Nature of Transition Zone Development and Groundwater Transport at Three North Carolina Piedmont Locations

Piedmont Mountains Cooperative Study

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&

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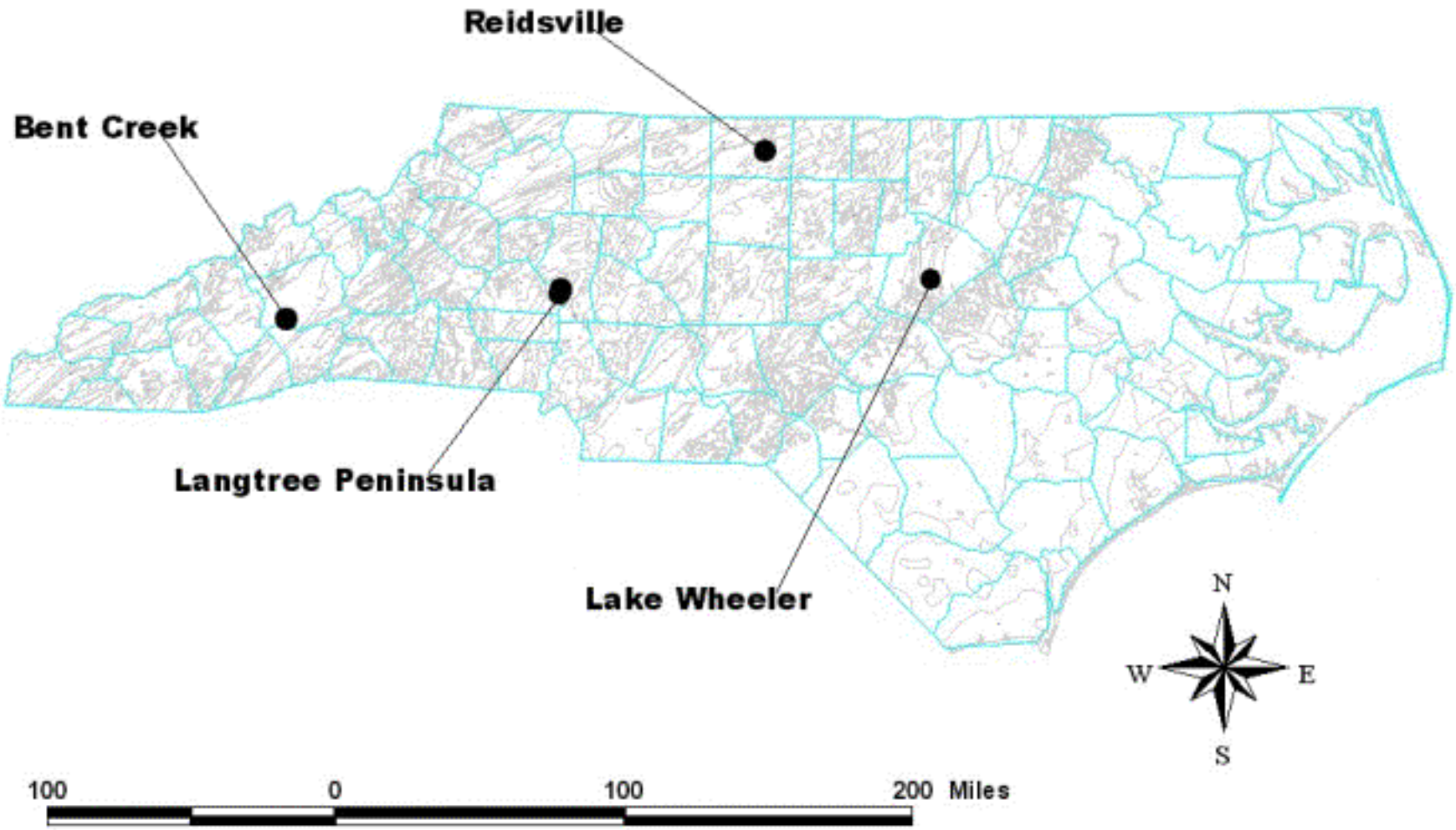
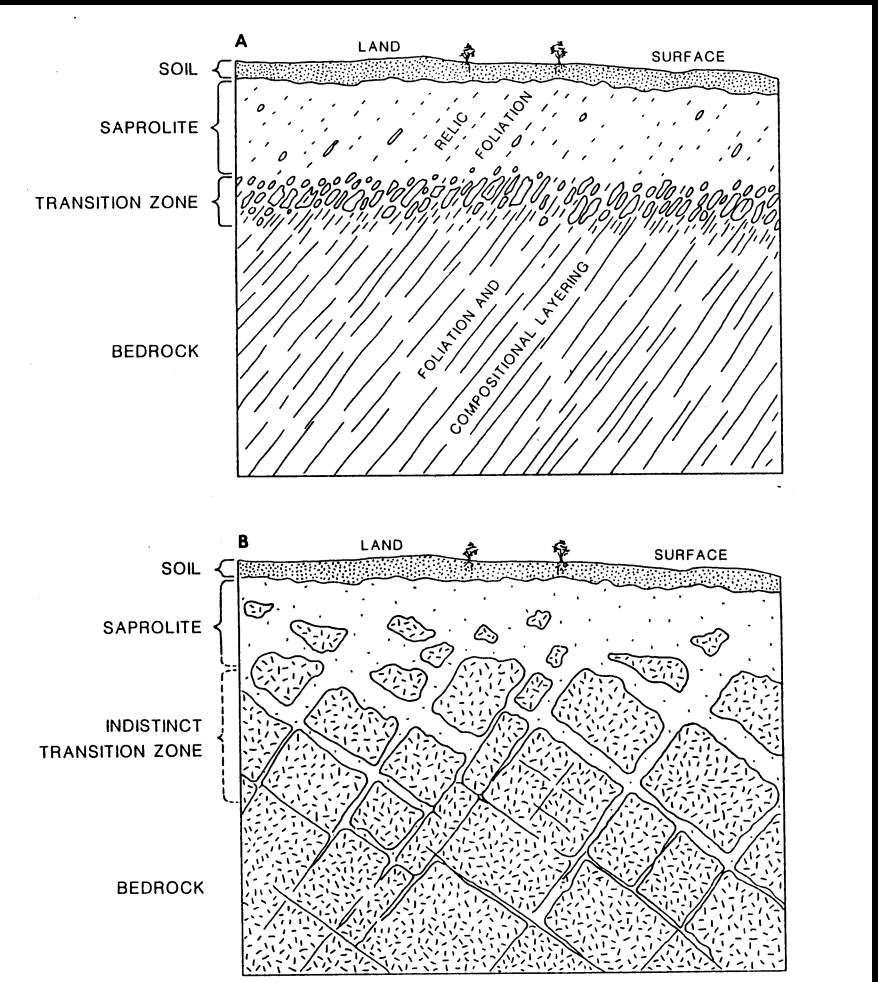
Map of Current Project Locations



Transition Zone – The highly fractured portion of the upper consolidated bedrock and the portion of the lowermost saprolite having the highest hydraulic conductivity. (NCREP Group working definition)

OR

Transition Zone – A zone of relatively high permeability resulting from incomplete chemical and mechanical alteration of the bedrock. (Legrand and Nelson, in press - working definition for Conceptual Model)



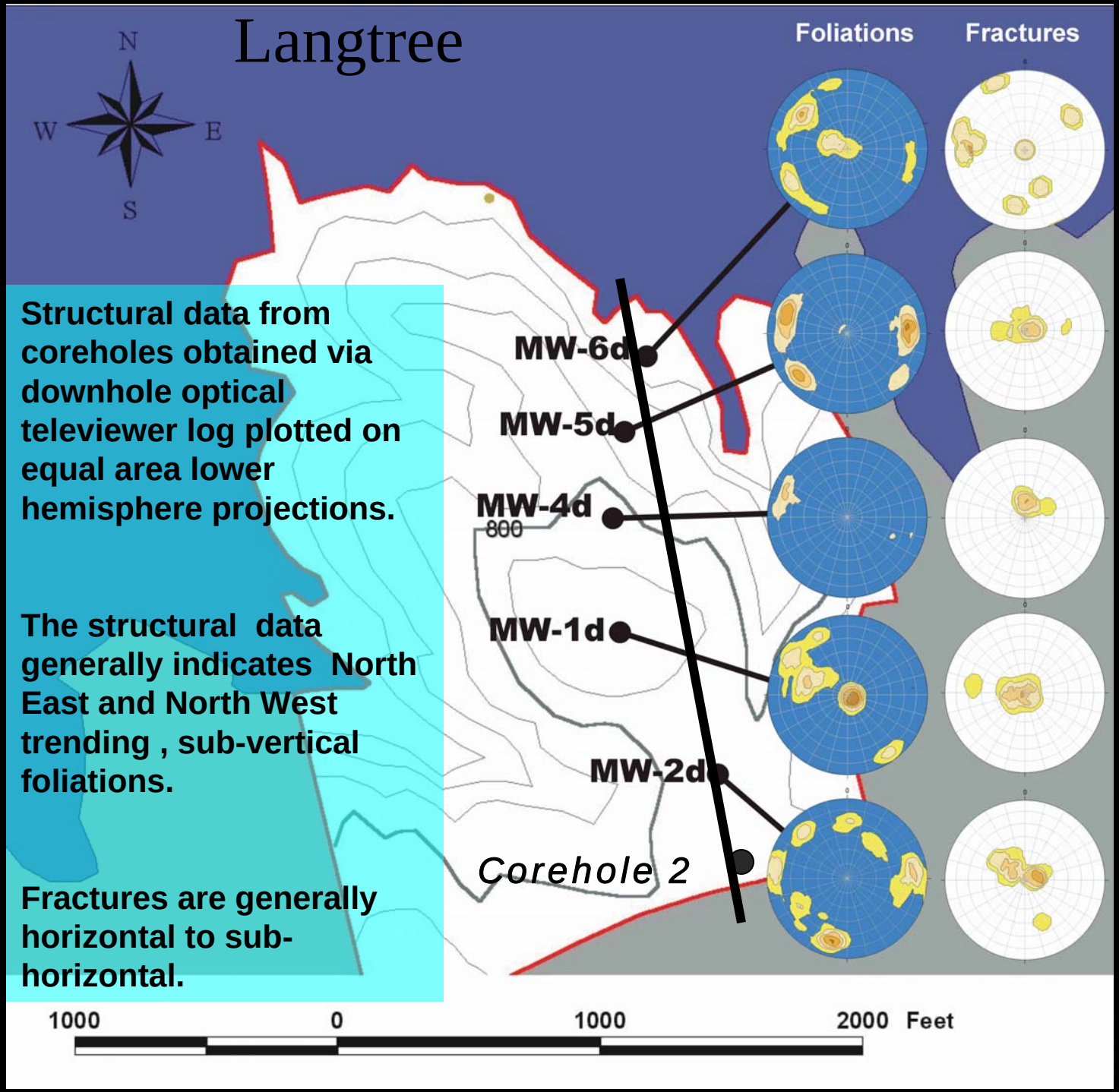
Conceptual variations in transition zone definition due to rock type (from Harned and Daniel, 1992)

340

Common Assumptions

- Transition Zone Always Present
- Has a uniform thickness within a single site.
- Transition Zone has different hydraulic properties than bounding materials.
- Transition Zone plays key role in the transport of water between storage and discharge areas.
- Most productive fractures are near the transition zone.
- Bedrock fractures are directly connected to overlying regolith.

Langtree



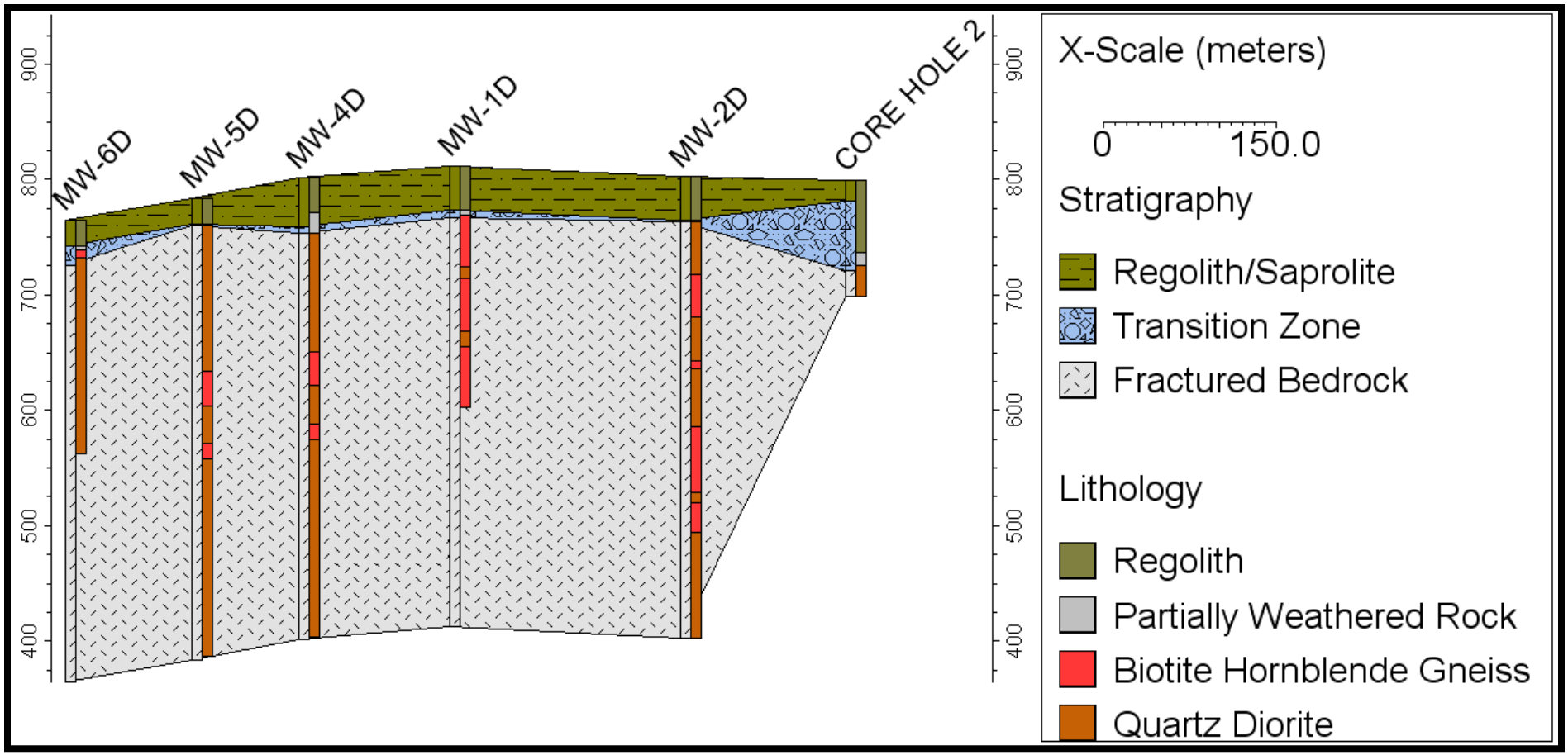
Structural data from coreholes obtained via downhole optical televiewer log plotted on equal area lower hemisphere projections.

The structural data generally indicates North East and North West trending , sub-vertical foliations.

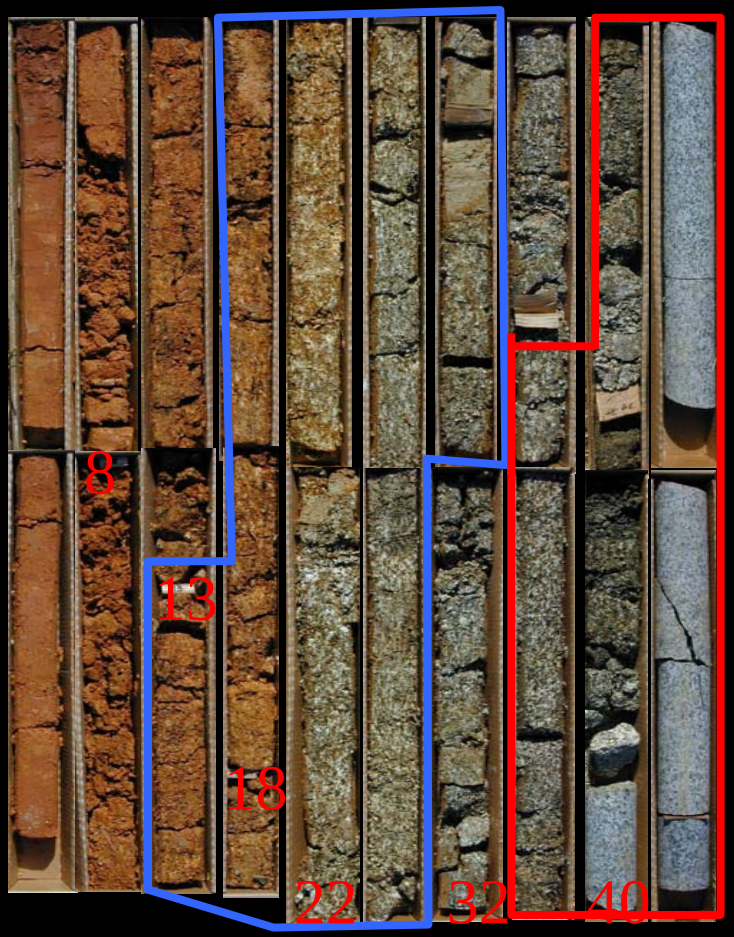
Fractures are generally horizontal to sub-horizontal.

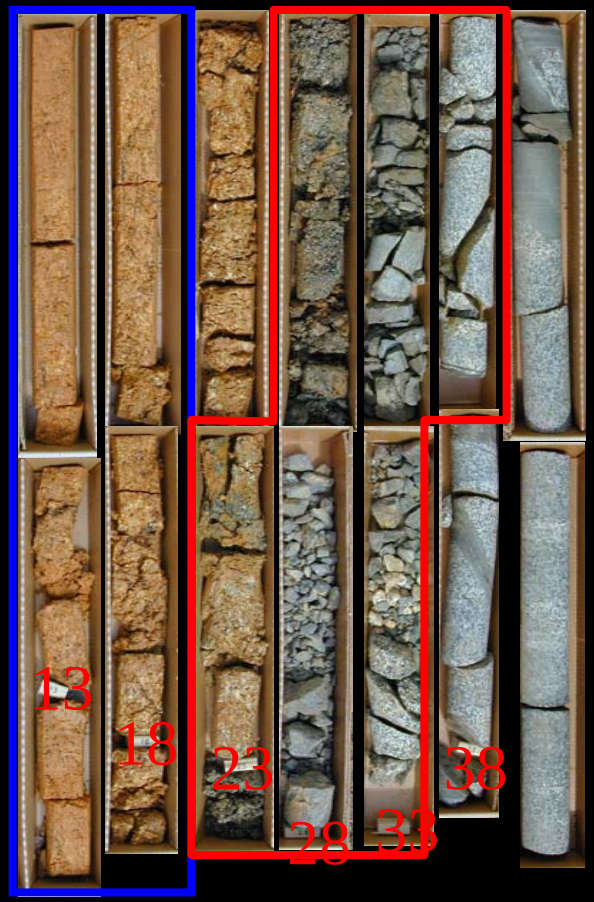
Geologic Cross Section Davidson College Lake Campus, Langtree Peninsula, Iredell County, North Carolina

Generally shows a non-uniform transition zone



Langtree Cores





Cluster 1

Shallow K = 3.75x10^{-5} ft/sec

Greater than

“Tran. Zone” K= 1x10^{-5} ft/sec

Cluster 2

Shallow K = 5x10^{-5} ft/sec

Greater than

“Trans. Zone” K = 3x10^{-6} ft/sec

Cluster 6

Shallow K = 5x10^{-5} ft/sec

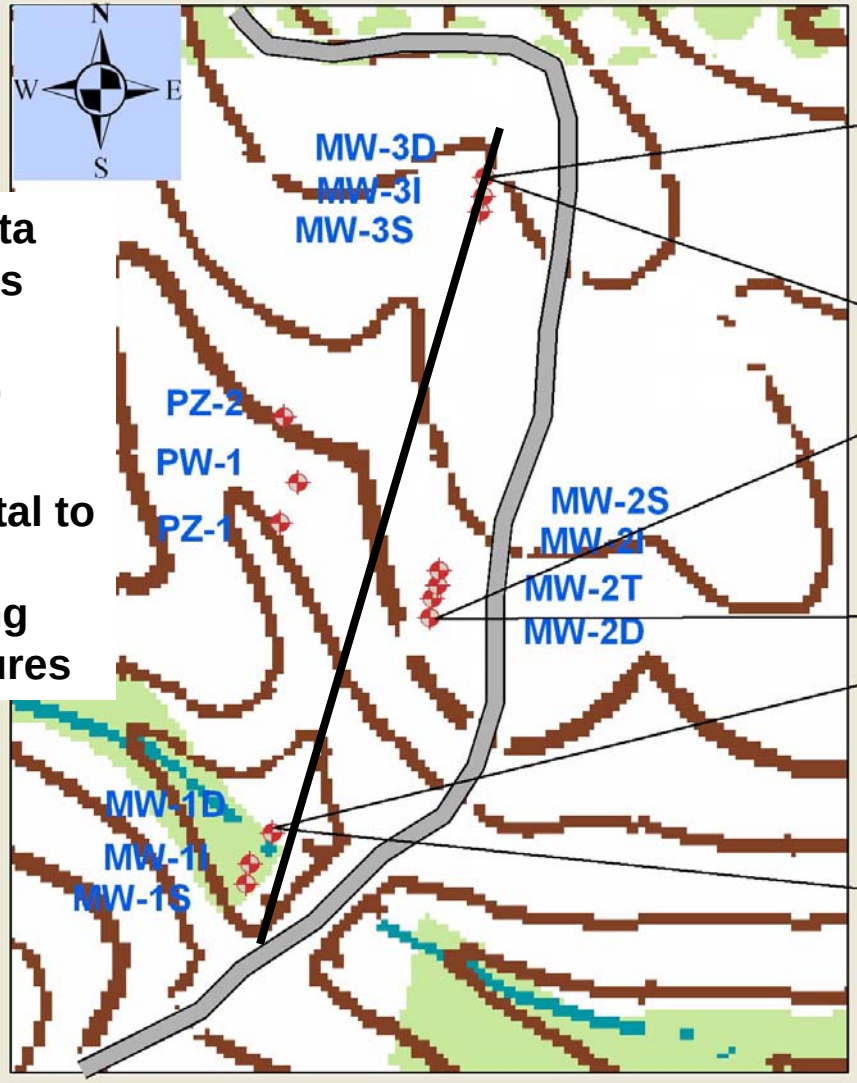
Less than

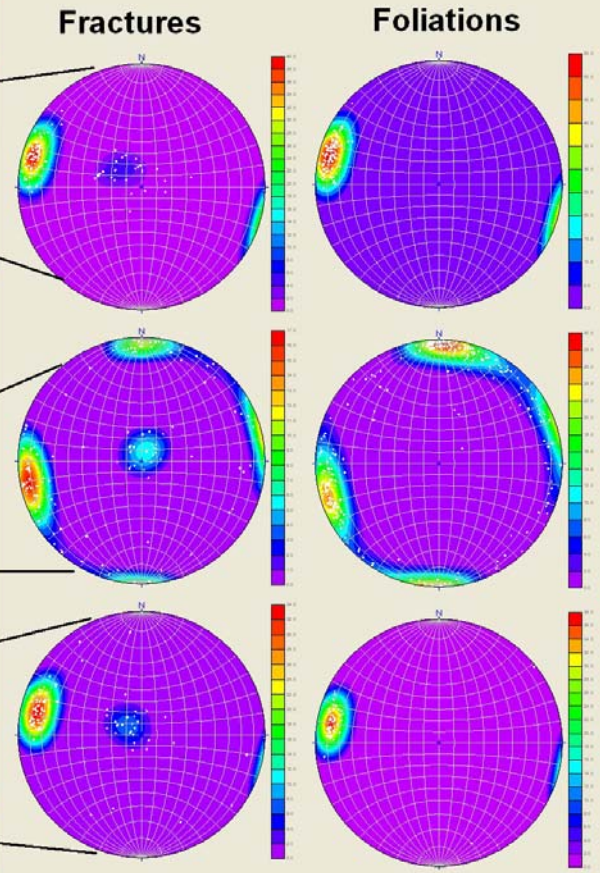
“Trans. Zone” = 4x10^{-4} ft/sec

Lake Wheeler Site

The structural data generally indicates North East sub-vertical foliations.

Fractures are generally horizontal to sub-horizontal or north east trending sub vertical fractures

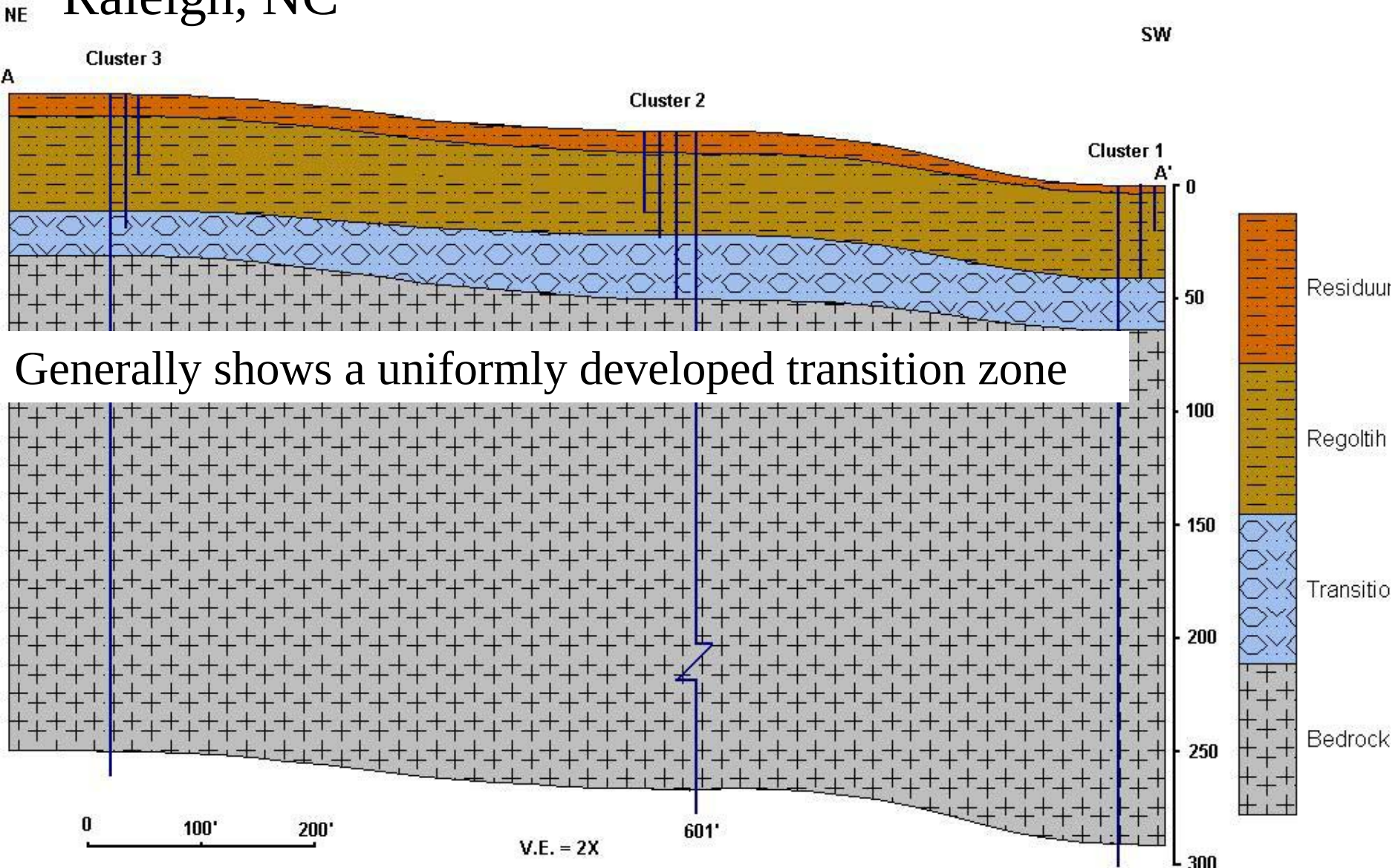




Monitoring Well Locations

300 150 0 300 Feet

Geologic Cross Section, Lake Wheeler Research Site, Raleigh, NC



Generally shows a uniformly developed transition zone

Figure 6. Diagram showing the thickness of the regolith and transition zone, and depth to bedrock at the Lake Wheeler Road Research Station.

Lake Wheeler Cores

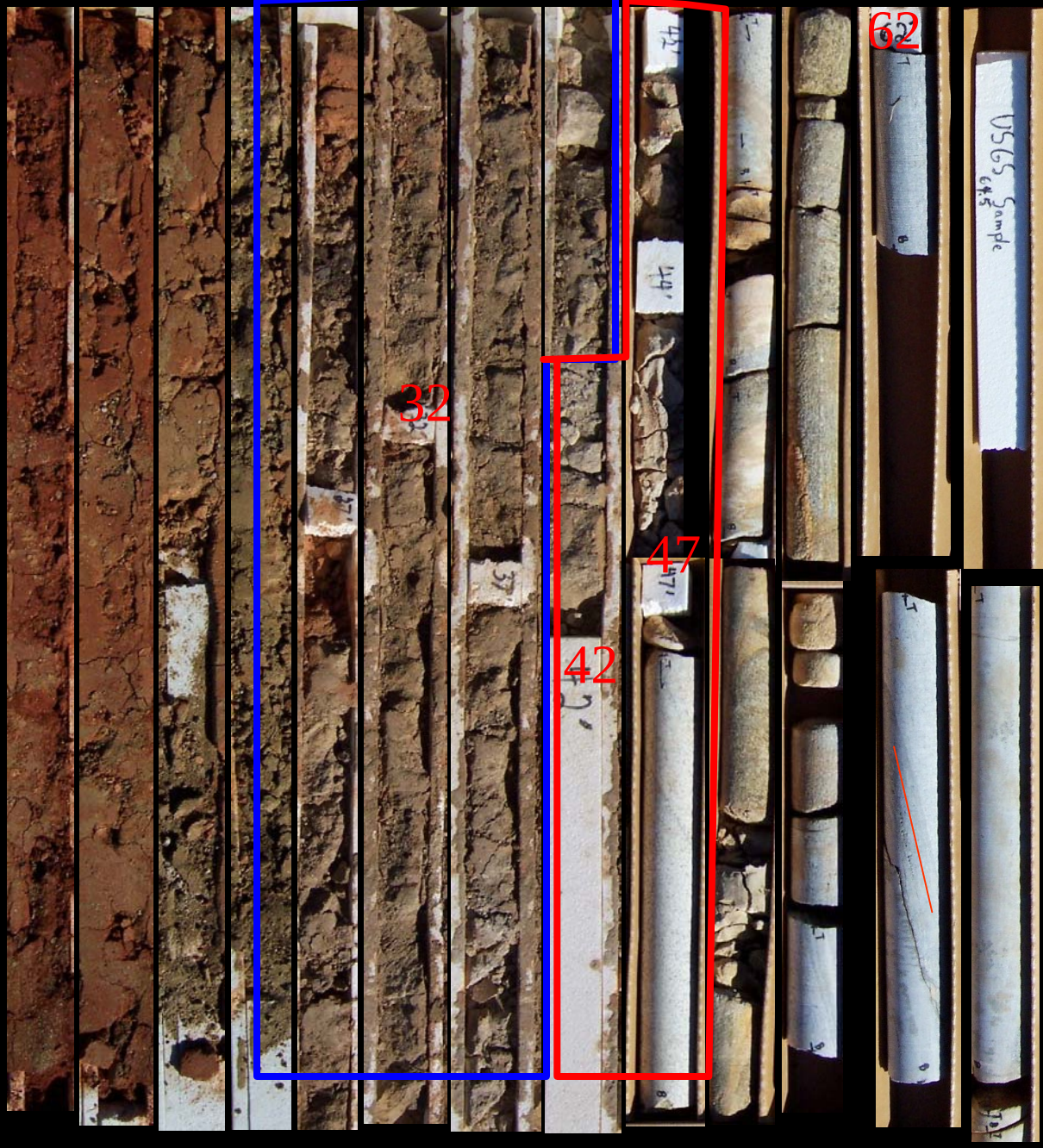
Shallow

K=8.3x10^{-5} cm/sec

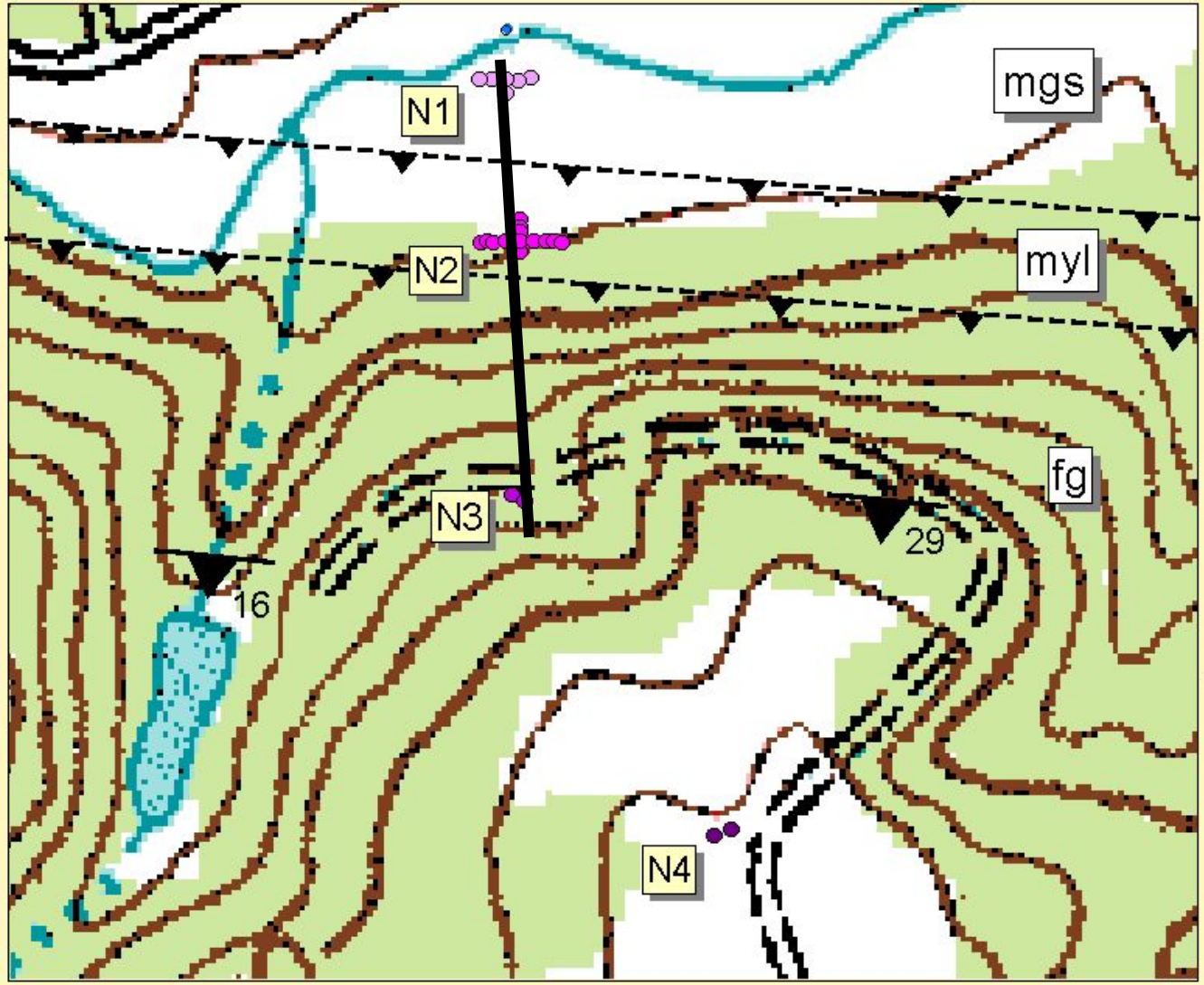
Less than

“Transition Zone”

K=2.43x10^{-4} cm/sec



Upper Piedmont Research Station Northern Well Transect



mgs=mica gneiss and schist
myl=mylonitic schist and gneiss
fg=felsic gneiss

Approximate trace of Carroll Creek shear zone

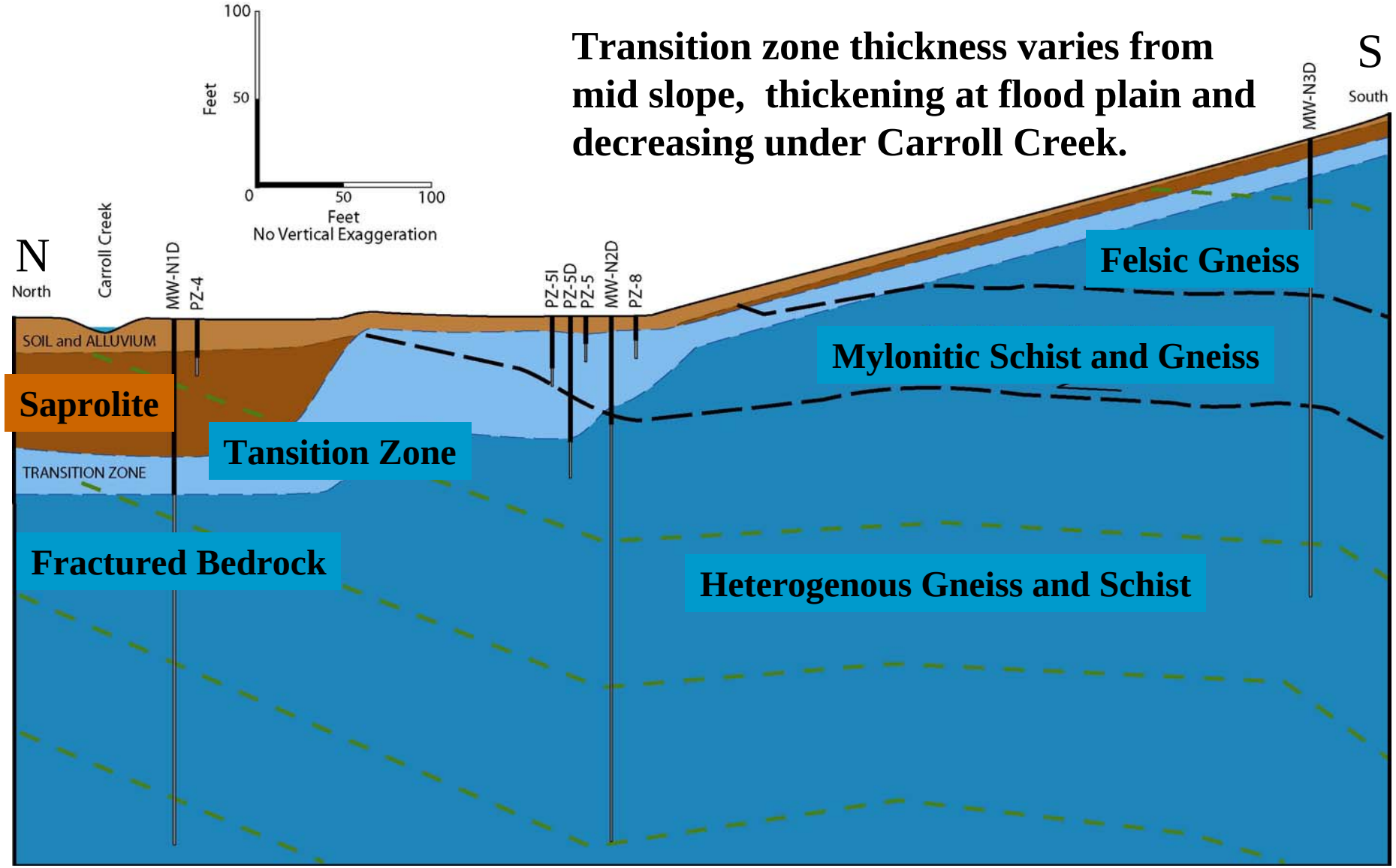
29 Strike and dip of gneissic layering and foliation

N
W E
S

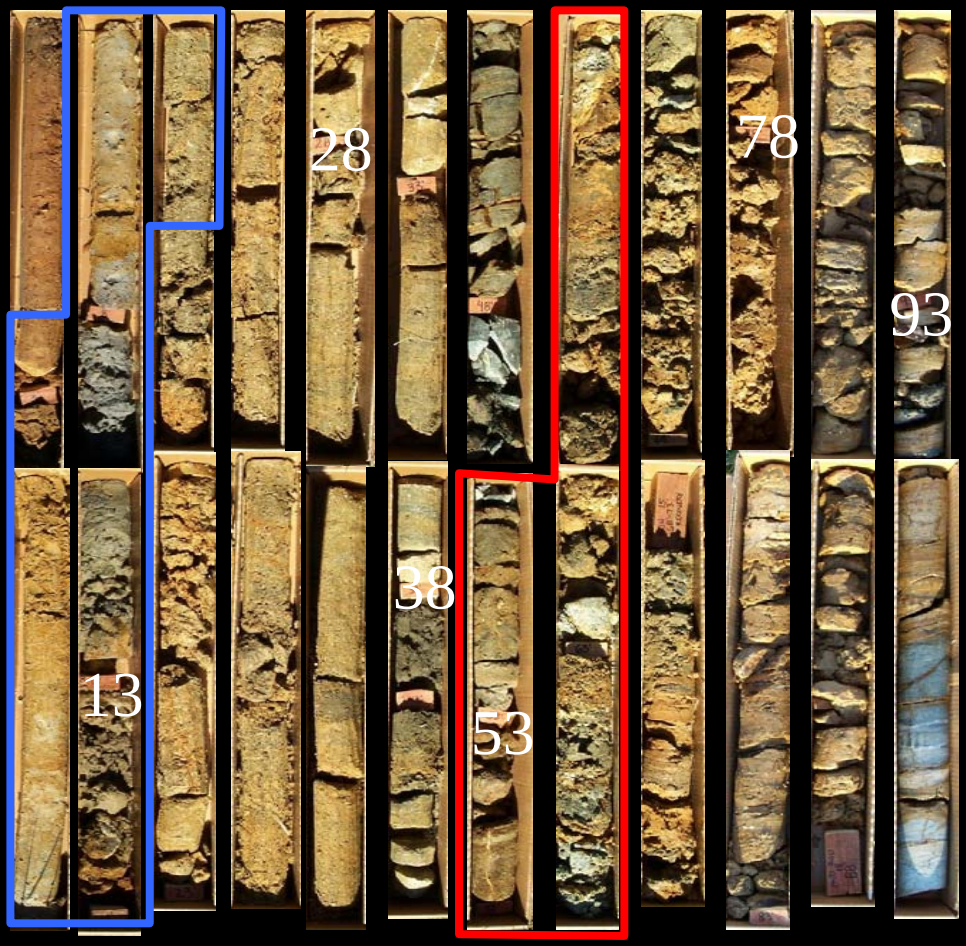
0 500 1000
Feet

Geology adapted from Horton and Geddes (in press)

Geologic Cross Section, Upper Piedmont Research Station, Reidsville, North Carolina



Upper Piedmont Cores

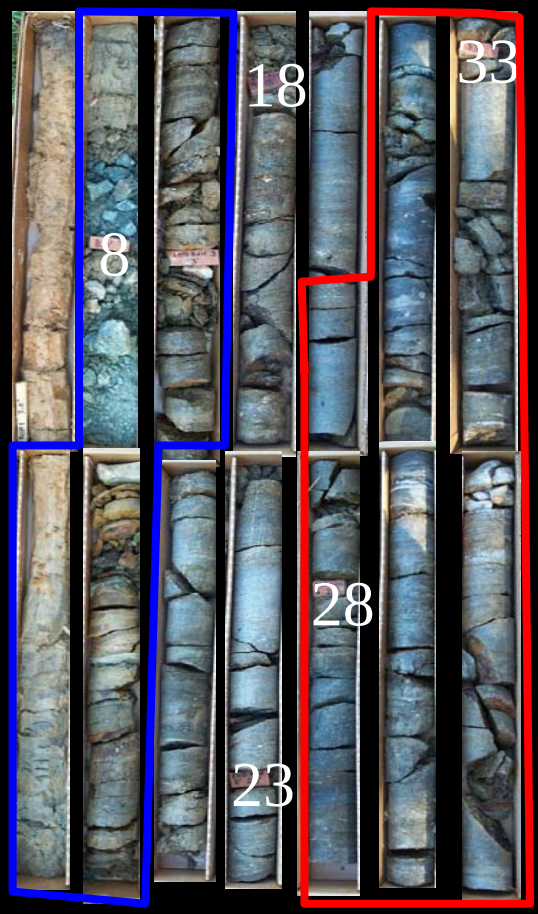


Cluster CH-N1

Shallow Zone K = $1x10^{-5}$ cm/sec

Greater than

“Transition Zone” K = $3x10^{-6}$ cm/sec

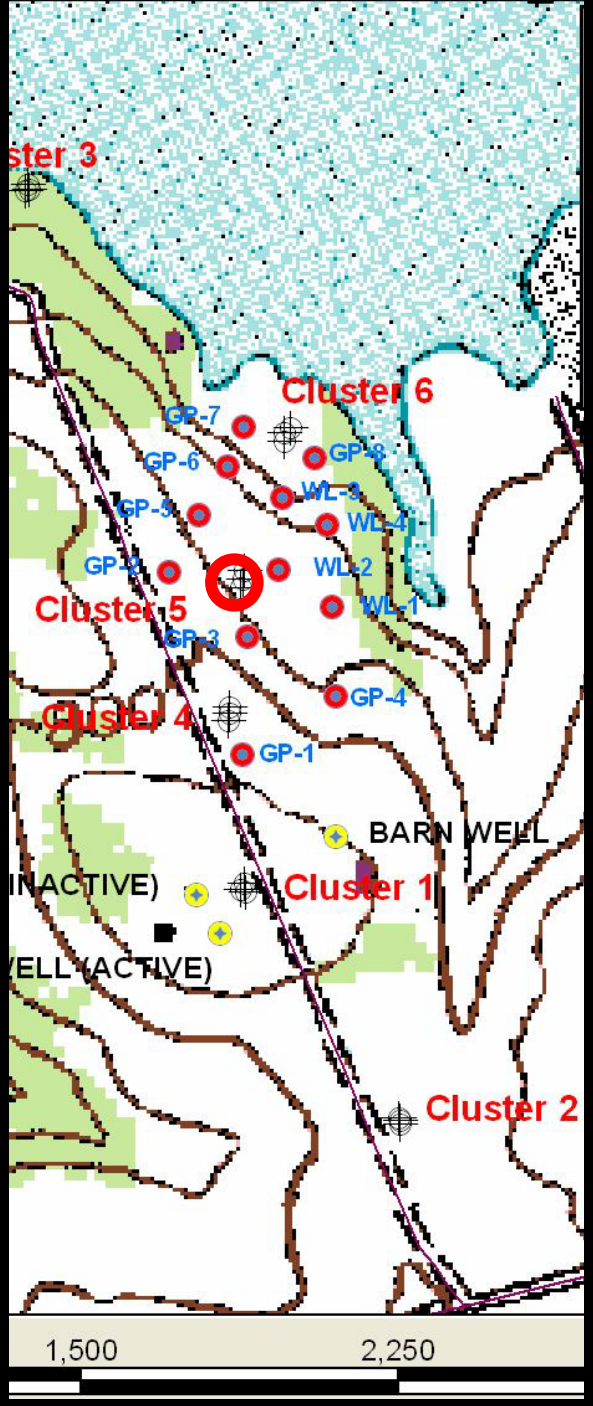


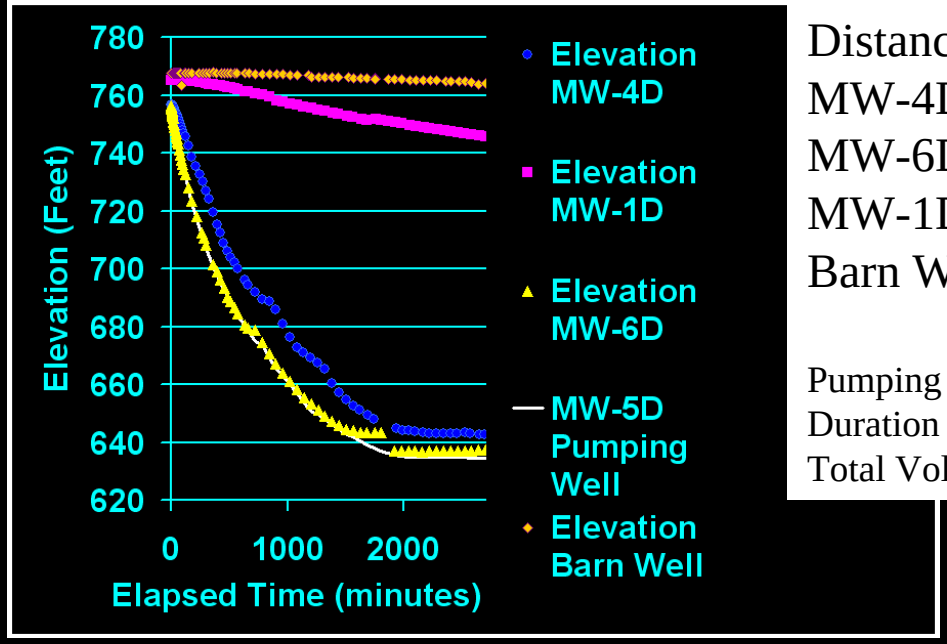
Cluster CH-N2

Shallow Zone K = $5x10^{-4}$ cm/sec

Greater than

“Transition Zone” K = $5x10^{-5}$ cm/sec

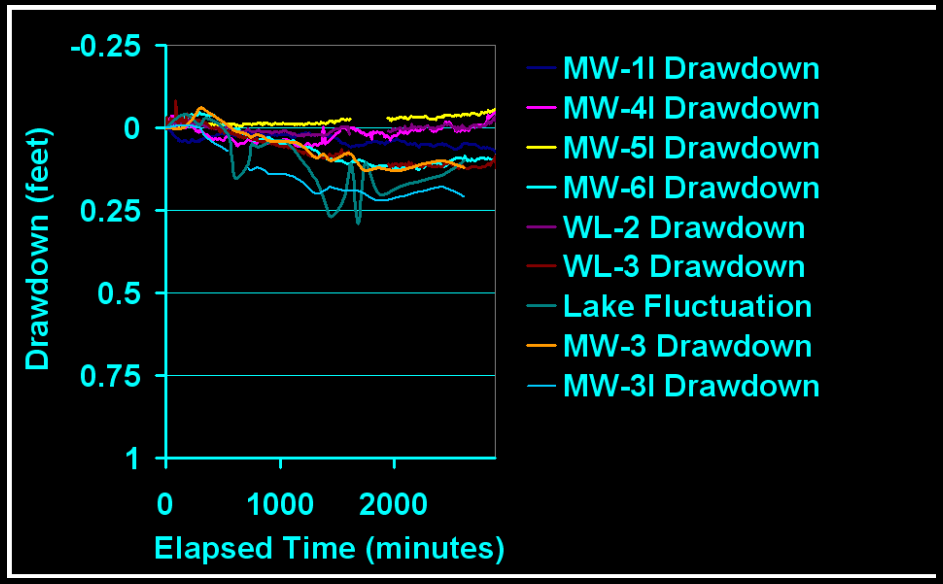




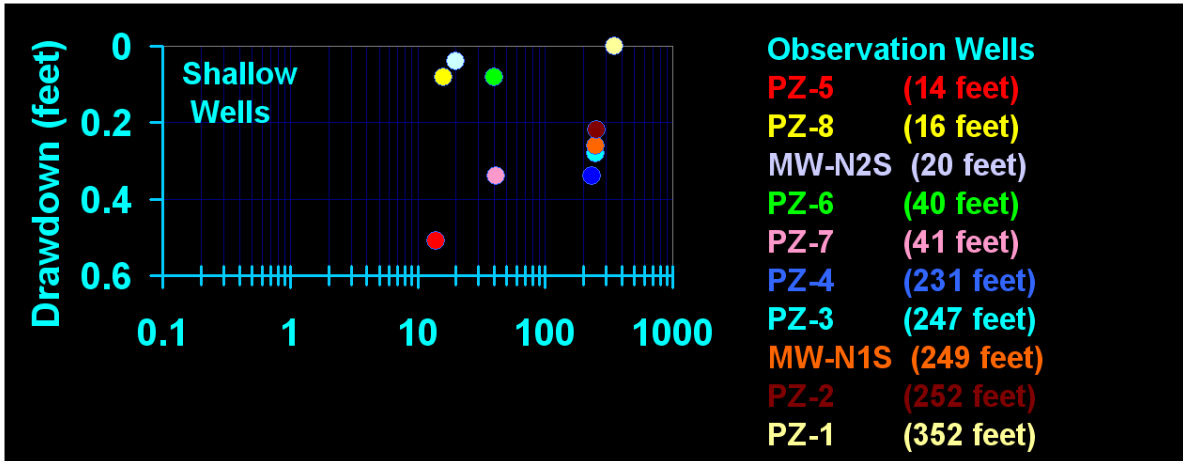
Distance from MW-5D

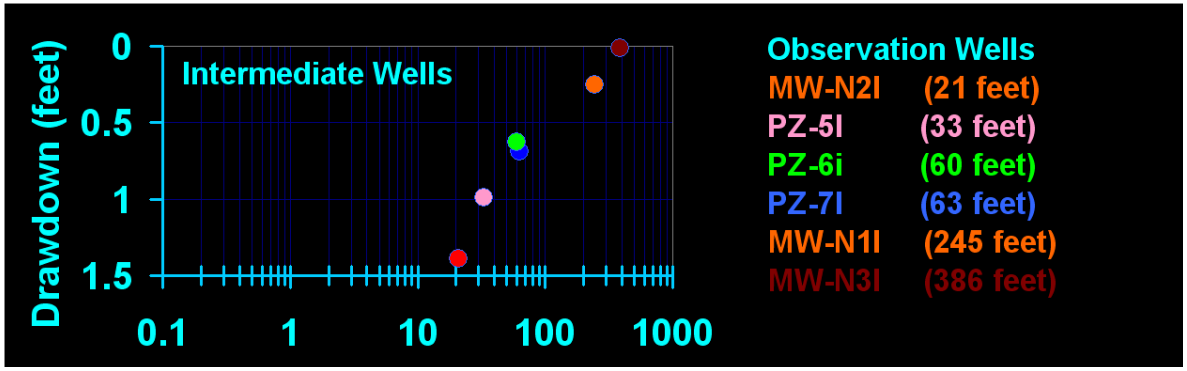
MW-4D	302 feet
MW-6D	361 feet
MW-1D	730 feet
Barn Well	808 feet

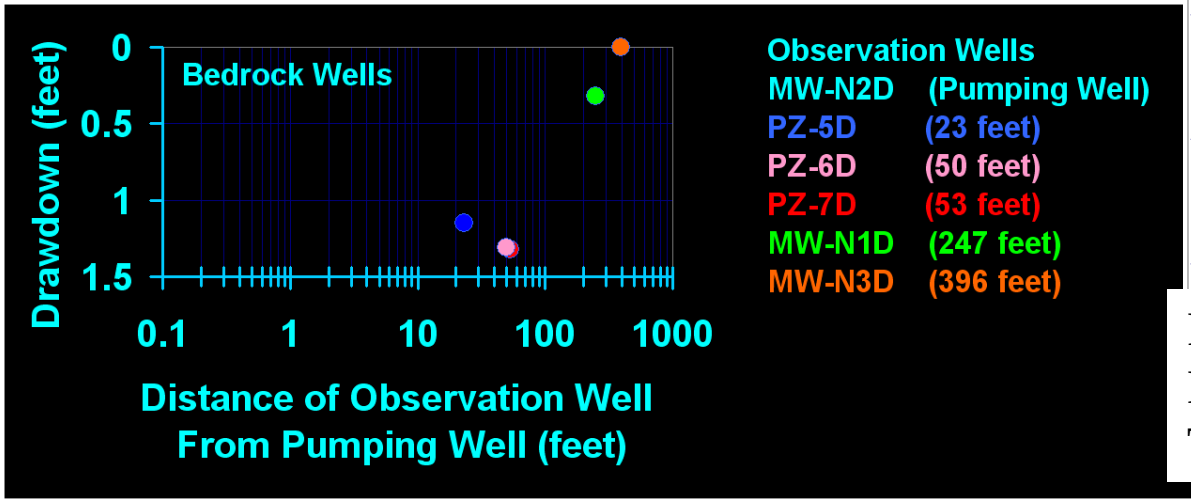
Pumping Rate – 12 gpm
Duration - 48 hours
Total Volume – 34,560 gallons

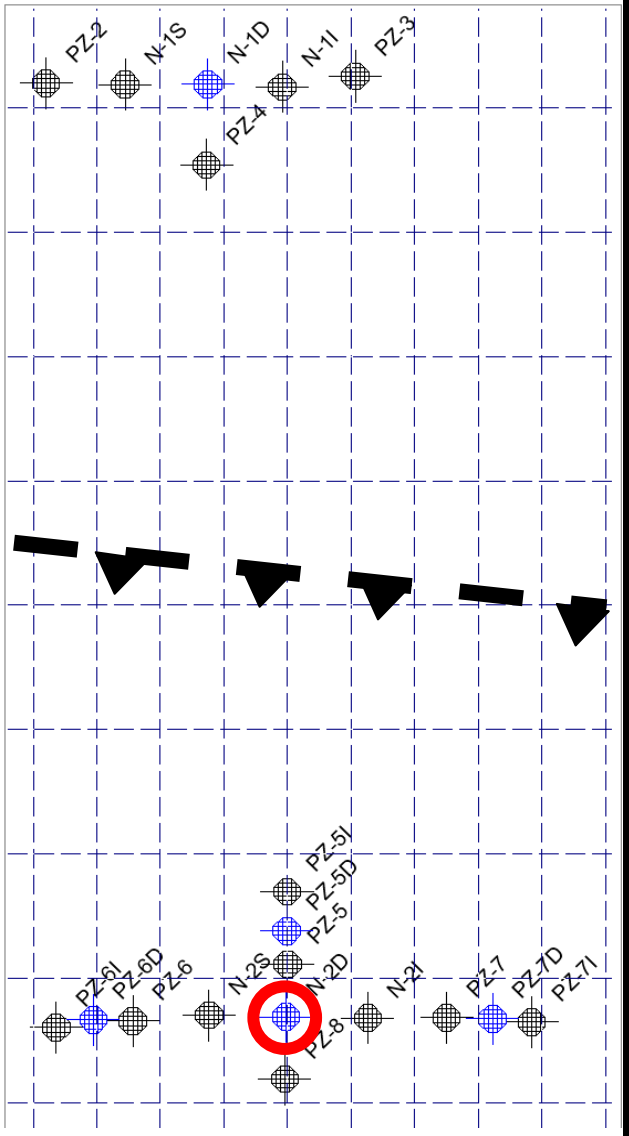


Langtree Peninsula Pump Test Results
Time Drawdown Analysis





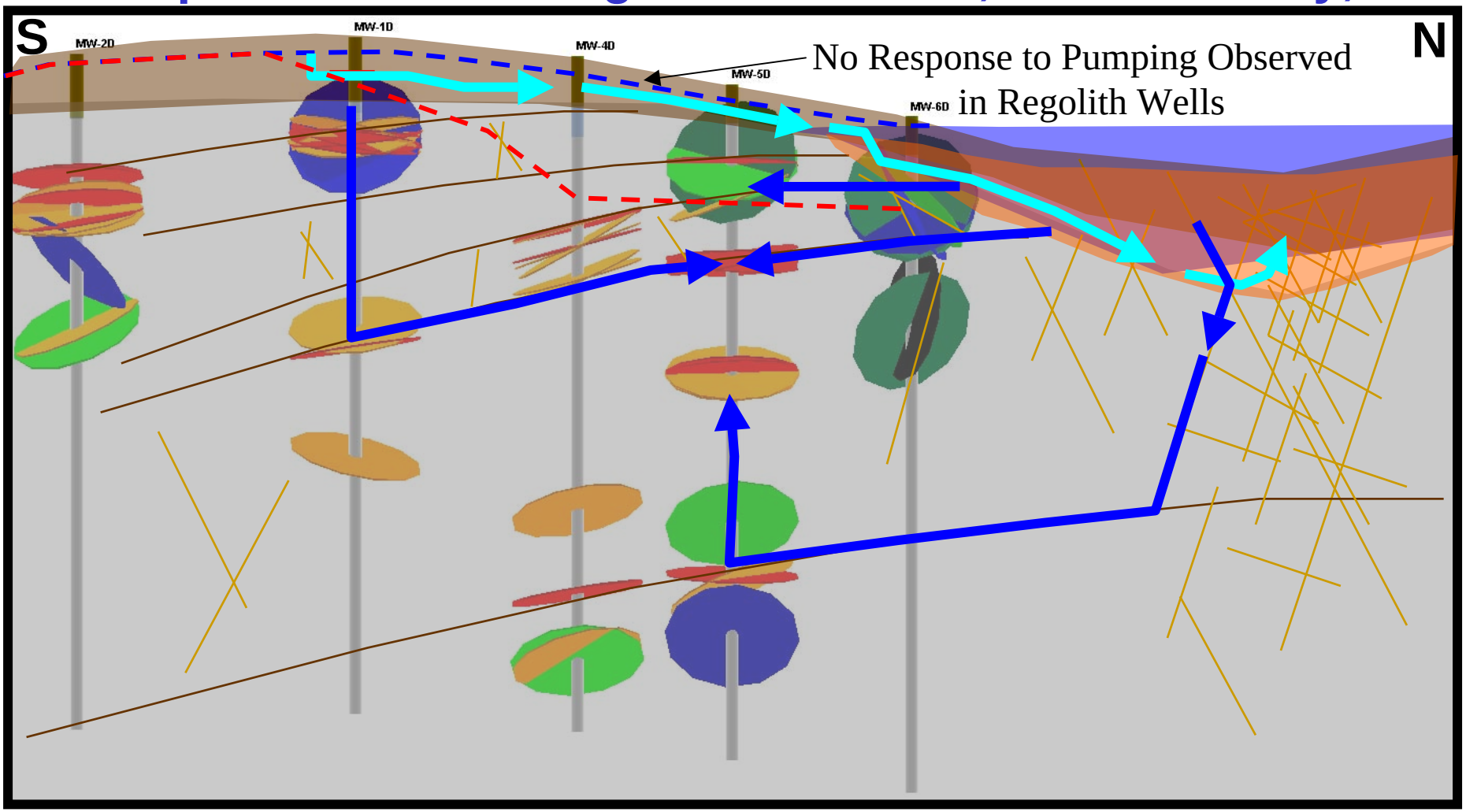




Pumping Rate – 6.5 gpm
Duration – 48 hours
Total Volume – 18,720 gallons

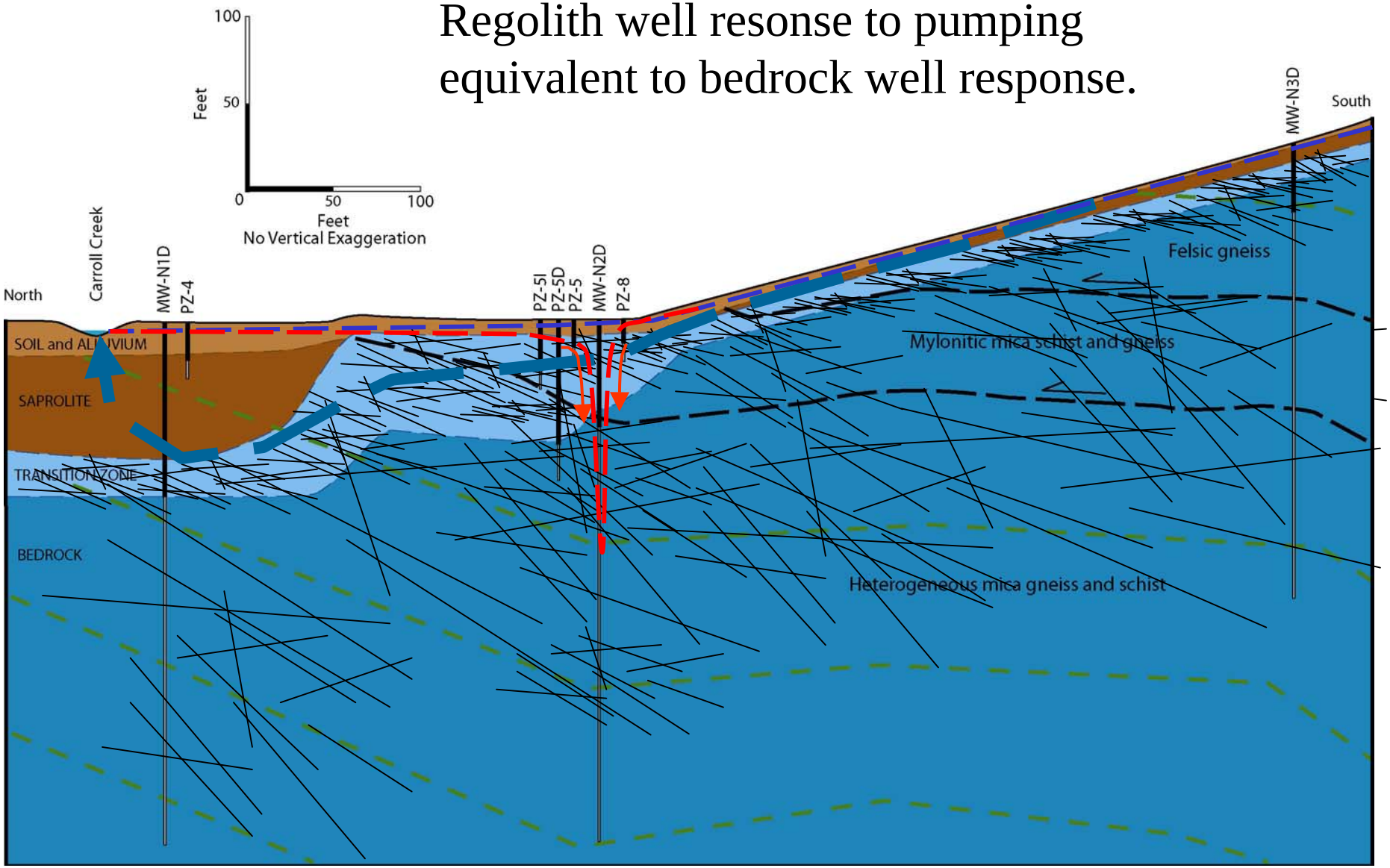
Upper Piedmont Pumping Test Results - Distance Drawdown Analysis

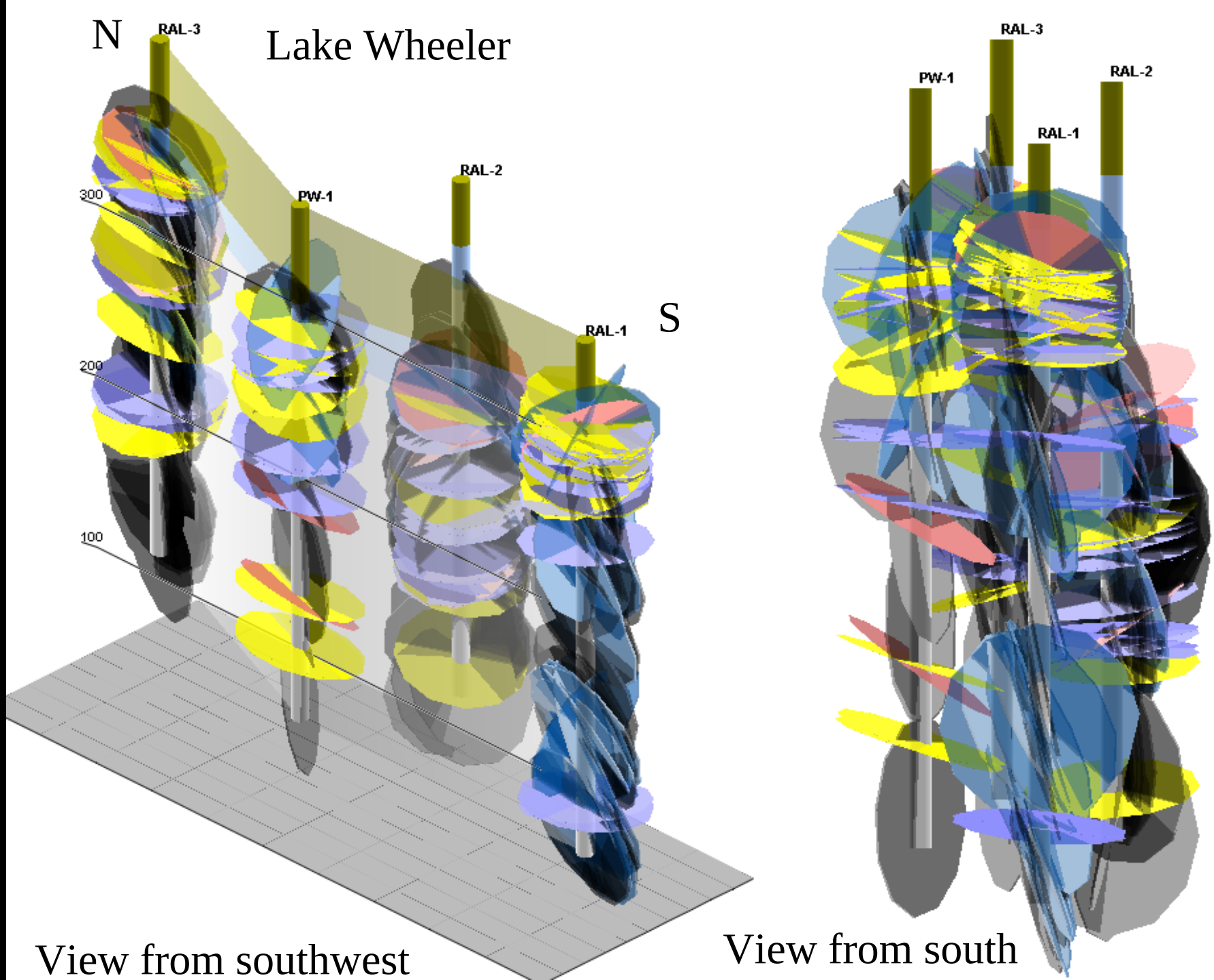
Conceptual Model – Langtree Peninsula, Iredell County, NC



Upper Piedmont

Regolith well resonse to pumping equivalent to bedrock well response.




N
Lake Wheeler
RAL-3
PW-1
RAL-2
RAL-1
300
200
100
S
RAL-3
PW-1
RAL-2
RAL-1
View from southwest
View from south

Review of Assumptions

- Transition Zone Always Present – True, though thickness can vary greatly (even at same site) and can grade to near zero.
- Transition Zone has different hydraulic properties than bounding materials. Not always, based on preliminary data.
- Transition Zone plays key role in the transport of water between storage and discharge areas or points (wells). - Not able to evaluate at this time; additional aquifer testing is planned.
- Most productive fractures are near the transition zone. – Not true at every site; depends on fracture orientations and fracture density.
- Bedrock fractures are directly connected to overlying regolith. Not always based on observations at Langtree.

The transition zone is not as predictable as the current conceptual model suggests.

Future Plans

We presently have four active research stations in the Piedmont and Mountains of NC and will continue studies over the next five years.

In the fall we will begin phase 1 of installing four new sites to be studied over the next 10 years.