Site-Wide FRC Model Update

NABIR Fall Meeting
October 2005

Modeling Approach

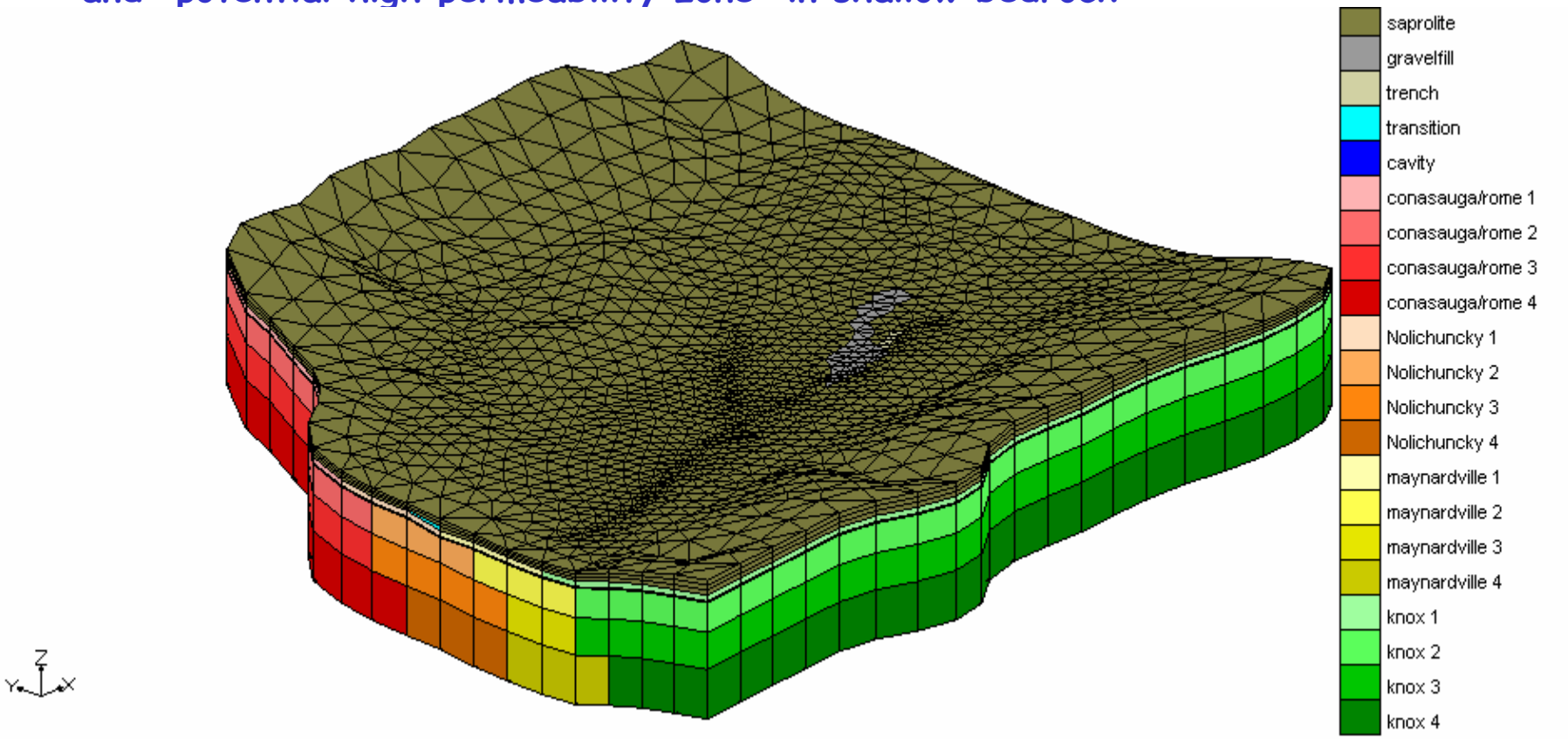
- Using HYDROGEOCHEM version 5 which is an enhancement of HBGC123D
- Models 3D transient sat/unsat flow, heat transport, dissolved transport, and complex biogeochemical reactions
- Allows user-definable kinetic functions, which provides flexibility to adapt to new formulations as our understanding improves
- Models fully anisotropic porous media suitable for representing densely fractured, dipping bedrock and saprolite

Updates to Site-wide Model

- Modify gravel fill zone west of Area 3 to incorporate new info on its spatial distribution
- Modify areal extent of the rock-saprolite transition zone based on new boring and geophysical data
- Incorporate Area 2 permeable barrier trench
- Add bedrock fracture zone west of S3 Ponds inferred from geophysical transects
- Divide S3 pond area into quadrants to allow simulation of variable discharge and contaminant release during operation
- Refine grid vertically and areally to accommodate above and recalibrate flow and transport models

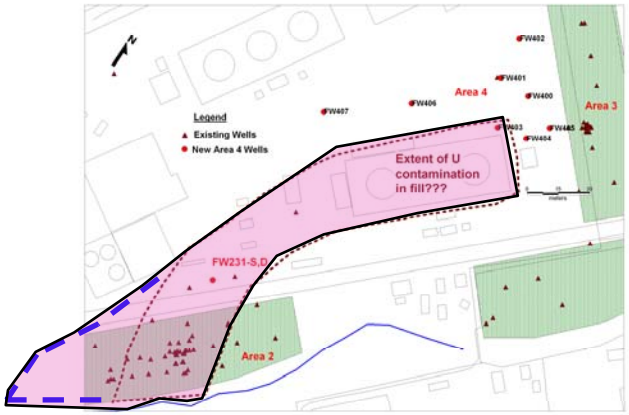
Discretized Model Domain

- 8 layers and 21304 elements & 9 layers and 12312 nodes
- 4 types of bedrock plus saprolite, gravel fill, trench, "transition" zone and "potential high permeability zone" in shallow bedrock

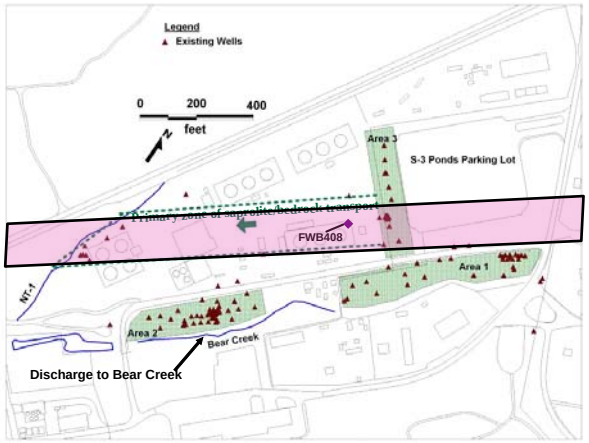


Model Updates

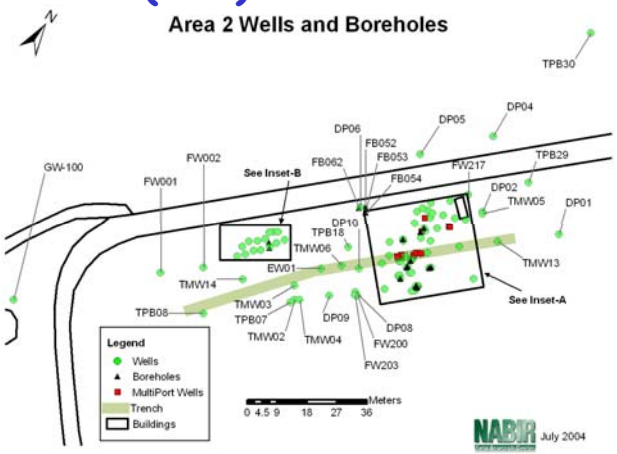
- Gravel fill (larger)



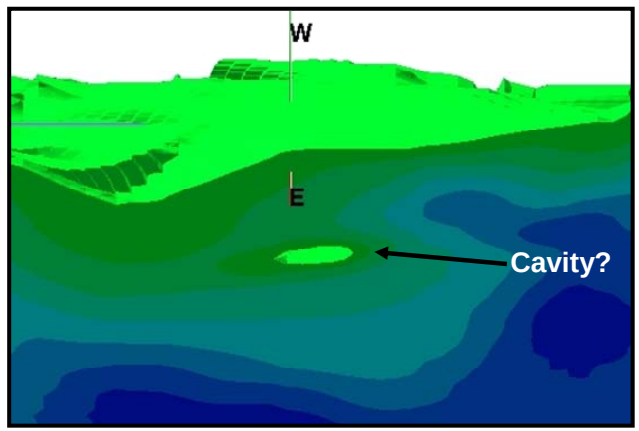
- Transition zone (smaller)



- Trench (new)



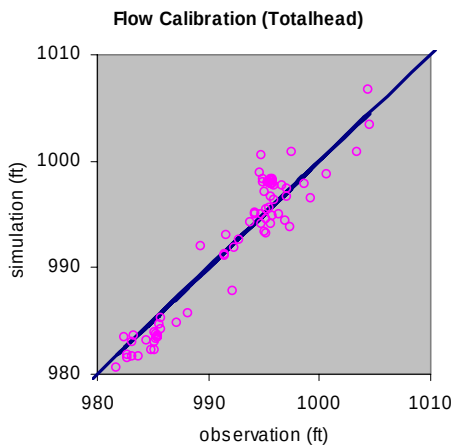
- High permeability rock zone? (new)

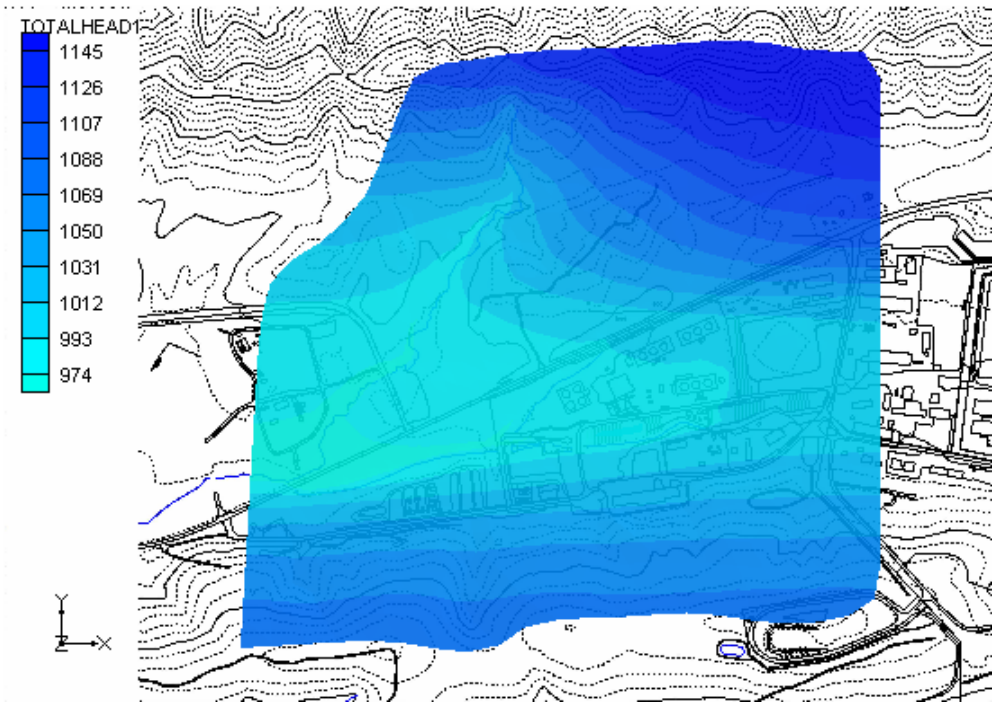


Flow Model Calibration

Calibration procedure

- Invert using nonlinear optimization code (PEST)
- Time-averaged water levels for 74 wells
- Average streamflow at Bear Creek NT-2 gauging station





Base streamflow (L/d)

measured:3.59e5

model: 3.28e5

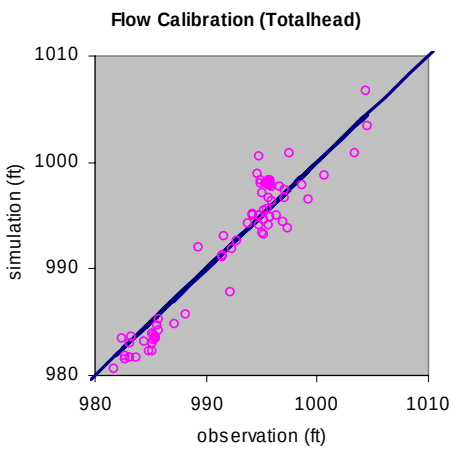
Flow Model Calibration

Parameters calibrated

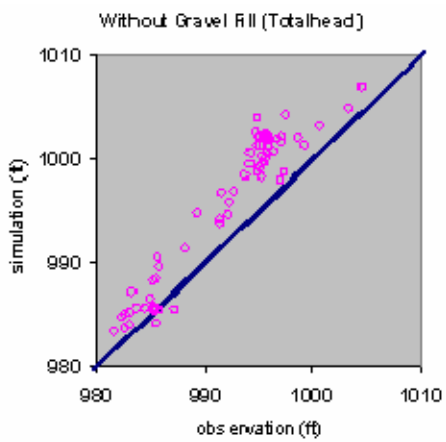
- Recharge zones:
  - Hill slopes – 0.426 ft/yr
  - Valley – 0.496 ft/yr
  - Paved areas – 0 ft/yr
- Conductivity (K_S along strike, K_D along dip, K_C cross-bed)
  - Saprolite: K_S = 2.31e-4 cm/s, $K_D = K_C$ = 2.31e-5 cm/s
  - Transition zone and potential high permeability zone:
    - K_S = 2.78e-3 cm/s, K_D = 9.27e-5 cm/s, K_C = 2.78e-4 cm/s
  - Gravel fill and trench: $K_S = K_D = K_C$ = 0.01 cm/s
  - Rock units (reported range: 6.00e-6 ~ 7.64e-2 cm/s)
    - Average conductivity along strike for top: 6.59e-4 cm/s
    - Average in-bed anisotropy: 0.15
    - Average cross-bed anisotropy: 0.03
    - Average depth reduction factor: f_{avg}=4.
  - $K(z)=K(0)\exp(-fz/z_T)$, where z_T is total thickness of rock layers

Model Calibration Sensitivity

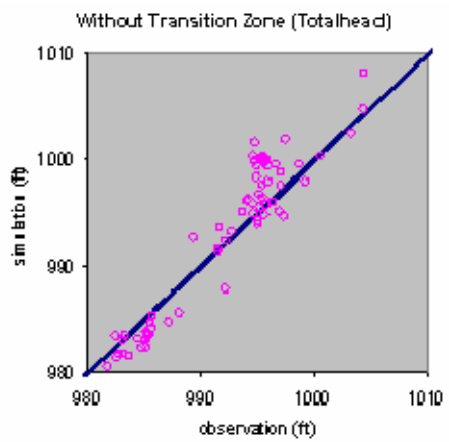
Base Case



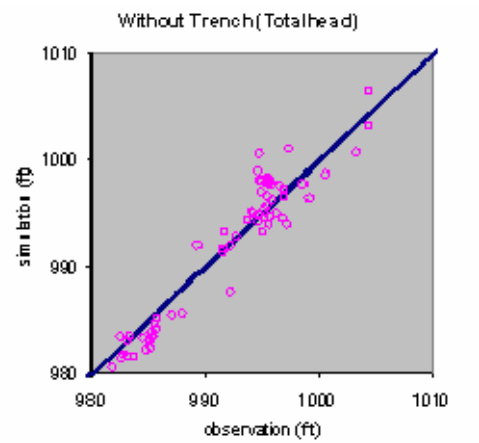
Gravel fill



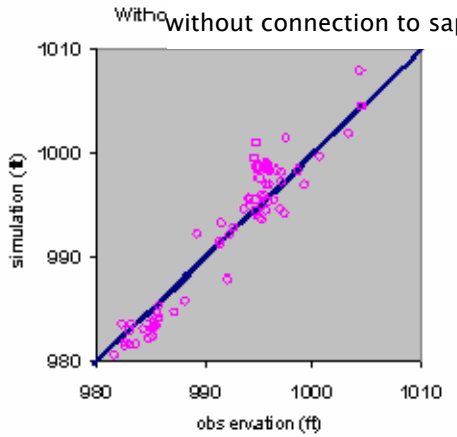
Transition zone

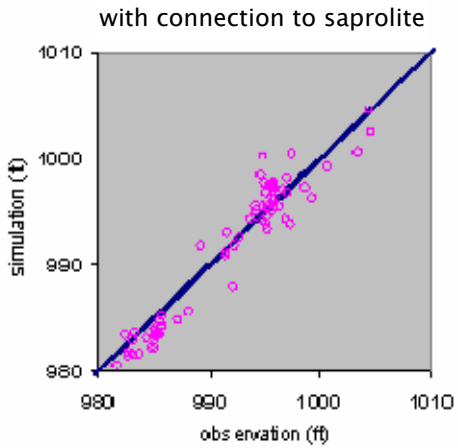


Trench



Potential high permeability zone

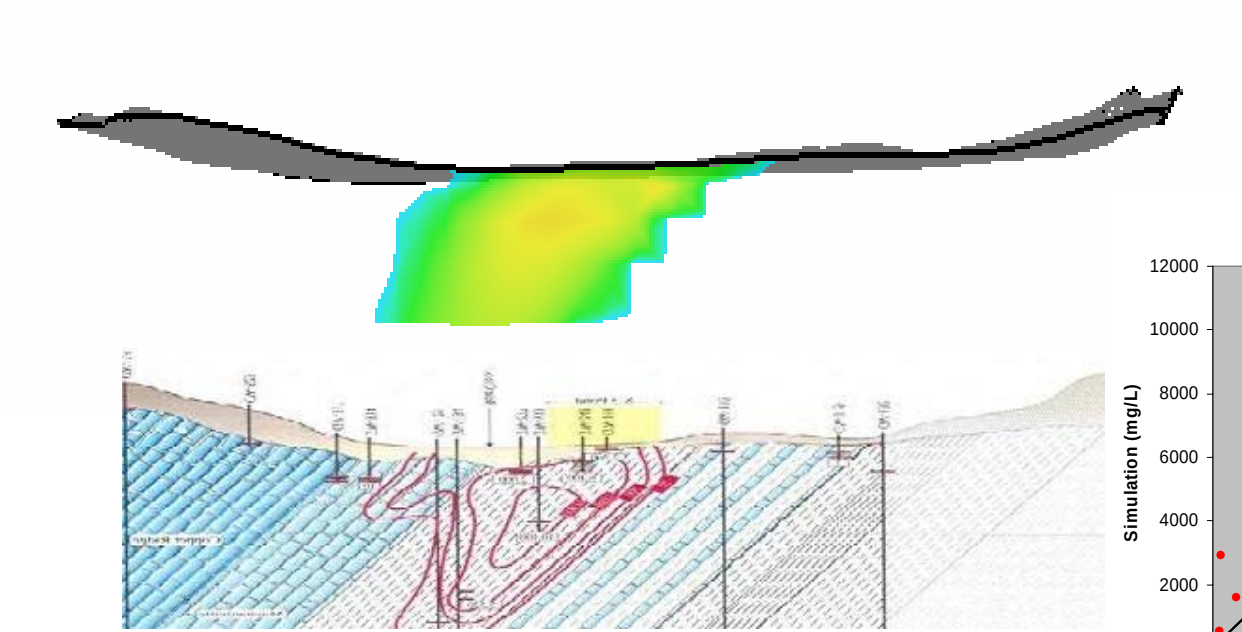


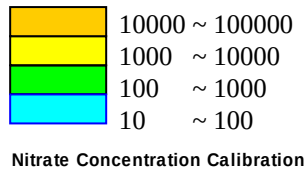


Transport Model Calibration

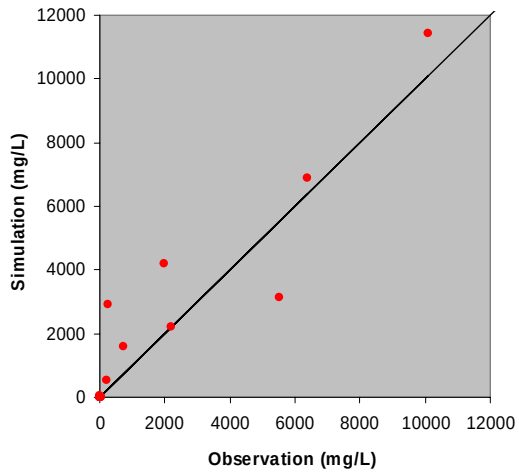
Calibration procedure

- Fit parameters to C(x,y,z,t) data from 18 wells





Nitrate Concentration Calibration



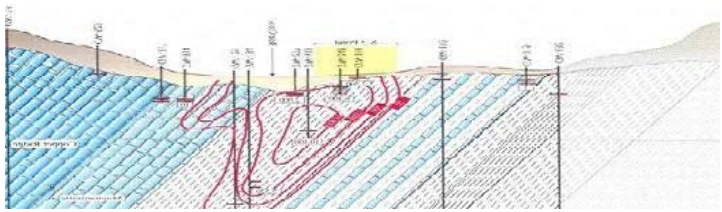
Transport Model Calibration

Parameters calibrated

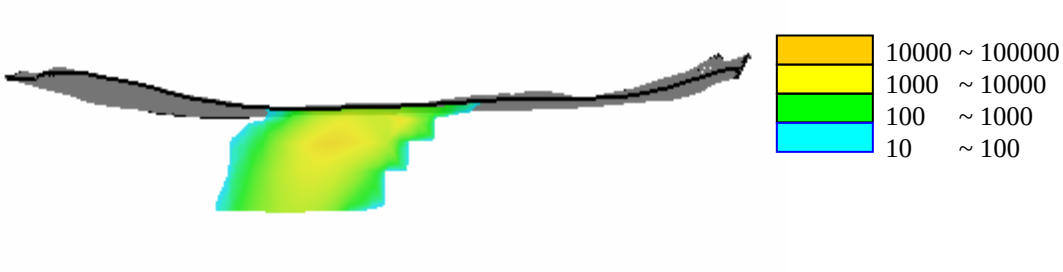
- Dispersitivity
  - A_L = 10 m
  - A_T = 0.1 m
- Porosity
  - Saprolite: 0.2
  - Transition zone: 0.2
  - Rock units
    - average porosity for top rock layer: 0.16
    - average depth reduction factor: f=3.38

$$\theta = \theta(0) \exp(-f z/z_T)$$

Nitrate Transport Model Results, ca. 1995

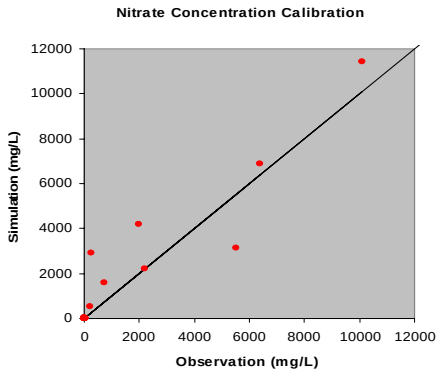


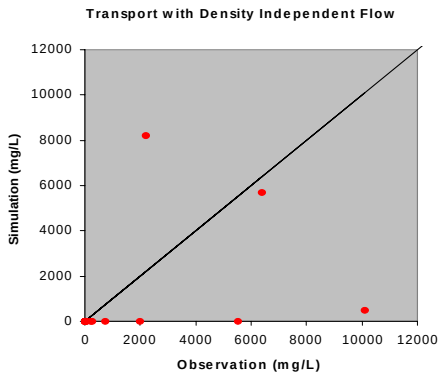
Density-driven flow moves nitrate plume deeper near source as observed in field



Transport Simulation Coupled with Density-dependent Flow

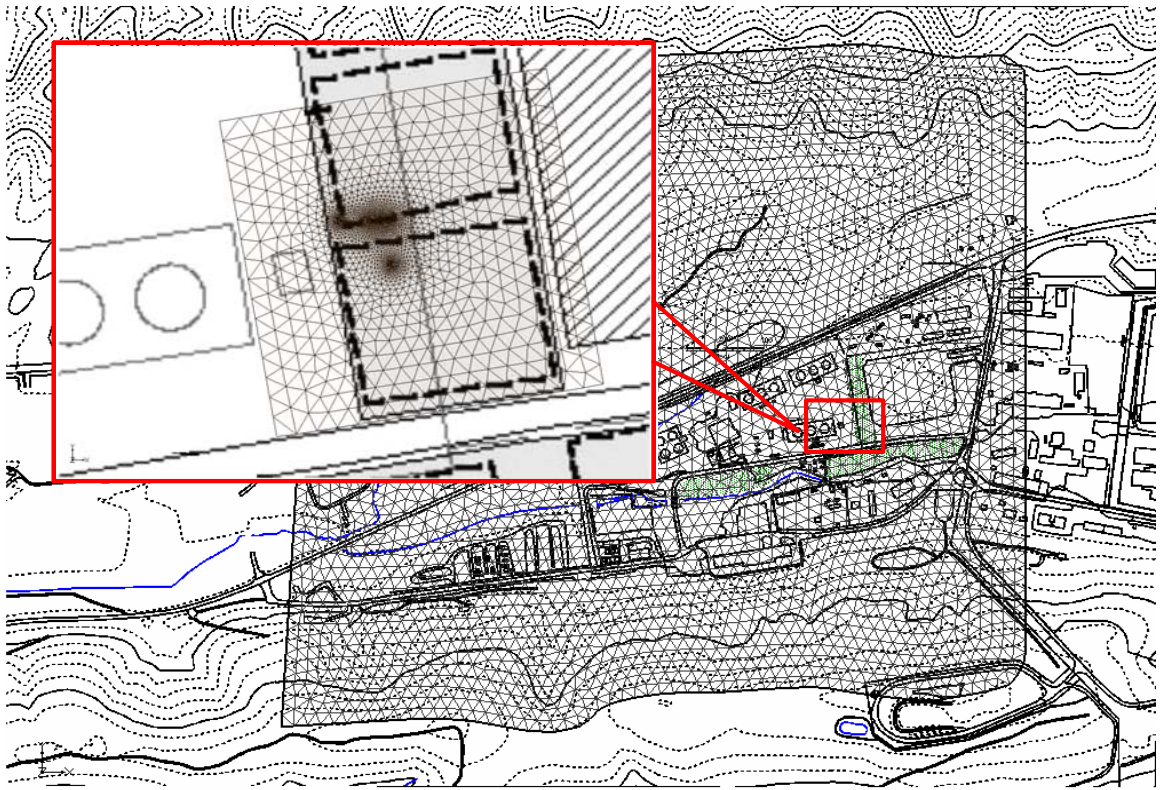
Transport Simulation with Steady-State Flow Solution





Implement Higher Resolution Area 3 Submodel

Purpose: Assist in design of new experimental plots near FW106 to avoid interactions with existing study plots



Future Plans

- Complete analysis of new Area 3 experimental plot
- Perform additional refinements as needed
- Conduct sensitivity analyses to assess effects of data uncertainty
- Incorporate geochemical reaction network into site-wide model