North Carolina
Division of Water Resources
Groundwater Resources Section
Groundwater Management Branch
2021 Annual Report

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Division of Water Resources
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W 29D, Chinquapin Elementary School
Groundwater Monitoring Station, Duplin County

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1.0 Introduction

The State of North Carolina (the State) relies on groundwater for approximately 50 percent of its drinking (potable) water use. In addition, the State has thousands of agricultural and industrial groundwater users. The North Carolina Department of Environmental Quality (DEQ), Division of Water Resources (DWR), and preceding agencies have operated, installed, and monitored a statewide monitoring well network from the 1960s to the present. The operation of this monitoring well network is an essential part of DWR's mission to ensure that the State has an adequate water supply for its citizens. Information collected quarterly from this well network include the following:

- Evaluating climatic influences on the State's groundwater supply, including effects of drought and recharge-discharge relationships;
- Monitoring human-induced impacts on the State's groundwater 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;
- Providing supporting data for enforcement and creation of current and future groundwater usage regulations, such as the Central Coastal Plain Capacity Use Area rules;
- Periodic sampling of the monitoring well network to establish background levels for constituents (e.g., nitrates, etc.); and
- Providing high quality groundwater data to local governments, groundwater professionals, and the public to use in making informed decisions in groundwater related issues.

Cove City (R 23X)
Jones County, NC

Data collected from the network are available to the public through DWR's internet website https://www.ncwater.org/GWMB. These data include groundwater levels, water quality measurements, well construction information, borehole log construction (lithological and

geophysical), groundwater monitoring station locations, and geophysical/lithological data collection from non-DWR well sites.

2.0 Purpose and Scope

The 2021 Annual Report summarizes field activities and conclusions derived from activities performed or associated with the Groundwater Management Branch during the July 1, 2020 through June 30, 2021 fiscal year (FY 2021). These activities include the groundwater monitoring well network water level (quantity) and water quality data statistics, monitoring well installations, including both new installations and acquired wells, monitoring equipment usage and evaluations, site surveys, local monitoring well network information, and a summary of the Central Coastal Plain Capacity Use Area FY 2021 activities.

3.0 Background

DWR and its predecessor agencies have operated the statewide Groundwater Resource Monitoring Program from the 1960s to the present. The active monitoring well network has expanded by approximately forty-five percent (325 monitoring wells) by either installation or acquisition of new monitoring wells since 1998.

The U.S. Geological Survey (USGS) has also contributed to the monitoring of the State's groundwater resources under a cooperative agreement between the State of North Carolina and the Federal government. The USGS cooperative well network consists of 13 monitoring wells, seven of which are also part of the DWR statewide network.

River Park North Station (M 24L)
Pitt County, NC

Clarks Station, (S 22J)
Craven County, NC

Rose Hill Station, (V 32V)
Duplin County, NC

Three local cooperative networks whose water level data are currently being uploaded to the DWR database and contribute to both the statewide monitoring well network and the drought network are the Orange Well Network (OWN) in Orange County, the Guilford County network, and the Western Carolina Hydrological Research Station (WCHRS) in Jackson County. The statewide monitoring well network includes two wells, CC Old Well(Q 94I1) and Stillwell Building (Q 94J1) from the WCHRS cooperative network. The water level data can be viewed by the public on the DWR website https://www.ncwater.org/GWMB.

4.0 DWR Statewide Monitoring Well Network Overview

4.1 Description

The monitoring well network currently consists of 703 wells at 234 monitoring stations (sites), divided into six regions, comprising 68 counties (Figure 1). There are 56 wells located in the Piedmont and Mountain physiographic provinces (Piedmont and Mountain) and 647 wells

located in the Coastal Plain physiographic province (Coastal Plain). The Coastal Plain relies more heavily on groundwater supplies than either the Piedmont or Mountains. Consequently, groundwater monitoring and research have been more concentrated in the Coastal Plain.

In the past few years, more resources have been invested in monitoring the Piedmont and Mountain groundwater conditions to better understand the impact of drought cycles on groundwater supplies and their contribution to surface water flow. There were 49 DWR wells within the monitoring well network used to assess drought conditions in the FY 2021 (Figure 2).

Of the 234 monitoring stations, 87 are on State or Federal property, 63 are located on property owned by local governments, 80 are located on private property through agreements with landowners, and 4 stations are located on properties where the landowner indicates that the land property ownership may change. 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 well sites 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.

Video-logging
Nashville Well 8 (I 31N1)
Nash County, NC

4.2 Monitoring

The statewide monitoring network is divided into six regions (Figure 1). One staff member is responsible for each region. Staff member responsibilities include visiting the wells quarterly to collect water level data, collecting data from drought wells monthly if needed, performing routine site maintenance, keeping automatic data recorders in working order, and keeping sites accessible and aesthetically pleasing. Additional site activities (i.e., recorder removal/replacement, site maintenance, video-logging, etc.) are conducted on an as needed basis.

Depth to groundwater 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 unvented pressure transducers (data loggers). Hourly water level data are extremely valuable in assessing aquifer recharge, impacts of large storms on groundwater conditions, and delineation of aquifer boundaries. Manual water level readings and daily automatic recorder water level data are typically published on the DWR website. However,

hourly data is available upon request for specific wells. Table 2 summarizes site and recorder distribution by region.

In addition to the recorders mentioned above, Solinst Telemetry System (STS) recording units have been installed in sixteen wells that are included in the Drought Indicator Well network. They consist of one pressure transducer, one barometer (corrects for air pressure), and are powered by a twelve-volt battery. Data is collected by a controller unit that stores hourly readings. The readings are sent to the home station (DWR web page server) every reporting interval (currently 3 hours) via a cell phone modem. DWR uses the STS system on the Drought Indicator Well network to take the place of monthly visits. They are serviced every quarter or semi-annually depending on battery life. The STS data is especially helpful in keeping the Drought Indicator well water levels up to date at https://www.ncwater.org/droughtwells. Table 3 summarizes STS system information.

STS Repair
Lewiston Station (H 22I), Bertie County,

4.3 Chloride Sampling

Chloride samples were collected from select wells in the Coastal Plain during the FY 2019. The samples were analyzed using the Quantab® field method. Field results were used to monitor the migration of the fresh water-salt water interfaces in the Coastal Plain aquifers.

Additional chloride samples are collected for field analyses when new monitoring wells are installed and as needed for special projects. The next chloride sampling event will occur in September-October 2021 to track salt water encroachment conditions. Section 5.2 summarizes the FY 2020 chloride sampling event.

Depth to Groundwater Measurement
Powell Drive (K 40M)
Raleigh, Wake County, NC

5.0 Well Network Statistics

5.1 Groundwater Data Collection

Depth to groundwater was measured in 704 wells in the FY 2021. It is not uncommon for this number to differ from the total number of wells currently in the network (e.g., well abandonment, well removal, etc.). Table 4 contains DWR monitoring well network statistics from January 1, 2005 through June 30, 2021. Statistics may vary in comparison to previous years due to additional data entry in the DWR database as older field books are scanned and unrecorded data entered. 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 2020 represents the most water level data collected in any single year since starting the monitoring well network operation. The FY 2021 data was collected from January 1 through June 30, 2021.

Chloride Sampling
Beaver Creek (S 26I)
Jones County, NC

Data obtained from DWR and its predecessor agencies, including records dating from the 1960s through 1980s, continue to be digitized and data recorded into the DWR online database. These data include, but are not limited to, water level data, well construction records, well development information, chloride sampling events, memorandums of agreement, and field notes.

5.2 Chloride Sampling

In 2019, a chloride sampling event was conducted at 413 DWR monitoring wells. Samples were collected from September 18, 2019 through October 25, 2019, except for one site, Four Mile Desert, which was sampled on November 20, 2019. During the event, groundwater was analyzed using Quantab® chloride test strips, and conductivity, salinity, and pH were measured using YSI® portable probes.

The purpose of chloride sampling is to monitor salinity levels and trends at the fresh water-salt water interface within each of the major coastal plain aquifers. Salinity levels and the location of the interface can change as a result of sea level rise, storm surges during hurricanes, groundwater pumping, and mine dewatering. Chloride levels are used to determine if groundwater is fresh (< 250 ppm chloride) or salty (≥ 250 ppm chloride). Chloride sampling is also used to identify the transition zone between the fresh and salty zones. This transition zone is characterized by a

vertical salinity gradient within the aquifer in which salinity increases with depth, from fresh to salty. Salinity zones and chloride results for three of the state's major aquifers, the Black Creek Aquifer (Kbc), the Upper Cape Fear Aquifer (Kucf) and the Lower Cape Fear Aquifer (Klcf), are summarized in Figures 4, 5, and 6, respectively.

Turkey Station, (U 34B)
Turkey, Sampson County, NC

Figure 4 shows sample results from selected Black Creek aquifer wells sampled in 2019. Increasing chloride trends continued at Lee Creek and Aurora II, both of which are located near open-pit mines where large-scale dewatering is occurring. Increasing chloride was also observed at Long Creek. Chloride continues to decrease at Folkstone as a result of regional water level rebound attributed to reductions in Cretaceous aquifer pumping in accordance with Central Coastal Plain Capacity Use Area (CCPCUA) mandates. A chloride decline was also seen at Holly Shelter, however, this likely is the result of fresh water entering the well during flooding of the Northeast Cape Fear River. During the 2019 sampling event, a total of 45 Black Creek wells were sampled. Of these, 8 wells showed chloride increases from the previous sampling event in 2017 and 9 wells had chloride levels exceeding 250 mg/l. The CCPCUA is discussed further in Section 9.

Figure 5 shows sample results from selected Upper Cape Fear aquifer wells sampled in 2019. In the northeastern part of the state, chloride levels continued to decrease at Moyock, Morgans Corner, Windsor well H 20T3, Gold Point, Bear Grass, Old Sparta, and North Pitt High School. These reductions are potentially attributable to CCPCUA pumping reductions. Chloride levels at Windsor well H 20T4, Clarks, West Research Campus, La Grange and Comfort increased by up to 167 mg/l since the 2017 sampling event. Holly Shelter showed a dramatic decrease in chloride, however as in the Black Creek well, this is attributed to inundation during flooding. In DWR's other Upper Cape Fear wells, chloride was either below 250 mg/l or not detected. During the 2019 sampling event, a total of 52 Upper Cape Fear wells were sampled. Of these, 5 wells showed chloride increases from the previous sampling event in 2017 and 11 wells had chloride levels exceeding 250 mg/l.

Figure 6 shows sample results from selected Lower Cape Fear aquifer wells sampled in 2019. With the exception of Morgans Corner, chloride levels in the northern coastal plain aquifer remained the same or decreased since the 2017 sampling event. The increase at Morgans Corner of 291 mg/l was unexpected since chloride levels had been decreasing since 2010. Within the central and southern coastal plain, chloride increased at North Pitt High School, Falkland, and West Research Campus by up to 106 mg/l since the 2017 sampling event. South of West Research Campus, chloride levels decreased below 2017 levels in all wells except Kelly, which showed a chloride increase of 95 mg/l. The chloride decrease of over 4,000 mg/l at Jones

Middle School is attributed to fresh water entering the well during flooding. During the 2019 sampling event, a total of 27 Lower Cape Fear wells were sampled. Of these, 5 wells showed chloride increases from the previous sampling event in 2017 and 12 wells had chloride levels exceeding 250 mg/l.

Additional information on chlorides is available from the Groundwater Management Branch map interface and water quality data page at https://www.ncwater.org/GWMB.

Geophysical Log and Sample Identification Df Walker Elementary School (G 15E) Edenton, Chowan County, NC

5.3 Well Installation and Development

From February 2021 through April 2021 the following monitoring wells were installed using the mud rotary drilling method:

- Turkey Monitoring Station in Sampson County, five wells installed (U 34B10, U 34B11, U 34B12, U 34B13, U 34B14); and
- Pondberry Bay Monitoring Station in Sampson County, three wells installed (U 37D1, U 37D2, U 37D3).

From June 1, 2021 through June 26, 2021 the following monitoring wells were installed using the mud rotary drilling method:

- DF Walker Elementary School Station in Chowan County, three wells installed (G 15E1, G 15E2, G 15E3).

On June 28, 2021, drilling for the Shingle Landing Station in Currituck County (B 10K) commenced. The drilling details for the referenced station will be included in the 2022 Annual Report.

A pilot hole was previously advanced at the newly installed Turkey and Pondberry Bay stations by AC Schultes of North Carolina from Rocky Point, NC. Both pilot holes were installed using the mud rotary drilling method. The boreholes were used to construct monitoring wells U 34B14 and U 37D2. DWR staff collected samples of the drill cuttings at ten-foot intervals to assess the borehole lithology.

A pilot hole was previously advanced at the newly installed DF Walker Elementary School Station by Toano Well and Pump Service, Inc. from Toano, Virginia. The pilot hole was

installed using the mud rotary drilling method. The borehole was used to construct monitoring well G 15E1. DWR staff collected samples of the drill cuttings at ten-foot intervals to assess the borehole lithology.

Well Installation
DF Walker Elementary School (G 15R)
Edenton, Chowan County, NC

In addition, a borehole geophysical log was obtained by lowering a probe into the pilot hole borehole once the borehole was completed for each of the three referenced stations. The geophysical log makes a detailed record of the geologic formations in the borehole. Geophysical and lithologic log interpretation enabled the DWR staff to identify aquifers and confining units and optimize screen intervals. The wells were installed using 4-inch PVC riser and 10 to 20 feet of 4 to 4.5-inch stainless steel continuous wire wrap V-slot screen except for monitoring well G 15E3, DF Walker Elementary School Well, which was constructed using 4-inch PVC riser and 10 feet of schedule 80 PVC slotted 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 to provide a sufficient bentonite seal in the well. Table 5 summarizes the monitoring well construction information. The FY 2021 completed monitoring station well locations are included in Figure 1.

Development of the well removes fine-grained sediments from the vicinity of the well screen and ensures proper hydraulic connection with the aquifer. During well development, field data was 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 to stop well development. DWR staff developed the Pondberry Bay monitoring well station in the FY 2021 (Table 6). The Turkey and DF Walker Elementary School stations will be developed in FY 2022.

Well Development
Pondberry Bay Station (U 37D), Sampson County, NC

5.4 Acquired Network Wells

During the FY 2021, DWR acquired four existing wells, Nashville Well 2 (I 31H1), Nashville Well 4 (I 31I1), Nashville Well 8 (I 31N1) in Nash County, and Stone Mountain (D 68G1) in Wilkes County. Details of the monitoring stations are included in Table 5.

5.5 Well Maintenance

The well network requires continual maintenance to keep active monitoring stations usable. Many of the wells exceed 30 years in age and are constructed of materials that are susceptible to corrosion, especially in acidic or saline groundwater conditions. Some older wells were constructed with outdated, less than desirable construction practices which included 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 147 wells remain in the network that were

constructed with reducers. DWR has implemented a long-term program for replacing damaged or unsuitably constructed wells with new, properly constructed wells.

5.6 Automatic Water Level Recorders

Automatic water level recorders play an integral role in the DWR monitoring program. Hourly water level measurements are collected using unvented submersible pressure transducers (data loggers). They allow for economical collection of near-continuous data at remote well stations. Two primary recorders (Onset Computer's Hobo U20 series and Solinst Telemetry System or STS) were utilized in the FY 2021 referenced in Table 2. Table 7 lists the recorders outfitted on network wells as of June 30, 2021.

5.7 Site Surveys

Concrete survey monuments have been installed at each of the 234 active monitoring well stations within the network. Five of those stations have more than one monument.

Each of the installed monuments have been surveyed using Survey Grade Global Positioning System (GPS) to calculate the most accurate horizontal and vertical location data possible, with the exception of wells installed or acquired in the FY 2021. DWR was unable to get elevations at two monitoring stations, Beach Grove School Field Well (M93L) and Woody Creek (M93R), due to the inability to acquire a cell phone signal at the station's location. GPS surveying will be conducted again in the summer/fall of the FY 2022 to provide horizontal and vertical data on any newly installed and acquired monitoring well stations.

Monument Installation
DF Walker Elementary School (G 15E)
Edenton, Chowan County, NC

Leveling
Four Mile Desert (E 31M)
Perquimans County, NC

6.0 Local Monitoring Well Network Information

6.1 Orange County Monitoring Well Cooperative Network

The creation of the Orange County Groundwater Observation Well Network, referred to as Orange Well Net (OWN), was proposed in May 2005. It was decided to utilize existing bedrock wells in lieu of installing new wells for monetary reasons. In March 2010, the OWN included six inactive bedrock wells for groundwater data collection. In 2011, three regolith wells were added to the OWN as a result of a cooperative arrangement. In 2012, two bedrock wells (Ray Road and Rocky Ridge) were removed from the network. These wells were replaced with two bedrock wells (4D in Duke Forest and a well at the former Orange County 911 Center). The wells that were most recently added to the network are the Brumley East well, as the result of an agreement with the Triangle Land Conservancy, and the Duke Forest 4S and 4I wells, with the agreement (informal) of DWR and Duke Forest. Table 8 summarizes the OWN well information. Figure 7 is a map of the OWN well locations.

Groundwater data is collected periodically from the OWN. This data is collected to assess groundwater availability and concerns locally in Orange County. The data is formatted and uploaded to the DWR groundwater database and is available to the public. Table 9 is a summary of the OWN statistics from March 2010 through June 30, 2021. The 2011, 2012, and 2013 OWN Annual Reports are available on the DWR website. Wesley Poole (Water Resources Coordinator for the Orange County Department of Environment, Agriculture, Parks and Recreation), the OWN Annual Reports, and information provided by the DWR database, are the sources for the Orange County Monitoring Well Network information provided herein.

6.2 Guilford County Monitoring Well Cooperative Network

The Guilford County groundwater monitoring network was established in 2002 and includes eight monitoring well stations located on public properties owned by Guilford County or the City of Greensboro. Each well site was selected to represent an area of the county and to minimize the influence of any existing water supply wells nearby. Table 10 summarizes the Guilford County monitoring well information. In addition, NC A&T State University uses the Knox Road Station for their hydrology class and the students use the data from this station for their course project.

Water levels are collected manually on the same day of each month. Hourly data is collected using Global Water WL16 submersible transducers and are downloaded at the time of manual collection of depth to groundwater levels. The data is formatted and uploaded to the DWR groundwater database which is available to the public.

Table 11 summarizes the Guilford County monitoring well statistics from 2008 through June 30, 2021. Figure 8 is a site map of the Guilford County monitoring well locations. Gene Mao (Guilford County Department of Health and Human Services, Division of Environmental Health, Health, Environment, & Risk Assessment Unit), and information obtained from the DWR database, are the sources for the Guilford County Monitoring Well Network information provided herein.

6.3 Western Carolina Hydrological Research Station Cooperative Network

Western Carolina Hydrological Research Station Cooperative Network. The Western Carolina Hydrological Research Station, (WCHRS), was established in 2010 in a partnership between Western Carolina University (WCU) and DEQ. The WCHRS is comprised of approximately 40 monitoring wells and is located within the Cullowhee Creek watershed. According to the WCU description of the WCHRS located in the DWR database, "the well network was designed to study groundwater interaction with streams in a headwaters region typical of the southern Appalachians." The hydrologic station is unique in that it serves four distinct, but mutually supportive roles:

1) hydrologic monitoring and research;
2) research-based education of undergraduates;
3) real-world training of future hydrology and geoscience professionals; and
4) incubator for doing and advancing models for course-based undergraduate research experiences.

Measurement of wells and water levels at GG1, WCHRS, Jackson County, NC

It was decided in 2017 that the WCHRS cooperative well network would be comprised of seventeen of these wells, including two wells acquired by DWR, Stillwell Building Station (Q 94J1) and the CC Old Well Station (Q 94I1), which are both active wells in the statewide monitoring well network. Table 12 summarizes the WCHRS cooperative network well information. Figure 9 is a map of the WCHRS cooperative network well locations. Groundwater data is collected periodically, mostly by students, from the WCHRS. Data from select wells are formatted and uploaded to the DWR groundwater database and are available to the public. Table 13 is a summary of the WCHRS statistics from 2011 through June 30, 2021.

Research at the WCHRS focuses on four broad questions:

1) How does the interaction of groundwater and stream water vary with their landscape setting?
2) Where and when does recharge of groundwater occurs in the watershed?
3) What is influence of historic land uses & ongoing changes in land cover on water resources and quality?
4) How does the sensitivity of groundwater to climate/weather changes vary in different settings?


Installation and completion of a new stream flume in the Western Carolina Hydrologic Research Station

During the pandemic, activity in the WCHRS slowed, but continued. WCU students in classes on Hydrogeology, Wetlands, Soils and Hydrology used the site and the DWR database extensively. Student-driven research led to the installation of a new flume being installed on a small station creek, which helped understand water budgets. The research showed adjacent headwater streams can have different flow and water quality traits due to variations in the connection and depth of groundwater feeding the stream.

Mark Lord and David Kinner, Professors of Geology with the Department of Geosciences and Natural Resources, WCU in Cullowhee, NC, the http://wchrs.wcu.edu/ website, and information provided by the DWR database are the sources for the WCHRS information provided herein.

7.0 Planned Activities

7.1 New Well Installation

Monitoring well network expansion efforts for the FY 2022 will focus mainly on Onslow, Sampson, Chowan, Currituck, Edgecombe, Scotland, and Robeson counties. Table 14 summarizes the potential upcoming expansion of the network in FY 2022.

7.2 Well Abandonment/Station Removal

Some wells throughout the network that cannot be used due to bad construction, screening in multiple aquifers, unsafe location, owner decision to no longer allow access, etc., may be abandoned during the FY 2022.

Two wells, Scotts Hill (Q 32D1) and Moss Hill (R 29T2) were removed from the active monitoring well network during the FY 2021. The original Turkey Station was abandoned

(U34B4 and U34B6) and these well were replaced with the newly installed Turkey Station wells in the FY 2021. Table 15 summarizes which wells were moved to inactive status or abandoned with an explanation as to why.

Groundwater Sampling
North Pitt Station (L 24B)
Pitt County, NC

8.0 Water Quality

Since 2015 the Groundwater Management Branch has supported Tasks 5 & 6 of the North Carolina FY 2016 Workplan for the Clean Water Act Section 106 Groundwater Grant (EPA).

Task 5 - Characterize the State's Groundwater Resources, and Task 6 - Groundwater Monitoring Program

The Division of Water Resources conducts an active program of groundwater monitoring that advances the DWR mission by improving DWR's knowledge in the following areas:

1 Impacts of land-applied wastes, artificial infiltration practices, or other human activities, including:
- Potential impacts of these activities on the surficial aquifer and the secondary impacts to the deeper aquifers or surface waters;
- The occurrence of "emerging contaminants" related to these activities; and
- Effectiveness of regulations and permits for these activities.

2 Threats to groundwater quality, including:
- The existence, nature, and scope of emerging or existing threats;
- Assessment of the causes and factors affecting naturally occurring contamination, agricultural contamination, or contamination resulting from activities permitted by DWR; and
- Tracking the status of groundwater quality across the state.

The goal of all characterization, monitoring, and investigation efforts is to improve DWR's understanding of the causes and extent of problems, to minimize human exposure to contaminants, and identify areas where regulations or best management practices can be improved to prevent contamination from occurring.

Groundwater Sampling
North Pitt Station (L 24B), Pitt County, NC

The state has an extensive network of groundwater monitoring stations which can be utilized as an ambient groundwater monitoring network. Prior to December 2015, the Piedmont-Mountain Resource Evaluation Program sampled wells annually from a well network installed and constructed for characterizing the relationship of water quality to underlying geology in the Piedmont and Mountain physiographic provinces. Less water quality monitoring occurred in the Coastal Plain in the last two decades.

The Groundwater Management Branch intends to collect samples from each active well in the statewide monitoring well network. In the FY 2020, samples were collected from 25 monitoring stations. The samples were analyzed for the following parameters:

- Standard private well parameters – arsenic (As), barium (Ba), cadmium (Cd), chromium (Cr), copper (Cu), fluoride (Fl), lead, (Pb) iron (Fe), magnesium (Mg), mercury (Hg), nitrates (NO_3), selenium (Se), silver (Ag), sodium (Na), zinc (Zn), pH, and bacterial indicators;
- Ammonium (NH_4), total Kjeldahl nitrogen (TKN), organic nitrogen, and phosphate (PO_4);
- Volatile organic compounds (VOCs), and pesticides (also consult with area agricultural experts on local practices);
- Major ions (Na, calcium (Ca), potassium (K), manganese (Mn), sulfate (SO_4), (carbon trioxide (CO_3), bicarbonate (HCO_3) and chlorides (Cl);
- Per- and polyfluoroalkyl substances (PFAS);

- Metals
  - Dissolved (filtered in field) (geochemistry applications require dissolved metals)
  - Total (drinking water standards are based on total metals)
  - Cu and Zn, (in both swine permits and the standard private well suite)
  - Coal ash metals – this would incur only minor additional costs yet would increase our knowledge of naturally occurring contaminants of interest to the coal ash program.
    - Note, currently chromium analysis performed by the DWR lab is not sufficiently precise enough to satisfy coal ash program needs. Analysis for hexavalent chromium would need to be sent to a private lab at some cost.
    - Note, currently the DWR lab analyzes for total vanadium. The 2L standard for vanadium (V) is under review and will probably be based on particular species of V, not total V.
- Field parameters
  - Specific conductivity, pH, dissolved oxygen (DO), temperature (˚C), oxidation-reduction potential (ORP).

In addition to the referenced groundwater sampling events, five groundwater stations in New Hanover County were sampled specifically for per-and polyfluoroalkyl substances (PFAS), a group of man-made chemicals that includes perfluorooctanoic acid (PFOA), perfluorooctanesulfonic acid (PFOS), GenX and others. The wells were sampled using a high-density polyethylene (HDPE) Super/Skinny Sleeve. By using this method, a grab sample of groundwater is collected from the screened interval (or any interval of interest) of the well with minimal disturbance and effort, thus eliminating the need for purging three well volumes.

Groundwater sampling protocol is included in Appendix A. Field data information for the 2020 FY are included in Table 16. Laboratory analytical results received for the 2020 FY are available upon request. In the FY 2021, groundwater samples will continue to be collected from wells in the monitoring well network and analyzed for the parameters referenced above. Analytical data is now available to the public using the GWMB webpages.

Bean Shoals Station (E 61P1)
Pilot Mountain State Park
Surry County, NC

9.0 Central Coastal Plain Capacity Use Area

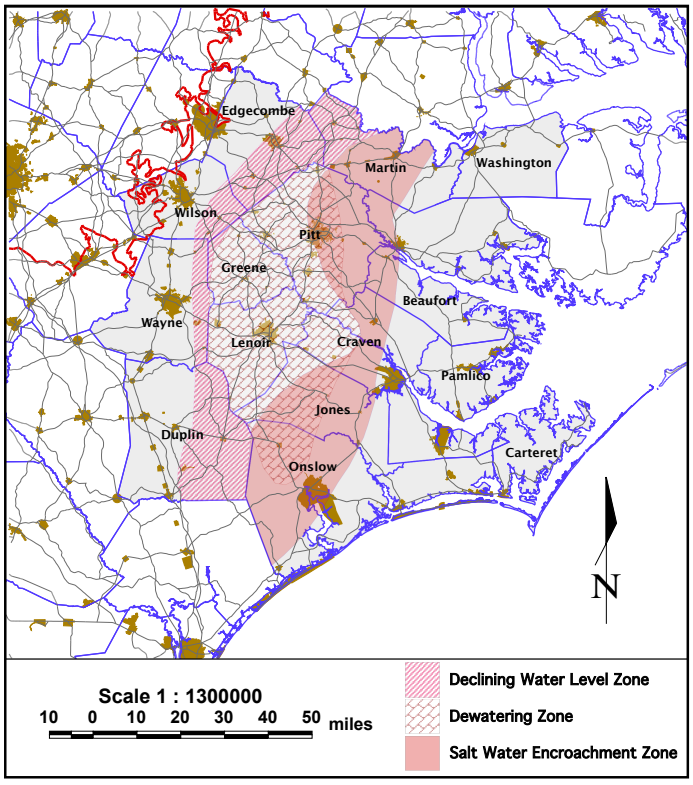
The Central Coastal Plain Capacity Use Area (CCPCUA) is a 15-county region in the coastal plain that is an example of a water overuse situation. On August 1, 2002, the CCPCUA rules came into effect because of significant groundwater depletion problems. As stated in 15A NCAC 2E .0501, "the intent of this Section [the CCPCUA rules] is to protect the long term productivity of aquifers within the designated area and to allow the use of groundwater for beneficial uses at rates which do not exceed the recharge rate of the aquifers…" For many years, water was withdrawn from the deep confined aquifers, which are a primary source of water in the CCPCUA, at a rate that was greater than they were naturally recharged. If this situation had been allowed to continue indefinitely, the aquifers could have been permanently damaged, impairing their ability to function as a water supply.

The goal of the DWR is to regulate water withdrawals in the Central Coastal Plain (CCP) under the authority of the Environmental Management Commission (EMC). The following summarizes how these withdrawals are regulated:

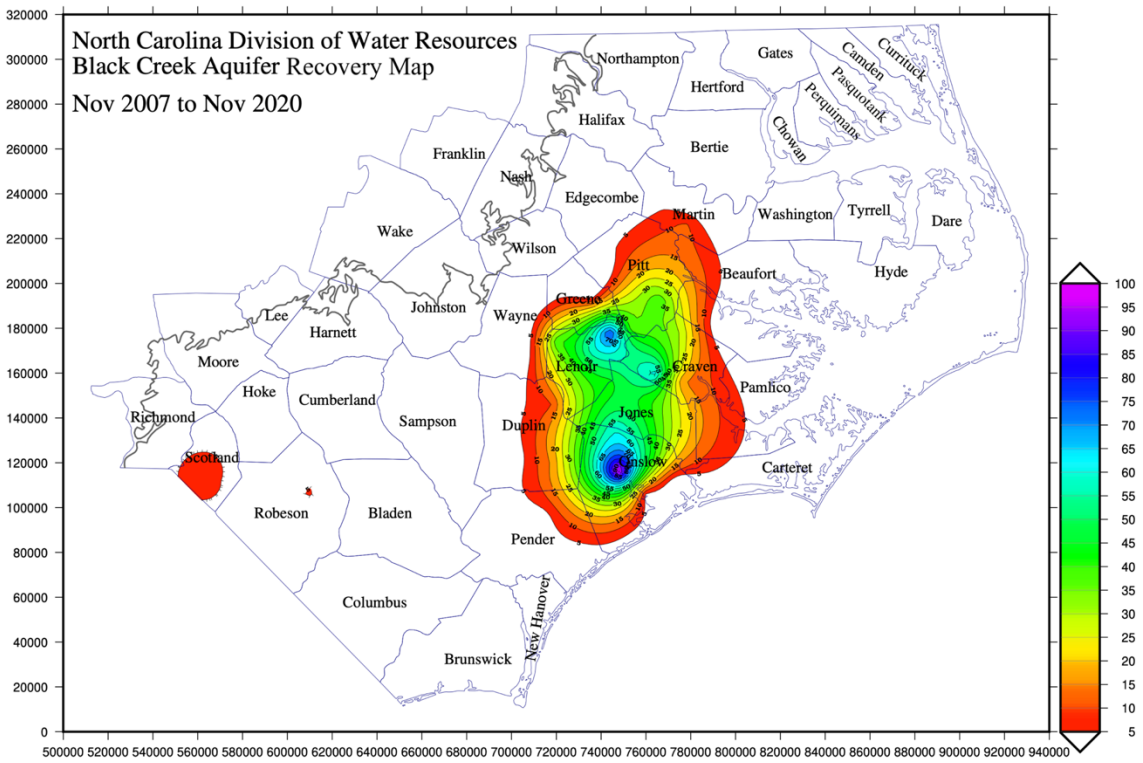
- Water withdrawal permits are required for groundwater users who withdraw greater than 100,000 gallons of water per day.
- Annual registration and reporting of withdrawals is required for surface and groundwater withdrawals greater than 10,000 gallons per day.
- Counties included in the CCPCUA are Beaufort, Carteret, Craven, Duplin, Edgecombe, Greene, Jones, Lenoir, Martin, Onslow, Pamlico, Pitt, Washington, Wayne, and Wilson.

DWR collects depth to water level measurements and water quality sampling event data from monitor wells within the state's well network and CCPCUA permitted wells to assess aquifer conditions. 15A NCAC 2E .0503 requires that DWR assess aquifer conditions in 2008, 2013 and 2018 to determine if CCPCUA rule changes are necessary. Through the CCPCUA permitting system, large groundwater users (>100,000 gpd) in some parts of the capacity use area were required to progressively reduce withdrawals in 2008, 2013, and 2018 to allow the aquifers to recover. The managed withdrawals from these aquifers have allowed the aquifers to recover as depicted in the following recovery maps of the Black Creek and Upper Cape Fear Aquifers.

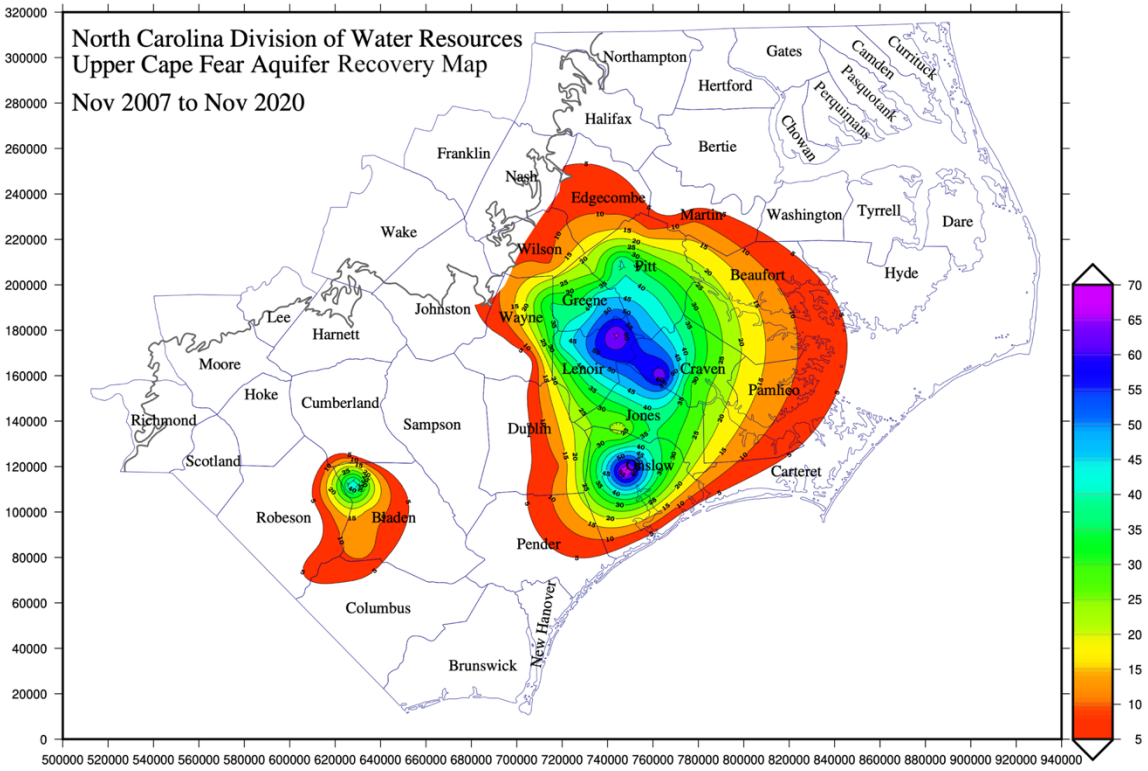
CCPCUA Cretaceous Aquifer Zones



The following map of the Black Creek Aquifer shows the areas where groundwater levels have risen between 5 feet (red) to more than 95 feet (pink) from November 2007 through November 2020. The largest recovery is observed in the Onslow County area where water users have made large investments in developing the Castle Hayne aquifer as an alternate water source.



The following map of the Upper Cape Fear Aquifer shows the areas where groundwater levels have risen between 5 feet (red) to more than 65 feet (purple) from November 2007 through November 2020. The largest recovery is observed in the Lenoir County area due to the development of a surface water treatment plant on the Neuse River in 2008, and Craven County area which developed wells in the Castle Hayne aquifer as an alternate water source.



Based on analysis of water level and water quality concentration data gathered through January 2013 in the CCPCUA, and a thorough review of aquifer conditions, DWR concluded that no action needed to be taken by the EMC to alter either the reduction zone boundaries or rule language in 15A NCAC 2E .0503 but recommended the use of temporary permits under rule.0502. This may give certain permit holders a stable withdrawal rate which is higher than indicated by their reduction schedule and reduction zone, provided that all well construction and reporting criteria are met as specified in the 2013 CCPCUA Assessment Report, which can be viewed at https:/www.ncwater.org/CCPCUA under the miscellaneous link.

DWR uses a series of criteria to evaluate each production well and aquifer conditions by individual permit in the permitting process. This enhanced permit application review allows the division to alter an individual permit holder's reduction requirements if the permit holder can demonstrate they are using the groundwater at a sustainable rate. As of June 30, 2021, the following twelve permit holders have acquired temporary permits: Greene County Regional Water System, Craven County Water, Jones County Regional Water, City of New Bern, Town of La Grange, Town of Snow Hill, Town of Winterville, Belfast-Patetown Sanitary District, Northwestern Wayne Sanitary District, Southeastern Wayne Sanitary District, Fork Township Sanitary District, and Chinquapin Water Association, Inc.

Although the CCPCUA rules require assessments to be produced in 2008, 2013, and 2018, the DWR staff will continue to constantly track aquifer conditions to best serve the permit holders in the region and to provide awareness of potential groundwater supply issues. The 2018 assessment concluded with the EMC's approval of the report on October 10, 2018. The assessment report reviewed aquifer data in a similar fashion to previous efforts in 2008 and 2013. Water levels in the Black Creek and Upper Cape Fear aquifers were found to be equilibrating to the lower rate of aquifer use as water systems continue to shift demand to other sources which include surface water and shallower aquifers. While water level data are consistent with sustainable use of the aquifer system, chloride concentrations are somewhat inconsistent. Smaller and static cones of depression have developed in the Peedee and Castle Hayne aquifers in response to new well fields and are only visible using the combined DWR and permit holder water level data. Figures 10 through 16 depict the water levels provided by the CCPCUA permit holders and DWR's groundwater monitoring stations in each of the seven major aquifers in the Coastal Plain Physiographic Province. Figure 10 (Yorktown Aquifer Potentiometric Surface Map), Figure 11 (Castle Hayne Aquifer Potentiometric Surface Map), Figure 12 (Beaufort Aquifer Potentiometric Surface Map), Figure 13 (Peedee Aquifer Potentiometric Surface Map), Figure 14 (Black Creek Aquifer Potentiometric Surface Map), Figure 15 (Upper Cape Fear Aquifer Potentiometric Surface Map), and Figure 16 (Lower Cape Fear Aquifer Potentiometric Surface Map).

Reports referencing the CCPCUA rules along with water use and permit holder information may be viewed by visiting the DWR's CCPCUA website, https:/www.ncwater.org/CCPCUA. Figure 17 is a summary of water withdrawals reported by permit holders and registrants within the CCPCUA for the calendar year 2020 is included in. Water withdrawal summaries of historical years may be found on the CCPCUA website.

N.C. General Statute 150B-21.3A requires state agencies to review existing rules every 10 years, determine which rules are still necessary, and either re-adopt or repeal each rule as appropriate. In May of 2021, a public hearing was held for the Rules Re-adoption of 15A NCAC O2E (Water Use Registration and Allocation). The public comment period ended July 2, 2021. DWR staff will submit the Hearing Officers report to the Environmental Management Commission in November 2021.

10.0 Summary and Conclusions

DWR and its predecessor agencies have maintained and monitored a statewide network of groundwater monitoring wells used to assess North Carolina's groundwater supply since the 1960s.

Data collected from the monitoring well network are available to the public through DWR's Internet website, https://www.ncwater.org/GWMB. These data include, but are not limited to, groundwater levels, chloride measurements, well construction information, lithological and geophysical logs, groundwater monitoring station locations, well coordinates and elevations, and data from many non-DWR wells.

The monitoring well network consists of 703 monitoring wells at 234 individual stations. From July 2020 through June 2021, groundwater level data were collected from 704 wells within the network. These data include manual measurements taken quarterly from wells plus hourly water levels collected using automatic data recorders from 589 wells.

Sixteen STS units have been installed as of FY 2021 on drought monitoring network wells. The addition of the STS units replace monthly site visits, allow access to current water level data, and provide positive economic impacts.

Chloride sampling was performed on 413 wells from September through November 2019. Sampling results indicated that there continues to be concern for salt water encroachment especially near larger pumping centers located near the fresh water – salt water interface. Chloride levels were collected in 45 Black Creek wells. Of these, eight wells showed chloride increases since 2017 and nine wells exceeded 250 mg/l. Chloride levels were collected in 52 Upper Cape Fear wells. Of these, five wells showed chloride increases since 2017 and eleven wells exceeded 250 mg/l. Chloride levels were collected in 27 wells from the Lower Cape Fear aquifer. Of these, five wells showed increases since 2017 and twelve wells had chloride levels exceeding 250 mg/l.

In FY 2021, five monitoring wells were installed at the Turkey Station and three wells were installed at the Pondberry Bay Station in Sampson County, and three wells were installed at the DF Walker Elementary School in Chowan County.

Four existing wells, Nashville Well 2 (I 31H1), Nashville Well 4 (I 31I1), Nashville Well 8 (I 31N1), in Nash County, and Stone Mountain (D 68G1) Stone Mountain State Park in Wilkes County, were acquired and added to the monitoring well network in FY 2021.

Two wells, Turkey Station (U 34B4, and U 34B6) in Sampson County, were abandoned during FY 2021. Two wells, Scotts Hill (Q 32D1) in Wayne County and Moss Hill (R 29T2) in Lenoir County, were removed from the active well network during FY 2021.

There are three local networks whose water level data are currently being uploaded to the DWR database. The OWN in Orange County, the Guilford County network, and the WCHRS in Jackson County water level data can be viewed by the public on the DWR website.

Survey monuments have been installed at each of the well stations. Survey Grade GPS will be performed on the newly installed and acquired well stations during FY 2022.

DWR has tentative plans to expand the monitoring well network by installing up to 23 wells at seven sites in FY 2022.

Monitoring well network expansion efforts for FY 2022 will focus mainly on Sampson, Chowan, Currituck, Edgecombe, Onslow, Scotland, and Robeson counties.

Groundwater quality staff collected groundwater samples from thirty-five (35) monitoring stations in FY 2021. Samples were analyzed and results were added to the water quality database.

Fifteen counties in the Central Coastal Plain are governed by the Central Coastal Plain Capacity Use Area rules. Data collected from the monitoring well network is being used to assess aquifer conditions and determine whether or not changes to the rules are warranted. Based on the results of the 2018 assessment, concluding with the EMC's approval of the report on October 10, 2018, DWR did not pursue rule changes. Instead, DWR will continue issuing temporary permits under rule 15A NCAC 2E .0502 which can ease withdrawal reduction requirements for certain permit holders but adds other permit conditions.

N.C. General Statute 150B-21.3A requires state agencies to review existing rules every 10 years, determine which rules are still necessary, and either re-adopt or repeal each rule as appropriate. In May of 2021, a public hearing was held for the Rules Re-adoption of 15A NCAC O2E (Water Use Registration and Allocation). The public comment period ended July 2, 2021. DWR staff will submit the Hearing Officers report to the Environmental Management Commission in November 2021.

FIGURES

Figure 1
NC Division of Water Resources - Ground Water Management Branch
Monitoring Well Station Locations
2021 Annual Report

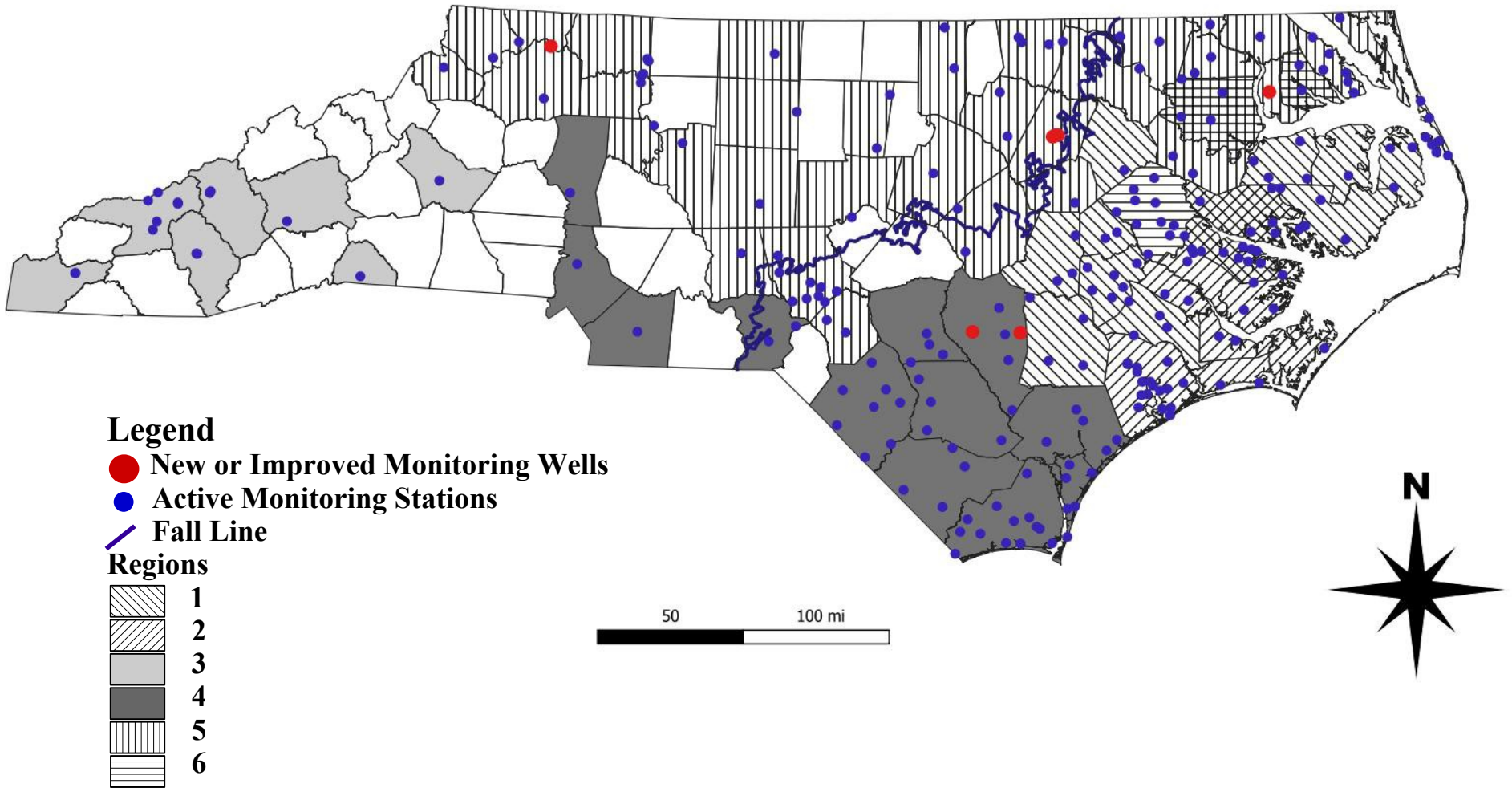


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Figure 2
NC Division of Water Resources – Ground Water Management Branch
Drought Indicator Well Network
2021 Annual Report

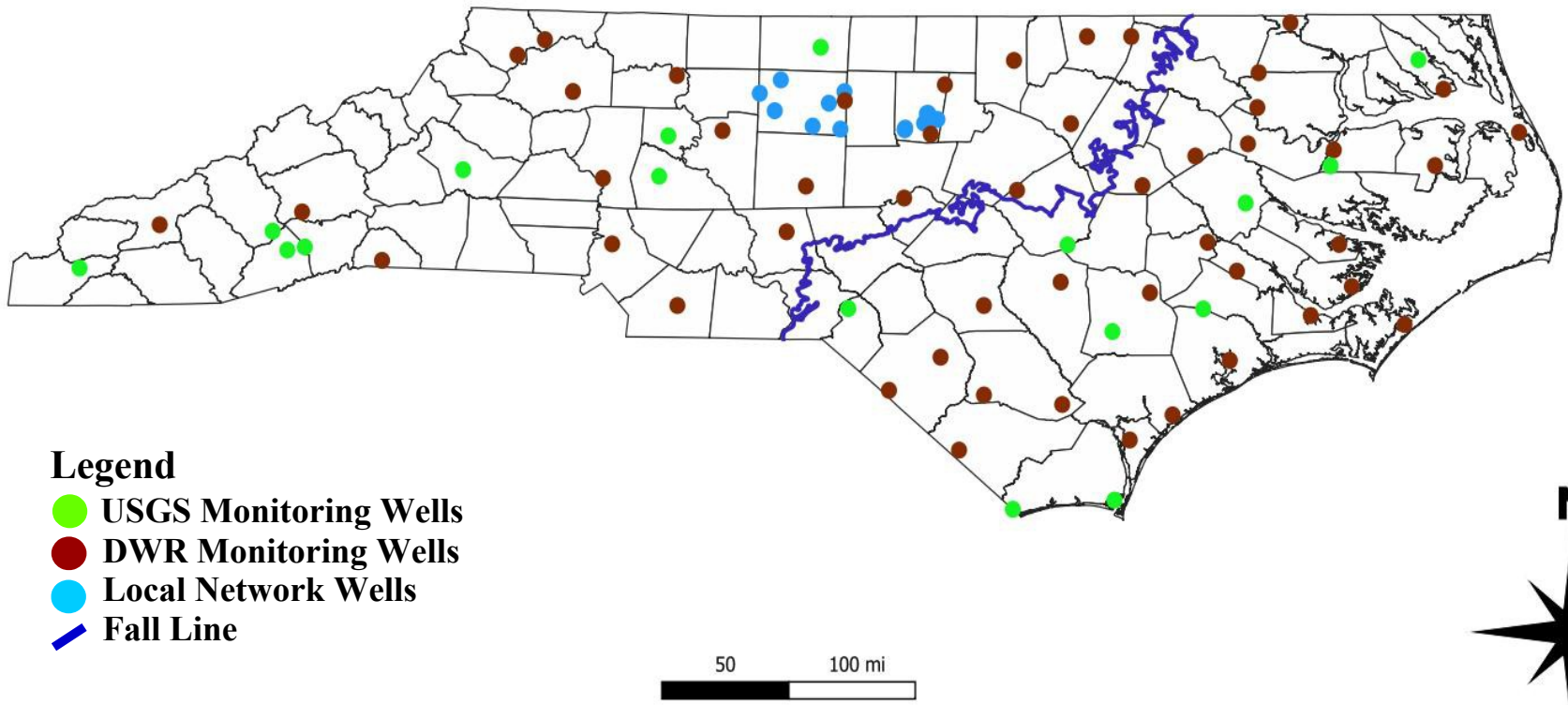


Figure 3
NC Division of Water Resources – Groundwater Management Branch
Water Level Data Plot
2021 Annual Report

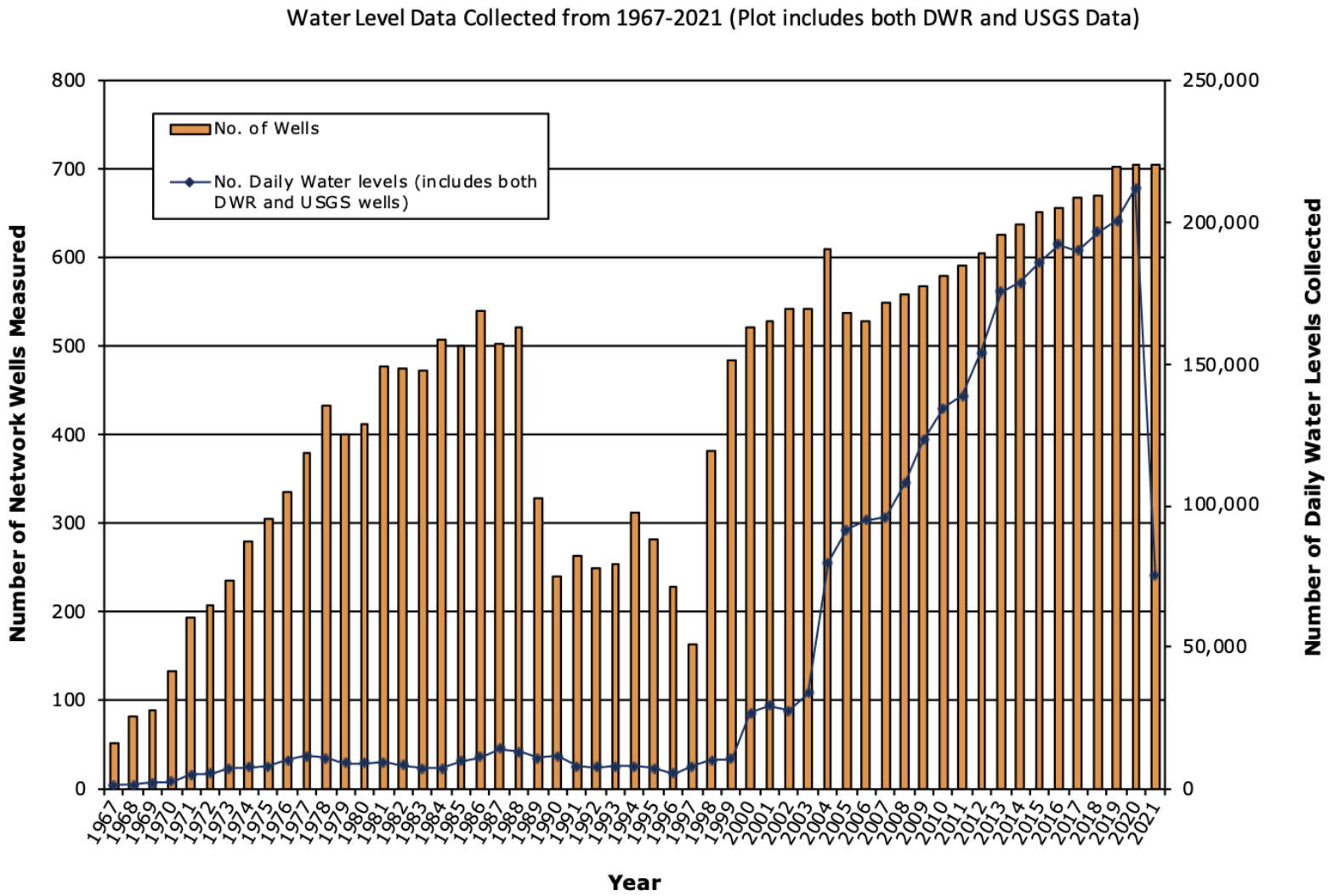
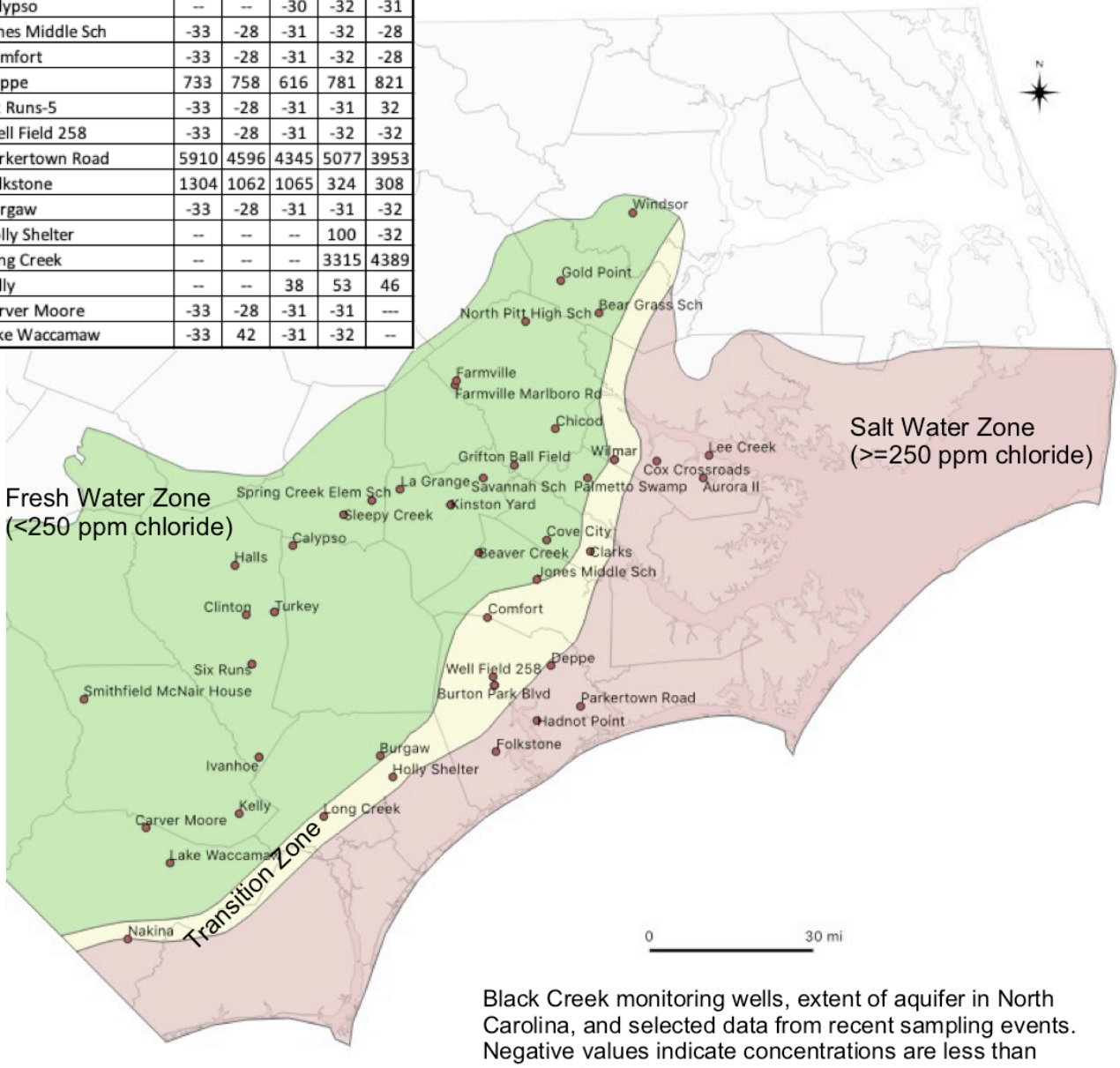


Figure 4
NC Division of Water Resources
Groundwater Management Branch
Chloride Levels in the Cretaceous Black Creek Aquifer
2021 Annual Report

MONITORING STATION	2010	2012	2015	2017	2019
	CHLORIDES (mg/l)				
Windsor	--	-28	-31	-26	-32
Gold Point	-33	-28	-31	-31	-32
Bear Grass Sch	-33	-28	-31	-26	61
Chicod	49	35	38	45	46
Lee Creek	6766	6888	7904	9056	7906
Wilmar-5	400	434	--	496	468
Wilmar-9	239	194	--	188	211
Palmetto Swamp	49	35	38	45	39
Grifton Ball Field	-28	-28	-31	-32	-32
Aurora II	6765	7562	9634	8124	9794
La Grange	--	-28	-31	-32	-32
Spring Creek Elem Sch-3	--	--	-31	-32	-32
Cove City	-33	-28	-31	-32	-28
Clarks	54	179	144	136	153
Beaver Creek	-33	-28	-31	-32	-28
Calypso	--	--	-30	-32	-31
Jones Middle Sch	-33	-28	-31	-32	-28
Comfort	-33	-28	-31	-32	-28
Deppe	733	758	616	781	821
Six Runs-5	-33	-28	-31	-31	32
Well Field 258	-33	-28	-31	-32	-32
Parkertown Road	5910	4596	4345	5077	3953
Folkstone	1304	1062	1065	324	308
Burgaw	-33	-28	-31	-31	-32
Holly Shelter	--	--	--	100	-32
Long Creek	--	--	--	3315	4389
Kelly	--	--	38	53	46
Carver Moore	-33	-28	-31	-31	---
Lake Waccamaw	-33	42	-31	-32	--

Figure 4 is based on the 2019 fall chloride sampling event (which is also the most recent chloride sampling event performed by DWR staff)

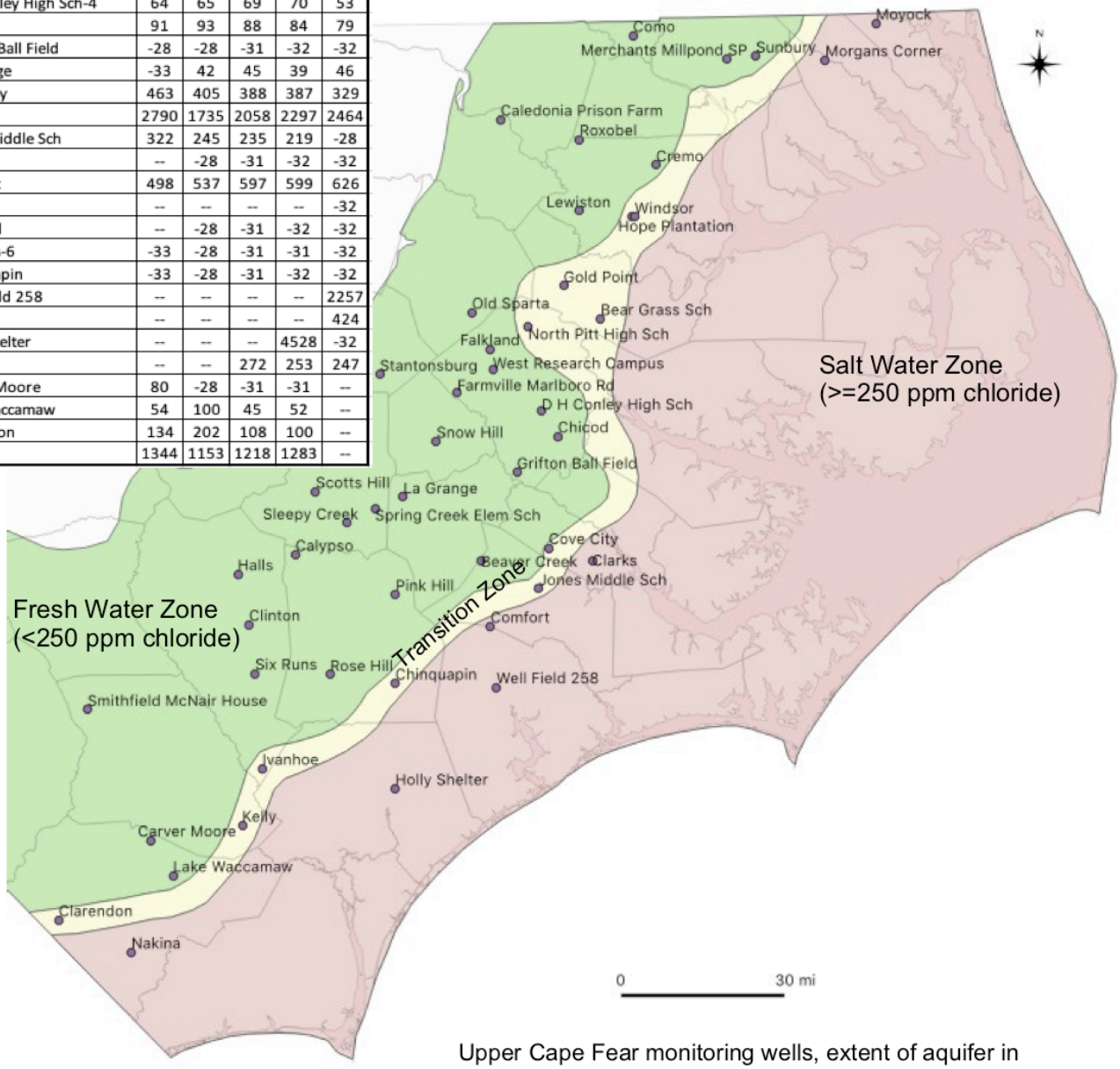


Black Creek monitoring wells, extent of aquifer in North Carolina, and selected data from recent sampling events. Negative values indicate concentrations are less than amount shown.

Figure 5
NC Division of Water Resources
Groundwater Management Branch
Chloride Levels in the Cretaceous Upper Cape Fear Aquifer
2021 Annual Report

MONITORING STATION	2010	2012	2015	2017	2019
	CHLORIDES (mg/l)				
Moyock	943	826	744	717	686
Morgans Corner	733	580	535	599	537
Merchants Millpond SP	--	--	--	--	53
Cremo-6	-33	28	-31	-26	-32
Roxobel	-33	-28	-31	-26	-32
Windsor	--	236	144	194	164
Lewiston	-33	-28	-31	-26	-32
Gold Point-3	54	172	186	164	136
Gold Point-7	372	343	362	416	331
Bear Grass Sch	-33	111	45	50	32
Old Sparta	-33	56	31	41	-31
North Pitt High Sch-4	463	284	293	314	267
North Pitt High Sch-5	400	327	--	337	331
Falkland	-33	-28	-31	-32	-32
West Research Campus-5	54	57	61	59	89
D H Conley High Sch-4	64	65	69	70	53
Chicod	91	93	88	84	79
Grifton Ball Field	-28	-28	-31	-32	-32
La Grange	-33	42	45	39	46
Cove City	463	405	388	387	329
Clarks	2790	1735	2058	2297	2464
Jones Middle Sch	322	245	235	219	-28
Pink Hill	--	-28	-31	-32	-32
Comfort	498	537	597	599	626
Clinton	--	--	--	--	-32
Rose Hill	--	-28	-31	-32	-32
Six Runs-6	-33	-28	-31	-31	-32
Chinquapin	-33	-28	-31	-32	-32
Well Field 258	--	--	--	--	2257
Ivanhoe	--	--	--	--	424
Holly Shelter	--	--	--	4528	-32
Kelly	--	--	272	253	247
Carver Moore	80	-28	-31	-31	--
Lake Waccamaw	54	100	45	52	--
Clarendon	134	202	108	100	--
Nakina	1344	1153	1218	1283	--

Figure 5 is based on the 2019 fall chloride sampling event (which is also the most recent chloride sampling event performed by DWR staff)

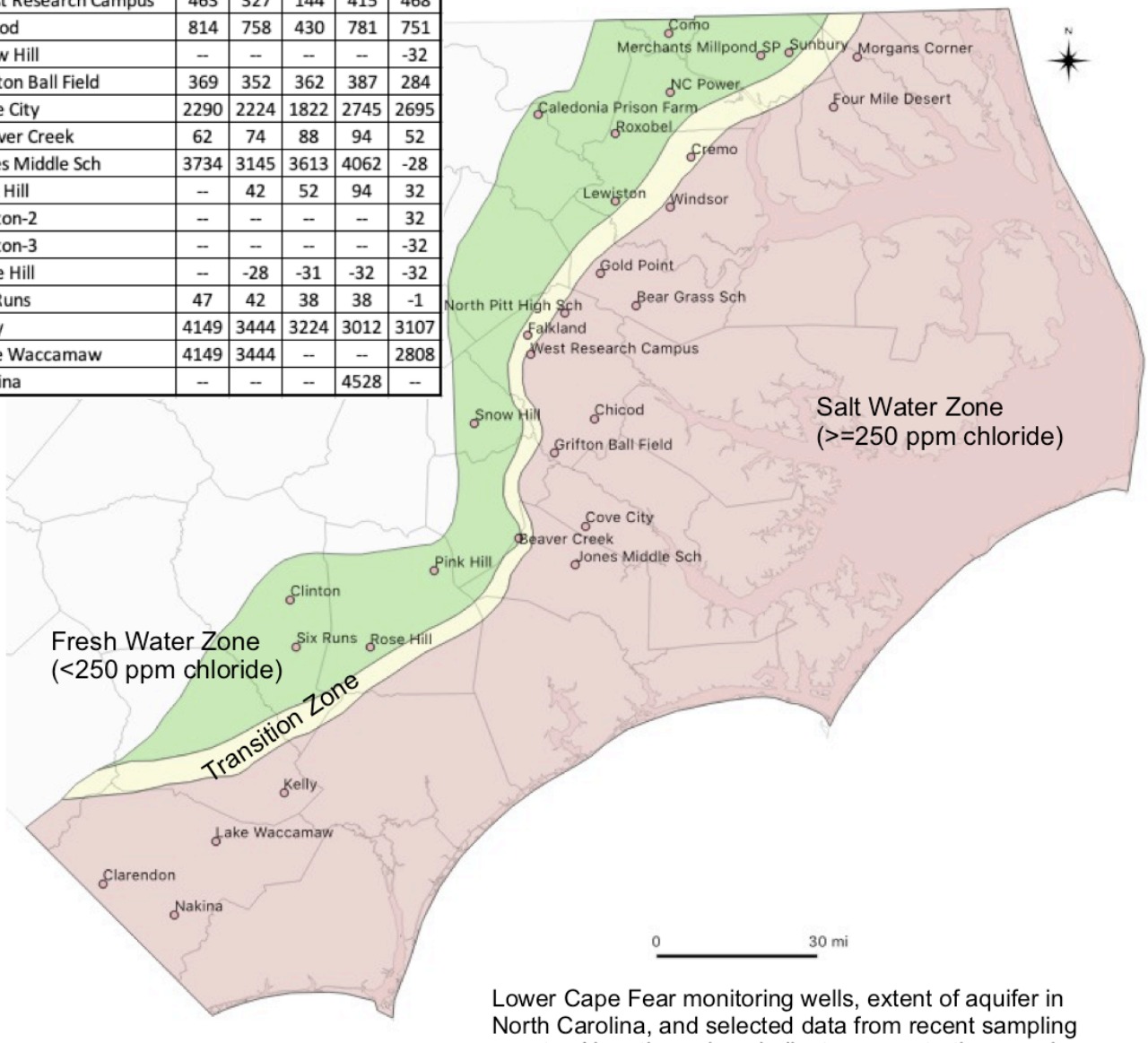


Upper Cape Fear monitoring wells, extent of aquifer in North Carolina, and selected data from recent sampling events. Negative values indicate concentrations are less than amount shown.

Figure 6
NC Division of Water Resources
Groundwater Management Branch
Chloride Levels in the Cretaceous Lower Cape Fear Aquifer
2021 Annual Report

Figure 6 is based on the 2019 fall chloride sampling event (which is also the most recent chloride sampling event performed by DWR staff)

MONITORING STATION	2010	2012	2015	2017	2019
	CHLORIDES (mg/l)				
Como-6	90	93	88	90	46
Como-7	-33	28	-31	-31	-32
Morgans Corner	5096	5095	3853	3662	3953
Sunbury	160	103	--	--	--
Merchants Millpond SP	--	--	--	--	308
NC Power	--	--	--	--	-32
Four Mile Desert	--	--	--	--	1748
Cremo	174	126	132	137	39
Roxobel	-33	28	-31	26	-32
Windsor	--	1220	430	449	381
Lewiston	40	35	-31	-26	-32
Gold Point	868	892	791	781	751
Bear Grass Sch	1023	2420	655	1283	--
North Pitt High Sch	798	758	655	645	751
Falkland	239	227	201	-32	89
West Research Campus	463	327	144	415	468
Chicod	814	758	430	781	751
Snow Hill	--	--	--	--	-32
Grifton Ball Field	369	352	362	387	284
Cove City	2290	2224	1822	2745	2695
Beaver Creek	62	74	88	94	52
Jones Middle Sch	3734	3145	3613	4062	-28
Pink Hill	--	42	52	94	32
Clinton-2	--	--	--	--	32
Clinton-3	--	--	--	--	-32
Rose Hill	--	-28	-31	-32	-32
Six Runs	47	42	38	38	-1
Kelly	4149	3444	3224	3012	3107
Lake Waccamaw	4149	3444	--	--	2808
Nakina	--	--	--	4528	--



Lower Cape Fear monitoring wells, extent of aquifer in North Carolina, and selected data from recent sampling events. Negative values indicate concentrations are less than amount shown.

Figure 7
NC Division Water Resources - Groundwater Management Branch
Orange Well Net Cooperative Monitoring Well Network
Orange County, NC
2021 Annual Report

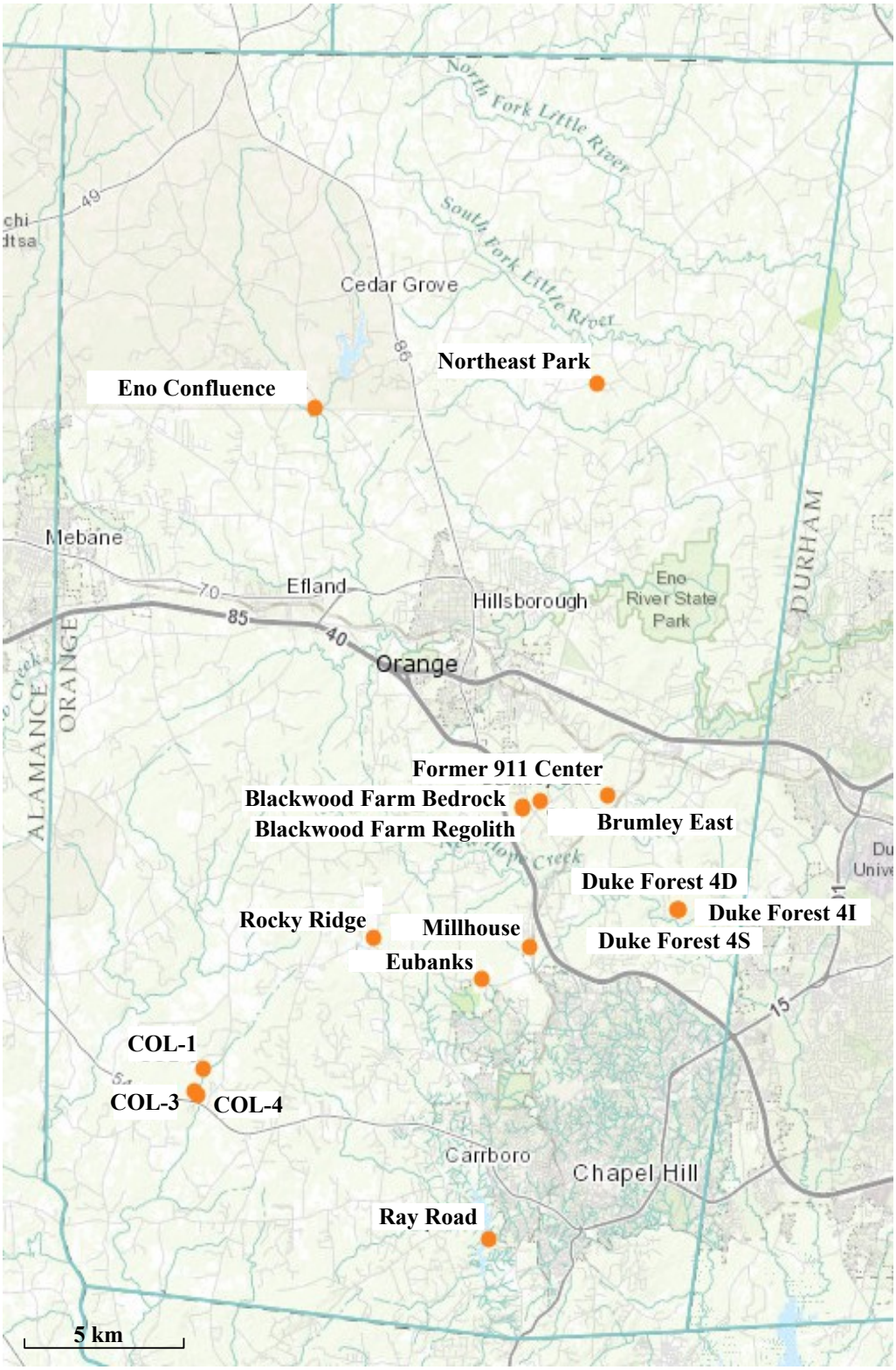


Figure 8
NC Division of Water Resources Ground Water Management Branch
Guilford County Cooperative Monitoring Well Network
Guilford County, NC
2021 Annual Report

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Figure 9

NC Division of Water Resources - Ground Water Management Branch
Western Carolina Hydrological Research Station
Cooperative Monitoring Well Network
Jackson County, NC
2021 Annual Report

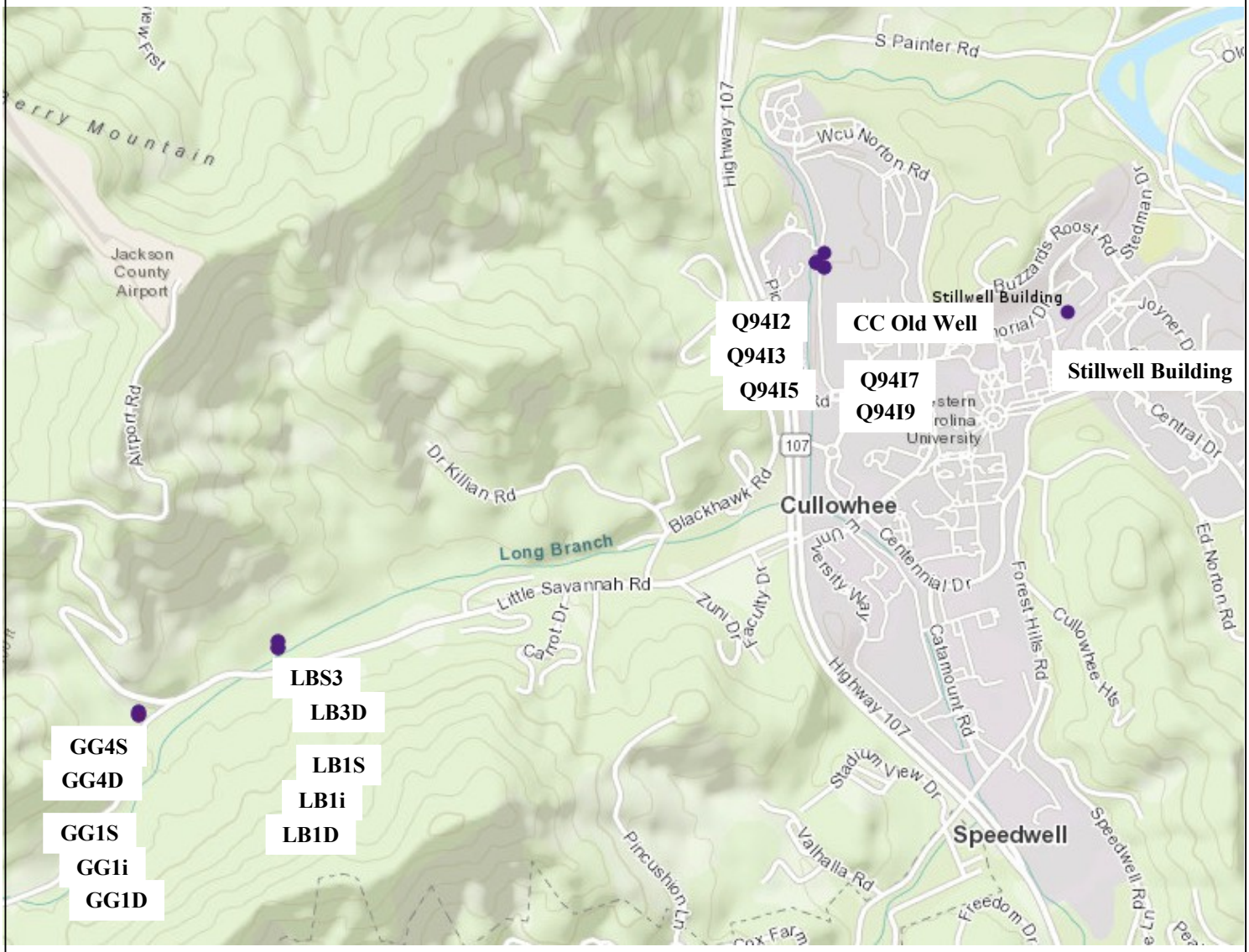

Figure 10

NC Division of Water Resources - Groundwater Management Branch

Yorktown Aquifer Potentiometric Surface Map

2021 Annual Report

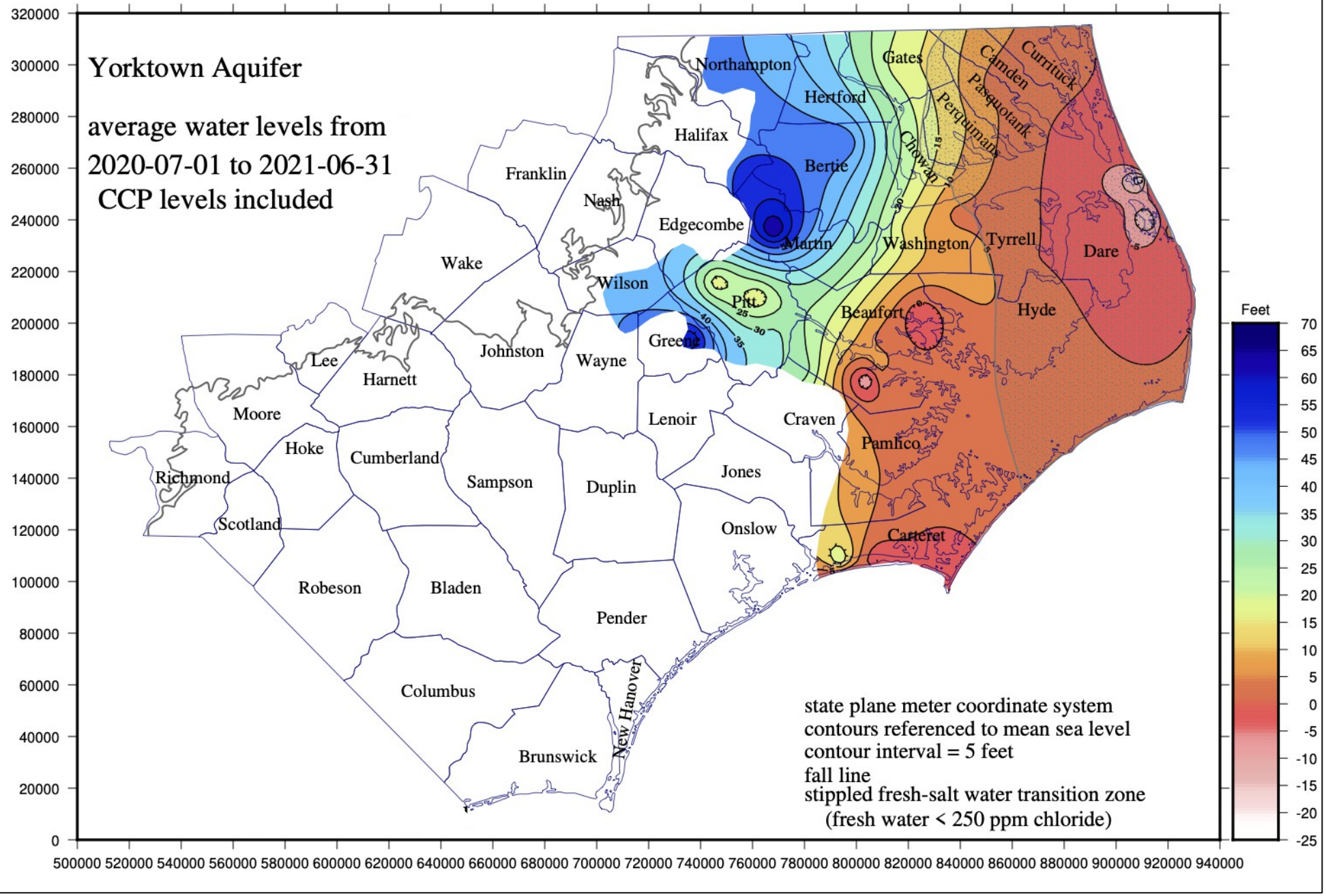

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Figure 11
NC Division of Water Resources - Groundwater Management Branch
Castle Hayne Aquifer Potentiometric Surface Map
2021 Annual Report

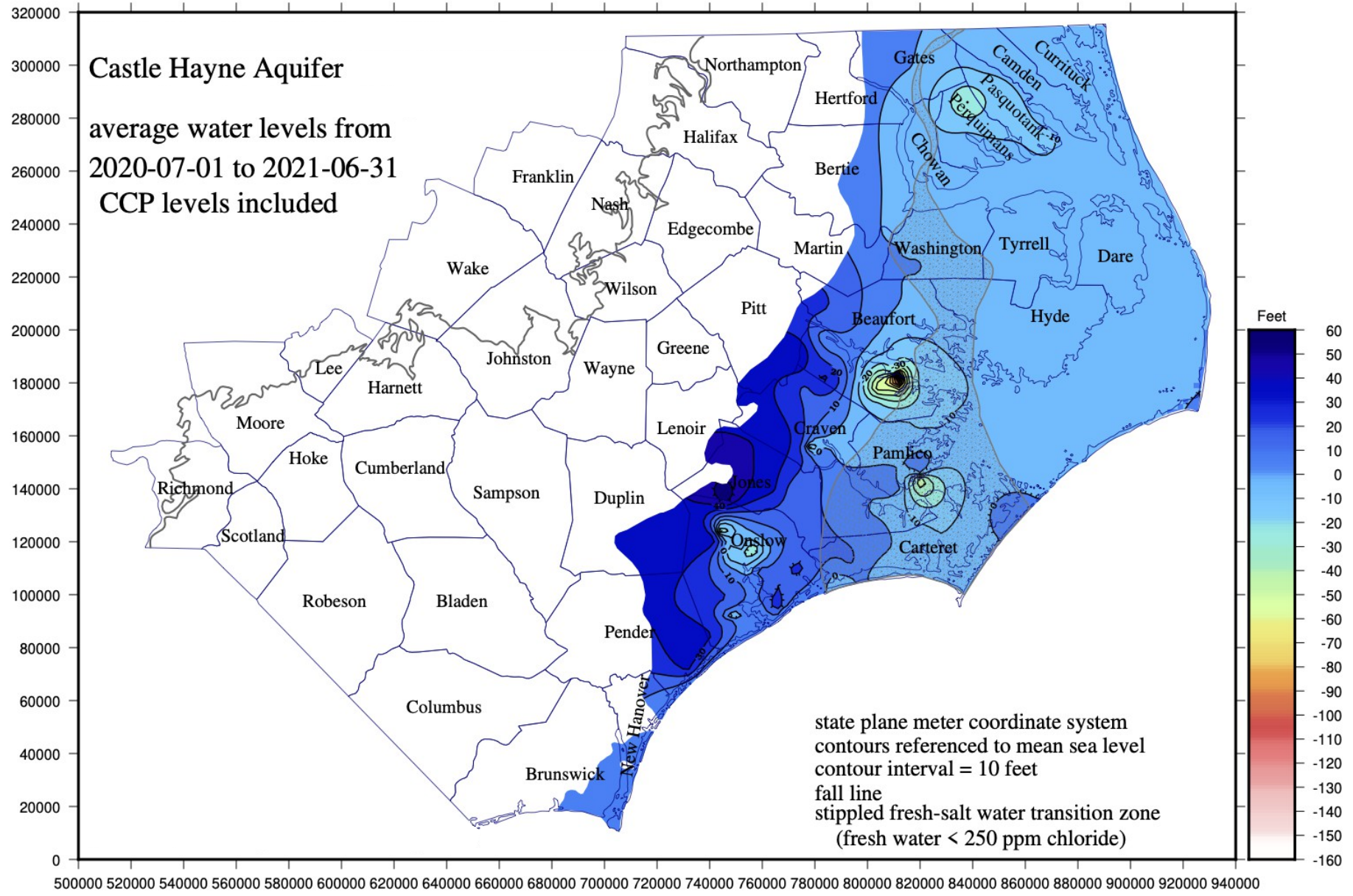

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Figure 12
NC Division of Water Resources - Groundwater Management Branch
Beaufort Aquifer Potentiometric Surface Map
2021 Annual Report

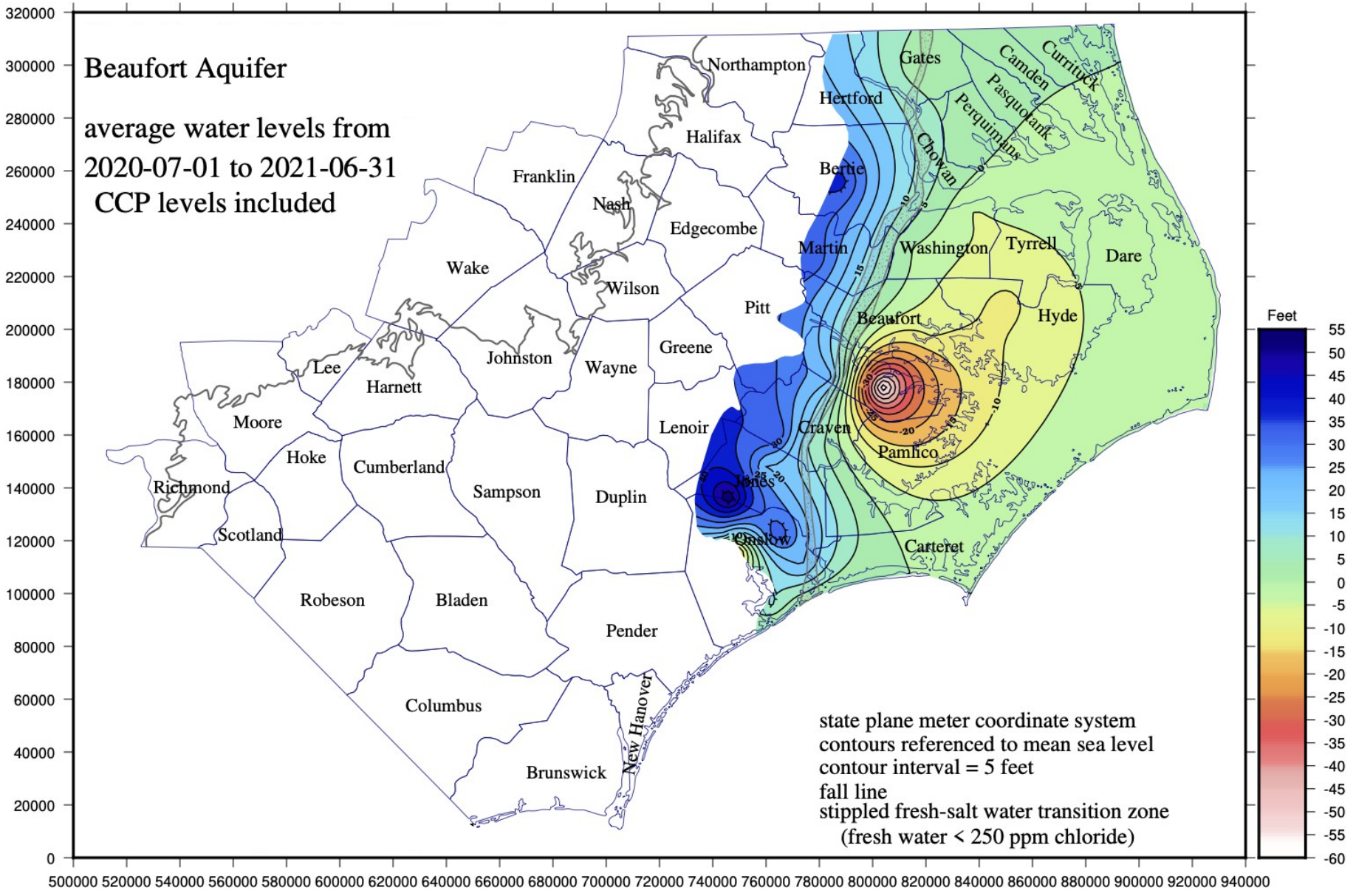

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Figure 13
NC Division of Water Resources - Groundwater Management Branch
Peedee Aquifer Potentiometric Surface Map
2021 Annual Report

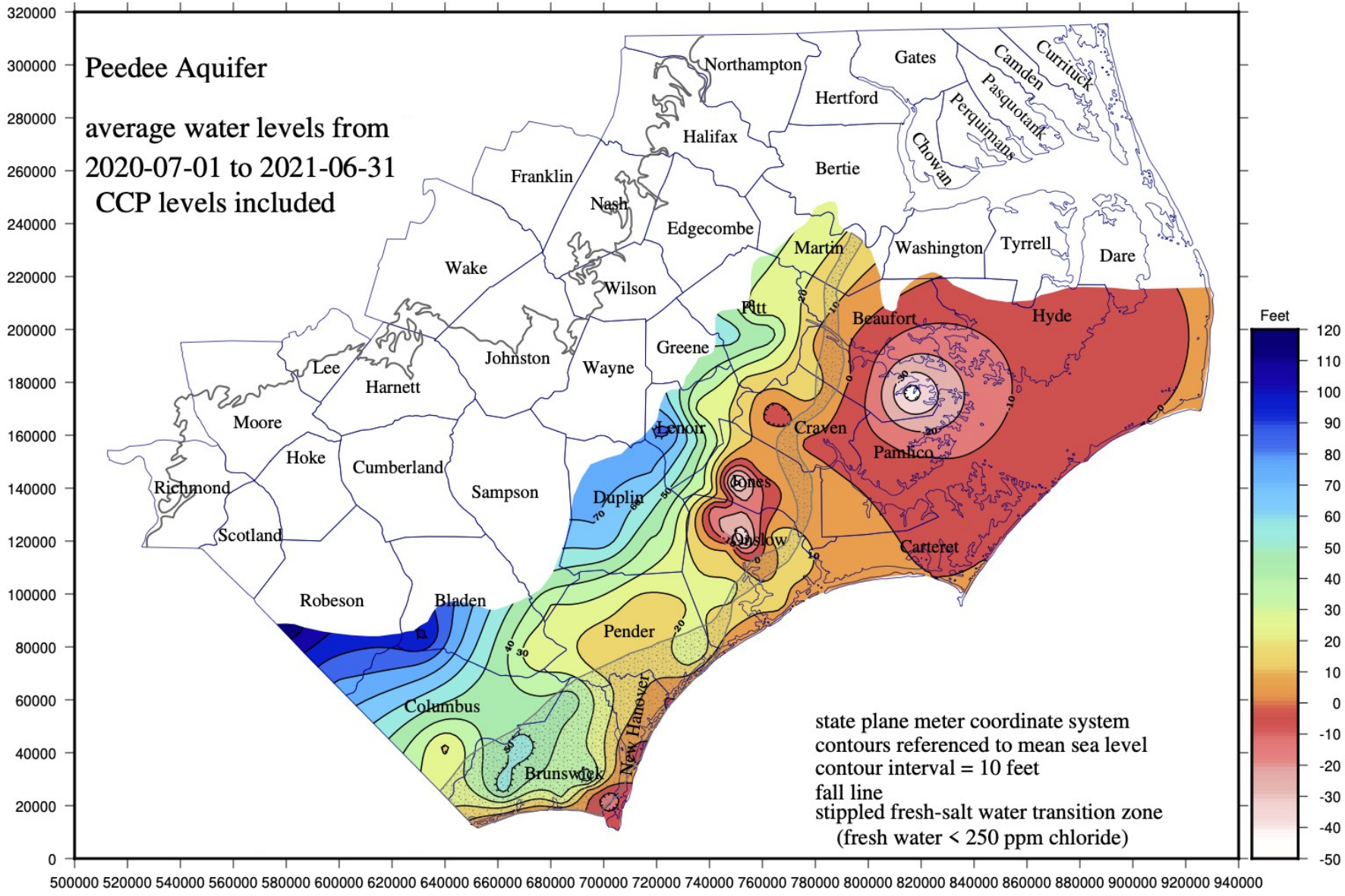

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Figure 14
NC Division of Water Resources - Groundwater Management Branch
Black Creek Aquifer Potentiometric Surface Map
2021 Annual Report

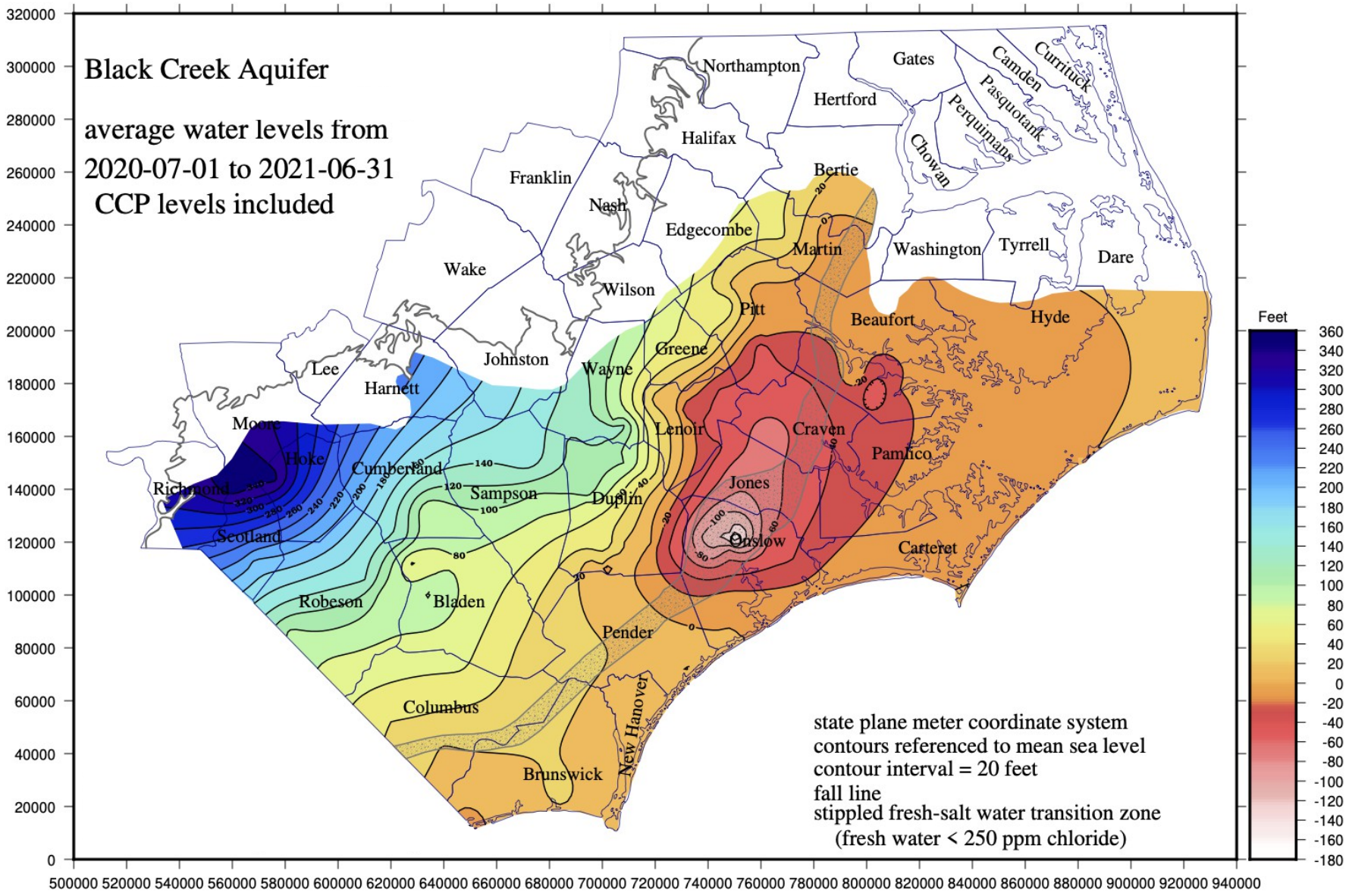

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Figure 15
NC Division of Water Resources - Groundwater Management Branch
Upper Cape Fear Aquifer Potentiometric Surface Map
2021 Annual Report

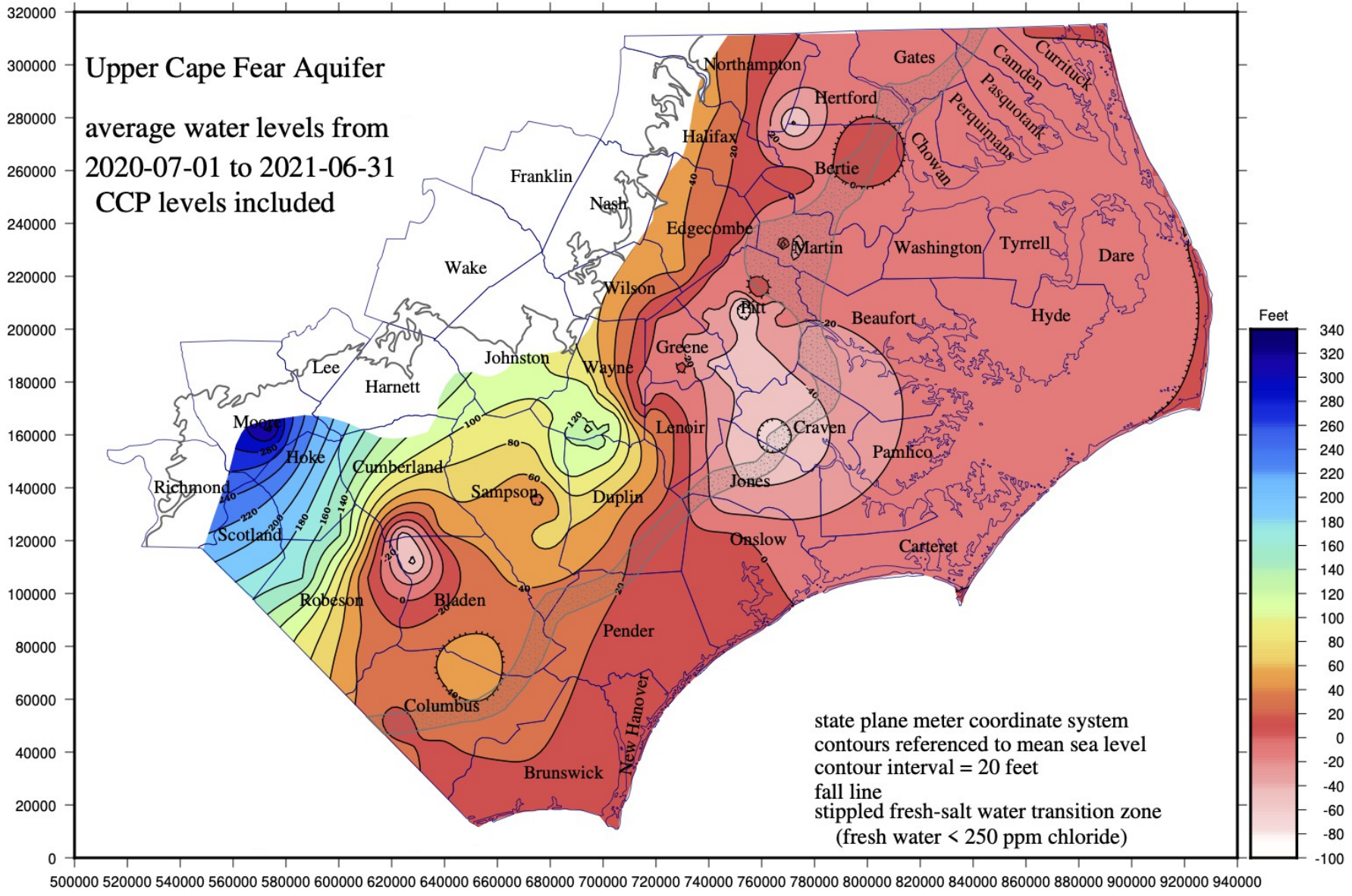

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Figure 16
NC Division of Water Resources - Groundwater Management Branch
Lower Cape Fear Aquifer Potentiometric Surface Map
2021 Annual Report

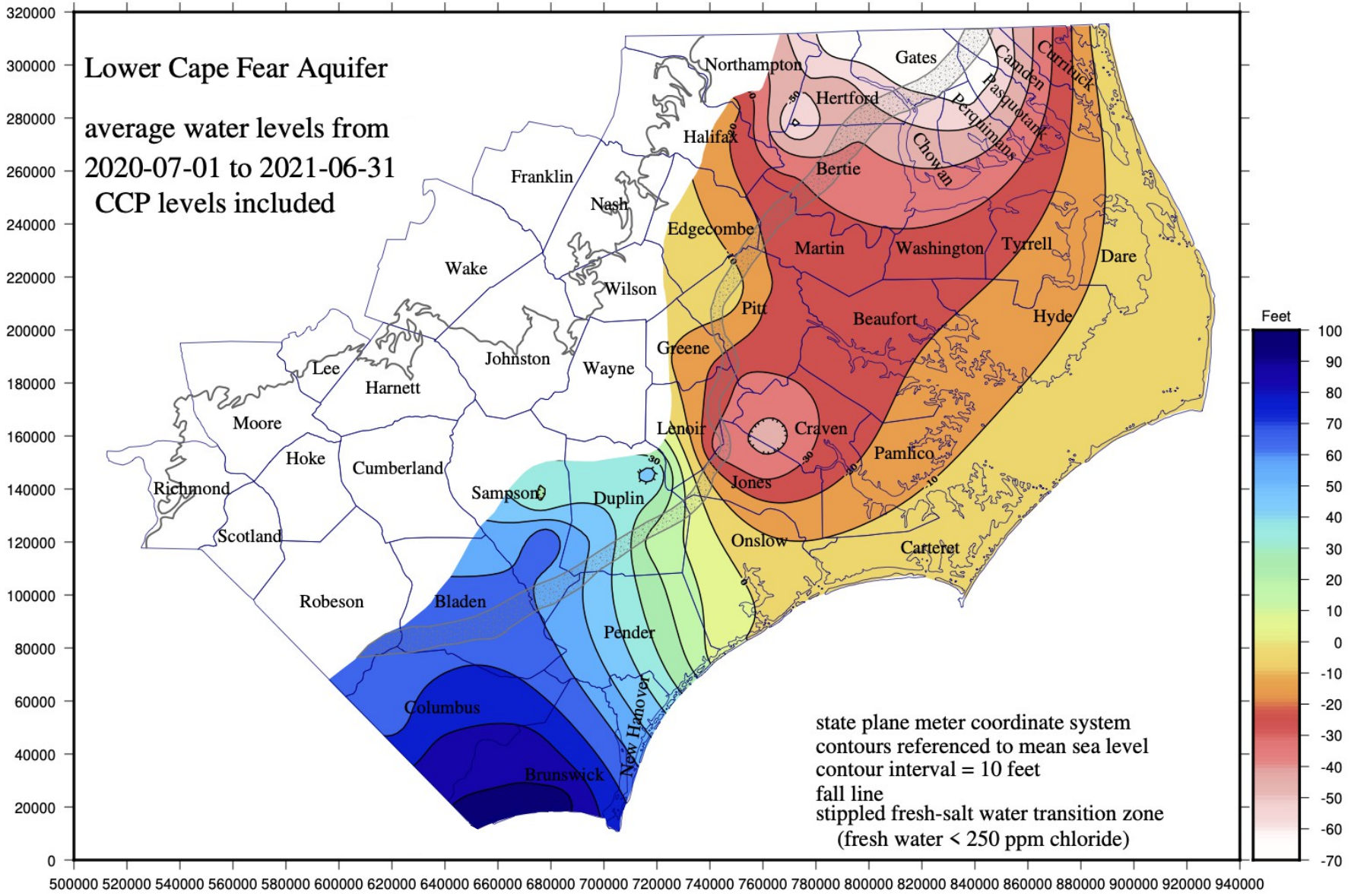

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Figure 17
NC Division of Water Resources - Groundwater Management Branch
CCPCUA 2020 Water Withdrawal Summary
2021 Annual Report

Central Coastal Plain Capacity Use Area 2020 Water Withdrawal Summary Tables

Tables compiled 07-09-2021, units are gallons per day

Permitted				Reported for 2020					
Current Permit Limits				Ground Water					Surface Water
County	max daily	yearly (ABRs)	yearly (2018)	by all permits	# of permits	% reported	by yearly permits	by registrations	by registrations
Beaufort	181,356,400			47,444,846	40	60		1,580	285,478
Carteret	27,428,080			7,574,575	21	76		87,769	4,603
Craven	74,816,800	6,956,526	1,814,132	21,616,448	33	79	2,787,975	41,684	14,709,031
Duplin	73,552,325	2,805,747	2,297,255	7,893,385	66	73	1,879,808	99,751	3,315
Edgecombe	13,068,000	527,697	429,388	2,034,643	12	92	280,479		571,266
Greene	623,000	3,058,197	914,551	1,079,688	4	100	1,061,038	42,475	
Jones	48,929,600	679,282	169,821	16,942,948	9	56	394,553		
Lenoir	6,925,320	13,522,312	3,522,953	4,428,268	16	75	3,269,887		7,877,315
Martin	4,440,000	4,895,506	2,226,326	1,422,964	14	86	791,047	29,098	21,938,536
Onslow	62,400,600	9,845,143	2,461,286	23,736,632	19	63	3,549,701	178,667	
Pamlico	35,712,000			1,636,574	12	75			
Pitt	7,718,080	8,651,572	2,521,003	2,020,308	21	90	1,484,952	81,390	14,059,671
Washington	59,652,000			1,555,395	34	65		7,397	
Wayne	19,921,200	4,340,026	2,010,532	5,196,496	23	74	966,619		10,116,559
Wilson	6,464,160	658,883	491,218	1,107,289	7	86	368,918	174,961	9,116,354
Totals:	623,007,565	55,940,891	18,858,465	145,690,457	331**	73	16,834,976	744,772	78,682,128

Yearly permit limits are linked to withdrawals from the Cretaceous aquifers where reductions are mandated. As phased reductions occur, annual limits allow permit holders more flexibility to plan when withdrawals are made. ABR refers to "Approved Base Rate" and is the annual rate calculated based on 1997 or August 1, 1999 through July 31, 2000 withdrawals. The ABR is the annual rate from which reductions take place (see CCPCUA FAQs). "Yearly (2018)" is the final rate of withdrawal if all three phases of reduction are administered. Figures in the "by all permits" columns are total withdrawals reported by all permit holders (max day and yearly).

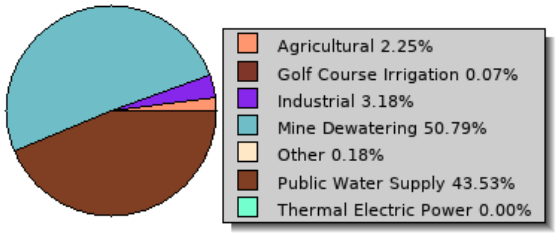
** A few permits have sources in two counties, so those permits are counted twice.

Permitted				Reported for 2020				
Current Permit Limits				Ground Water				Surface Water
Type of Use	max daily	yearly (ABRs)	yearly (2018)	by all permits	# of permits	% reported	by yearly permits	by registrations	by registrations
Agricultural	203,122,125	620,612	400,004	3,194,738	138	59	63,021	102,306	607,653
Golf Course Irrigation	3,954,000	85,589	85,589	62,658	11	64	2,762	42,624	61,377
Industrial	15,355,200	4,473,115	2,471,853	4,454,898	15	100	1,203,553	197,288	39,497,268
Mine Dewatering	251,842,080			74,295,593	61	70		75,450	574,581
Other	10,974,480	368,561	300,003	260,079	12	67	109,106		
Public Water Supply	137,759,680	50,393,015	15,601,016	63,422,492	86	97	15,456,535	327,104	37,941,249
Thermal Electric Power					86	97			
Totals:	623,007,565	55,940,891	18,858,465	145,690,457	323	73	16,834,976	744,772	78,682,128

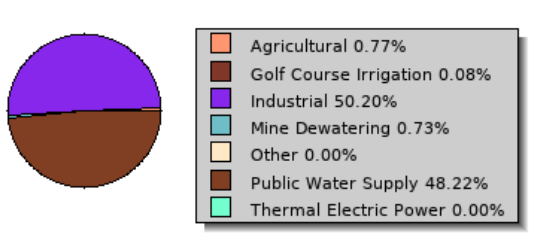
Permitted				Reported for 2020				
Current Permit Limits				Ground Water				
Aquifer	max daily	yearly (ABRs)	yearly (2018)	by all permits	# of permits	% reported	by yearly permits	by registrations
Basement rock	13,606,060			1,821,872	11	91		220,675
Black Creek	33,949,363	21,884,121	7,173,409	12,234,779	74	78	8,802,865	193,002
Peedee	18,940,050	6,877,228	1,785,236	1,585,163	21	76	116,815	81,789
Upper Cape Fear	51,795,362	27,129,542	9,849,819	13,523,865	90	86	7,899,774	194,617
Lower Cape Fear		50,001	50,001	75,032	1	100	15,522	
Surficial	130,695,630			26,746,532	71	64		175,593
Castle Hayne	335,972,850			88,860,391	129	66		353,142
Beaufort	3,495,250				1	100		61,253
Upper Tertiary								
Yorktown	34,553,000			842,824	18	49		6,315
Totals:	623,007,565	55,940,891	18,858,465	145,690,457	414**	73	16,834,976	744,772

** Many permits use multiple aquifers, so those permits are counted more than once.

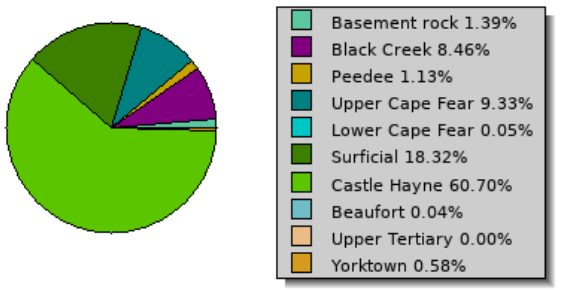
CCPCUA Reported Ground Water Withdrawals by Type of Use



CCPCUA Reported Surface Water Withdrawals by Type of Use



CCPCUA Reported Ground Water Withdrawals by Aquifer



TABLES

TABLE 1
Site Susceptibility Rating
North Carolina Division of Water Resources
Groundwater Management Branch
2021 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.

TABLE 2
Site and Recorder Distribution by Region as of 06/30/2021
North Carolina Division of Water Resources
Groundwater Management Branch
2021 Annual Report

Region	Parameter	Number	% of Region	% of Network
	Wells	151		21.6
1	Sites	45		19.3
	Hobo	129	85.4	18.4
	Solinst	1		
	Wells	177		25.3
2	Sites	39		16.7
	Hobo	159	89.8	22.7
	Solinst	0		
	Wells	15		2.1
3	Sites	15		6.4
	Hobo	12	80.0	1.7
	Solinst	2		
	Wells	185		26.4
4	Sites	55		23.6
	Hobo	140	75.7	20.0
	Solinst	6		
	Wells	121		17.3
5	Sites	66		28.3
	Hobo	108	89.3	15.4
	Solinst	7		
	Wells	51		7.3
6	Sites	13		5.6
	Hobo	48	94.1	6.9
	Solinst	0		

These are counts of the number of wells which have at least one recorder of the stated variety. These numbers do not indicate the total number of recorders deployed. For example, there are always two Solinst recorders on a well and only one is counted per well. In addition, Solinst recorders are always installed on wells with Hobos, so the number of Solinst recorders does not increase the total number of wells with recorders.

TABLE 3
Solinst Telemetry System (STS) Distribution by Region as of 06/30/2021
North Carolina Division of Water Resources
Groundwater Management Branch
2021 Annual Report

Region	Station Name	Well Number	Date Installed
1	Como	B 20U8	10/14/2014
1	Lewiston	H 22I3	06/20/2013
1	Manteo Airport	I 4W5	06/04/2014
1	Bunn	I 35K2	10/20/2016
2	Topsail Beach	BB 28J5	06/12/2014
3	Bryson City	O 97W2	02/18/2014
5	Clarendon	DD 42N1	04/24/2014
5	Rowland	Z 47R5	04/24/2014
5	Laurel Springs	C 71U1	10/11/2016
5	Gibsonville	G 50W2	09/26/2016
5	Wilkesboro	G 69J1	11/22/2016
5	Troutman	L 67U2	8/27/2014
5	NC Zoo	M 53L1	06/19/2014
5	Hornets Nest	Q 66C1	10/07/2014
5	Columbus	R 82I1	02/19/2014
5	Monroe	U 62A1	07/02/2014

TABLE 4
Monitoring Well Network Statistics (01/01/2005 through 6/30/2021)
North Carolina Division of Water Resources
Groundwater Management Branch
2021 Annual Report

Parameter	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Number of monitored wells	537	538	550	559	568	579	591	605	626	637
Manual water levels (tapedowns)	2,606	2,719	2,599	2,463	2,556	2906	2,624	2,953	3,265	2703
Daily water levels (automatic recorders	89,088	92,038	93,145	105,708	120,694	131,317	136,208	150,912	172,111	176,111
Total hourly water levels	2,141,368	2,229,355	2,294,909	2,593,630	2,961,371	3,163,188	3,276,496	3,622,891	4,128,993	4,225,684
Chloride Samples	17	22	175	12	17	251	21	274	13	10
Geophysical & lithologic logs at new stations	2	1	3	1	1	0	2	1	1	1

TABLE 4 (Continued)
Monitoring Well Network Statistics (01/01/2005 through 06/30/2021)
North Carolina Division of Water Resources
Groundwater Management Branch
2021 Annual Report

Parameter	2015	2016	2017	2018	2019	2020	2021
Number of monitored wells	651	655	667	671	702	705	704
Manual water levels (tapedowns)	3,140	2,996	3,477	3,890	4,085	3662	2065
Daily water levels (automatic recorders	182,907	189,302	186,558	192,646	200,395	211,823	75,540
Total hourly water levels	4,389,822	4,542,068	4,447,347	4,618,783	4,712,493	4,995,091	1,755,795
Chloride Samples	270	31	358	14	413	6	3
Geophysical & lithologic logs at new stations	2	2	3	1	3	5	3

TABLE 5
Well Construction Information for New Well Installation and Acquired Wells for the FY 2021
North Carolina Division of Water Resources
Groundwater Management Branch
2021 Annual Report

Well ID	Station Name	Date Installed	Well Diameter (inches)	Well Depth (ft bls)	Screened Interval (x to y ft bls)	Measuring Pt (MP)(ft)	Aquifer	**Water Level Date Measured (from MP) (ft)
U 34B10		03/25/2021	4	39	22-32	2.55	S	9.42 (04/15/2021)
U 34B11		03/23/2021	4	142	127-137	2.62	NDY	41.07 (04/15/2021)
U 34B12	Turkey	03/17/2021	4	260	245-255	2.61	NDY	44.24 (04/15/2021)
U 34B13		03/10/2021	4	335	320-330	2.55	NDY	44.86 (04/15/2021)
U 34B14		03/04/2021	4	446	427-437	2.70	NDY	98016 (04/15/2021)
U 37D1		03/30/2021	4	38	26-36	3.73	S	13.64 (05/19/2021)
U 37D2	Pondberry Bay	04/08/2021	4	360	303-313	2.71	NDY	147.59 (05/19/2021
U 37D3		04/13/2021	4	199	175-185	2.80	NDY	41.08 (05/19/2021)
G 15E1		06/17/2021	4	325	300-310	2.60	NDY	25.51 (06/29/2021)
G 15E2	DF Walker Elementary School	06/23/2021	4	195	175-185	2.60	NDY	26.31 (06/29/2021)
G 15E3		06/24/2021	4	30	17-27	2.35	S	5.58 (06/29/2021)

Well Construction Information for Wells Acquired in the 2021 FY

Well ID	Station Name	Date Acquired	Well Diameter (inches)	Well Depth (ft bls)	Screened Interval (x to y ft bls)	Measuring Pt (MP)(ft)	Aquifer	**Water Level Date Measured (from MP) (ft)
I 31H1	Nashville Well 2	12/10/2020	6	443	*145-443	1.15	Br	12.13 (04/21/2021)
I 31HI	Nashville Well 4	12/10/2020	6	120	*76-120	1.20	Br	15.66 (04/21/2021)
I 31N1	Nashville Well 8	12/10/2020	8	400	*41-400	2.41	Br	5.12 (04/21/2021)
D 68G1	Stone Mountain	05/27/2021	6	-	-	0.25	Br	8.47 (05/27/2021)

**Water Levels Reported from the Most Recent Date Water Level Collected (2020 FY)
*Indicates Open Hole
S - Surficial Aquifer
NDY - Not Determined Yet
Br - Bedrock
Stone Mountain will be video-logged in FY 2022 to confirm depth and screened interval

TABLE 6
Well Development Information for FY 2021
North Carolina Division of Water Resources
Groundwater Management Branch
2021 Annual Report

Well ID	Station Name	Date Developed
U 37D1	Pondberry Bay	06/14/2021
U 37D2	Pondberry Bay	06/14/2021
U 37D3	Pondberry Bay	06/14/2021

TABLE 7
Automatic Water Level Recorders as of 06/30/2021
North Carolina Division of Water Resources
Ground Water Management Branch
2021 Annual Report

Recorder Type	Number in Service*
HOBO U20 Water Level Logger (including separate barometer per station installed	806 (includes 220 barometers)
Solinst Telemetry System (STS)	32 (includes 16 barologgers and 16 leveloggers)

***As of June 30, 2020**

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

TABLE 8
Orange Well Network Monitoring Well Information
Orange County, NC
North Carolina Division of Water Resources
Ground Water Management Branch
2021 Annual Report

Quad	Well Name	Total Depth (ft bgs)	Casing Depth (ft bgs)	Land Surface (ft)	Aquifer	Geology
G 44G1	Northeast Park NES	45	15	622	Bs	Epiclastics
G 45F1	Eno Confluence Property	192	37	611	Br	Felsic Tuff
H 44P1	Blackwood Farm Bedrock	302	100	556	Br	Felsic Lavas and Tuffs (Dacite)
H 44P2	Former 911 Center	400	85	581	Br	Altered Tuff
H 44P3	Blackwood Farm Regolith	45	15	556	Bs	Felsic Lavas and Tuffs (Dacite)
H 44R1	Brumley East	605	108	562.39	Br	Mafic Lavas and Tuffs
I 44B1	Duke Forest DF-4D	397.09	82.1	424.91	Br	Felsic Plutonics
I 44B2	Duke Forest DF-4S	25	15	428.81	Bs	Felsic Plutonics
I 44B3	Duke Forest DF-4I	41	26	426.77	Br	Felsic Plutonics
I 44F1	Millhouse Road	166	67	517	Br	Epiclastics
I 45G1	Rocky Ridge	Removed from network in 2012				
I 45J1	Eubanks Road	141	33	525		
I 46R1	Andrews Rd. (COL-1)	30	10	514	Bs	Felsic Tuff
I 46R2	Hwy 54 (COL-3)	40.5	25	516	Bs	Epiclastics
I 46W1	Orange Grove Rd (COL-4)	32	17	502	Bs	Epiclastics
J 45J1	Ray Road	Removed from network in 2012				

bgs – below ground surface
** Estimated Elevation

TABLE 9
Orange Well Network Statistics (2008 through 06/30/2021)
North Carolina Division of Water Resources
Ground Water Management Branch
2021 Annual Report

Parameter	2008	2009	2010	2011	2012	2013	2014	2015	2016
Manual water levels (tapedowns)	3	18	49	68	59	54	52	75	71
Daily water levels (automatic recorders	-	-	1,612	2,783	3,095	3,281	3,468	4,286	5,096
Total hourly water levels	-	-	38,802	66,689	74,065	78,636	83,090	102,643	121,985

TABLE 9 (continued)
Orange Well Net Network Statistics (2008 through 06/30/2021)
North Carolina Division of Water Resources
Ground Water Management Branch
2021 Annual Report

Parameter	2017	2018	2019	2020	2021
Manual water levels (tapedowns)	80	65	54	72	52
Daily water levels (automatic recorders	4,865	4,744	4,721	4,616	2,182
Total hourly water levels	116,515	113,565	114,948	109,219	52,219

TABLE 10
Guilford County Monitoring Well Information
North Carolina Division of Water Resources
Ground Water Management Branch
2021 Annual Report

Quad	Station Name	Date Installed	Well Diameter (inches)	Well Depth (ft)	Casing Depth (ft)	Land Surface (ft)	Aquifer	City
F 54O1	Summerfield (Jack Dent Park)	10/2/02	6.25	103	81	858.5	Br	Summerfield
G 50H1	Prison Farm	5/14/04	6.25	120	45	685	Br	Gibsonville
G 51B1	Northeast Park	6/24/15	6.125	100	77	683	Br	Gibsonville
G 56L1	Triad Park	10/9/02	6.25	140	0	925	Br	Colfax
H 51D1	Knox Road	10/9/02	-	-	39	715	Br	McLeansville
H 55L1	Gibson Park	4/15/03	6.25	205	79	813	Br	Jamestown
I 50P1	Station 45 (Humble Road)	12/15/04	6.25	180	124	679.5	Br	Liberty
I 52N1	Hagan Stone Park	05/17/03	6.125	100	52	755	Br	Pleasant Garden

TABLE 11
Guilford County Monitoring Well Network Statistics (2005 through 06/30/2021)
North Carolina Division of Water Resources
Ground Water Management Branch
2021 Annual Report

Parameter	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Manual water levels (tapedowns)	-	28	14	28	35	77	77	56	63	49	69	71
Daily water levels (automatic recorders	2,106	1,884	1,922	1,892	2,000	2,592	2,561	2,474	2,585	2,562	2,592	941
Total hourly water levels	-	-	-	-	-	3	-	-	-	-	36,415	22,636

TABLE 11 (continued)
Guilford County Monitoring Well Network Statistics (2005 through 06/30/2021)
North Carolina Division of Water Resources
Ground Water Management Branch
2021 Annual Report

Parameter	2017	2018	2019	2020	2021
Manual water levels (tapedowns)	72	55	79	62	23
Daily water levels (automatic recorders)	432	134	1,258	2,572	1,010
Total hourly water levels	10,379	3,216	37,281	62,634	24,280

TABLE 12
WCHRS Network
Monitoring Well Information
North Carolina Division of Water Resources
Ground Water Management Branch
2021 Annual Report

Quad	Station Name	Date Installed	Well Depth (meters)	Casing Depth (meters)	Screen (meters)	MP (meters above land surface)	Land Surface (NED Elevation) (meters)	Geology	Aquifer
Q 94H1	GG1S	11/30/2009	2.41	0.88	0.88-2.4	1.02	683.26	colluvium/saprolite	Bs
Q 94H2	GG1i	11/30/2009	4.42	3.81	3.81-4.42	0.99	683.26	saprolite	Bs
Q 94H3	GG1D	11/30/2009	7.56	6.95	6.95-7.56	0.97	683.26	saprolite	Bs
Q 94H11	GG4S	11/30/2009	2.83	1.31	1.31-2.83	0.89	682.93	colluvium/saprolite	Bs
Q 94H13	GG4D	11/30/1999	7.80	7.19	7.19-7.8	1.01	682.93	saprolite	Bs
Q 94H14	LB3S	11/30/1999	2.65	1.13	1.13-2.65	1.02	667.35	colluvium/saprolite	Bs
Q 94H16	LB3D	11/30/2009	5.43	4.82	4.82-5.43	1.05	667.35	saprolite	Bs
Q 94H22	LB1S	11/30/2009	2.47	0.94	0.94-2.46	1.00	667.15	colluvium/saprolite	Bs
Q 94H23	LB1i	11/30/1999	3.87	3.26	3.26-3.87	1.00	667.15	saprolite	Bs
Q 94H24	LB1D	11/30/1999	5.67	5.06	5.06-5.67	0.96	667.15	saprolite	Bs
Q 94I1	CC Old Well	11/22/2004	6.28	0.30	0.30-6.40	0.82	634.00	saprolite	Bs
Q 94I2	CC1S	11/30/2009	2.53	1.01	1.01-2.53	1.01	633.07	alluvium/saprolite	Bs
Q 94I3	CC1i	11/30/1999	3.29	2.99	2.99-3.29	1.05	633.07	saprolite	Bs
Q 94I5	CC1D	11/30/1999	5.64	5.33	5.33-5.63	1.02	633.07	saprolite	Bs
Q 94I7	CC2S	11/30/1999	2.68	1.16	1.16-2.68	0.98	634.15	alluvium/saprolite	Bs
Q 94I9	CC2D	11/30/2009	6.31	5.70	5.70-6.31	0.99	634.15	saprolite	Bs
Q 94J1	Stillwell Building	-	61.27	25.91	25.91-61.27	0.65	655.45	-	Br

Note: All monitoring wells are located in Jackson County, NC

TABLE 13
WCHRS Network Statistics (2011 through 06-30-2021)
North Carolina Division of Water Resources
Ground Water Management Branch
2021 Annual Report

Parameter	2011	2012	2013	2014	2015	2016	2017
Manual water levels (tapedowns)	238	628	661	469	422	486	661

TABLE 13 (Continued)
WCHRS Network Statistics (2011 through 06-30-2021)
North Carolina Division of Water Resources
Ground Water Management Branch
2021 Annual Report

Parameter	2018	2019	2020	2021
Manual water levels (tapedowns)	517	165	180	15

TABLE 14
Potential Network Expansion FY 2022
North Carolina Division of Water Resources
Ground Water Management Branch
2021 Annual Report

Proposed Station	County	Proposed Well Screens (ft bls)	Aquifer
		20-30	Surficial
Near Intersection of		41-51	Black Creek
US Hwy 421 and US Hwy 13	Sampson	168-178	Upper Cape Fear
		347	Pilot Hole (Estimated top of basement)
		20-30	Surficial
Near Valhalla	Chowan	130-140	Yorktown
		225-235	Castle Hayne
		30-40	Surficial
Near Moyock	Currituck	200-210	Yorktown
		530-540	Castle Hayne
		600-610	Beaufort
Red Bank Station	Robeson	71-81	Black Creek
		20-30	Surficial
		60-70	Yorktown
Near Macclesfield	Edgecombe	120-130	Upper Cape Fear
		260-270	Lower Cape Fear
		292	Pilot Hole (Estimated top of basement)
		20-30	Surficial
Near Laurinburg	Scotland	120-130	Black Creek
		332-342	Upper Cape Fear
		360	Pilot Hole (Estimated top of basement)
Wellfield 258 Station or	Onslow	720-730	Black Creek
close proximity		824-834	Upper Cape Fear

TABLE 15
Well Removal and Abandonment Information for FY 2021
Sorted by Well Number
North Carolina Division of Water Resources
Ground Water Management Branch
2021 Annual Report

Well ID	Station Name	Inactive Date	Comment
Q 32D1	Scotts Hill	11/02/2020	Due to the location of the well in the homeowners flower bed and the landowner wanting to use the well from time to time, it was decided to move the well to inactive status.
R 29T2	Moss Hill	11/02/2020	The decision was made to move this well to inactive status for two reasons: 1) being that it is a hybrid well and 2) its location in the school yard.
U 34B4 U 34B6	Turkey	03/26/2021	Each well was abandoned due to well construction issues and replaced with new wells included in the Turkey station installed during the 2021 FY.

Table 16
Summary of Field Parameters (Sorted by Station Name) FY 2021
(Measured using a YSI ProDSS meters)
North Carolina Division of Water Resources
Ground Water Management Branch
2021 Annual Report

Station Name	Well	County	Date	Temp ^{0}C	Conductivity (µS/cm)	DO (ppmv or mg/L)	pH	Salinity (ppt)
Arapahoe	S 18U3	Pamlico	04/20/2021	17.7	237.2	0.32	7.80	0.11
Arapahoe	S 18U9	Pamlico	04/20/2021	18.0	590	0.21	7.36	0.29
Arapahoe	S 18U10	Pamlico	04/20/2021	18.0	453.6	0.23	7.43	0.22
Arapahoe	S 18U11	Pamlico	04/20/2021	14.9	120.1	0.35	5.59	0.06
Bay City	R 17I1	Pamlico	08/05/2021	17.0	800	0.18	6.81	0.39
Bay City	R 17I2	Pamlico	08/05/2021	18.1	975	0.17	7.35	0.48
Bean Shoals	E 61P1	Surry	05/11/2021	15.8	202.7	0.12	6.95	0.10
Beaver Creek	D 72Y1	Ashe	11/05/2020	12.4	62.9	10.45	6.73	0.03
Bodie Island	K 2E2	Dare	11/09/2020	19.7	11989	0.10	8.67	6.88
Bodie Island	K 2E4	Dare	11/09/2020	20.5	31496	0.15	7.47	19.86
Bodie Island	K 2E7	Dare	11/09/2020	20.5	1561	0.29	7.05	0.79
Carver Moore	AA 39V2	Columbus	01/13/2021	20.3	505	0.28	8.97	0.24
Carver Moore	AA 39V3	Columbus	01/13/2021	20.0	343.5	0.11	9.90	0.16
Cremo	F 19V2	Bertie	03/25/2021	16.7	163.0	0.36	6.64	0.08
Cremo	F 19V3	Bertie	03/25/2021	16.5	480.6	0.36	8.40	0.23
Cremo	F 19V5	Bertie	03/30/2021	20.2	1817	0.11	9.32	0.92
Cremo	F 19V6	Bertie	03/30/2021	16.4	1004	0.27	9.94	0.50
Densons Creek Park	P 54H1	Montgomery	06/15/2021	17.6	272.9	0.75	6.05	0.13
Falkland	L 25P1	Pitt	08/27/2020	18.9	2138	0.22	8.08	1.10
Falkland	L 25P2	Pitt	08/27/2020	18.3	90.4	0.15	6.02	0.04

Table 16 (continued)
Summary of Field Parameters (Sorted by Station Name) FY 2021
(Measured using a YSI ProDSS meters)
North Carolina Division of Water Resources
Ground Water Management Branch
2021 Annual Report

Station Name	Well	County	Date	Temp ^{0}C	Conductivity (µS/cm)	DO (ppmv or mg/L)	pH	Salinity (ppt)
Falkland	L 25P3	Pitt	08/27/2020	17.2	324.0	0.16	7.20	0.16
Falkland	L 25P4	Pitt	08/27/2020	19.0	320.8	0.28	6.96	0.15
Falkland	L 25P5	Pitt	08/27/2020	23.9	104.7	2.02	4.73	0.05
Falkland	L 25P5	Pitt	09/16/2020	21.5	136.5	1.85	4.75	0.06
Falkland	L 25P1	Pitt	03/09/2021	18.2	167.5	0.40	7.30	0.08
Falkland	L 25P2	Pitt	03/09/2021	16.4	104.5	0.47	6.10	0.05
Falkland	L 25P3	Pitt	03/09/2021	16.6	323.2	0.47	7.85	0.15
Falkland	L 25P4	Pitt	03/09/2021	17.6	299.8	1.53	7.00	0.14
Falkland	L 25P5	Pitt	03/09/2021	12.6	84.5	2.92	4.66	0.04
Fort Fisher	GG 31J1	New Hanover	10/07/2020	23.6	506	0.29	6.06	0.24
Four Mile Desert	E 13M1	Perquimans	02/23/2021	16.4	1733	0.14	7.04	0.88
Four Mile Desert	E 13M3	Perquimans	02/23/2021	18.2	7535	0.17	8.28	4.18
Grassy Ridge	E 61C1	Surry	06/01/2021	15.6	60.9	7.43	5.95	0.03
Hornets Nest	Q 66C1	Mecklenberg	12/15/2020	14.5	253.3	3.71	6.77	0.12
I40/I95	P 38I1	Johnston	07/30/2020	18.9	247.2	0.22	8.40	0.12
Ivanhoe	Y 34P2	Sampson	07/22/2020	24.6	443.5	0.20	8.10	0.21
Ivanhoe	Y 34P3	Sampson	07/22/2020	18.5	237.4	0.32	6.27	0.11
Ivanhoe	Y 34P7	Sampson	07/22/2020	18.5	417.7	0.22	6.95	0.20
Ivanhoe	Y 34P9	Sampson	07/22/2020	21.2	2321	0.10	8.20	1.19
Ivy Bluffs	E 62U1	Yadkin	05/11/ 05/12/2021	14.9	39.0	8.01	5.77	0.02
Laurel Springs	C 71U1	Alleghany	10/14/2020	12.2	86.6	8.42	5.86	0.04
Lewiston	H 22I3	Bertie	04/15/2021	14.8	305.1	0.49	6.80	0.15
Lewiston	H 22I4	Bertie	04/15/2021	18.7	2589	0.18	8.88	1.34
Lewiston	H 22I5	Bertie	04/15/2021	17.7	1973	0.26	8.42	1.07
Lewiston	H 22I6	Bertie	04/15/2021	16.5	467.6	0.36	7.80	0.23

Table 16 (continued)
Summary of Field Parameters (Sorted by Station Name) FY 2021
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Station Name	Well	County	Date	Temp ^{0}C	Conductivity (µS/cm)	DO (ppmv or mg/L)	pH	Salinity (ppt)
Merchants Millpond	C 16S1	Gates	01/21/2021	18.4	1133	0.22	8.37	0.57
Merchants Millpond	C 16S2	Gates	01/21/2021	16.6	928	0.48	8.56	0.46
Merchants Millpond	C 16S4	Gates	01/21/2021	15.7	165.6	0.40	6.04	0.08
Merchants Millpond	C 16S5	Gates	01/21/2021	14.9	122.8	0.30	4.78	0.06
Merchants Millpond	C 16S6	Gates	01/21/2021	19.8	2063	0.19	7.98	1.06
Merchants Millpond	C 16S3	Gates	01/27/2021	17.5	1156	0.20	8.17	0.58
Nakina	EE 39O1	Columbus	12/03/2020	18.9	13260	0.18	7.32	7.67
Nakina	EE 39O2	Columbus	12/03/2020	18.8	125.1	0.11	4.84	0.06
Nakina	EE 39O3	Columbus	12/03/2020	19.7	1562	0.27	8.22	0.79
Nakina	EE 39O4	Columbus	12/03/2020	18.7	481.9	0.30	9.38	0.23
Nakina	EE 39O5	Columbus	12/03/2020	20.1	4213	0.23	7.81	2.25
Nakina	EE 39O6	Columbus	12/03/2020	19.1	598	0.35	9.06	0.29
Nashville Well 2	I 31H1	Nash	01/07/2021	18.1	92.8	0.63	5.81	0.04
Nashville Well 4	I 31I1	Nash	12/21/2020	17.6	91.1	7.14	6.23	0.04
Nashville Well 8	I 31N1	Nash	02/04/2021	16.5	109.3	5.07	6.29	0.05
North Pitt	L 24B2	Pitt	09/08/2020	17.6	311.8	0.29	6.72	0.15
North Pitt	L 24B3	Pitt	09/08/2020	18.5	4956	0.14	8.60	2.67
North Pitt	L 24B5	Pitt	09/08/2020	18.5	2228	0.25	7.59	1.15
North Pitt	L 24B6	Pitt	09/08/2020	17.7	466.4	0.20	7.38	0.23
North Pitt	L 24B7	Pitt	09/08/2020	22.9	214.4	6.02	4.23	0.10
Northampton East High School	C 23Y1	Northampton	05/04/2021	16.7	60.1	5.93	5.80	0.03

Table 16 (continued)
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Station Name	Well	County	Date	Temp ^{0}C	Conductivity (µS/cm)	DO (ppmv or mg/L)	pH	Salinity (ppt)
Pilot Mtn Well 2	D 61X1	Surry	06/02/2021	15.1	100.5	5.18	6.32	0.05
Purser	P 21N1	Craven	07/07/2021	18.3	347.1	0.19	6.85	0.17
Purser	P 21N2	Craven	07/07/2020	18.7	121.1	0.34	5.95	0.06
Purser	P 21N3	Craven	07/07/2020	22.7	153.6	1.54	5.71	0.07
Rex Rennert	V 45U2	Robeson	04/08/2021	20.2	923	0.14	7.88	0.46
Rex Rennert	V 45U4	Robeson	04/08/2021	20.5	47.4	0.31	6.22	0.03
Rex Rennert	V 45U6	Robeson	04/08/2021	19.1	37.8	0.42	5.49	0.02
Rex Rennert	V 45U7	Robeson	04/08/2021	27.6	56.5	0.59	5.41	0.02
Rowland	Z 47R2	Robeson	06/09/2021	19.4	106	0.27	6.38	0.05
Rowland	Z 47R3	Robeson	06/09/2021	19.7	84.2	0.35	6.18	0.04
Rowland	Z 47R4	Robeson	05/27/2021	18.9	234.3	0.24	6.69	0.11
Rowland	Z 47R5	Robeson	05/27/2021	19.3	124.7	0.37	6.38	0.06
Saulston	O 30J1	Wayne	09/30/2020	17.3	87.9	0.30	5.79	0.04
Saulston	O 30J2	Wayne	09/30/2020	17.4	137.9	0.27	6.76	0.06
Saulston	O 30J3	Wayne	09/30/2020	21.4	369.5	0.30	10.75	0.18
Saulston	O 30J4	Wayne	09/30/2020	20.3	107.4	2.40	4.69	0.05
Sladesville	O 13F1	Hyde	07/16/2020	19.4	2703	0.12	7.63	1.40
Snow Hill	O 28K3	Greene	08/12/2020	20.0	667	0.15	7.89	0.33
Snow Hill	O 28K4	Greene	08/12/2020	19.2	128.9	0.11	6.88	0.06
Snow Hill	O 28K5	Greene	08/12/2020	18.5	99.0	0.46	6.37	0.05
Snow Hill	O 28K6	Greene	08/12/2020	19.9	230.8	0.32	6.08	0.11

Table 16 (continued)
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Station Name	Well	County	Date	Temp ^{0}C	Conductivity (µS/cm)	DO (ppmv or mg/L)	pH	Salinity (ppt)
Tater Hill	E 76Q1	Watauga	10/27/2020	13.5	43.0	9.91	6.27	0.02
Welcome	I 58Y2	Davidson	12/29/2020	17.4	108.1	5.90	6.80	0.05
Windsor	H 20T1	Bertie	04/28/2021	20.4	14648	0.08	6.93	8.53
Windsor	H 20T2	Bertie	05/19/2021	19.5	4576	0.28	8.96	2.45
Windsor	H 20T3	Bertie	05/25/2021	22.6	1414	0.25	8.73	0.71
Windsor	H 20T4	Bertie	04/28/2021	18.2	626	0.29	8.05	0.31
Windsor	H 20T6	Bertie	04/27/2021	19.9	410.3	0.84	8.50	0.20
Windsor	H 20T7	Bertie	04/28/2021	17.8	291.7	0.45	7.55	0.14
Windsor	H 20T8	Bertie	04/27/2021	16.2	156.6	1.27	6.16	0.07
Windsor	H 20T9	Bertie	04/27/2021	18.0	609	0.19	7.94	0.30

APPENDICES

APPENDIX A

GROUNDWATER SAMPLING PROTOCOL

Groundwater Sampling Protocol

Samples for the ambient monitoring program were collected in accordance with DWR procedures outlined in NCDWQ/APS 2006 to ensure that high quality, defensible data was collected. To ensure that only newly recharged groundwater was being sampled, wells were pumped until three well volumes had been removed. Where a well's total volume was too high to feasibly pump out three volumes, wells were purged until water quality parameters (temperature, pH, specific conductance, and dissolved oxygen) of purge water stabilized. Both submersible and peristaltic pumps were used in the field at the sampler's discretion depending on the total depth of the well and the hydraulic head difference to be overcome when pumping from the water table to the surface. To prevent contamination introduced while sampling, nitrile gloves were worn during all sampling events. Pumps were decontaminated after each use. In addition, blanks and duplicate samples were collected to provide quality assurance/quality control information. Trip blanks were taken on each sampling trip, and equipment blanks were taken from all equipment then analyzed. Field duplicates were taken to comprise 10% of the total samples collected.

The groundwater was analyzed for a broad suite of water quality and water chemistry parameters (see table below). Data from the ambient monitoring program may be used to characterize groundwater throughout the state as well as to address the concerns other programs and projects. Within DWR these concerns include for example salt water intrusion due to over-pumping, the source of organic nitrogen found in surface water bodies, the impact of concentrated farming activities on drinking water supplies, and the levels of naturally occurring contaminants such as metals. Since most of these wells are somewhat geographically isolated from human activities, the water collected is more likely to represent ambient conditions and not contamination.

Table of Sampling Parameters

Parameter Group	Parameters
Private Well Analytes (15A NCAC 18A .3803)	arsenic, barium, cadmium, chromium, copper, fluoride, lead, iron, magnesium, manganese, mercury, nitrate, nitrite, selenium, silver, sodium, zinc, pH
Nutrients*	Ammonia, total kjeldahl nitrogen, organic nitrogen, phosphorus
Metals (Dissolved and Total)*	Aluminum, antimony, beryllium, boron, calcium, cobalt, lithium, molybdenum, nickel, potassium, strontium, thallium, tin, titanium, vanadium
Major Ions	Bromide, chloride, fluoride, sulfate, carbonate, bicarbonate
PFAS	Per-and Polyfluoroalkyl compounds
Field Parameters	Specific conductivity, pH, dissolved oxygen (DO), oxidation-reduction potential (ORP), temperature
Organic Compounds	Volatile organic compounds, Semi-volatile organic compounds, Pesticides, select Per- and Polyfluoroalkyl Substances (PFAS)
Other	Alkalinity, total organic carbon, turbidity, total dissolved solids, silica, sulfide

*In addition to those required by 15A NCAC 18A .3803

References:

DCDWQ/APS, 2006, Quality Assurance/Quality Control and Standard Operating Procedures Manual for Sample Collection, December 2006

15a NCAC 18a Section .3800 - Private Drinking Water Well Sampling, .3803 - Sample Analysis