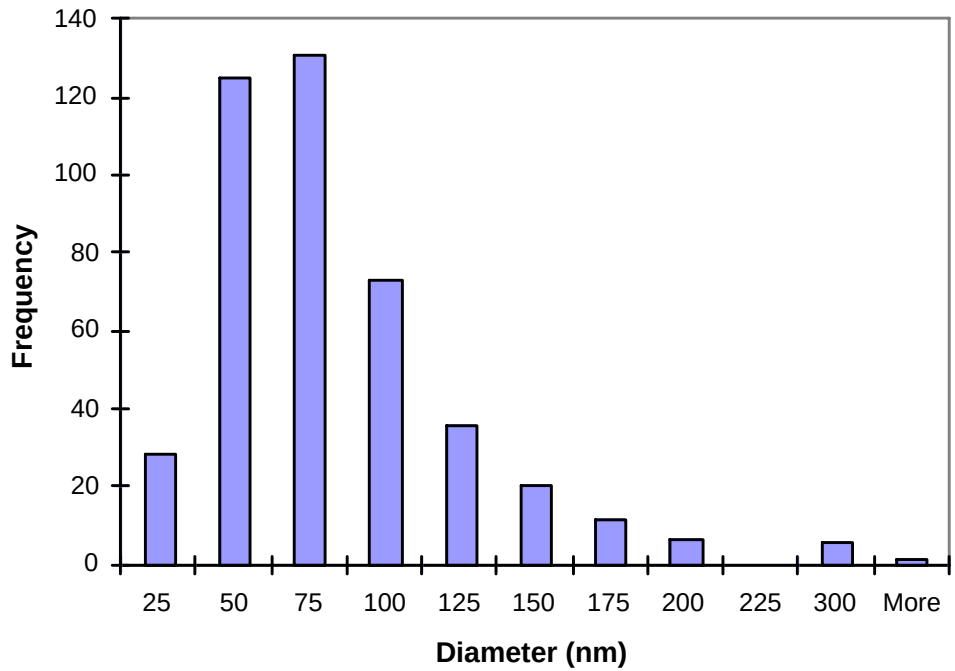
QuickTime™ and a Sorenson Video 3 decompressor are needed to see this picture.

# Methods of Synthesis



# Size (50-100 nm)

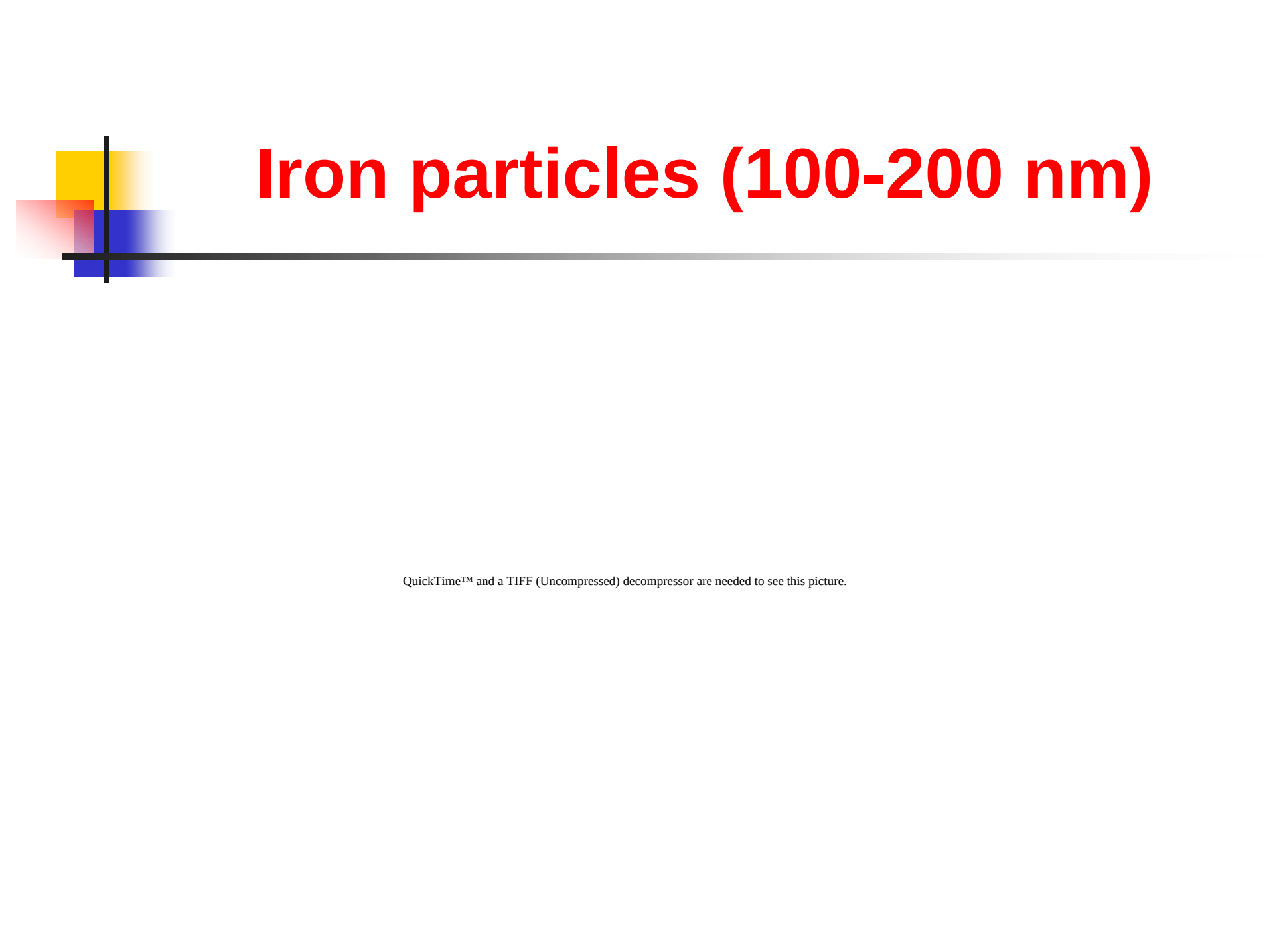


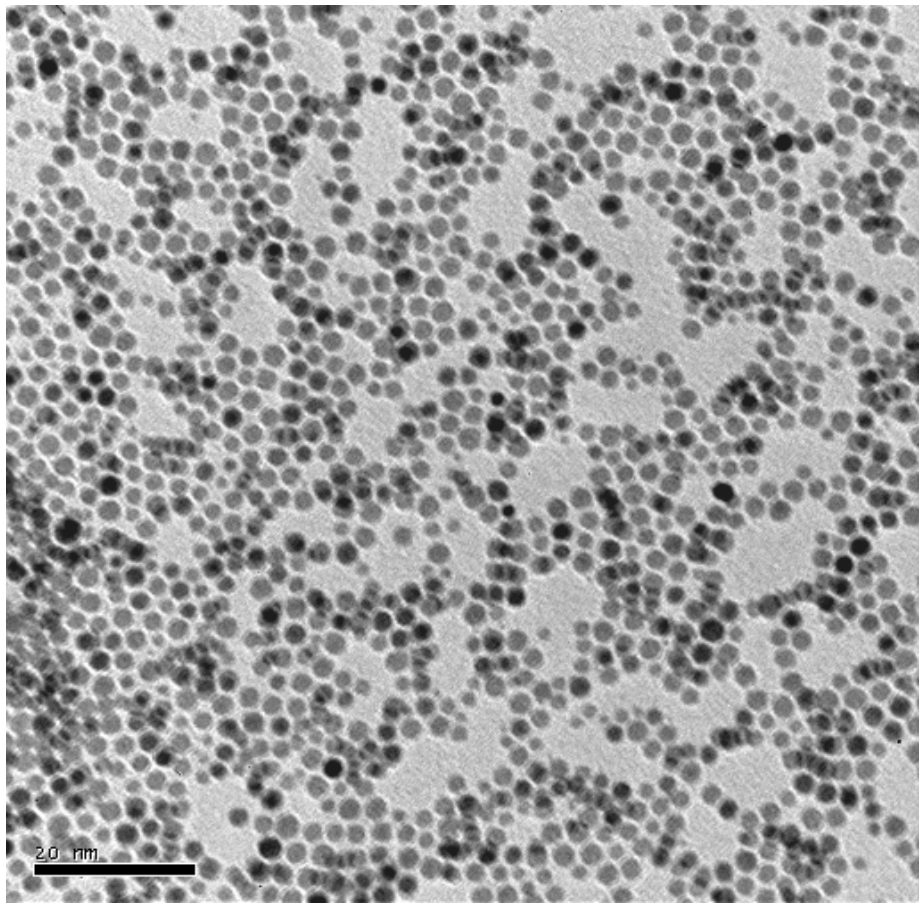
# 50 nm nanoparticle

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

# Iron particles (100-200 nm)



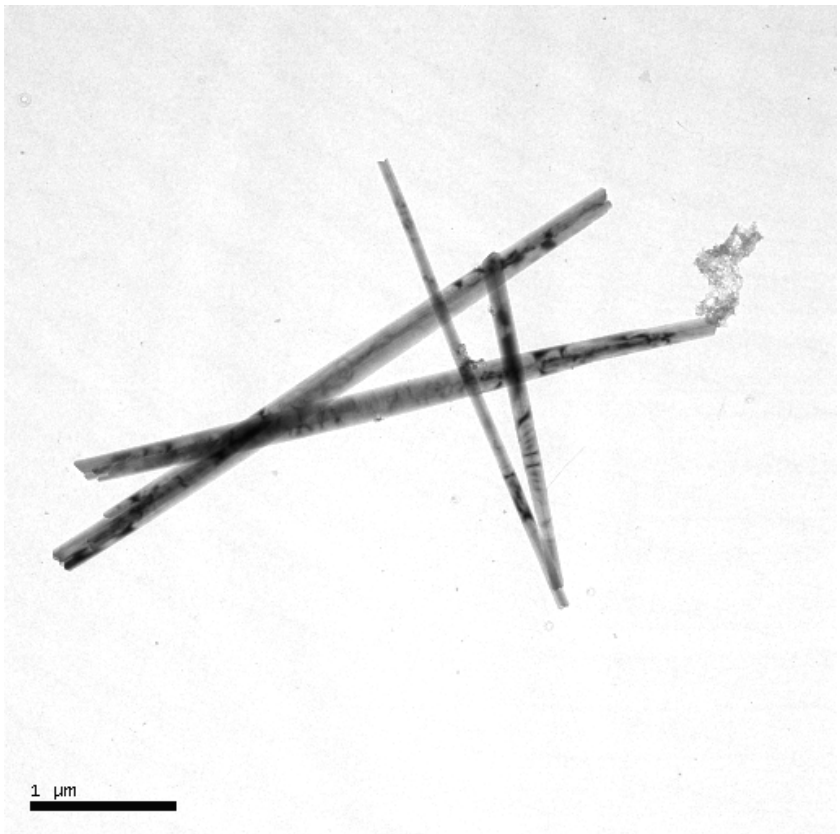
# Iron particles (3-5 nm)



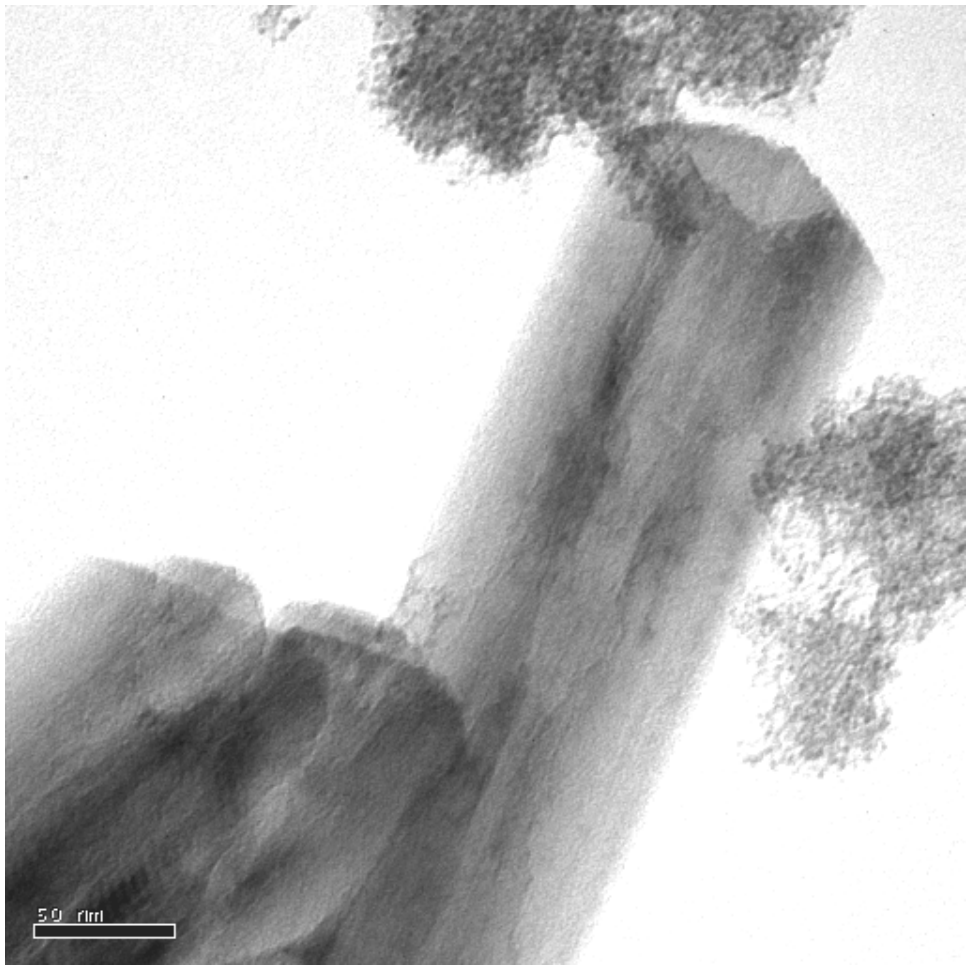
# Nano Iron Wire
# (dia 50-75 nm,10-20 μm long )

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

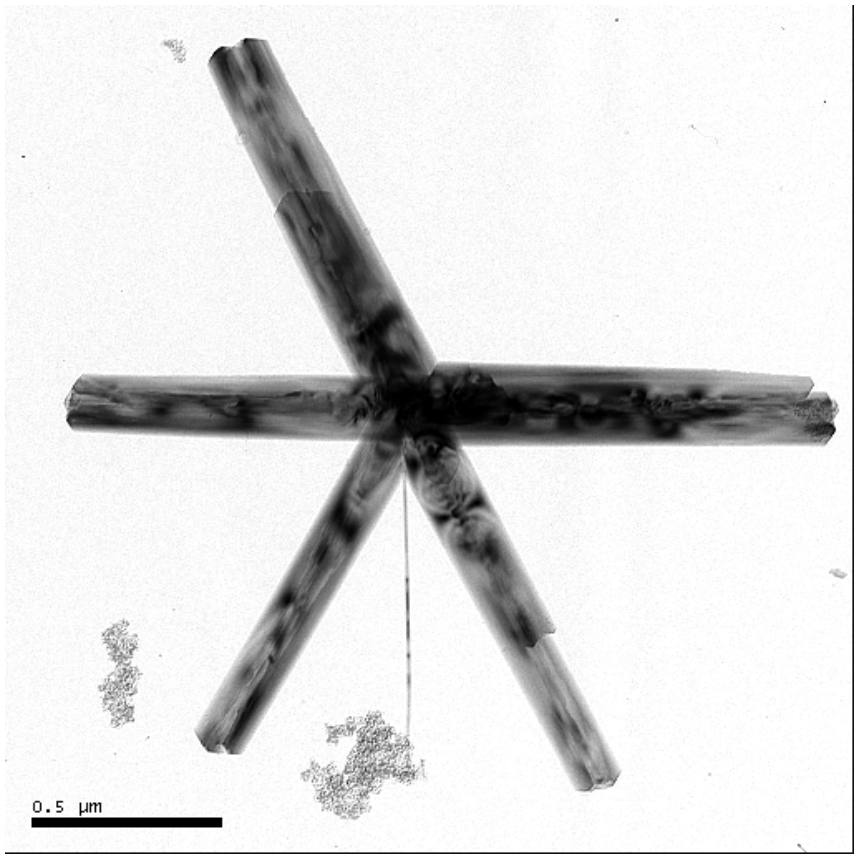
# Iron Rod (dia ~50 nm)



# Iron Tube (~ 50 nm)



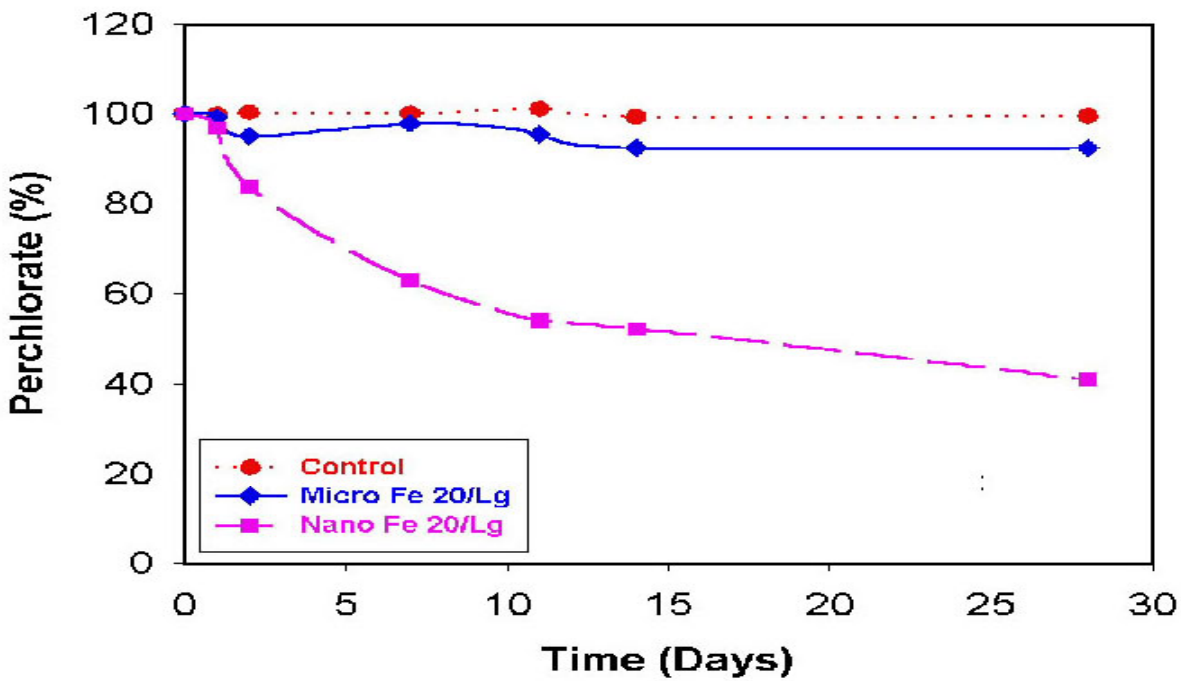
# Nano Iron Antenna (~50 nm)



# 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



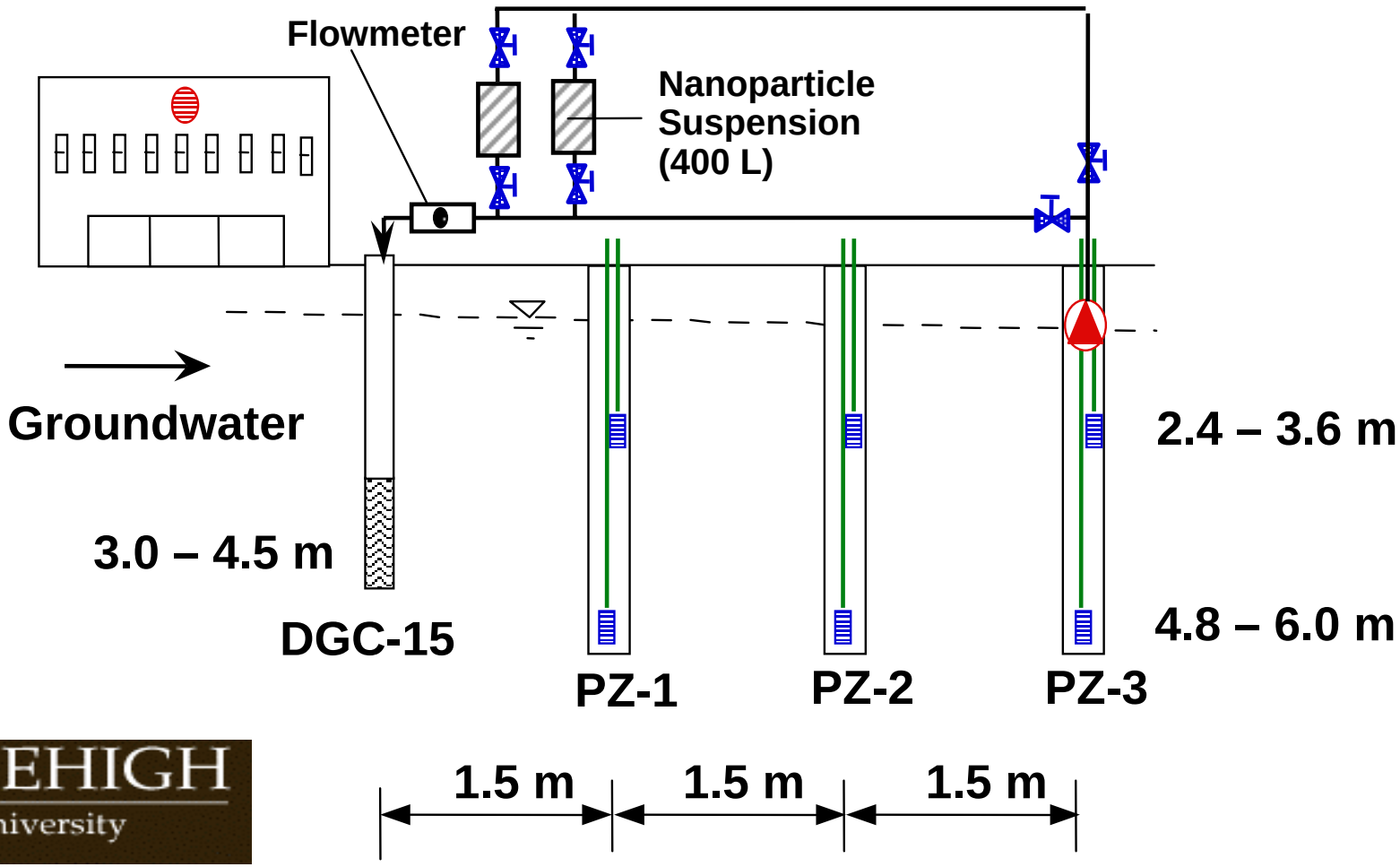

Initial perchlorate concentration 200 mg/L

# 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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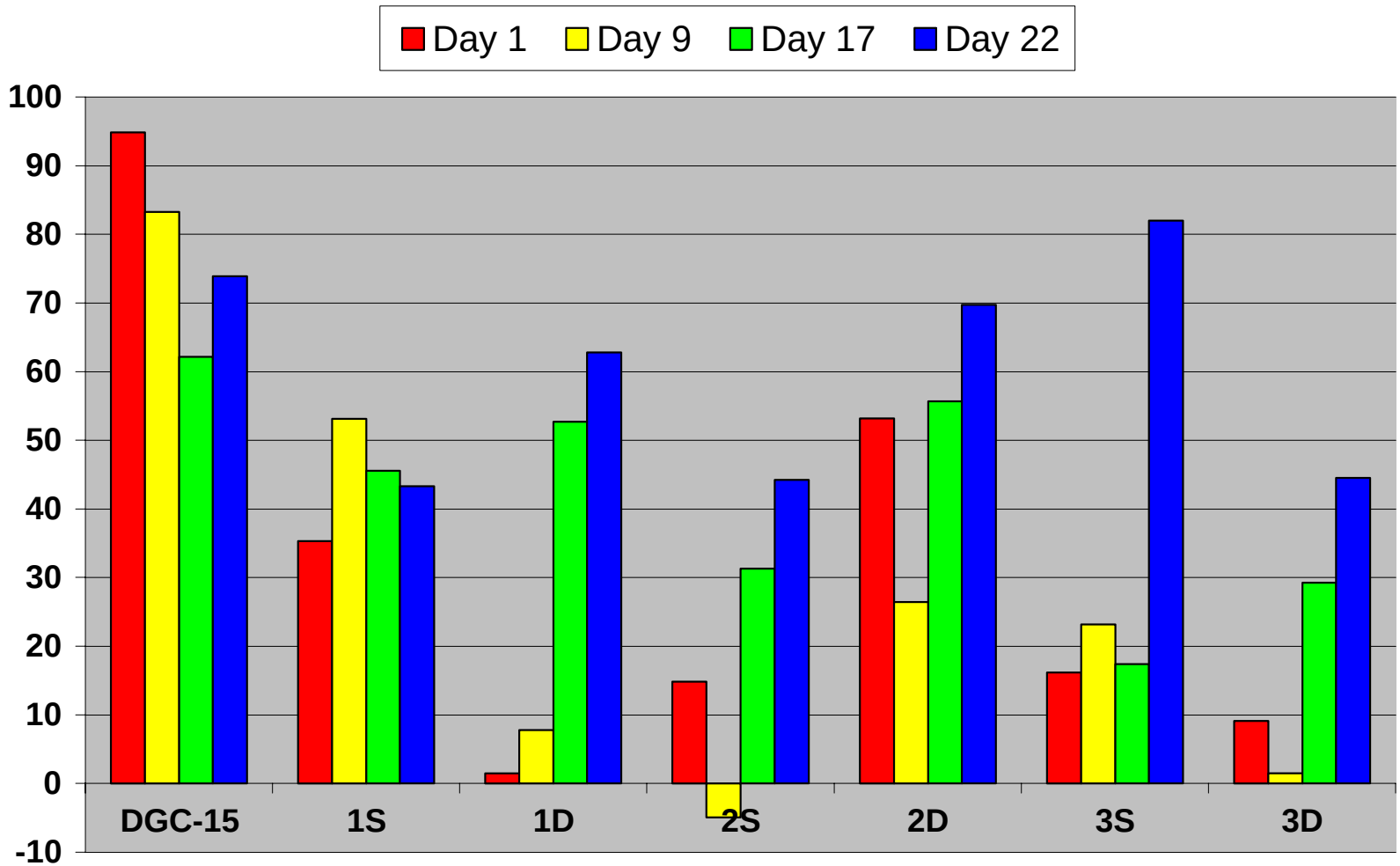
# Setting Up!

- 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 %



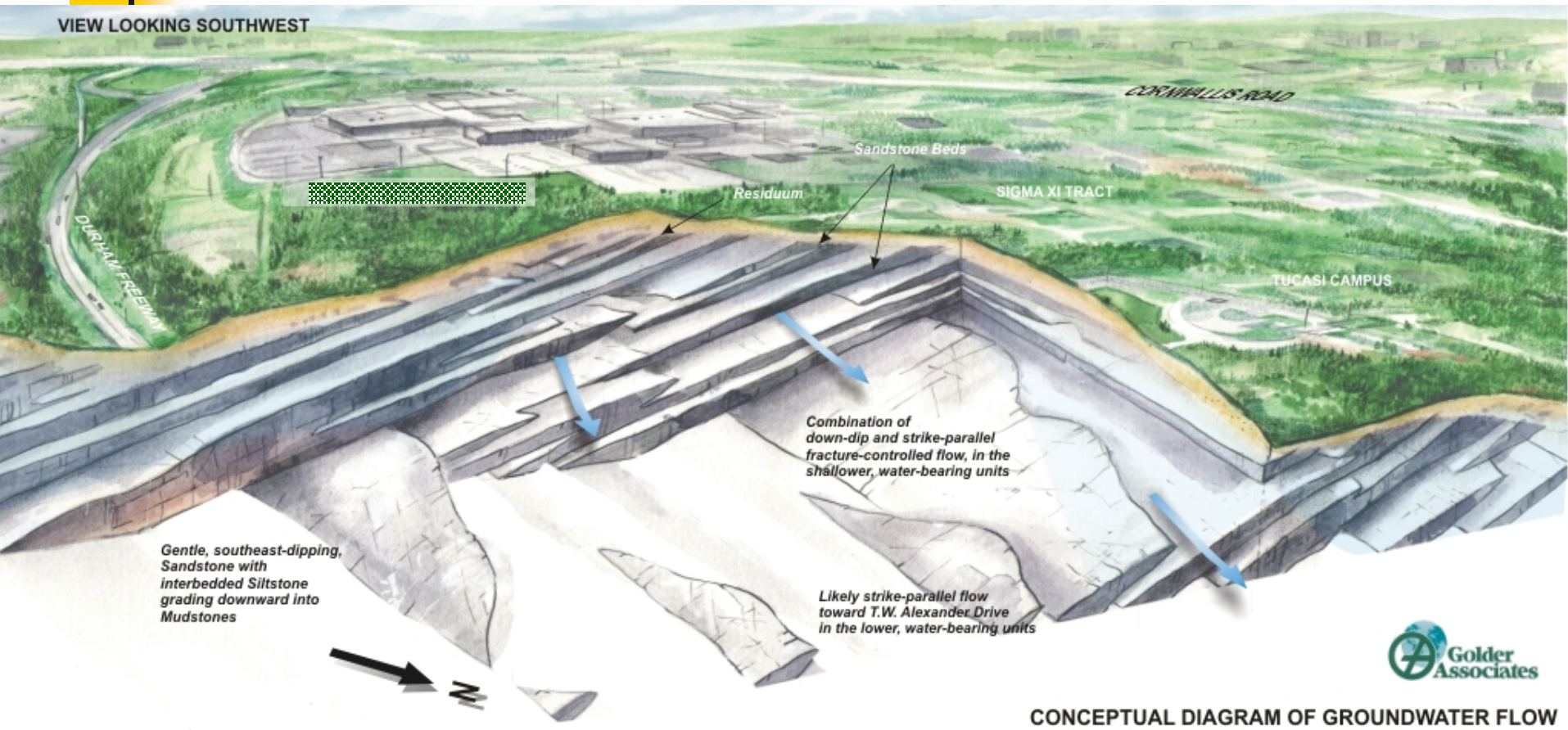
# Field Test - 2
# (Nano Fe 10 kg, 2002)

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

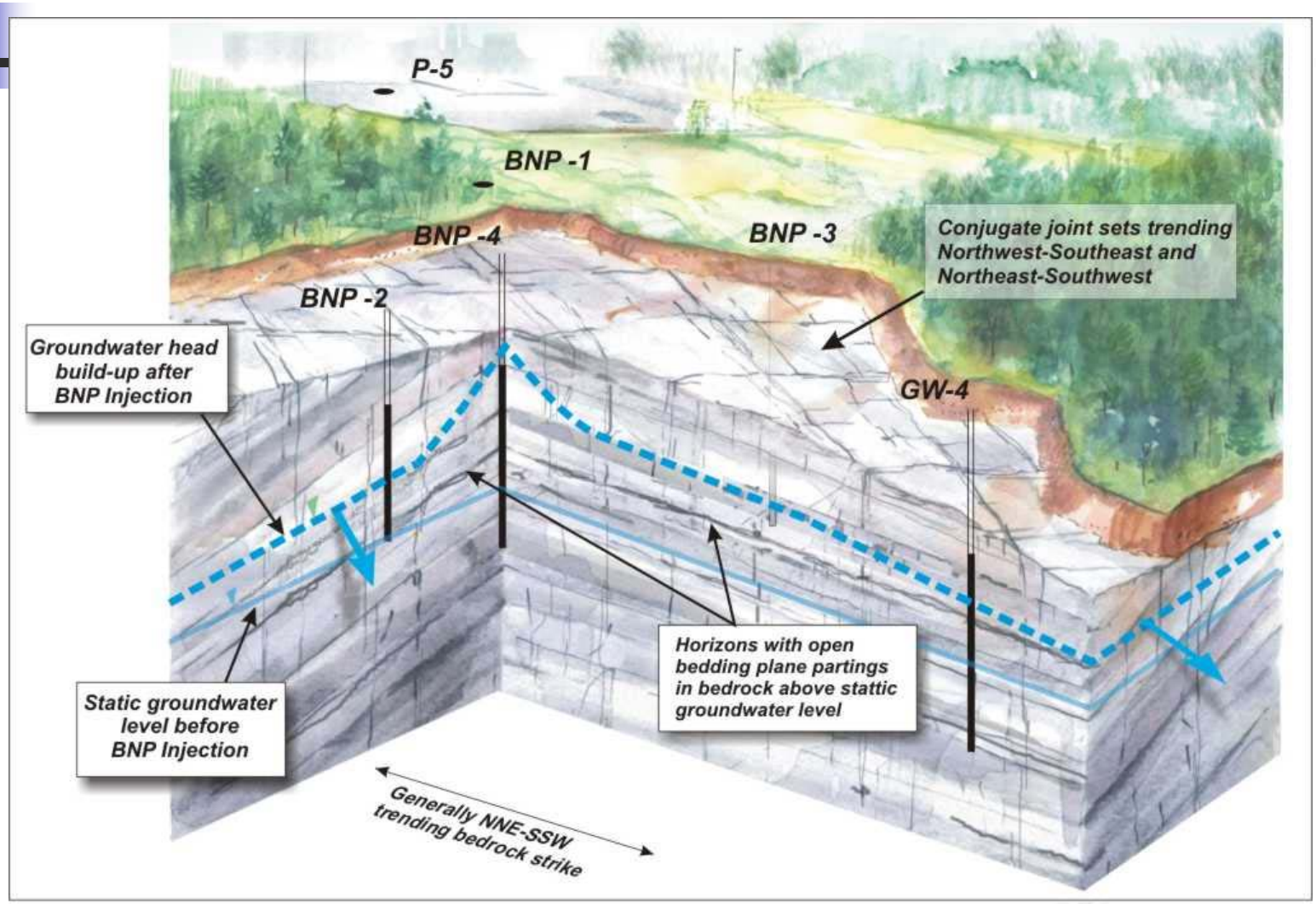
**Injection Well B-4**
**Monitoring Wells**

- **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**

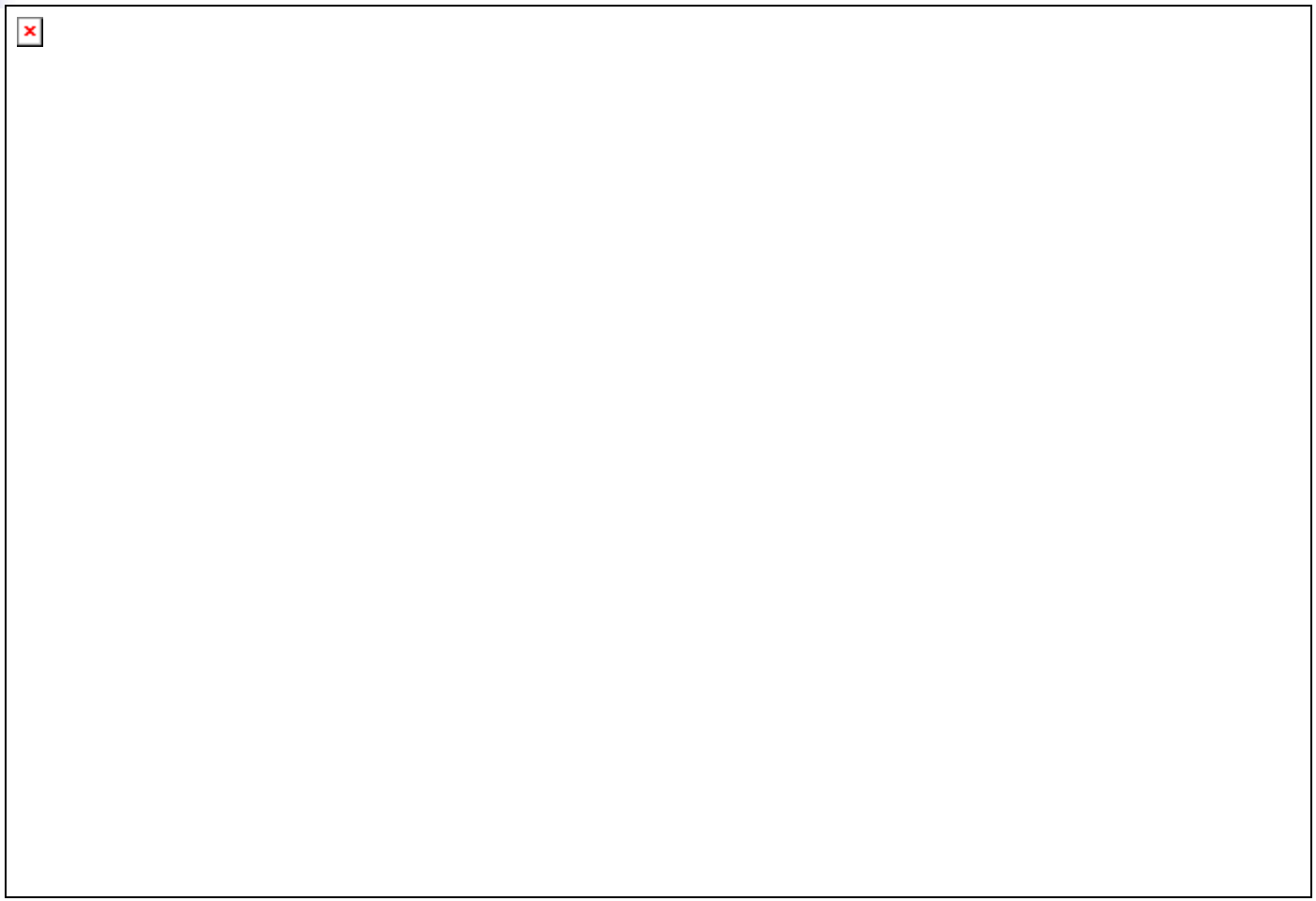
# Conceptual Geologic/Hydrogeologic Model



# Conceptual Model - Injection Area



# Field Test - 2 (10 kg Nano Fe )



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# Research Group