North Carolina Ground Water Resources Monitoring Well Network 2010 Annual Report

Susan Laughinghouse, L.G.
North Carolina Department of Environment and Natural Resources
Division of Water Resources
September 2010

1.0 Introduction

The State of North Carolina (the State) relies on ground water for approximately 50 percent of its drinking (potable) water use. The State has thousands of agricultural and industrial ground water users. Since 1998, the North Carolina Department of Environment and Natural Resources (DENR), Division of Water Resources (DWR) has monitored and maintained a statewide network of monitoring wells to assess North Carolina's ground water supply. The operation of this monitoring well network is an integral part of DWR's mission to ensure that the State has an adequate water supply for its citizens. Information (data) collected quarterly from this well network include the following:

- Evaluate climatic influences on the State's ground water supply, including effects of drought and recharge-discharge relationships;
- Monitor human-induced effects on the State's ground water supply, particularly in the regional aquifer systems of the Coastal Plain physiographic province. These effects include local and regional water level declines as well as migration of the fresh water-salt water interface within various aquifers;
- Provide supporting data for enforcement and creation of current and future ground water usage regulations, such as the Central Coastal Plain Capacity Use Area rules; and
- Provide high quality ground water data to local governments, ground water professionals, and the general public to use in making informed decisions in ground water related issues.

Data collected from the network are available to the public through DWR's internet website, *www.ncwater.org*. These data include ground water levels, chloride measurements, well construction information, borehole log construction (lithological and geophysical), ground water monitoring station locations, and geophysical/lithological data collection from non-DWR well sites.

2.0 Purpose and Scope

The 2010 Annual Report summarizes field activities and conclusions derived from activities performed during the July 1, 2009 through June 30, 2010 fiscal year. These activities include water level and water quality data statistics, monitoring well installations including new installations, monitoring equipment usage, and evaluations and site surveys.

3.0 Background

The statewide Ground Water Resource Monitoring Program was initially operated by the Division of Water Quality (DWQ) and its predecessor agencies. DWQ installed the original network wells in the 1960s and is responsible for installation of approximately 75 per cent of the monitoring well network. DWQ actively monitored the network through the early 1990s, collecting a portion of the ground water data currently contained within the network database. The program was transferred to DWR in 1998.

The U.S. Geological Survey (USGS) has also contributed to the monitoring of the State's ground water resources under a cooperative agreement between the State of North Carolina and the Federal government. The cooperative well network consists of 17 monitoring wells, many of which are also part of the DWR statewide network.

4.0 DWR Statewide Monitoring Well Network-Overview

4.1 Description

The monitoring well network currently consists of 563 wells at 186 monitoring stations (sites), divided into five regions, comprising 57 counties (Figure 1). There are 23 wells located in the Piedmont and Mountain physiographic provinces (Piedmont and Mountain) and 540 wells located in the Coastal Plain physiographic province (Coastal Plain). The Coastal Plain relies more heavily on ground water supplies than either the Piedmont or Mountain. As a result, ground water monitoring and research has been more concentrated in the Coastal Plain. Recently, more resources have been invested in monitoring the Piedmont and Mountain ground water conditions to better understand the impact of drought cycles on ground water supplies and their contribution to surface water flow. There are 39 wells within the monitoring well network used to assess drought conditions (Figure 2).

Of the 186 monitoring stations, 59 are on State or Federal property and 47 are located on property owned by local governments. The remaining 80 stations are located on private property through agreements with landowners. In the past, some wells have been abandoned at the landowner's request due to changes in land use or ownership. Due to the high cost of well construction combined with the fact that the wells are most valuable when they are monitored continuously over a period of decades, every attempt is made to put new stations in secure, stable locations. A scale has been developed to rank new and existing wellsites for potential well abandonment due to land-use issues in the future (Table 1). It is preferred that new wells be installed at sites with a susceptibility rating of 1 or 2.

TABLE 1
Site Susceptibility Rating
North Carolina Ground Water Resources Monitoring Well Network
2010 Annual Report

Susceptibility Rating	Description
1	**Secure**—station is located on State or Federal government property
2	**Secure**—station is located on local government or school property
3	**Moderately secure**—station is located on private property, but landowner does not give any indication that land use or property ownership may change
4	**Tenuous**—station is located on public or private property and landowner is giving indications that land use or property ownership may change
5	**Imminent threat**—station is on public or private property and landowner desires abandonment of well station.

4.2 Monitoring

The statewide monitoring network is divided into five regions (Figure 1). Table 2 summarizes site and recorder distribution by region. One staff member is responsible for managing each region. Staff member responsibilities include visiting the wells quarterly to collect water level data, performing routine site maintenance, and keeping automatic data recorders in working condition. Site maintenance includes clearing vegetation and ensuring that sites are easily accessible and esthetically pleasing. Additional site activities (i.e. recorder removal/replacement, weed/grass maintenance, etc.) are conducted on an as needed basis.

Depth to ground water level measurements are collected from the network in two different ways. Manual water levels are measured using electronic water level indicators. Hourly water level measurements are collected using one of two types of automatic water level recorders (shaft encoders or submersible pressure transducers, vented and unvented). Hourly water level data are extremely valuable in assessing aquifer recharge, impacts of large storms on ground water conditions, and delineation of aquifer boundaries. DWR typically publishes only the manual water level readings and daily water level data from recorders on the website. Hourly data is available upon request for specific wells.

Triennial chloride samples are collected from select wells in the Coastal Plain. The samples are analyzed using the Quantab field method. Field results are used to monitor the migration of the fresh water-salt water interface in the Coastal Plain aquifers. Additional chloride samples are collected for field analysis when new monitoring wells are installed and as needed for special projects. Chloride sampling will occur in September 2010. Section 5.2 summarizes the 2007 chloride sampling event.

TABLE 2
Site and Recorder Distribution by Region through 6/30/10
North Carolina Division of Ground Water Resources Monitoring Well Network
2010 Annual Report

Region	Parameter	Number	% of Region	% of Network
	Wells	112		19.9
	Sites	38		20.4
	Sutrons	4	3.6	0.7
1	WL15s	0	0.0	0.0
	WL16s	64	57.1	11.4
	Hobos	11	9.8	2.0
	All Recorders	81	69.4	13.4
	Wells	147	70.5	24.8
	Sites	40		21.5
	Sutrons	11	7.5	2.0
2	WL15s	32	21.8	10.5
	WL16s	59	40.1	9.3
	Hobos	20	13.6	3.6
	All Recorders	122	83.0	21.7
	Wells	110		21.4
	Sites	26		14.0
	Sutrons	3	2.7	0.5
3	WL15s	8	7.3	1.4
	WL16s	65	59.1	11.5
	Hobos	7	6.4	1.2
	All Recorders	83	75.5	14.7
	Wells	126		22.4
	Sites	43		23.1
	Sutrons	3	2.4	0.5
4	WL15s	15	11.9	2.7
	WL16s	34	27.0	6.0
	Hobos	7	5.6	1.2
	All Recorders	59	46.8	10.5
	Wells	68		12.1
	Sites	39		21.0
	Sutrons	8	11.8	1.4
5	WL15s	10	14.7	1.8
	WL16s	27	39.7	4.8
	Hobos	6	8.8	1.1
	All Recorders	51	75.0	9.1

5.0 2009-2010 Well Network Statistics

5.1 Ground Water Data Collection

Depth to ground water was measured in 560 of the 563 wells in the July 1, 2009 through June 30, 2010 fiscal year. One well, P17E4 (Whitley Farms was dry for four consecutive quarters, therefore, depth to ground water could not be measured in this well) and two new wells installed at Roxobel (F22B1 and F22B2). Table 3 contains DWR monitoring well network statistics from January 1, 2005 through June 30, 2010.

TABLE 3
DWR Monitoring Well Network Statistics (1-1-05 through 6-30-10)
North Carolina Ground Water Resources Monitoring Well Network
2010 Annual Report

Parameter	2005	2006	2007	2008	2009	2010
Number of monitored wells	542	544	555	565	575	563
Manual water levels (tapedowns)	2,542	2,720	2,610	2,462	2,554	1,395
Daily water levels (automatic recorders)	89,088	92,827	95,333	107,883	122,969	63,386
Total daily water levels	91,630	95,547	97,943	110,345	125,523	64781
Total hourly water levels	2,141,368	2,229,355	2,294,909	2,591,483	2,961,371	1,522,035
Chloride samples	17	22	173	12	18	5
Geophysical & lithologic logs at new stations	2	1	3	1	1	0

Figure 3 compares the number of wells monitored to the water level data collected from the network from 1967 to present. Hourly water level data is not included in this graph. Calendar year 2009 represents the most water level data collected in any single year since starting the monitoring well network operation. This is due to the gradual increase in the number of wells monitored and the increased use of automatic data recorders. The 2010 data was collected through June 2010.

Archived water level recorder charts obtained from DWQ with records dating from the 1960s through 1980s continue to be digitized and data recorded into DWR online database. Additional continued digitized information recorded in the database includes, but is not limited to, well construction records and field notes.

5.2 Triennial Chloride Sampling

The triennial chloride sampling was performed in September 2007. Ground water from 173 wells within the network was sampled for chlorides using Quantab® chloride titrators. Field data were collected for pH, conductivity and salinity using YSI® portable probes. The intention of the triennial chloride sampling is to assess the position of the fresh-salt water interface within each of the major coastal plain aquifers. Current results are compared to results of previous sampling events to evaluate potential landward migration of the fresh-salt water interface due to aquifer overuse. Chloride sampling results are posted in the database and the DWR website.

Sampling results indicate that there continues to be concern for salt water encroachment, especially near larger pumping centers located near the fresh-salt water interface (250 parts per million (ppm) chloride is considered salt water). The September 2007 chloride field sampling results associated with wells near larger pumping centers illustrate these type of issues:

- Chloride concentrations in the Castle Hayne aquifer well at the Godley Station increased from 137 ppm on September 15, 2004 to 564 ppm on October 11, 2007. This station is located near PCS Phosphate Inc. at Aurora, NC in Beaufort County.
- Chloride concentrations from the Peedee aquifer well at the Folkstone Station increased from 35 ppm on October 12, 1999 to 266 ppm on September 14, 2004 and measured 252 ppm on September 25, 2007. This station is located near the ONWASA Dixon well field in Onslow County.
- Chloride concentrations from the Upper Cape Fear aquifer well at the Gold Point Station increased from <28 ppm on September 30, 2004 to 162 ppm on September 24, 2007. This station is located near the town of Robersonville in Martin County.

Table 4 summarizes the chloride field analysis to date.

TABLE 4
Chloride Field Analysis to Date
Wells Q16G4, Y25Q4 and J22P5
Ground Water Resources Monitoring Well Network
2010 Annual Report

Station	Date	Chlorides (ppm)
Godley Station Q16G4	2/23/1981	No Reading Available
	7/14/1998	174
	10/7/1999	91
	9/15/2004	137
	10/11/2007	**564**
Folkstone Station Y25Q4	9/25/1982	No Reading Available
	8/6/1998	11
	10/12/1999	35
	9/14/2004	**266**
	9/25/2007	**252**
Gold Point Station J22P5	6/10/2002	10
	9/15/2004	<28
	9/30/2004	<28
	9/24/2007	162
Chloride Level for Salt Water		**250**

The triennial chloride sampling will take place again in September and October 2010.

5.3 Well Installation

From January through May 2010, three monitoring wells were installed at the Jones Middle School Station, Trenton, Jones County and two monitoring wells were installed at the Roxobel Station in Bertie County, North Carolina. The wells were installed using 4-inch PVC riser and 10 or 20 feet of 4 to 4.5-inch stainless steel continuous wire wrap V-slot screen. The wells were constructed of a gravel pack extending from the bottom of the screen to a minimum of five feet, but no more than ten feet, above the screen. A minimum of ten feet of bentonite overlays the top of the gravel pack in order to provide a sufficient bentonite seal in the well. Table 5 summarizes the monitoring well construction information.

A pilot hole was not advanced prior to installing these wells since both stations had pilot holes drilled previously when geophysical logging was conducted. Geophysical and lithologic log interpretation enabled the DWR staff to assess well screen intervals and the number of wells to be installed. After borehole advancement and well installation staff proceeded with well development and chloride measurement collection.

The wells were developed in June and July 2010 by pumping. Development removes fine-grained sediments from the vicinity of the well screen and ensures proper hydraulic connection with the aquifer. In addition, field data were collected for pH, conductivity, salinity, and temperature in thirty minute or hourly intervals. Field data exhibiting overall consistency was used to assist in the decision for well development completion.

5.4 Well Maintenance

The well network requires continual maintenance to keep existing monitoring stations usable. Many of the wells are over 30 years old and are constructed of materials that are susceptible to corrosion, especially in acidic or saline ground water conditions. Some older wells were constructed with outdated, less than desirable construction practices including backfilling boreholes with cuttings instead of neat cement or bentonite grout. Boreholes backfilled with cuttings form an inadequate seal and allow other aquifers to influence the water level and water quality in that well. Another outdated practice included well construction using telescoped casing. Telescoped casing uses a reducer to trim the well to a smaller diameter casing at depth apparently to save money during well construction. Telescoped wells are very susceptible to blockage at the depth of the reducer. Approximately 154 wells in the network were constructed with reducers. DWR has implemented a long-term program for replacing damaged or unsuitably constructed wells with new properly constructed wells.

Installation of new and replacement monitoring wells occupies a large portion of DWR's resources. Table 5 lists the new wells installed during the 2009-2010 fiscal year. The new wells are included on Figure 1.

TABLE 5
Well Construction Information*
Jones Middle School, Jones County/Roxobel, Bertie County North Carolina
Ground Water Resources Monitoring Well Network
2010 Annual Report

Well ID	Station Name	Date Installed	Well Diameter (inches)	Well Depth (ft bls)	Screened Interval (x to y ft bls)	Measuring Point (MP) (ft)	Aquifer	Water Level (from MP) (ft)
								Measured 6/15/10
T24J5	Jones Middle School	3/4/10	4	355	340-350	2.71	Pee Dee	19.60
T24J6	Jones Middle School	3/11/10	4	530	515-525	2.71	Black Creek	135.15
T24J7	Jones Middle School	3/19/10	4	810	795-805	2.84	Upper Castle Hayne	115.91
								Measured 7/2/10
F22B1	Roxobel	3/31/10	4	325	310-320	2.91	Not Yet Determined	157.15
F22B2	Roxobel	4/7/10	4	441	426-436	2.40	Not Yet Determined	134.59

bls – below land surface
*Wells had not been developed at the time this data was collected.

5.5 Automatic Water Level Recorders

Automatic water level recorders play an integral role in the DWR monitoring program. They allow for economical collection of near-continuous data at remote well stations. Four primary recorders are utilized (Table 6).

TABLE 6
Automatic Water Level Recorders
North Carolina Ground Water Resources Monitoring Well Network
2010 Annual Report

Recorder Type	Number in Service*
Sutron Corporation Model 8400A	45
Global Water Instrumentation, Inc. Model WL15	74
Global Water Instrumentation, Inc. Model WL16	255
HOBO U20 Water Level Logger (including separate barometer per station installed	51

***As of June 30 2010**

Note: Due to the large number of recorders employed by DWR, there are, at any given time, a number of units that are being serviced or refurbished. These units are not reflected in the above totals.

5.6 Site Surveys

Concrete survey monuments continue to be installed at each of the 186 monitoring well stations within the network. Once installation is complete, the monuments will be surveyed using the Global Positioning System (GPS) to calculate the most accurate horizontal and vertical location data possible. One hundred forty monuments have been installed date. It is anticipated that this work will be completed by Winter 2011. Surveying of the monuments will take place once monument installation at each well station is complete.

6.0 Planned Activities for FY 2010-2011

6.1 New Well Installation

Monitoring well network expansion efforts for FY 2010-2011 will be focused on Bertie, Bladen, Carteret, Columbus, Craven, Duplin, Halifax, New Hanover, Pender, Pitt, Sampson and Wayne Counties. DWR currently has plans to complete construction of the Rose Hill Station (V32V) in Duplin County and the Pink Hill Station (T29G) and possibly drill a new replacement station at the Caledonia Prison Farm in Halifax County. In addition, some wells throughout the network that cannot be used due to bad construction, screening in multiple aquifers, etc., may be abandoned during this upcoming fiscal year. Table 7 summarizes the possible upcoming expansion of the network in 2010-2011.

TABLE 7
FY 2010-2011 Network Expansion
North Carolina Ground Water Resources Monitoring Well Network
2010 Annual Report

Station Name/Quad	County	Existing Well Screens	Aquifer	Proposed New Well Screens	Aquifer
		83-98	Peedee		
		10-14	Surficial		
Rose Hill	Duplin	10-14	Surficial		
V 32V				398-408	Upper Cape Fear
				480-490	Lower Cape Fear
Pink Hill	Duplin	246-256			
T 29G		126-136			
		14			
				20-30	Surficial
				456-466	Upper Cape Fear
				560-570	Lower Cape Fear
Caledonia Prison Farm	Halifax			20-30	Surficial
				40-50	Yorktown
				86-96	Upper Cape Fear
				200-210	Upper/Lower Cape Fear
				220	Pilot Hole

7.0 Summary and Conclusions

The NCDENR, DWR has maintained and monitored a statewide network of ground water monitoring wells used to assess North Carolina's ground water supply since 1998.

Data collected from the network are available to the public through DWR's Internet website, *www.ncwater.org*. These data include, but are not limited to, ground water levels, chloride measurements, well construction information, borehole log construction (lithological and geophysical), ground water monitoring station location, and geophysical/lithological data collected from other (non-DWR) well sites.

The well network consists of 563 monitoring wells at 186 individual stations. From July 2009 through June 2010, ground water level data were collected from 560 wells within the network (one well was dry and two new wells are not included). These data include manual measurements taken quarterly from wells, plus hourly water levels collected using automatic data recorders from 409 wells.

A total of five monitor wells have been installed at two different stations. Three monitor wells were installed at the Jones Middle School Station in Trenton, Jones County and two wells were installed at the Roxobel Station in Bertie County. Borehole advancement and well installation included, but was not limited to, well development and collection of chloride measurements.

Archived water level recorder charts obtained from the DWQ with records dating from the 1960s through 1980s continue to be digitized and data recorded into the DWR online database. Survey monuments continue to be installed at each of the well stations with plans to survey each monument using global positioning system (GPS).

The triennial chloride sampling was performed on 173 wells in September 2007. Additional samples were collected from the new well installation in April/May 2008, in 2009 from the new installation, and in 2010 from new well installation. Sampling results indicated that there continues to be concern for saltwater encroachment especially near larger pumping centers located near the fresh-salt water interface. The triennial sampling will occur again in September and October 2010.

DWR has tentative plans to expand the monitoring well network by installing five to eight wells at three sites in fiscal year 2010/2011. In addition several wells in the network may be scheduled for abandonment or replacement.

FIGURES

Figure 1: North Carolina Division of Water Resources Monitoring Stations July 2010

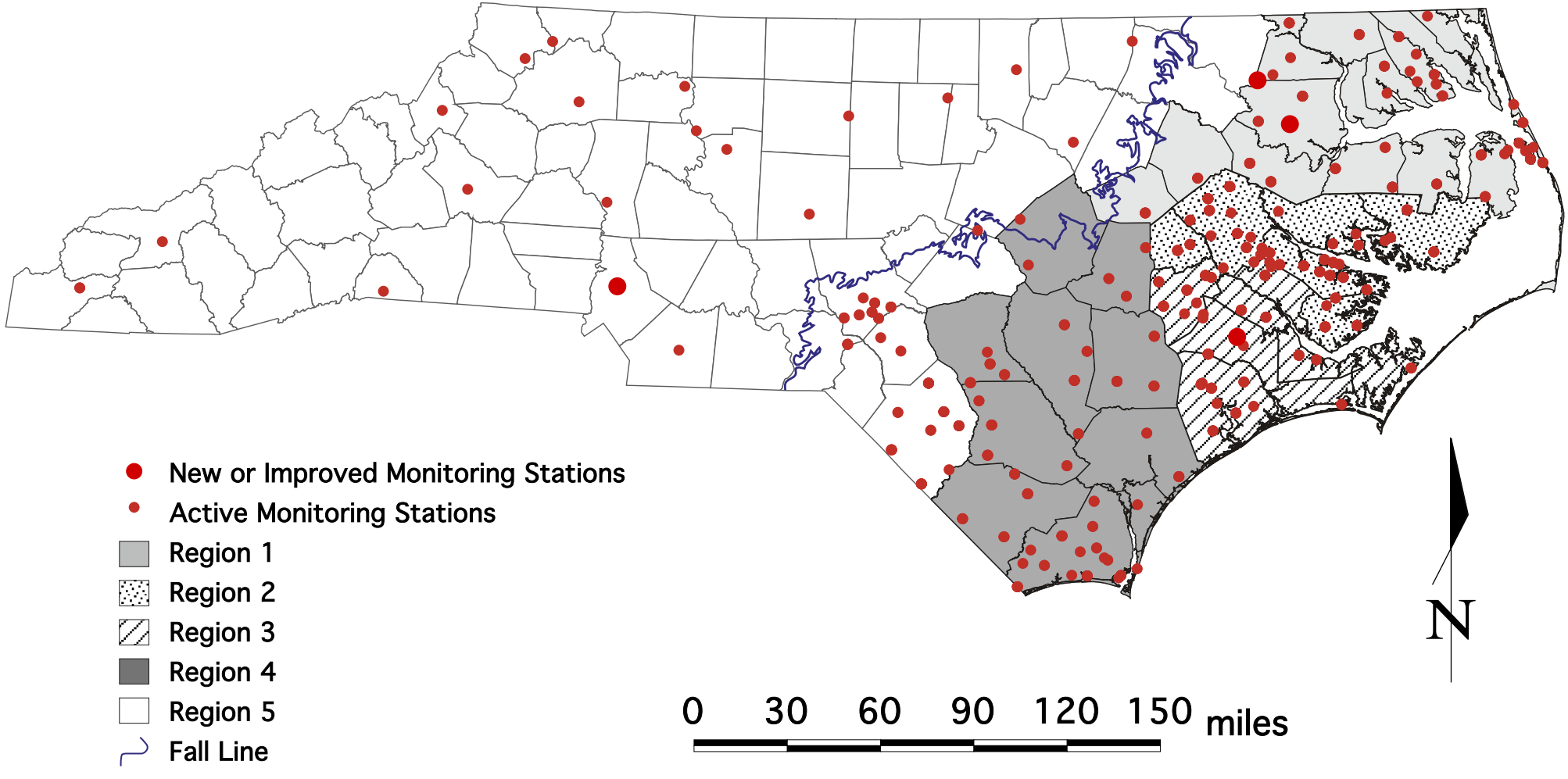

Figure 2: Drought Indicator Wells

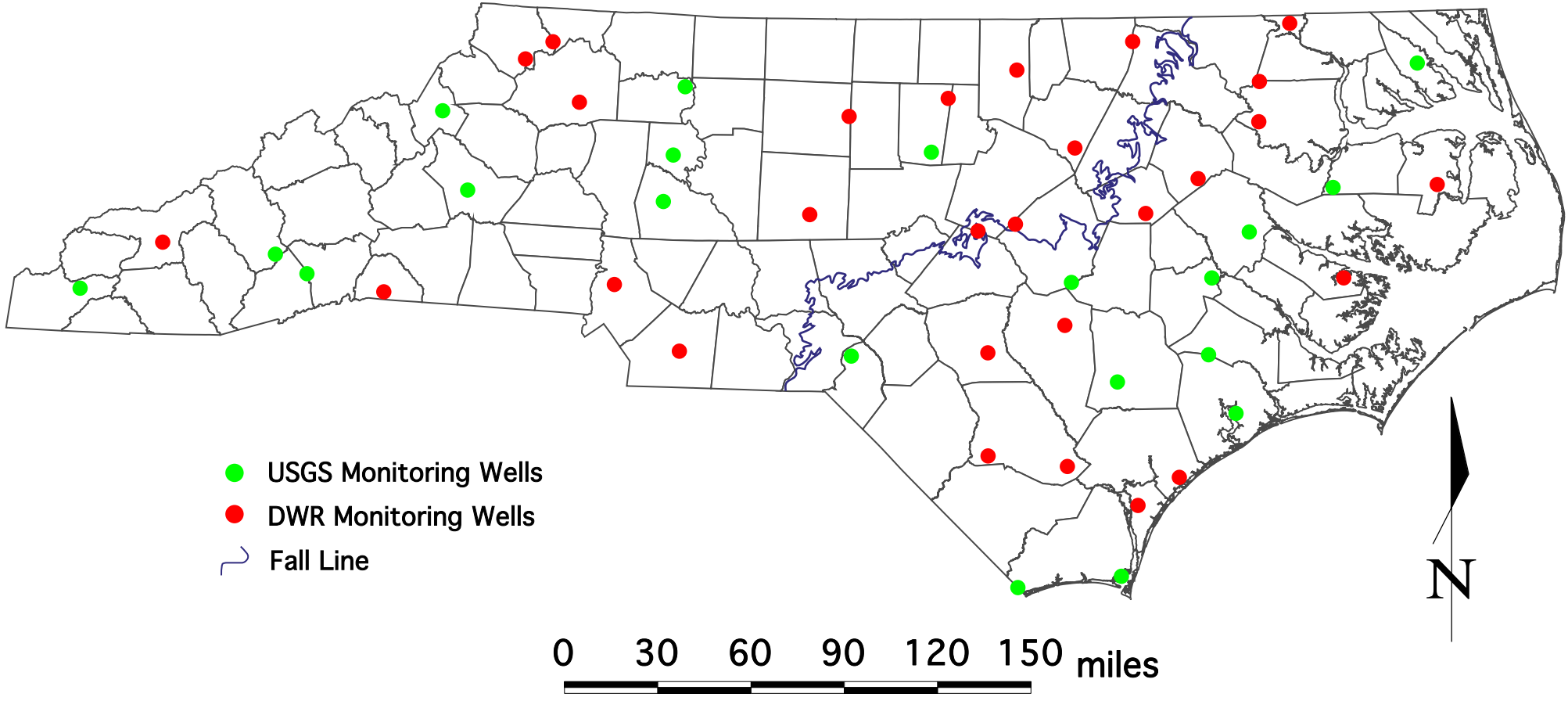

FIGURE 3
Water Level Data Collected from 1967-2010
(Plot includes both DWR and USGS Data)