A Hydrologic-Geophysical Method for Characterizing Flow and Transport Processes within the Vadose Zone

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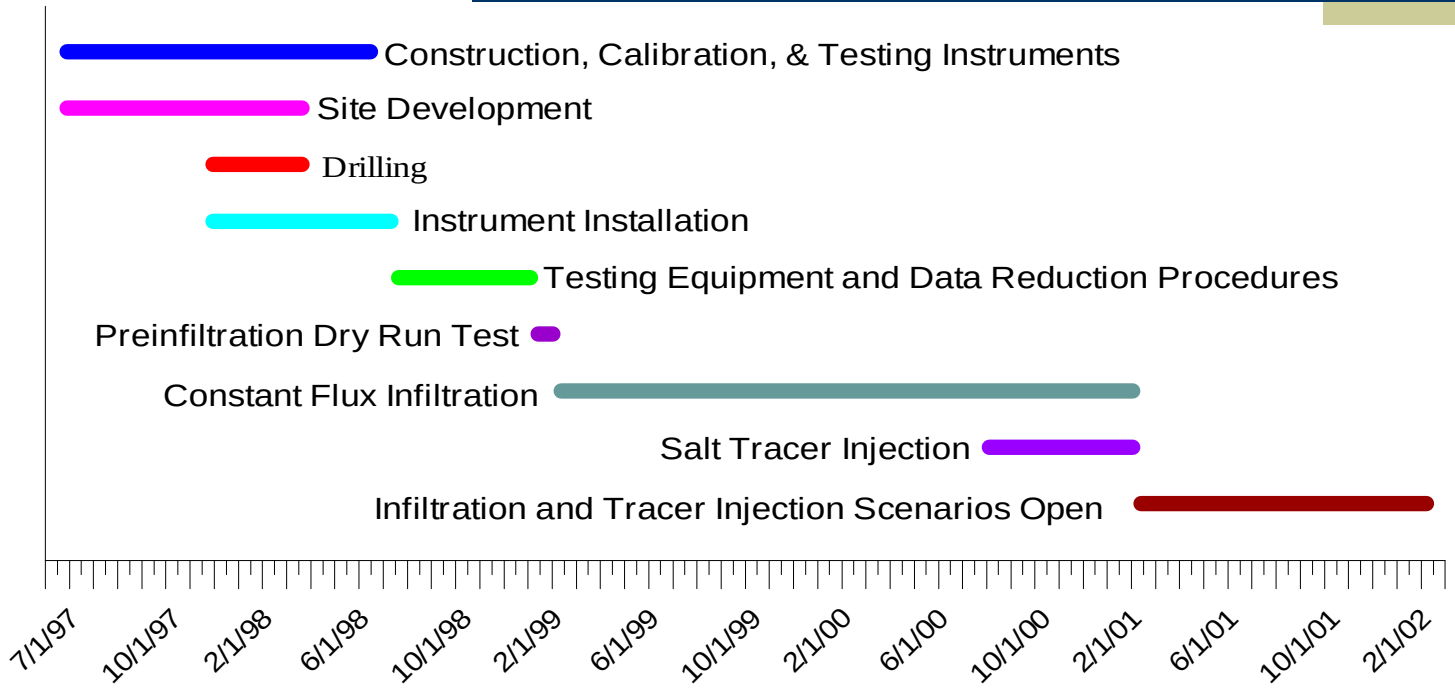
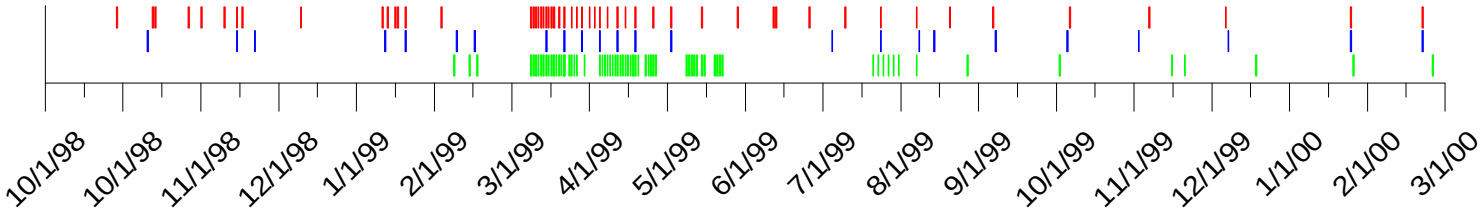
Project Objective

- To better understand flow and transport modes within the vadose zone at DOE sites, including the influence of natural heterogeneities and man-made structures.
  - Project will employ geophysical imaging techniques to image changes produced by mid-scale transport experiments as they occur.
  - Data will provide checks against which numerical flow and transport simulations will be compared.
- Builds on, and uses tools developed during, previous EMSP project.

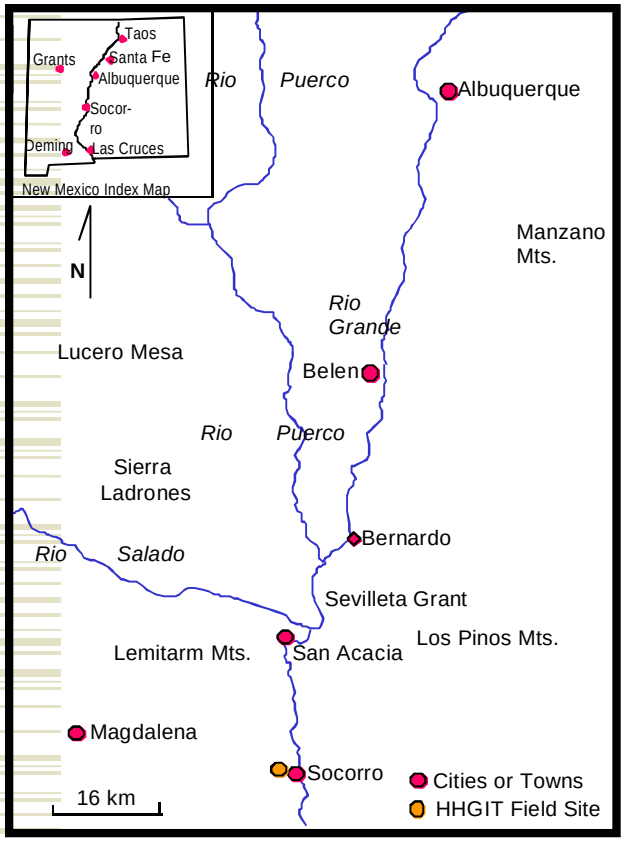
Infiltration Site History

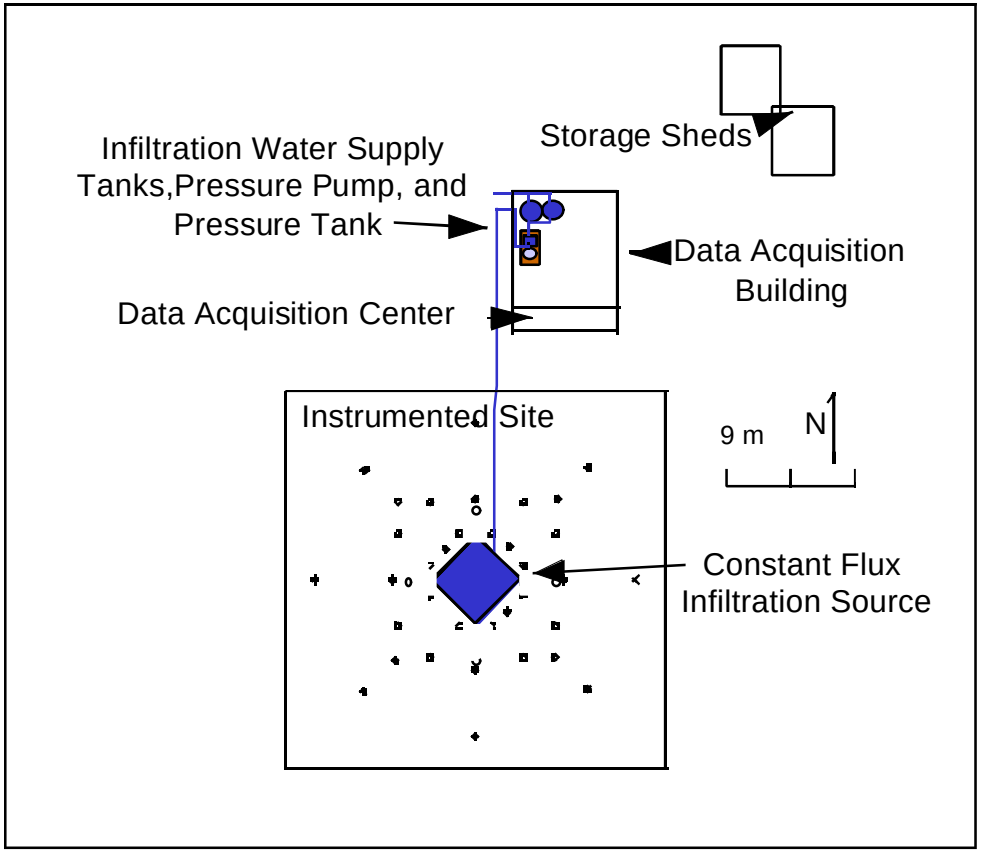


Data Collection History
neutron - red, XBGPR - blue, ERT - green

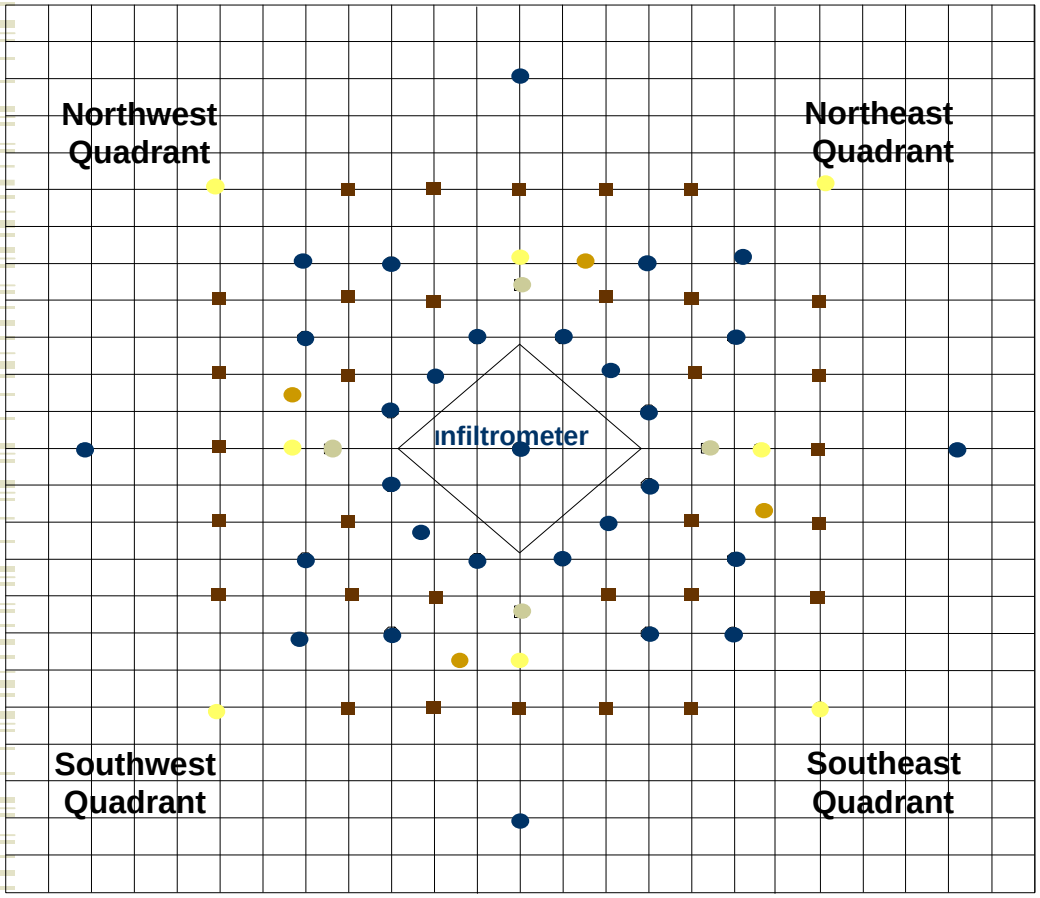


Site Location and Layout





Instrument Layout

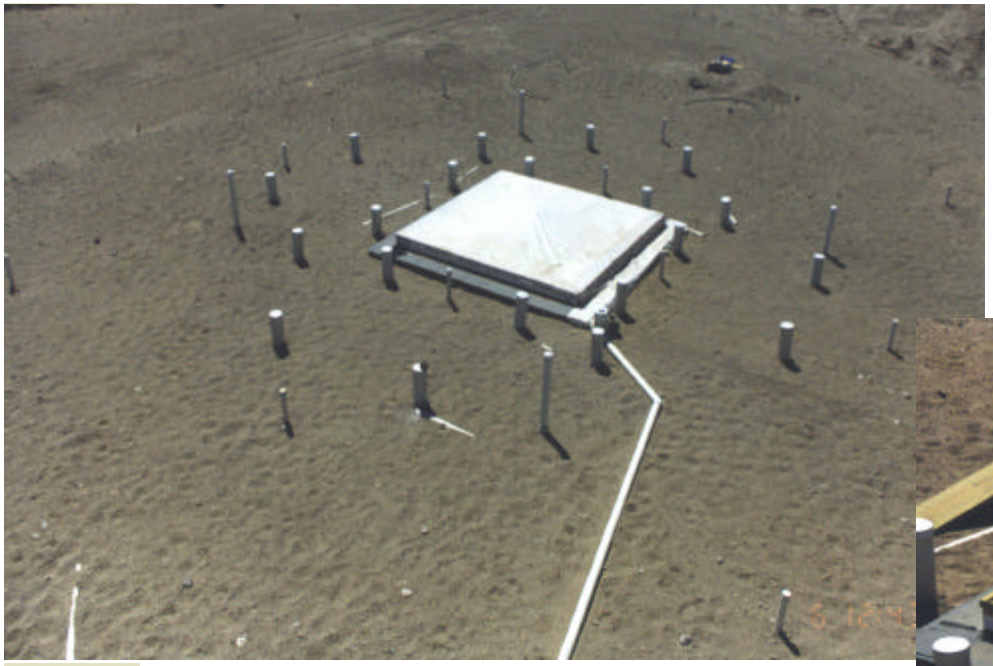


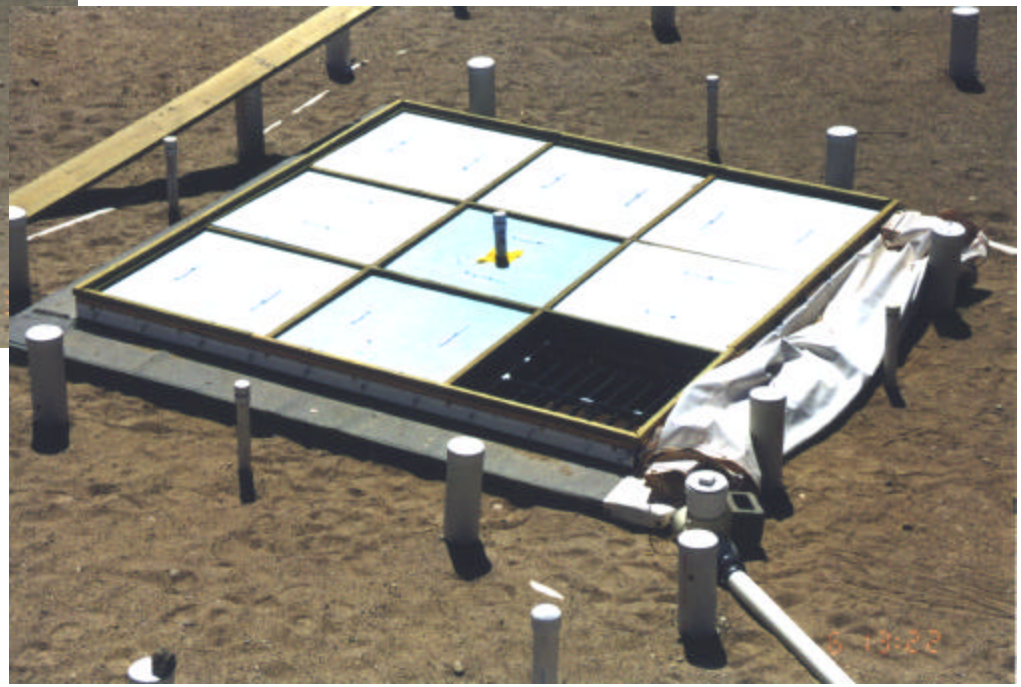
- Four-Nested Tensiometers, Suction Lysimeter and TDR Locations:
- Two-Nested Tensiometers Suction Lysimeter, and TDR Location
- PVC Cased Wells: Used for down-hole measurements.
- ERT Vertical Electrode Strings:
- ERT Surface Electrodes
- Continuous Core Sample Locations

3m

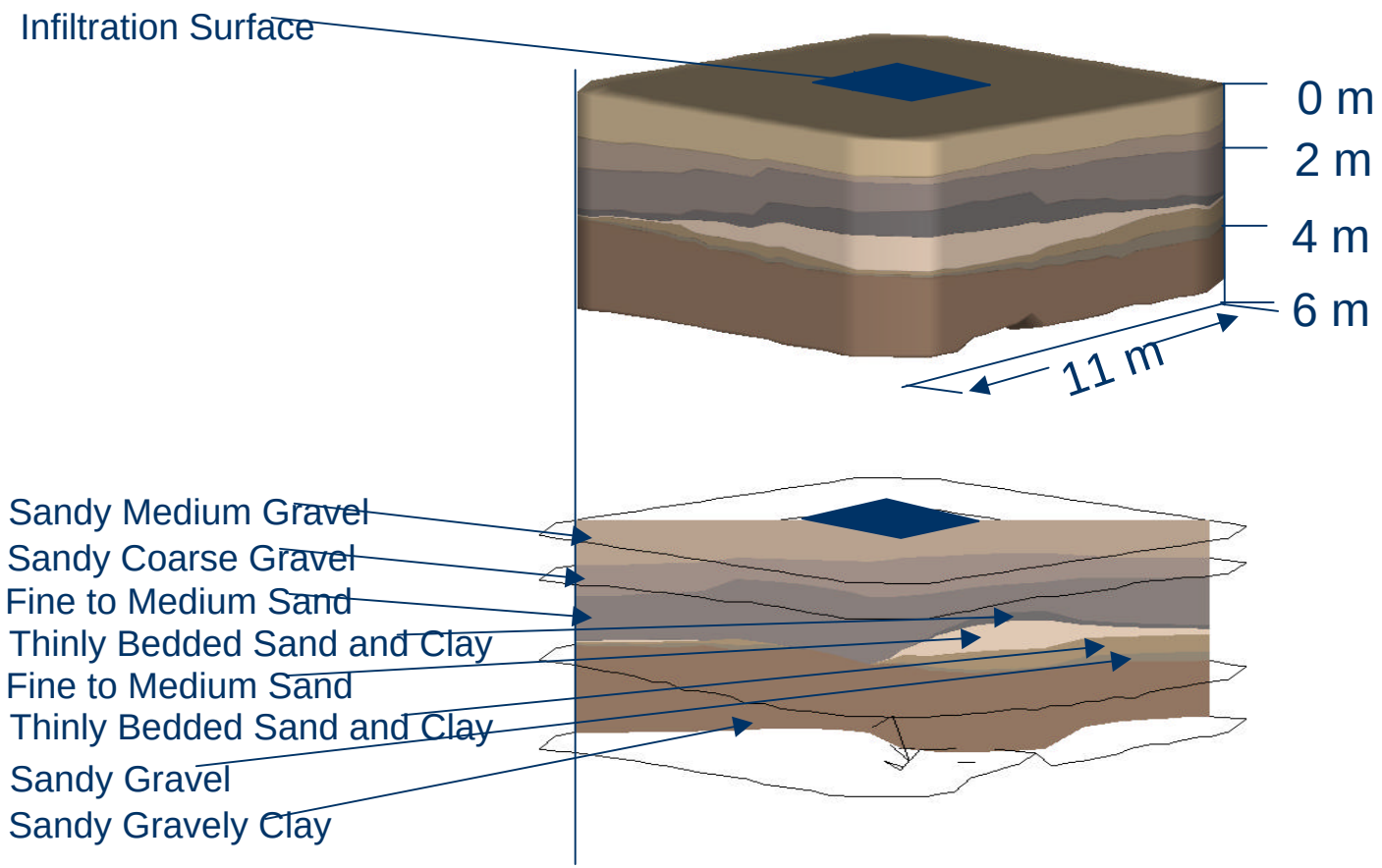
N

Site and Infiltrometer

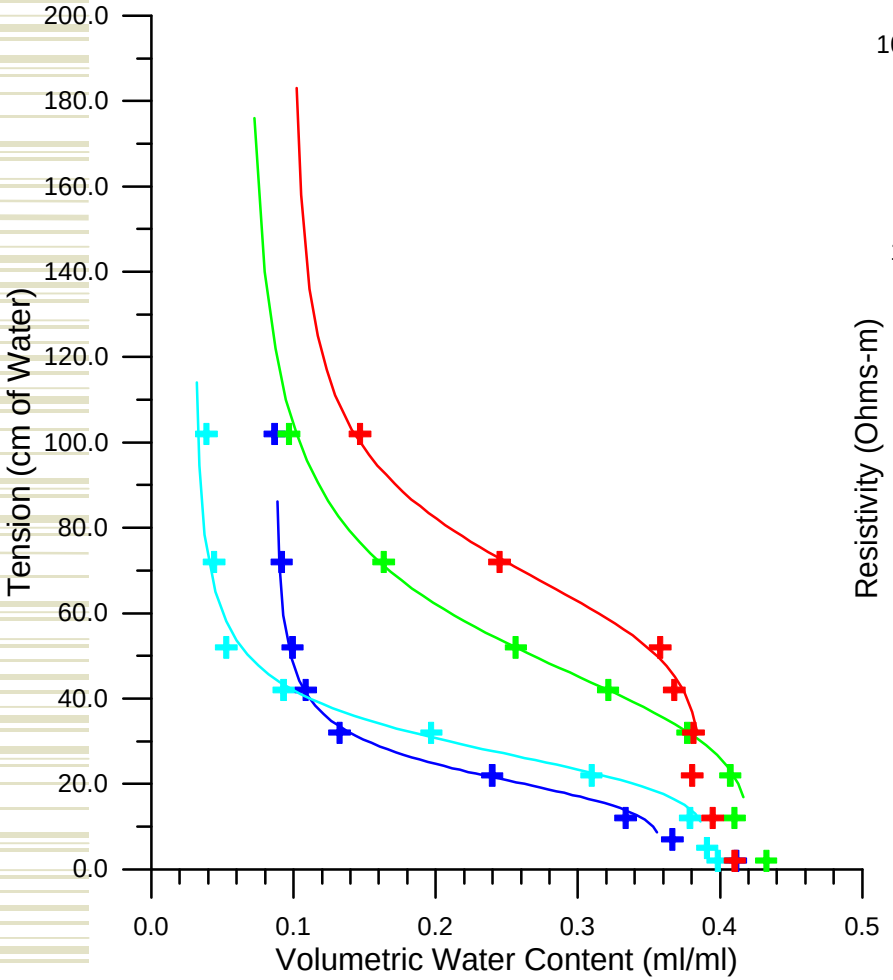


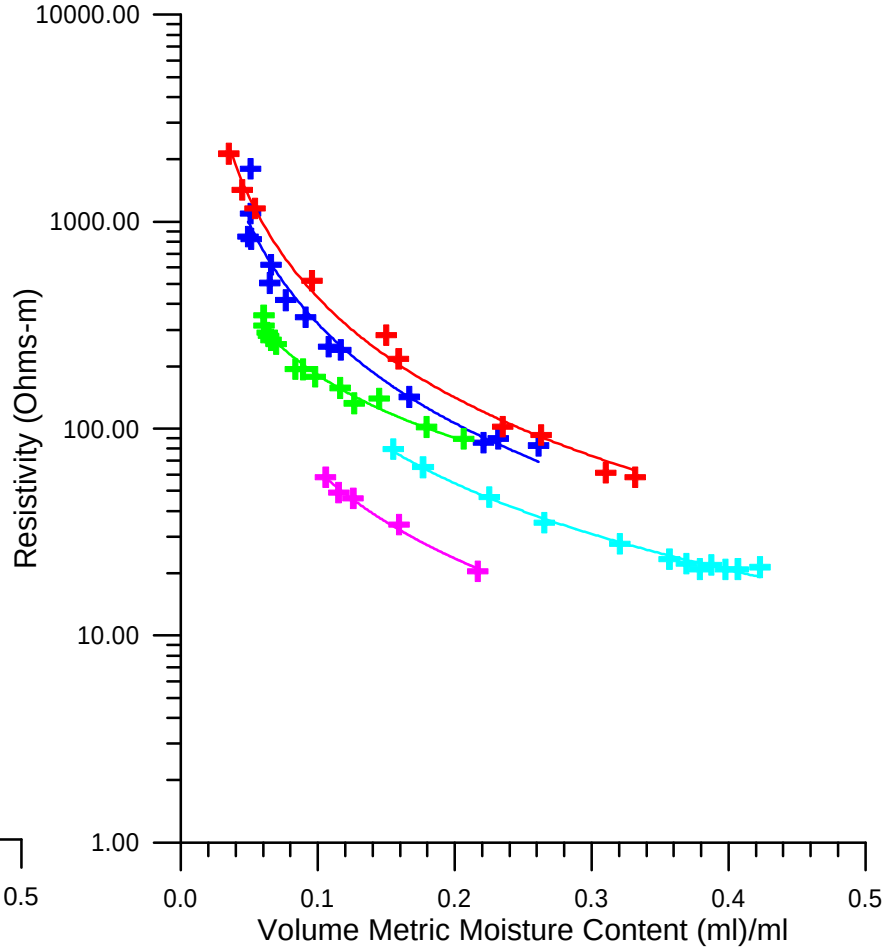


Estimated Site Geology

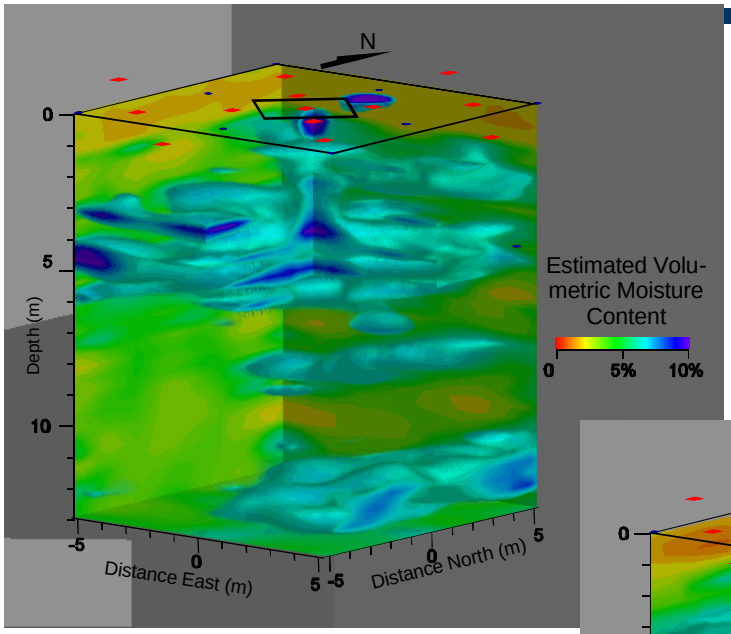


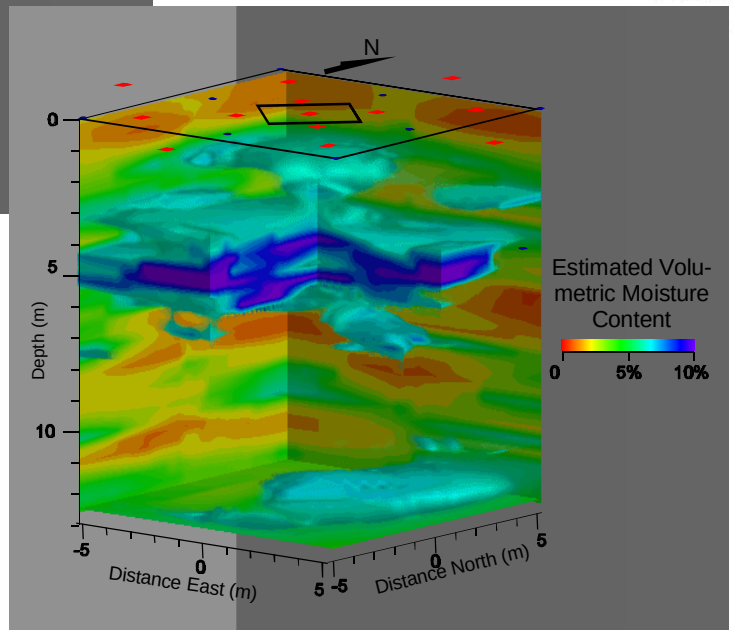
Hydrologic and Geophysical Sample Measurements

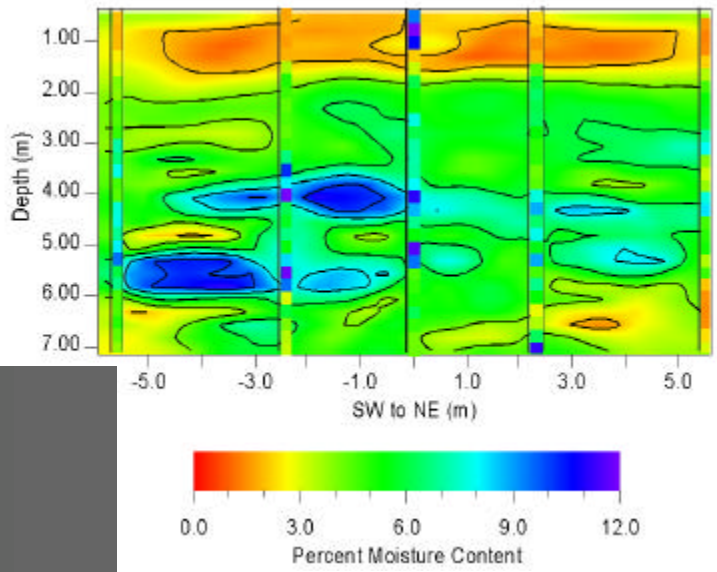




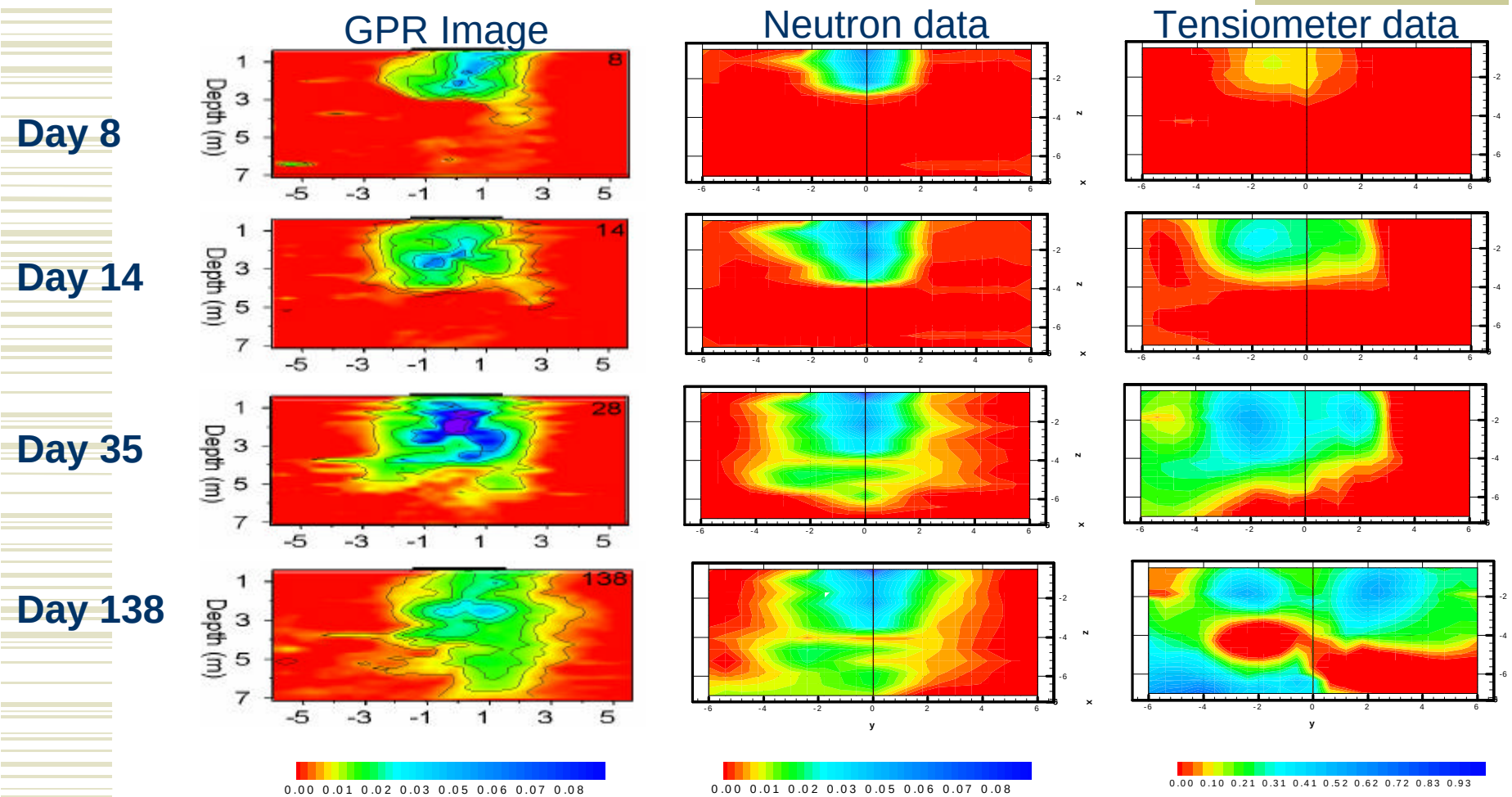
Preinfiltration Geophysical Estimates of Moisture Content







2D Slices of Infiltration Development



A HYBRID HYDROLOGIC - GEOPHYSICAL INVERSE TECHNIQUE FOR THE ASSESSMENT AND MONITORING OF LEACHATES IN THE VADOSE ZONE

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Multi-Phase Technologies

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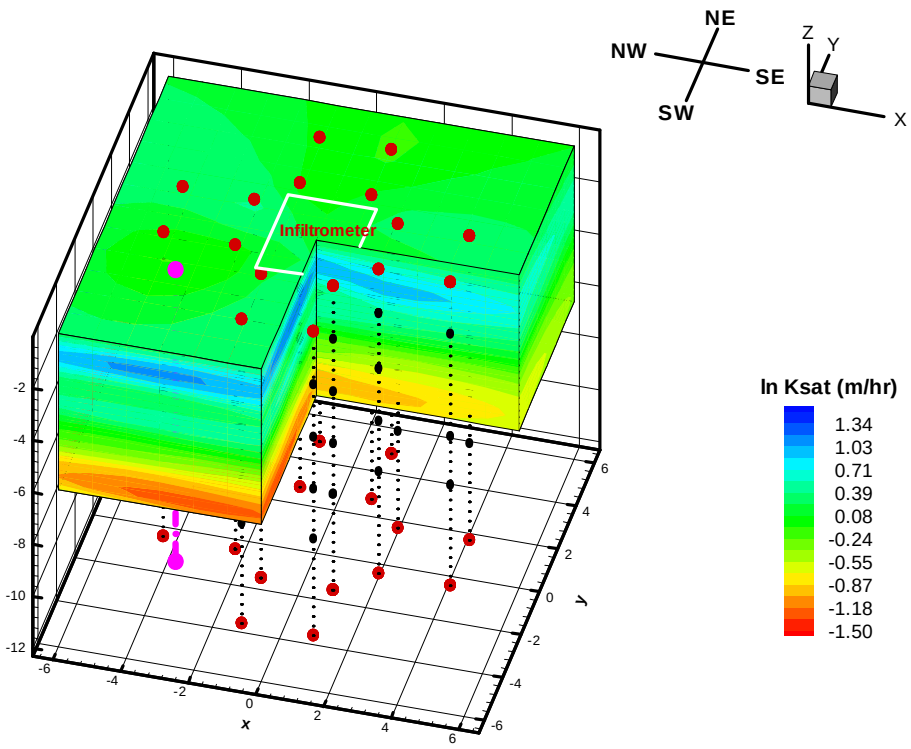
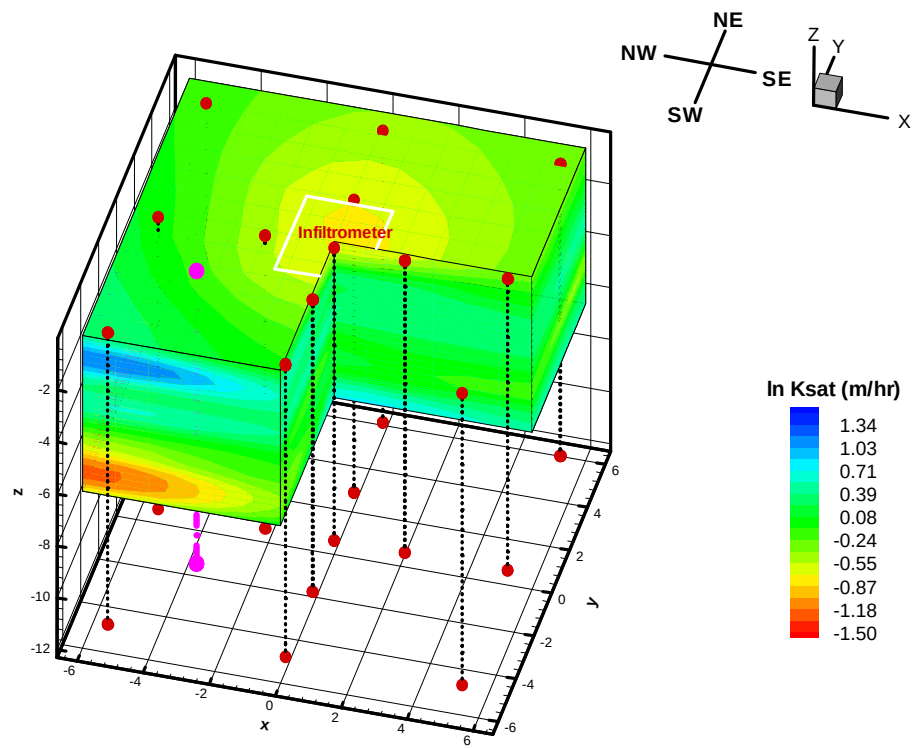
3-D Images of Moisture Change From Background Derived From ERT Data: Day 1 to Day 257

Saturated Hydraulic Conductivity Estimates Using Different Data

43 Tensiometer Locations

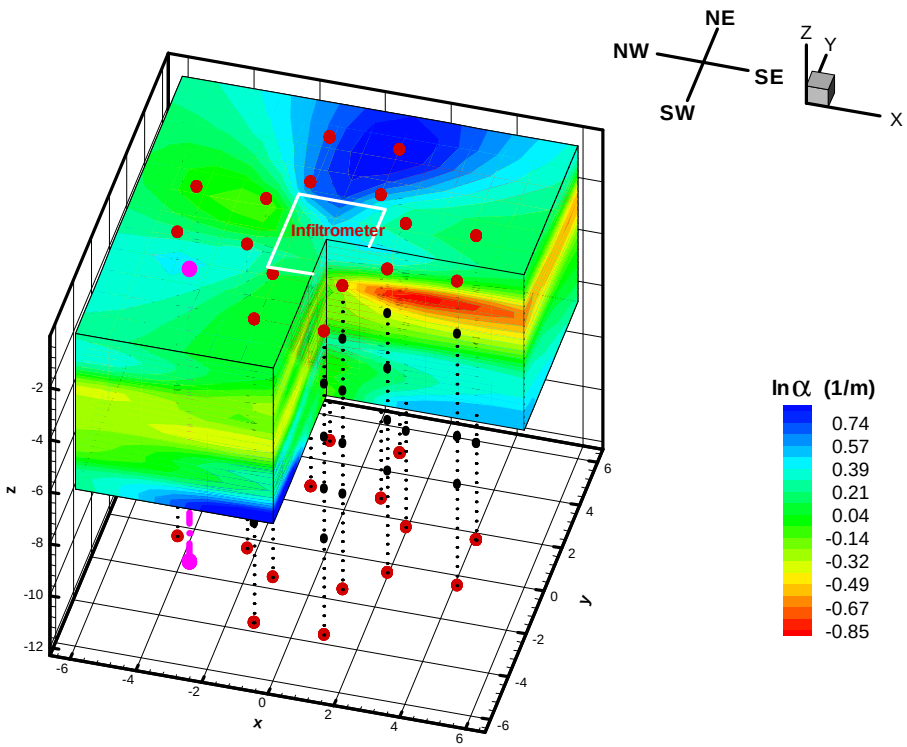


312 Neutron Locations

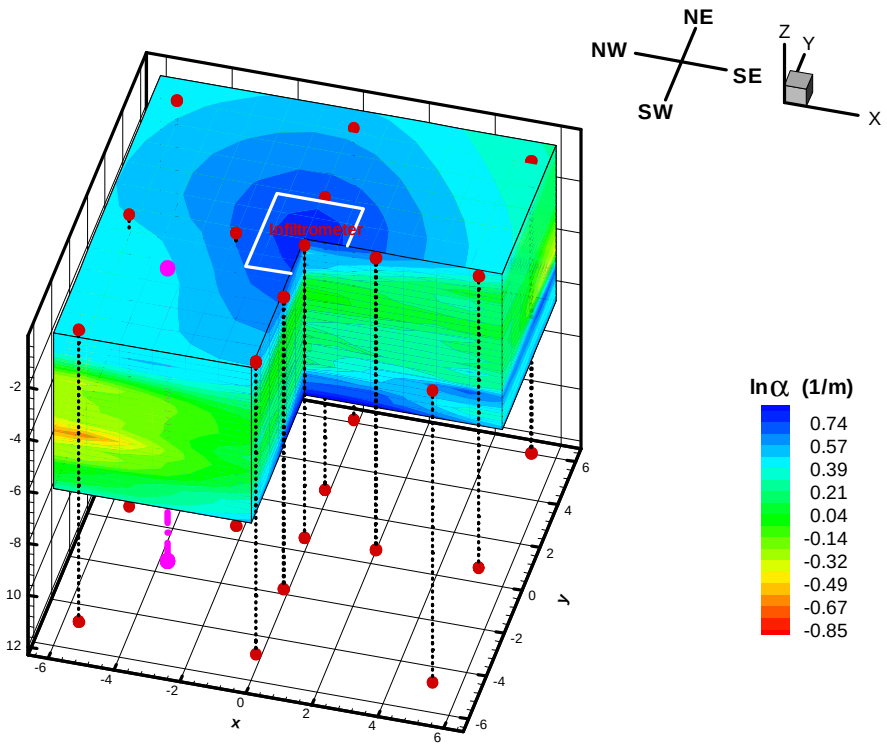


α Estimates

43 Tensiometer Locations

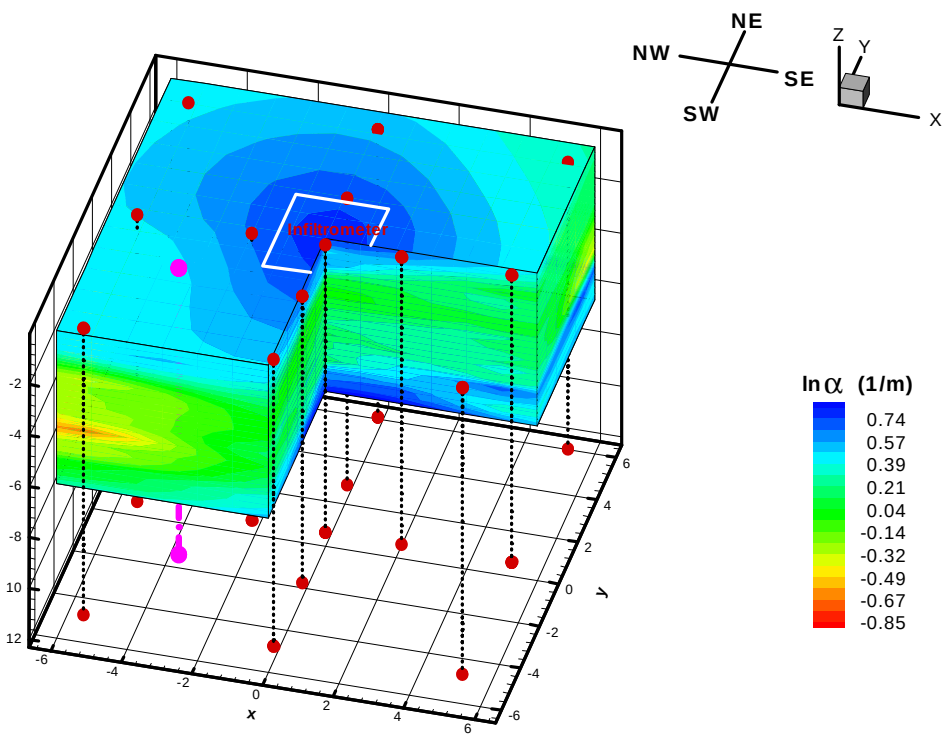


312 Neutron Locations

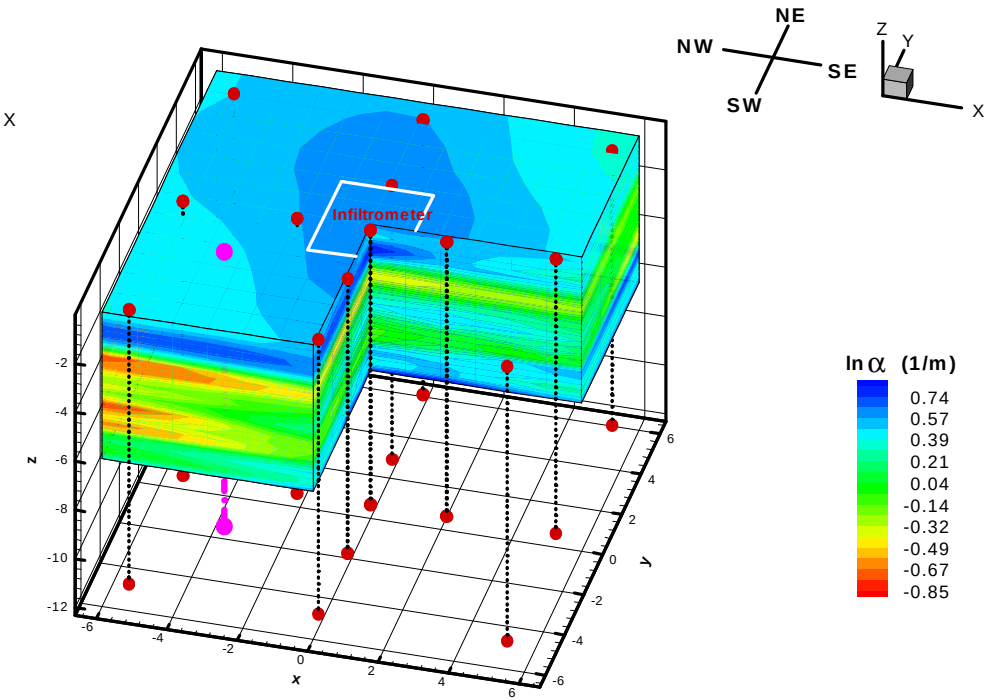


Effect of Correlation Length

X=Y=10m: Z=1.5m



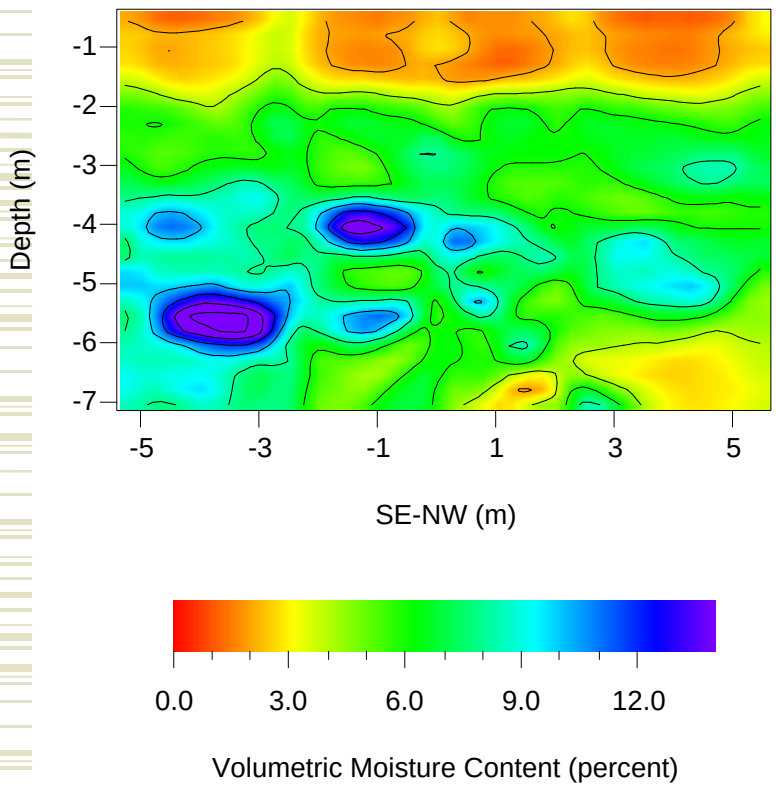
X=Y=40m: Z=1.5m

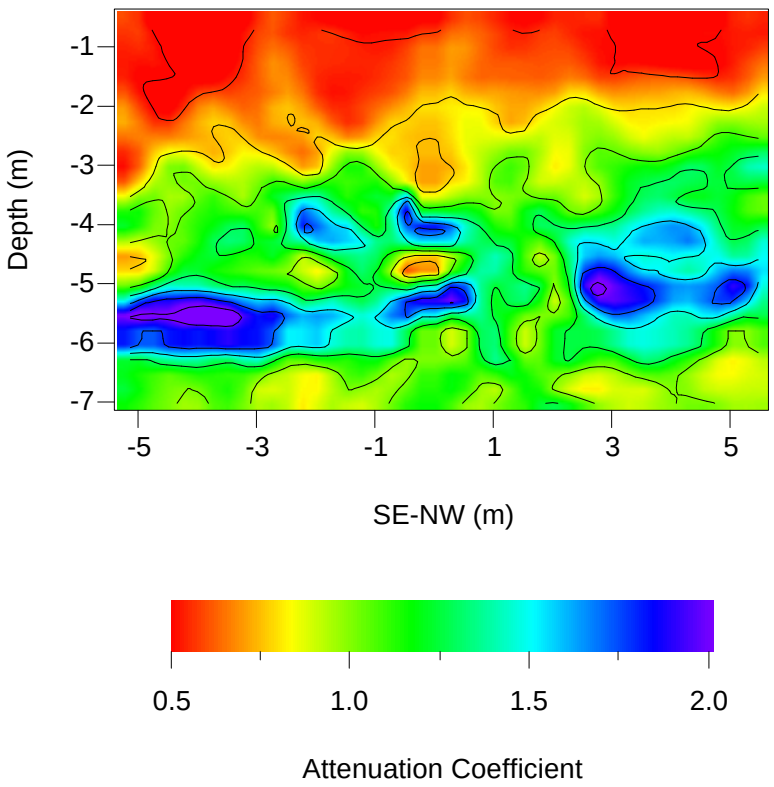


Recent Advancements

- Attenuation imaging of XBGPR data.
- Accuracy and precision analysis for geophysical data.
- Transport modeling of site using model derived from hydrologic inversion.
- Plan developed to introduce saline tracer into unsaturated flow field.

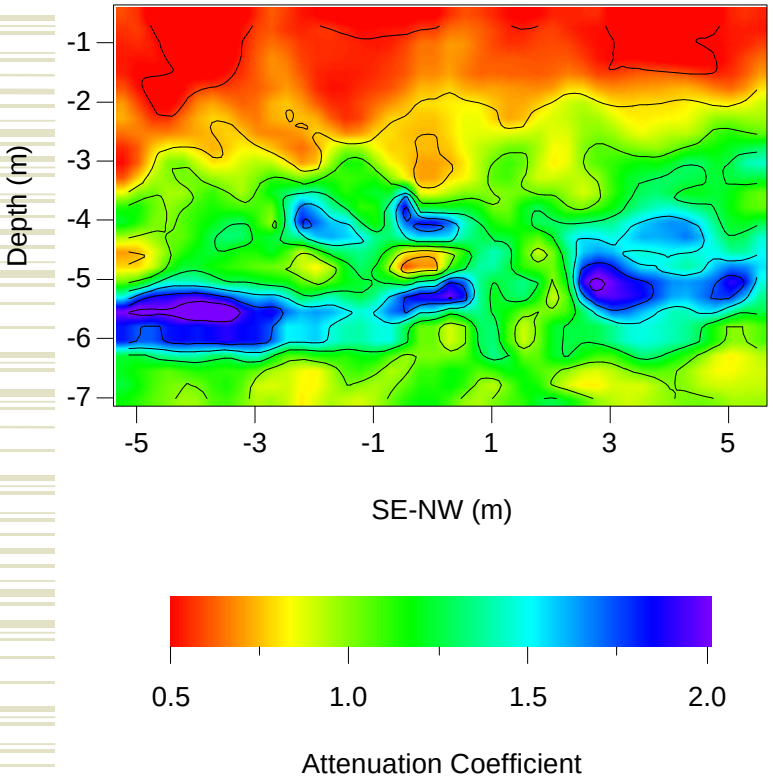
Attenuation Imaging of XBGPR Data



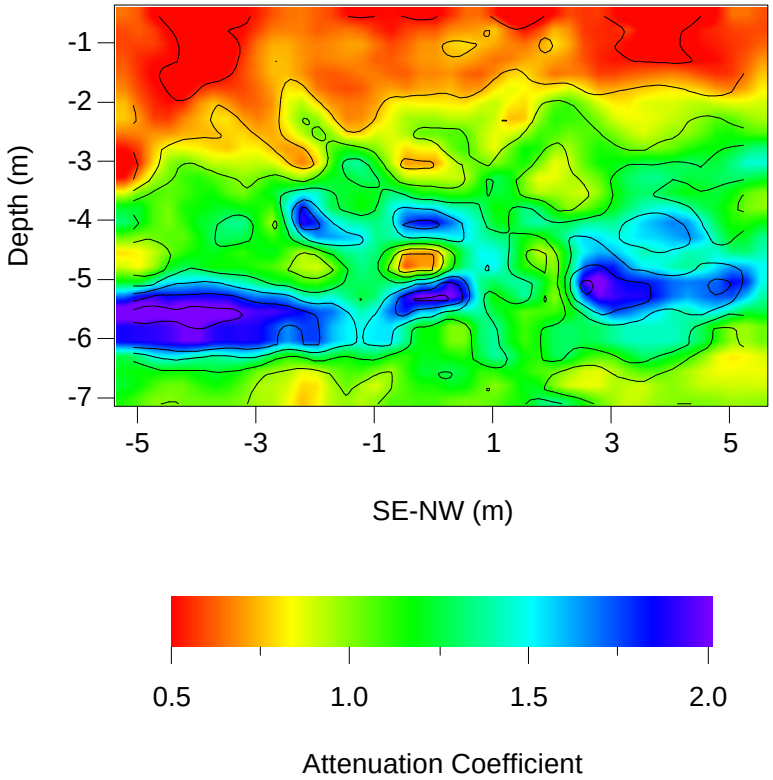


Attenuation Imaging of XBGPR Data

Preinfiltration

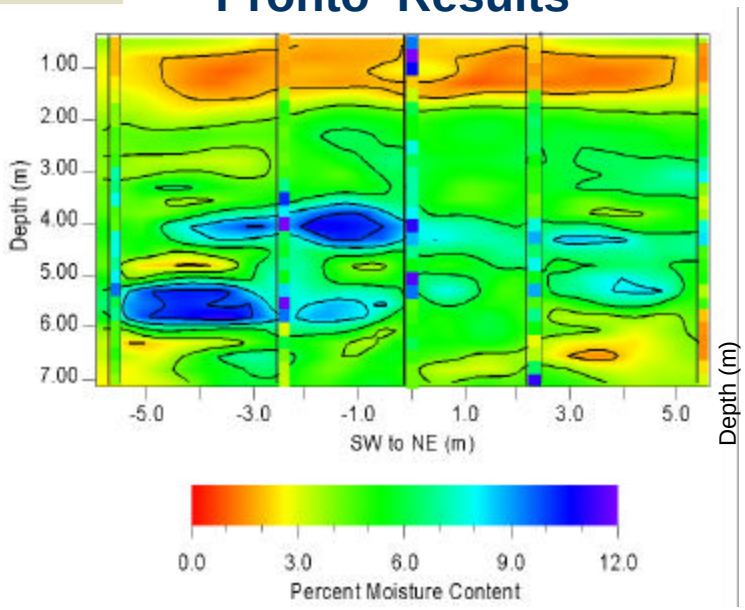


21 Post Infiltration

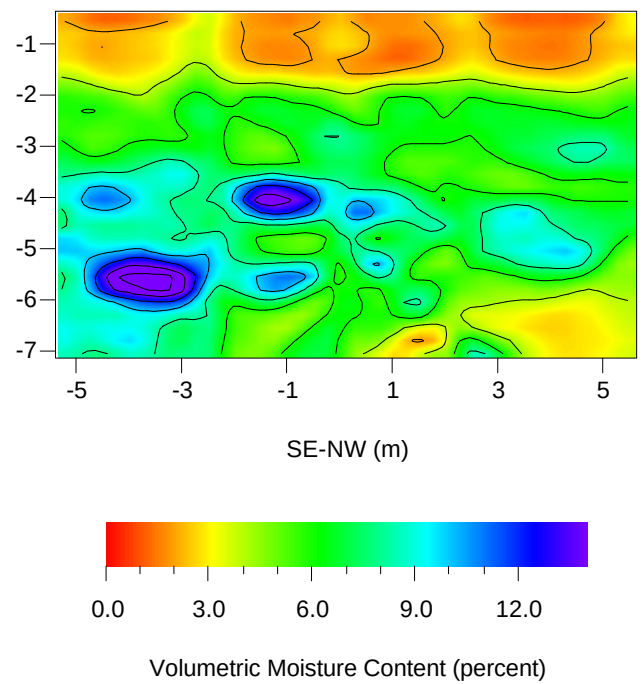


Accuracy and Precision Analysis of Geophysical Data

'Pronto' Results



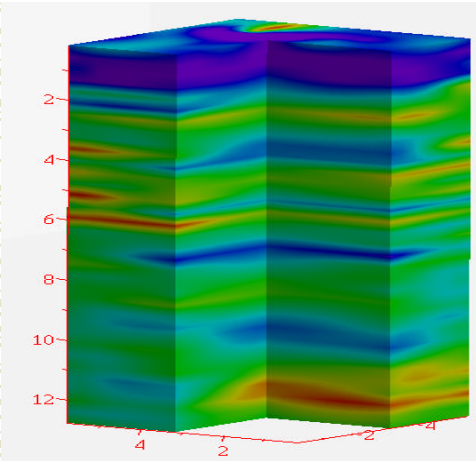
'GeoTom3D' Results



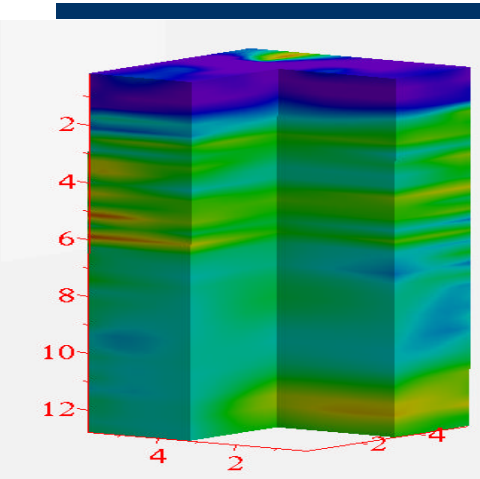
Examples of XBGPR RMS Error Analysis

1) Repeatability
   0.5%VMC
2) Against Neutron Data
   2.3% VMC
3) Imaging Schemes
   2.5% VMC

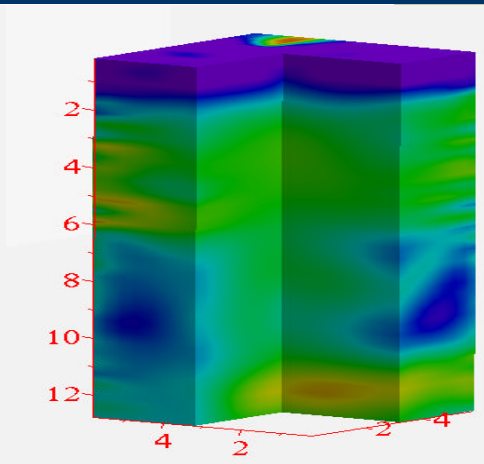
Accuracy and Precision Analysis of Geophysical Data – Electrical Anisotropy



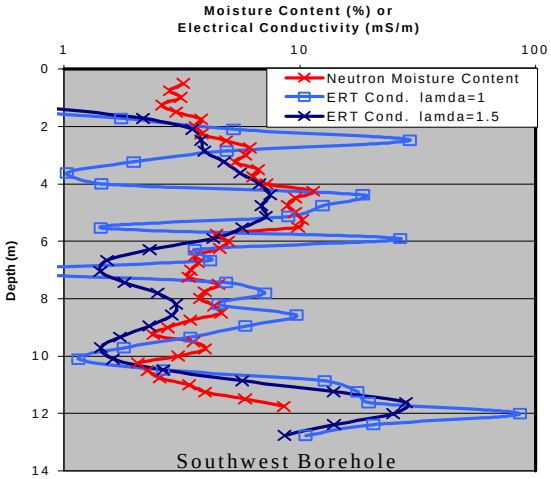
Coefficient of Anisotropy = 1.0

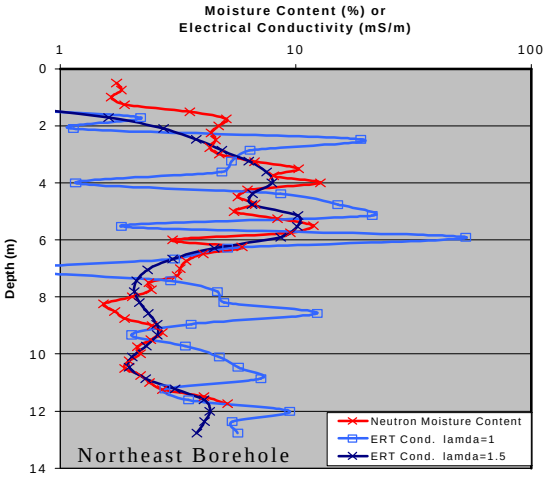


Coefficient of Anisotropy = 1.25

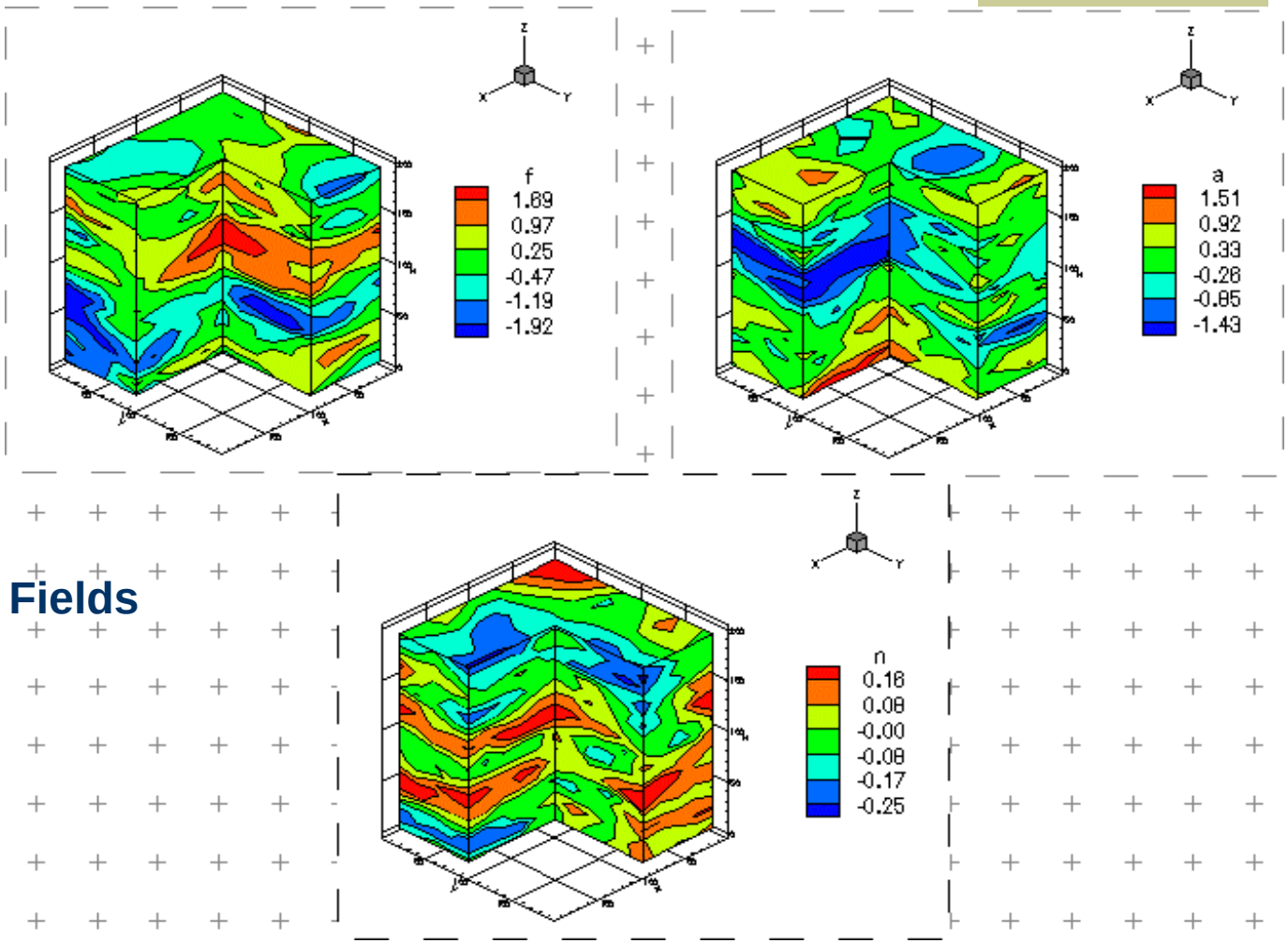


Coefficient of Anisotropy = 1.5



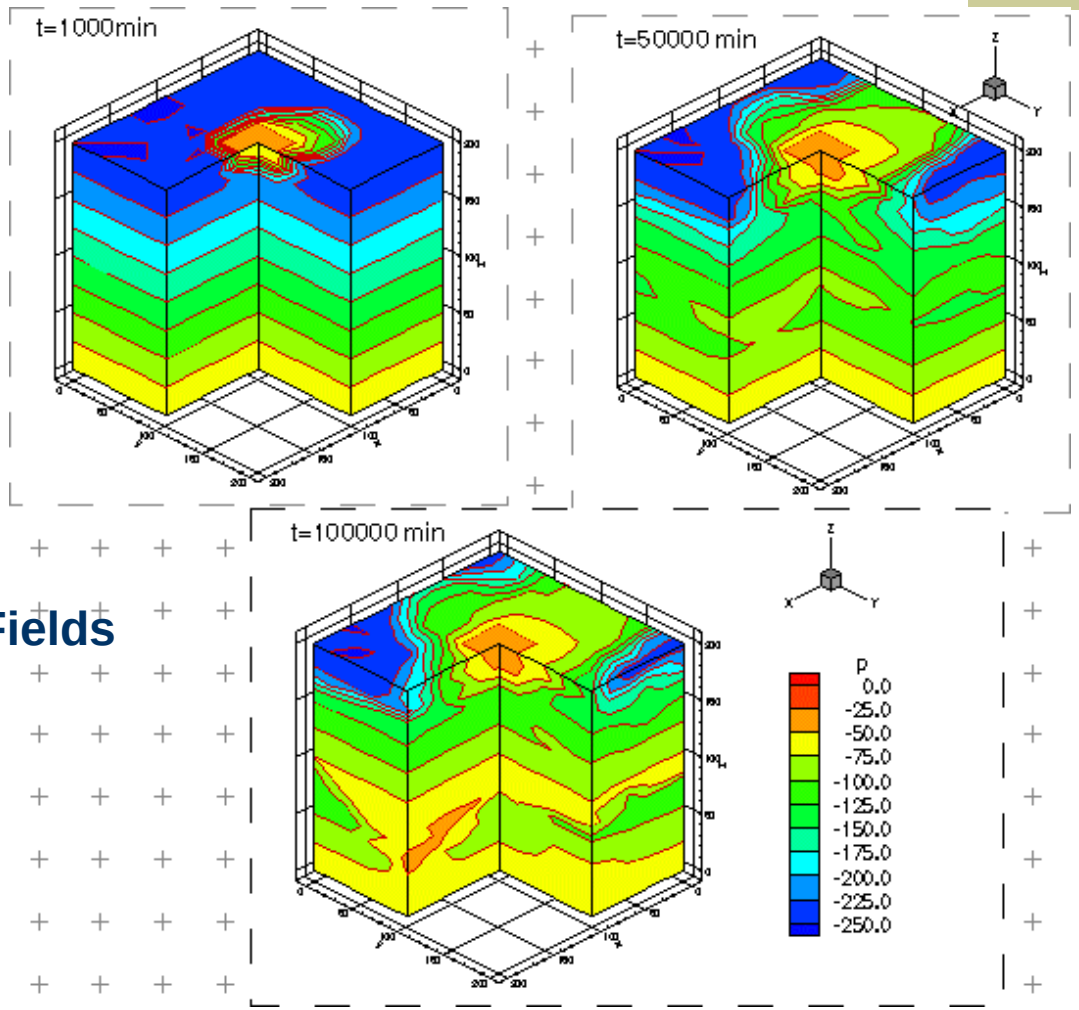


Simulation of Flow and Transport Experiment



Parameter Fields

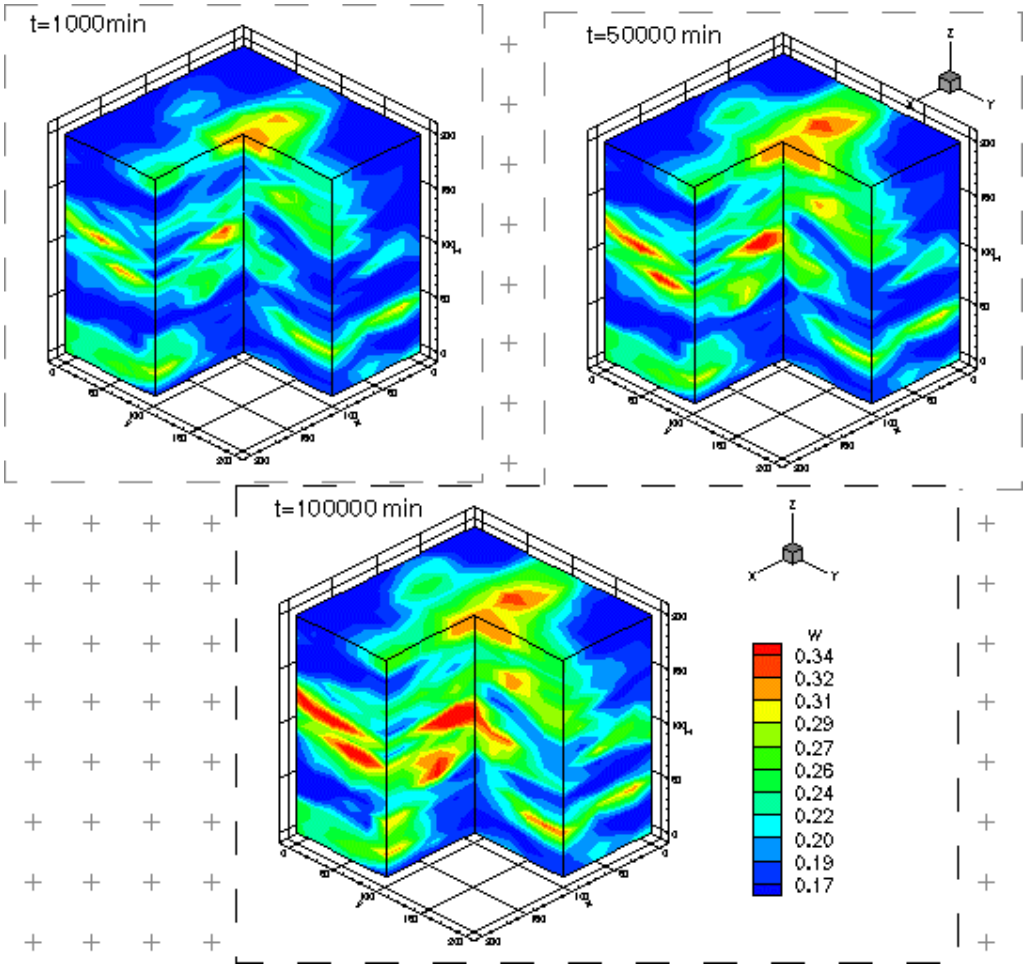
Simulation of Flow and Transport Experiment



Pressure Fields

Simulation of Flow and Transport Experiment

Moisture Fields



Planned Tasks

- Get tracer experiment up and running.
- Perform suite of numerical simulations of flow and transport experiments.
  - MMOC3.
  - 3D PoreSalsa comparison with ERT.
  - 2D Hydris simulation of XBGPR imaging.

What we would like to do….. if we had the money

- Parallelization, or other computational improvement of hydrologic inverse.
- Better ways for solving the Richard's equation.
- Systematic study of how each of the inputs effects hydrologic inverse results.
- Similar experiment at Hanford, or analysis of existing data.