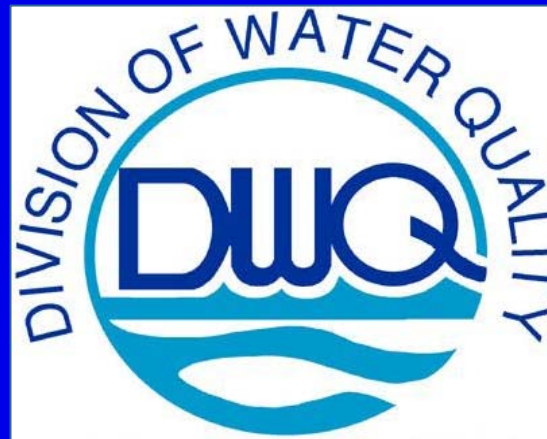




North Carolina
Piedmont and Mountains
Groundwater
Resource Evaluation Program (REP)

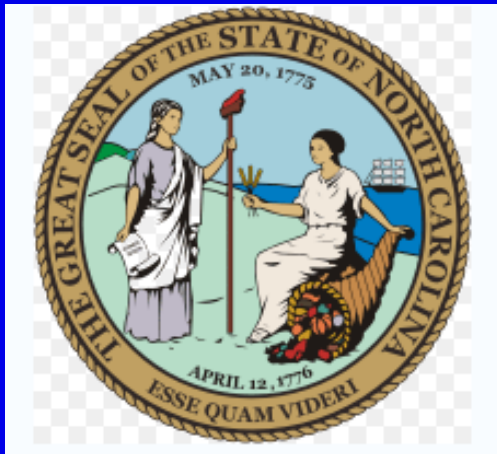


Aquifer Protection Section
Presented by Shuying Wang, May 2008



Capital: Raleigh

Largest City:
Charlotte



Total Area: 139,509 Km²

Ranked 28th in the US

Width: 340 Km

Length: 900 Km

Population: 8,049,313

Ranked 10th in the US

From http://en.wikipedia.org/wiki/North_Carolina



What is the REP ?

- A Groundwater Resource Evaluation Program for the Piedmont and Blue Ridge Mountains Provinces of North Carolina, covering 30,500 sq. miles and 65 Counties
- Funded by NC Legislature in SFY 2000-2001 to ensure the long term availability, sustainability and the quality of groundwater in the state
- A long-term study to improve scientific understanding of North Carolina's crystalline bedrock aquifer hydrogeology
- Joint program between NCDWQ and USGS

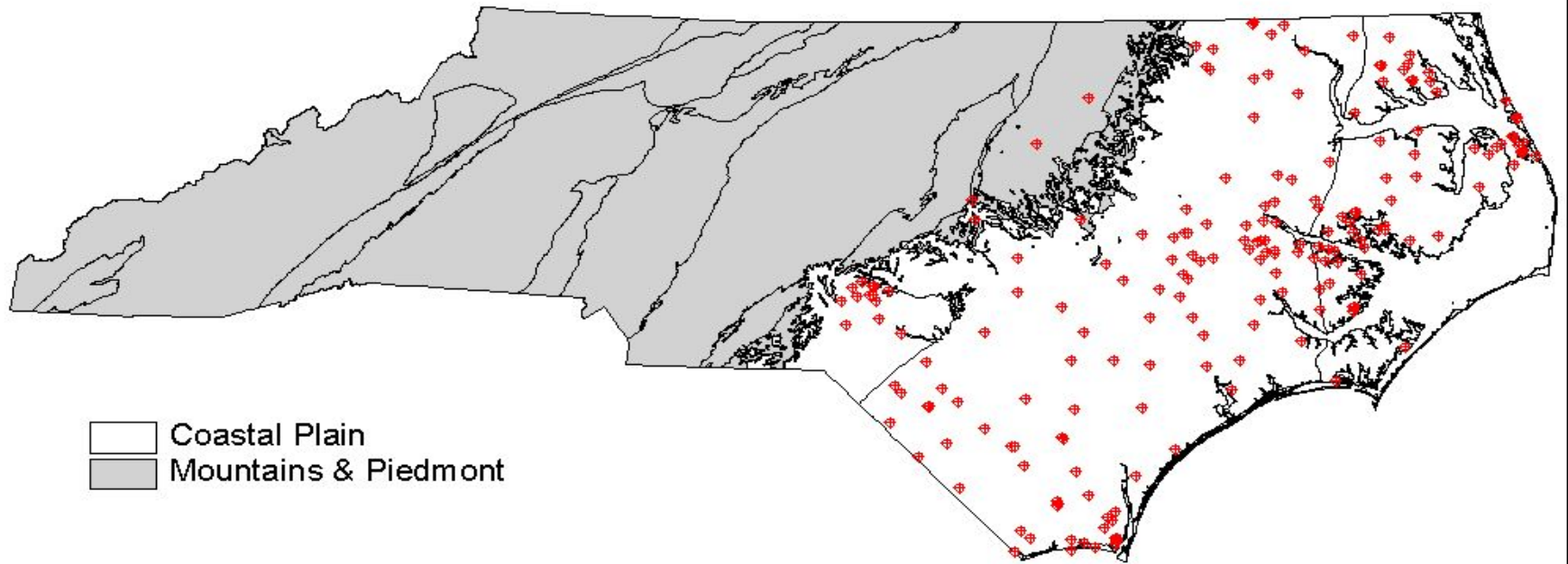
What the REP Does?

- Characterizes regional aquifer properties:
 - Physical hydrogeological characteristics
 - Groundwater quality – hydrochemistry
- Identifies areas vulnerable to contamination
- Understands groundwater-surface water interactions
- Develops groundwater assessment/remediation strategies and supports new policies/regulations
- Performs special studies

Why Do We Need the REP?

- Estimated over 5 million people in the Piedmont and Mountains Region rely on groundwater for potable use
- The hydrogeology of the regolith-fractured bedrock system is very complex and has not been studied intensively
- There is a general lack of detailed studies on groundwater quality (most previous detailed groundwater studies in the Piedmont and Mountains focused on groundwater quantity, not groundwater quality)
- Previous regional hydrogeologic investigations were focused on the Coastal Plain

Previous Groundwater Section Research Station Well Locations (1968 - 1990)



□ Coastal Plain
■ Mountains & Piedmont

⊕ Research Station Well Locations (429)

Until 1990

almost all studies were conducted on the Coastal Plain

REP Study Objectives

- Develop a comprehensive groundwater database for the N.C. Piedmont & Mountains Region
 - Existing and project-generated groundwater quantity and quality data
- Establish baseline of groundwater quality characteristics
- Establish a statewide ambient groundwater monitoring program
- Define the hydrogeologic framework for each physiographic province
 - Delineate “hydrogeologic terranes”
 - Develop comprehensive conceptual models
 - Determine relationships between geology and groundwater
 - Chemistry
 - Occurrence

REP Study Objectives cont'd

- Refine present knowledge of recharge and discharge processes
 - Estimate regional water budgets
 - Assess the relationships between groundwater recharge and discharge and their effects on surface water quality
- Amend the state groundwater standards (15A NCAC 2L) in accordance with study results
- Improve NCDENR's (DWQ and DWM) ability to manage pollution incidents, well and permitting programs

REP Study Objectives cont'd

- Provide educational outreach and training opportunities
- Help improve the general public's knowledge of the groundwater resource
 - Technical publications
 - On-site training and demonstrations
 - Educational presentations and displays

REP Study Methodology

- Analyze existing databases
 - Identify trends and data deficiencies
- Develop Standard Operation Procedures (SOP) and Work Plans
 - Ensure data consistency and reliability
- Locate stations with long-term access
 - Government- or University-owned properties
- Consider site access and logistics to locate wells

REP Study Methodology Continued

- Identify potential hydrogeologic research station locations
 - Identify hydrogeologic terranes and drainage basins, considering “transferability” of information
 - Evaluate weak/strong - low angle/vertical foliation affects on the development of the transition zone and fracture system
 - Consider depth of weathering/topographic setting

REP Study Methodology cont'd

- Get access agreements signed
- Devise drill plan and schedule
- Conduct Geologic mapping and surface geophysics
- Install research station borings and wells
 - Continuous wireline coring
 - One core from each well cluster
 - Wells were installed with air rotary and mud rotary techniques
 - Well Clusters along an assumed linear flow path from topographical high to low settings, wells at each cluster in different zones
 - Saprolite
 - Transition Zone
 - Bedrock (open hole)

REP Coring and Drilling Activities



Core Samples



Langtree



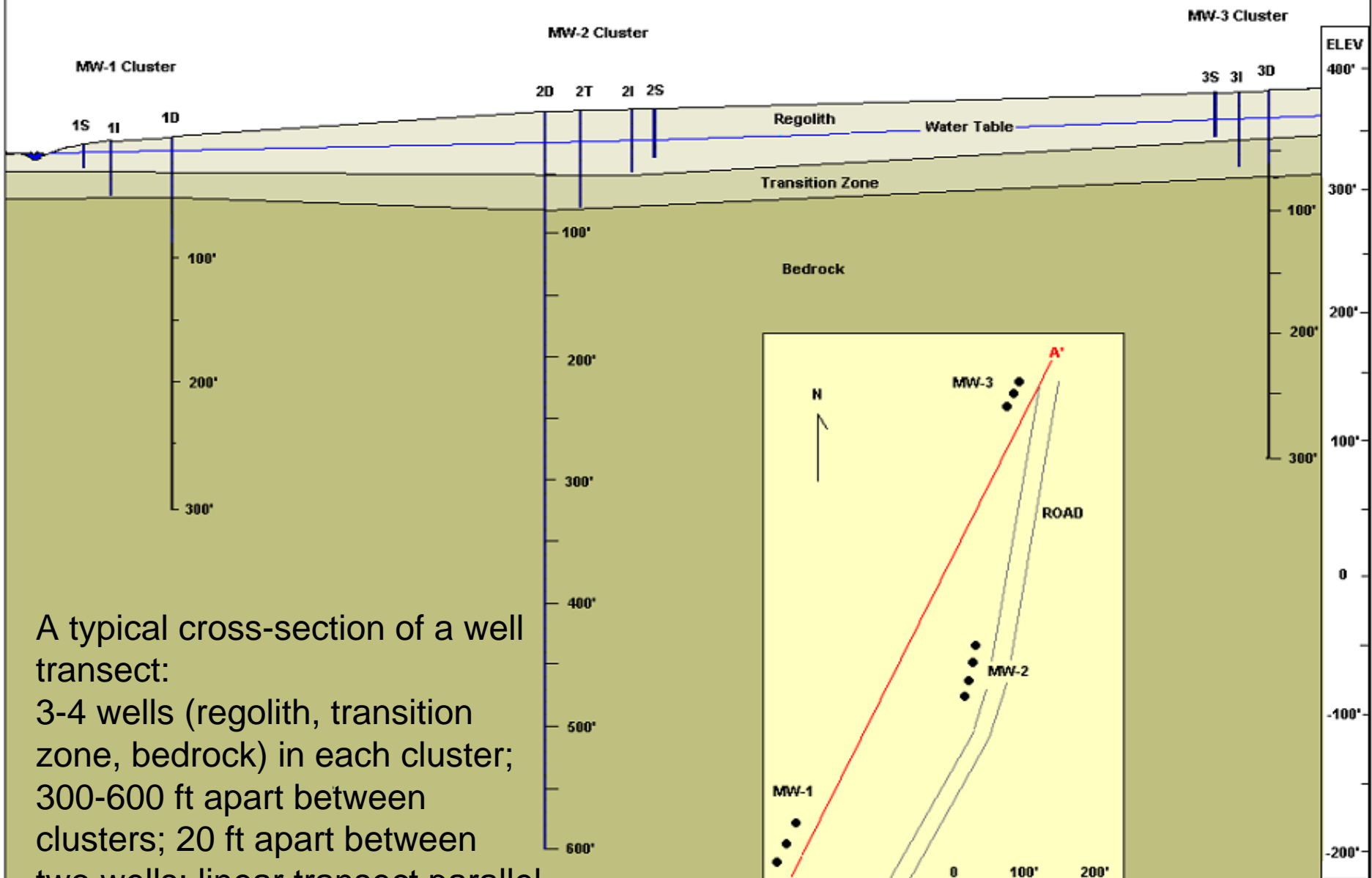
Reidsville



Bent Creek



Well Transect – Lake Wheeler Rd RS



A typical cross-section of a well transect:
3-4 wells (regolith, transition zone, bedrock) in each cluster;
300-600 ft apart between clusters; 20 ft apart between two wells; linear transect parallel to an assumed flow-path

REP Study Methodology cont'd

● On site testing and data collection

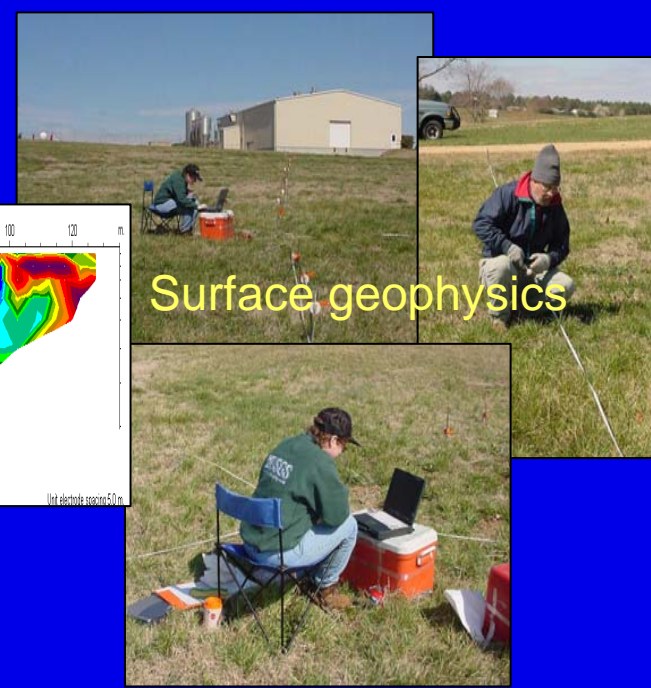
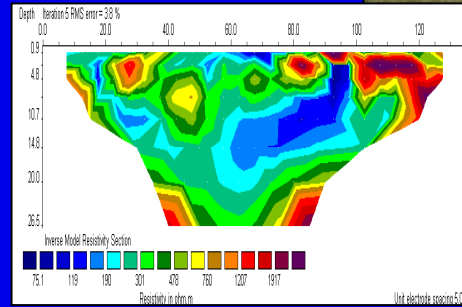
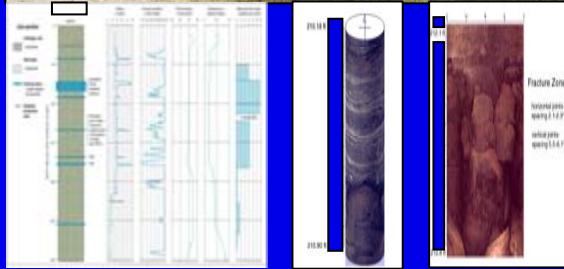
- Core and well construction logging
- Rock and groundwater sampling (for field and lab analyses)
- Surface geophysical survey and borehole geophysical logging
- Aquifer testing (slug and pumping)
- Tracer studies
- Age dating
- Traditional water level and quality monitoring
- Real-time satellite telemetry for water levels and quality parameters

● Data analysis

- Flow path studies
- Statistical analyses
- Refining conceptual models



← Borehole geophysics



Surface geophysics

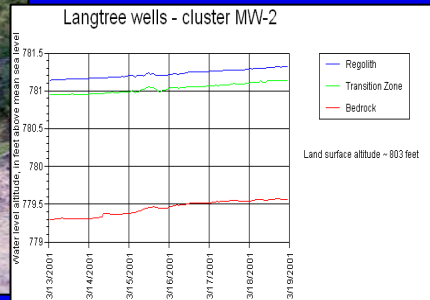
Sampling, Geophysics and Telemetry



Groundwater sampling



Satellite telemetry



REP Study Methodology cont'd

● Publish findings

- Peer-reviewed journals
- Professional conferences
- USGS and NC State publications and open-file reports
- Web-based documents

● Refine NCDENR guidance documents

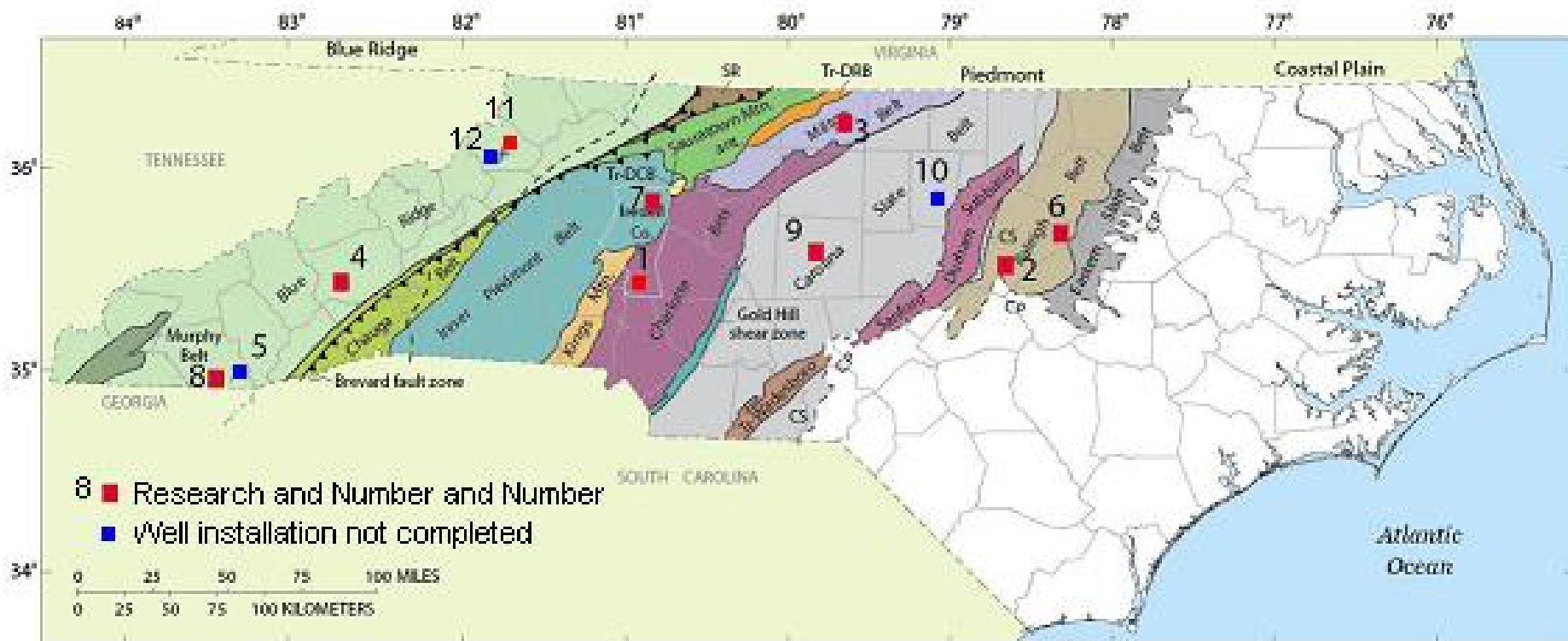
- Contaminant site assessments
- Well construction
- Permits

REP Team/Resources

- NCDWQ Aquifer Protection Section hydrogeologists
- USGS hydrogeologists and groundwater specialists
- Aquifer Protection Section drilling crews
 - CME-75; Schramm; Geoprobe
 - Pumps and other equipments
- Local university faculty
- Other investigators interested in “piggy-backing” their experiments

Approximate Locations of Current REP Stations

in Different Geologic Belts of Piedmont and Blue Ridge Provinces of North Carolina



■ Research and Number and Number
■ Well installation not completed

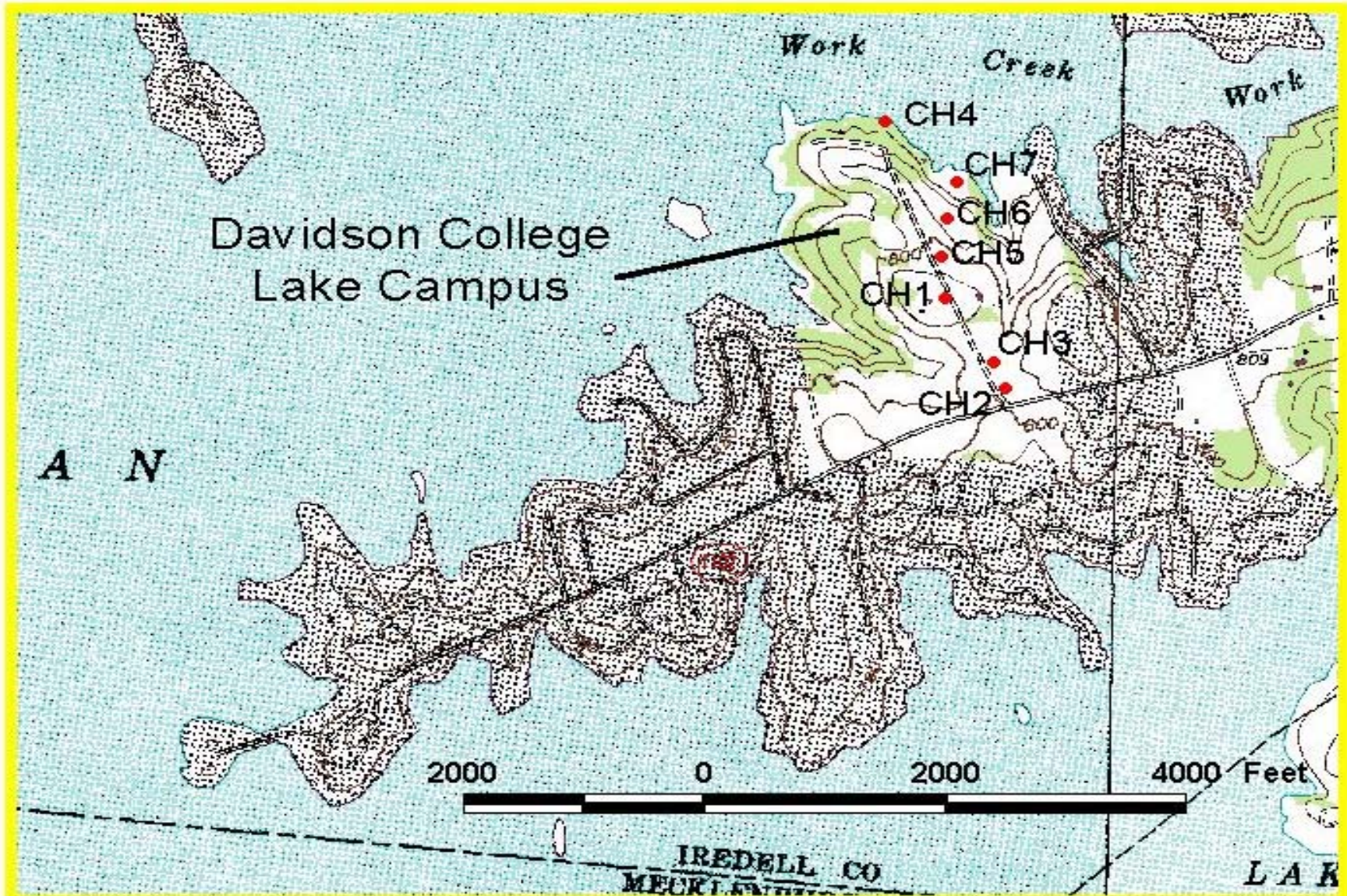
EXPLANATION

Map number	Research station
1	Langtree Peninsula at Lake Norman (LPRS)
2	North Carolina State University Lake Wheeler Road Field Laboratory (LWRRS)
3	North Carolina State University Upper Piedmont Research Station (UPRS)
4	Bent Creek Experimental Forest (BCRF)
5	City of Highlands; Cullasaja Watershed
6	Raleigh Hydrogeologic Research Station
7	Allison Woods Hydrogeologic Research Station
8	Coweeta Hydrogeologic Research Station
9	North Carolina Zoological Park Research Station
10	Duke Forest Research Station
11	Appalachian State University, Tater Hill
12	Town of Seven Devils

- - - - - Piedmont Crescent
 ——— Physiographic Province line

(modified from North Carolina Geological Survey, 1985; Daniel and Payne, 1990)

Langtree Peninsula Research Station



20-acre site/2000x750 ft flow scales, 7 CH, 6 cluster/29 wells

NCSU – Lake Wheeler Road Station

3 cluster + 3 add. wells, 1000 ft transect from topo high to low settings, 1 S.W. gage

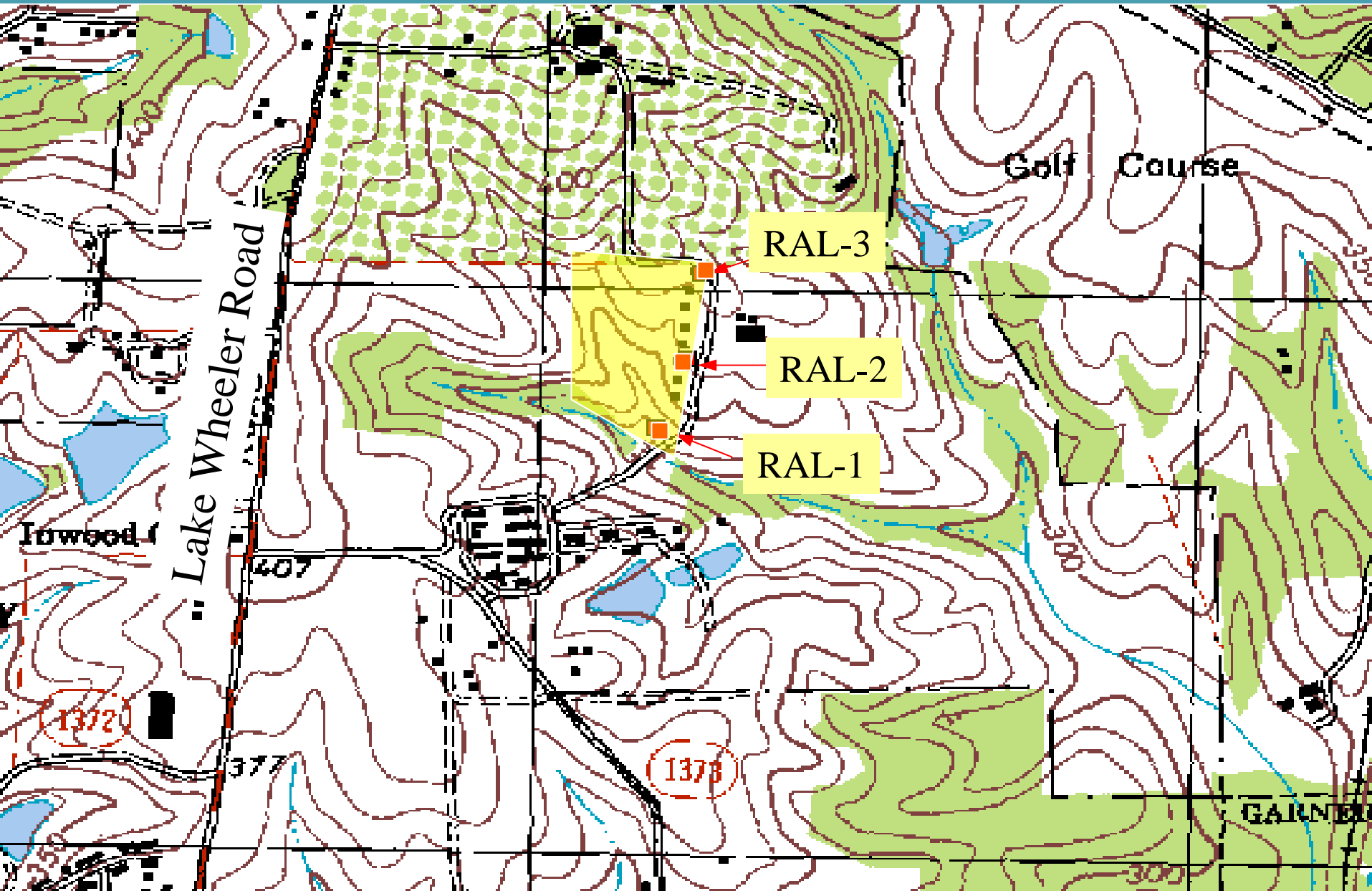
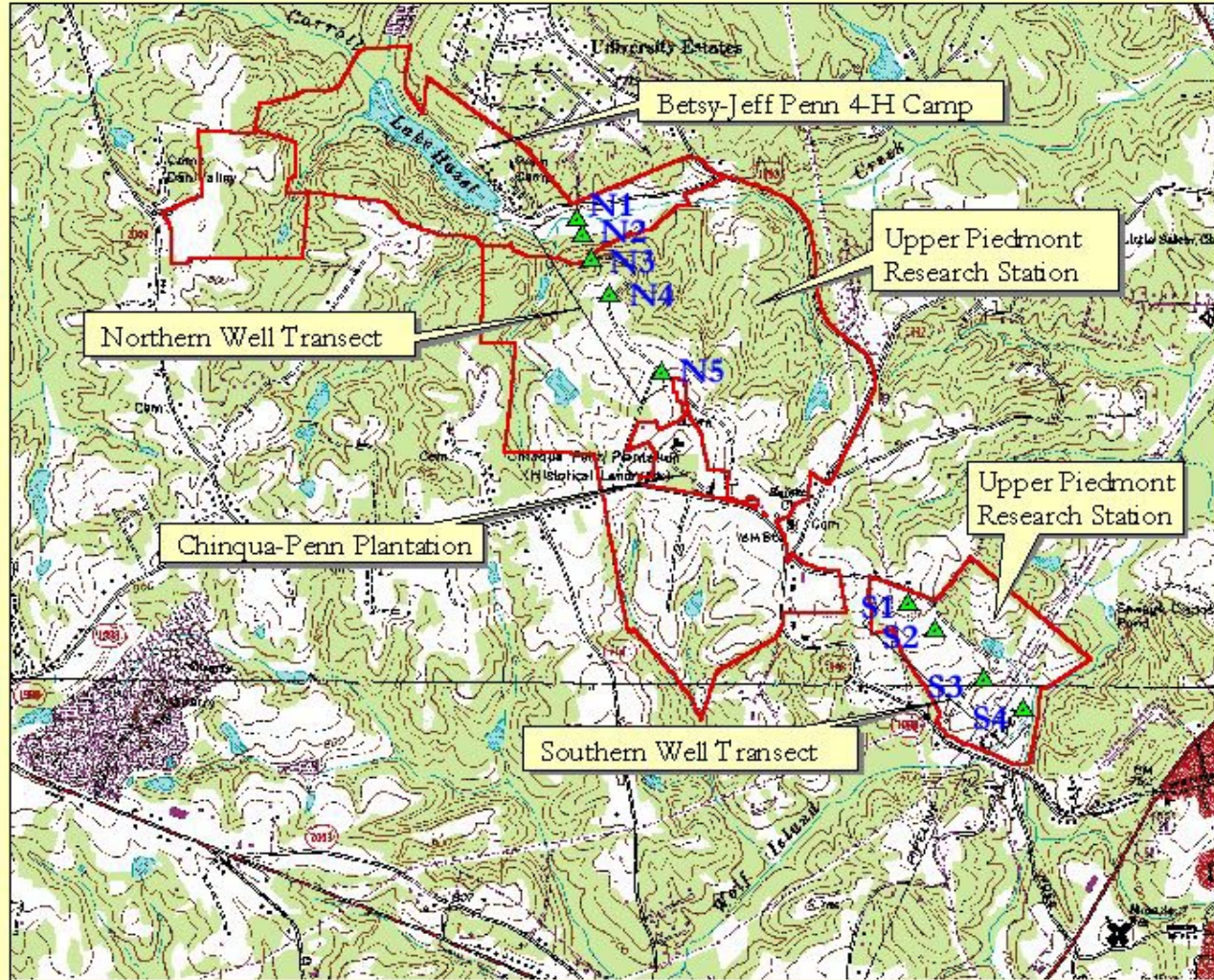


Figure 1:

Upper Piedmont Research Station

Property Boundaries and Proposed Well Cluster Locations



4800 Feet 2400 Feet 0 4800 Feet es



Base map: Portions of the Southeast Eden and Reidsville, NC USGS 7.5' topographic sheets.

2-2000 ft flow-path well transects, 7 well clusters, 20 MWs, 15 Pzs, 2 SW gages

NC Zoo Groundwater Research Station Site Map, Randolph, NC



Legend

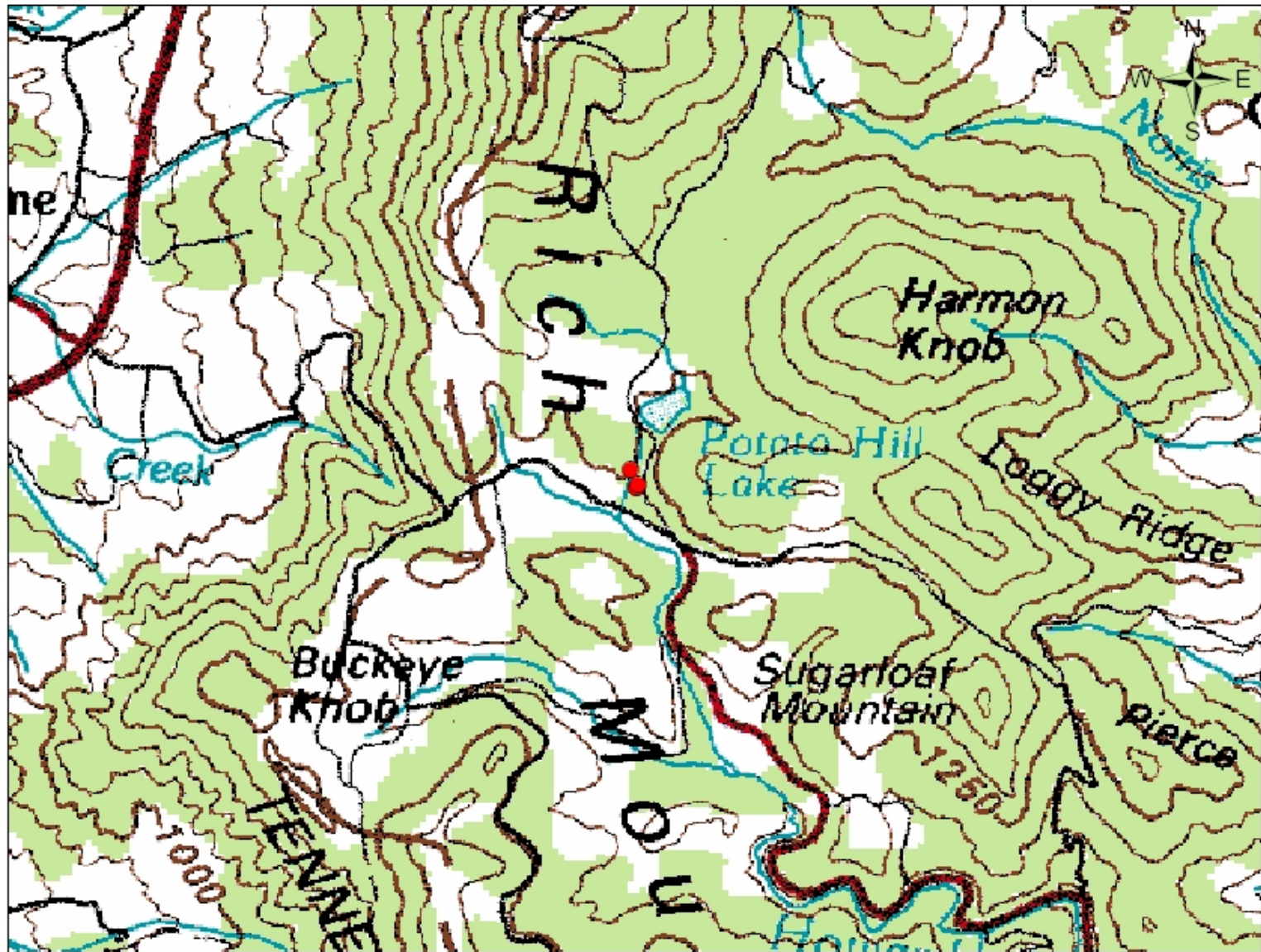
-  MWs_PZs
-  con_randolph_20

Scale 1:8,000



About 20 acre site, 1200 ft long flow path transect, 3 clusters, 10 MWs, 5 Pzs

Location Map of Tater Hill Hydrogeological Research Station Watauga County, NC



Legend

● Well_Or_CreekGage

0 550 1,100 2,200 Meters

Example of a well cluster



shuying.wang@ncmail.net

<http://h2o.enr.state.nc.us/aps/gpu/documents>