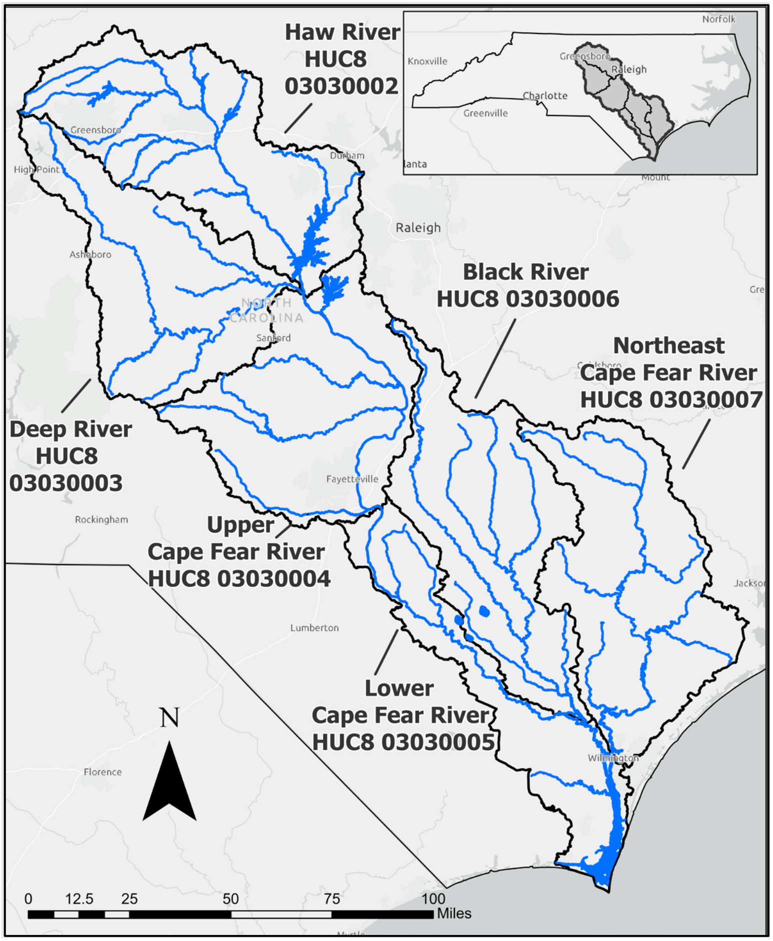

DRAFT
Chapter 5
Cape Fear River Basin
Water Quantity Assessment and Planning

BASINWIDE WATER RESOURCES MANAGEMENT PLAN

CYCLE 4 – CAPE FEAR RIVER BASIN 2026

North Carolina
Department of Environmental Quality
Division of Water Resources
Basin Planning Branch

NORTH CAROLINA
Department of Environmental Quality

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5 Water Quantity Assessment and Planning

Water resources in the Cape Fear River Basin include surface and groundwater, and water in impoundment systems. North Carolina has a diverse array of water users throughout the state, including public and private water systems that supply drinking water to their customer base and industries such as food production, wood manufacturing and metal processing and energy production (hydroelectric and thermoelectric). Water is also used statewide for agricultural, mining and recreational purposes. Water users also rely on private groundwater well(s) to supply water for residents and associated activities. The availability and continued use of water by all users is vital to the continued prosperity of the communities and ecosystems of this state.

There are several programs within the Department of Environmental Quality (DEQ) that provide information about how much water is being used in North Carolina. These include the Water Withdrawal and Transfer Registration (WWATR) Program, the Local Water Supply Planning (LWSP) Program, the Central Coastal Plain Capacity Use Area (CCPCUA) Program and the Interbasin Transfer (IBT) Certification Program. Several programs are also in place to protect drinking water sources including the Source Water Assessment Program (SWAP), the Surface Water Protection Program (SWPP) and the Wellhead Protection Program (WHP). Additionally, the Groundwater Resources Branch (GWRB) oversees the assessment, monitoring and management of the state's groundwater resources. More information about these programs can be found in subsequent sections of this chapter and in Chapter 3.

In addition to administering programs for water use and protection, DEQ plays a critical role in providing technical and managerial support for the development and use of surface and groundwater resources and for calculating the volume of water moving through a system. For agriculture water use, the North Carolina Department of Agriculture & Consumer Services (NCDA&CS) plays a critical role in collecting statewide water use data. The information presented here is based on the best available data and includes information about groundwater, streamflow, water use and demand, and hydrologic model results. This chapter also identifies and describes pertinent water-quantity information needed to evaluate water use and conditions in the Cape Fear River Basin. The chapter concludes with future considerations to better understand water use and protecting our water resources.

5.1 Groundwater and Geologic Setting

Groundwater plays a vital role in ecosystems, agriculture, and drinking water supplies. Stored beneath the Earth's surface, groundwater flows slowly through the pores and fractures of soil, sand, and rock. Most groundwater originates, or recharges, when liquid water at the land surface percolates through soil and rock, infiltrating beyond the root zone until it reaches the water table, a point below which the soil/sand/rock is fully saturated. The volume of groundwater storage and the rate of flow are governed by geology and climate. Thick deposits of sand and gravel, porous limestone, and fractured bedrock often store and transmit water in quantities sufficient to supply water to wells, springs, and streams. These formations are called aquifers. Conversely, clays and other low-permeability materials may store high volumes of water but transmit it very slowly, often acting as a near-impermeable barrier to flow. These formations are called aquitards. In all aquifers and aquitards, the elevation to which the water rises in a well, also called potentiometric surface elevation (or water level), is a proxy measurement for storage. A rise in water level corresponds with an increase in storage and declining water levels indicate a loss from storage.

When groundwater is removed by pumping, the change is offset by a reduction in groundwater storage. As water levels decline, discharge to other wells or to connected surface water bodies will also decline. If withdrawals are significant, water levels may not recover for years or decades. Over time, substantial overuse of groundwater may also lead to storage losses, or dewatering, caused by reduced water pressure in the aquifer. As water is removed, the weight of the overlying rock and sediment causes the aquifer materials to compress, reducing pore size and permeability. Dewatering can cause irreversible changes to aquifer productivity, and it contributes to land subsidence, sinkhole development, and salt-water encroachment in coastal aquifers. Changes to climate and landcover (e.g. deforestation, increase in impervious surfaces) that reduce the volume of water recharged can accelerate water level declines, especially in confined aquifers with narrow recharge zones.

The Cape Fear River basin has an abundant store of high-quality groundwater that supplies fresh water for human use and consumption, irrigation, industry, and power generation. For many water users in the Cape Fear basin, groundwater is the only water resource available. The Central Coastal Plain Capacity Use Area, declared in 2002, helps to promote sustainable groundwater use in 15 counties within the Coastal Plain. Three of these counties (Wayne, Duplin, and Onslow) are also part of the Cape Fear River Basin. Large water users who are subject to CCPCUA rules must obtain groundwater withdrawal permits and report daily water use and monthly water levels. More information about North Carolina's aquifers can also be found on DEQ's Division of Water Resources (DWR) Groundwater Resources Branch (GWRB) website and later in this chapter.

The future of groundwater in North Carolina is expected to include the continued use of resource management practices and technology to maximize and sustain its benefit. DWR anticipate that the continued population growth will require continued innovation in water reuse such as aquifer storage and recovery systems, expansion of regional water distribution systems and reverse osmosis as well as ongoing management of groundwater resources and capacity use programs to assure that adequate water supplies are available throughout the Cape Fear River Basin, especially within the Coastal Plain.

5.2 Geological Setting

The Cape Fear River Basin consists of three distinct geological regions: From west to east, these are the igneous and metamorphic crystalline rocks of the Carolina Slate Belt, the sedimentary deposits of the Early Mesozoic Durham-Sanford Basin and the sediments of the Coastal Plain. A generalized geologic cross section of the Cape Fear River Basin is provided in *Figure 5-1*.

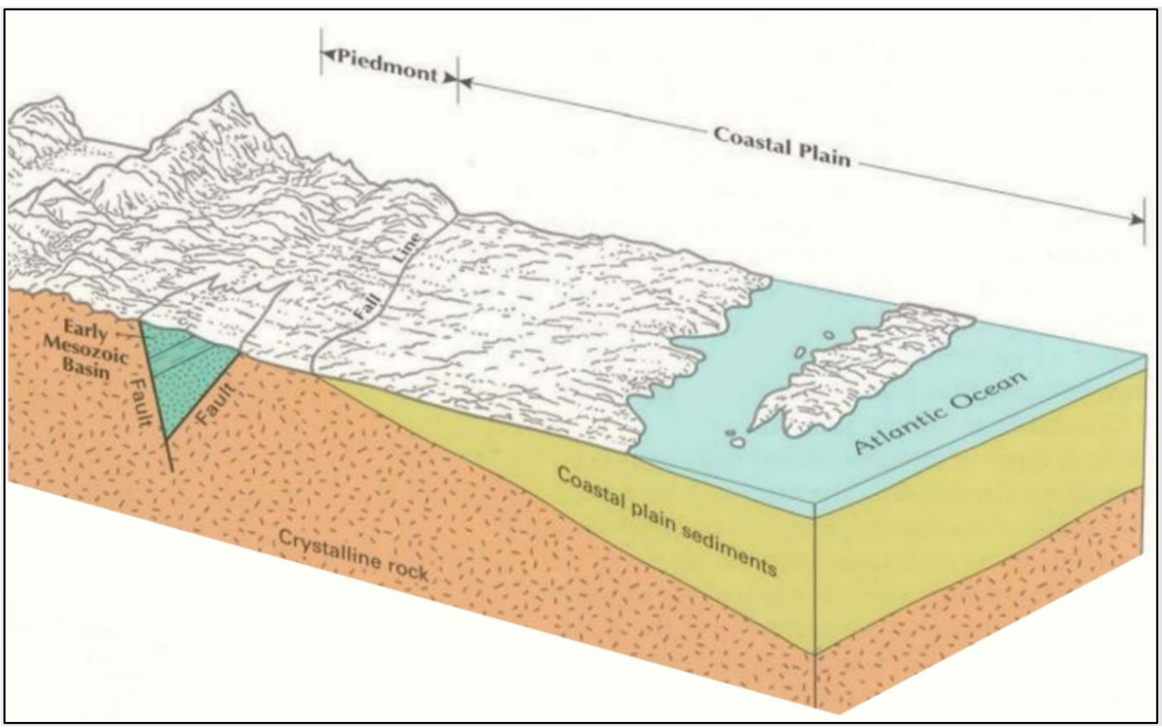
The Carolina Slate Belt consists of interbedded tuffs, breccias, argillites, flows and other metavolcanic crystalline rocks. The formation strikes northeast-southwest and dips steeply to the northwest. The age of the formation ranges from Proterozoic to Cambrian (*Figure 5-2*). Commonly, these metavolcanic rocks have been intruded by Jurassic-aged, north-to-northwest-trending diabase dikes and Proterozoic to Paleozoic-aged igneous intrusive rocks such as granite. Because of the seasonal, moist climate in North

Carolina, these rocks are often deeply weathered by natural earth processes to form thick zones of weathered rock, alluvium and soil called regolith.

The Durham-Sanford Basin is a northeast-trending downthrown fault block, or graben, which formed during the Triassic time-period (*Figure 5-2*). The basin is about 100 miles long and 10 to 15 miles wide, and extends through portions of Durham, Orange, Wake, Chatham, Lee and Moore Counties. The Durham-Sanford Basin contains up to 5,000 feet or more of sedimentary rock consisting of mudstone, sandstone, conglomerate and minor coal seams, in addition to Jurassic-aged diabase dikes.

The Coastal Plain is an eastward thickening wedge of fluvial-marine sediment representing more than 100 million years of cyclic sea level rise and fall (*Figure 5-2*). Deposited unconformably on underlying bedrock similar to that found in the Piedmont, the Coastal Plain sediments consist predominantly of sand, silt, clay and limestone deposits ranging in total thickness from zero at the fall line to 1,500 feet near the coastline in New Hanover County. Within the Cape Fear River Basin, the Coastal Plain is comprised of five major geologic units. From oldest to youngest, these are the Cretaceous Cape Fear, Black Creek and Peedee Formations, the Eocene Castle Hayne Limestone and an overlying sedimentary zone referred to as the surficial sands.

Figure 5-1: Adapted from Trapp and Horn, 1997, Simplified Geological Cross Section in the Cape Fear River Basin.



5.2.1 Groundwater Monitoring Network

DWR's Groundwater Resources Branch (GWRB) oversees the assessment, monitoring and management of the state's groundwater resources. Groundwater data, in combination with stream gage data, helps

DWR determine whether groundwater supplies are adequate for demand and being used sustainably, especially in areas with no surface water alternative. Most groundwater data is collected from the DWR GWRB Monitoring Well Network (MWN), which is comprised of approximately 700 groundwater wells distributed across over 200 stations throughout the state. Many stations, especially those in the Coastal Plain, have multiple wells to monitor multiple aquifers present at that location. Water level and water quality data collected from these wells are used to:

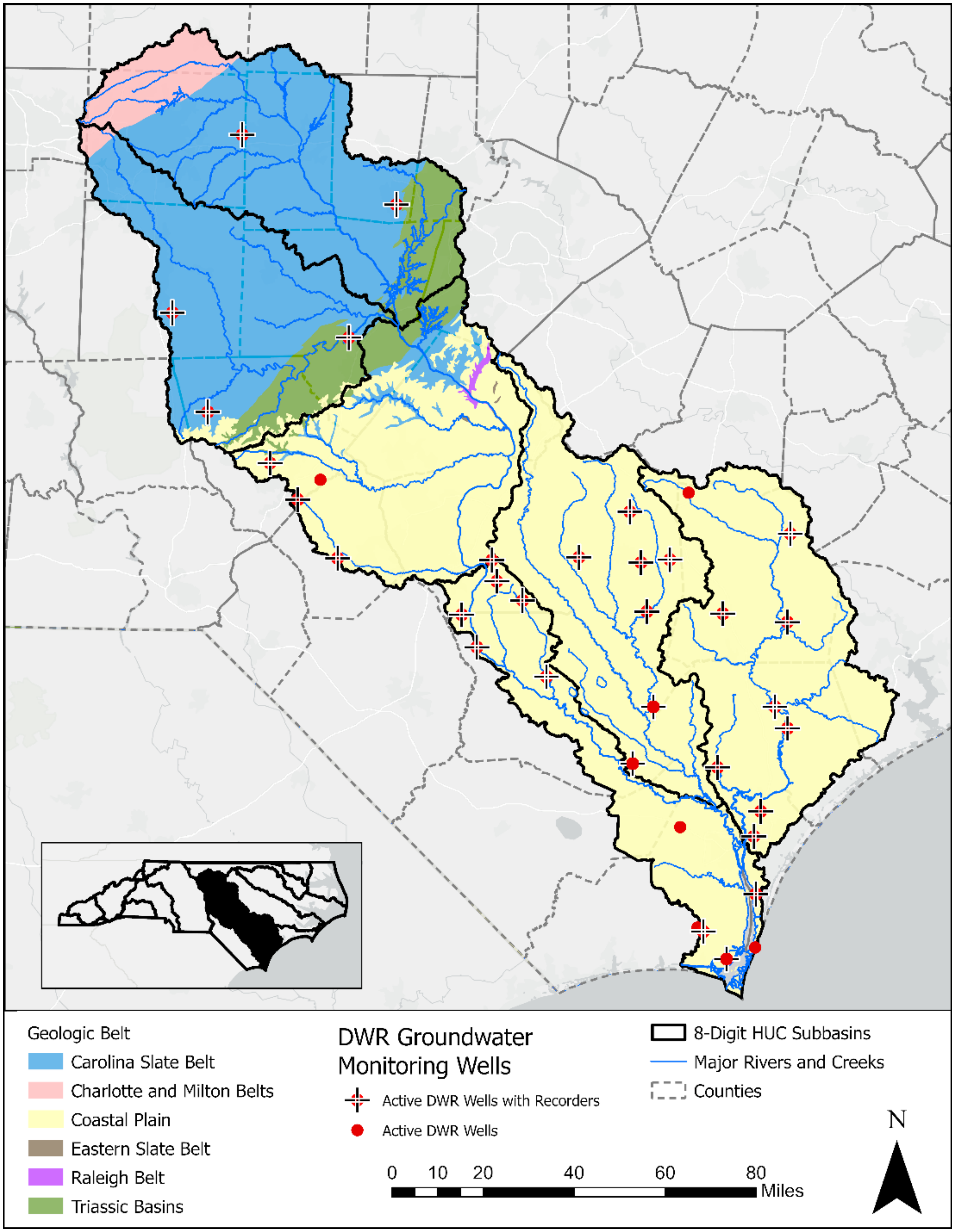
- Evaluate effects of recharge, discharge and drought on water supply
- Monitor well pumping to assure rates are sustainable
- Regulate the CCPCUA
- Monitor chlorides for saltwater intrusion
- Provide data to an array of agencies, businesses, and the public
- Develop a baseline understanding groundwater quality in the state, including emerging compounds

Additional information about the groundwater MWN is provided on the GWRB website (https://www.ncwater.org/?page=20). Available data include the location, elevation, screen depth and the aquifer for each network well; historic groundwater levels; an extensive interactive map interface with more than 30 data layers; chloride analyses showing fresh, transitional and saltwater zones within each aquifer; more than 3,500 lithologic and geophysical well logs; aquifer analysis tools; potentiometric surface maps for each aquifer; and the state hydrogeologic framework. Links are also provided to the GWRB Annual Well Network Report, which includes updated maps of the well network, describes any updates or changes that have affected the well network, and summarizes annual data collection (NCDEQ-DWR: North Carolina Groundwater Publications (ncwater.org)).

Since 2015, the GWRB MWN program has broadened its scope, to include groundwater quality parameters. In July 2019, the GWRB ambient groundwater monitoring program began sampling the MWN groundwater wells for PFAS in the lower region of the Cape Fear River Basin. This effort focused on 91 wells at 35 of the 39 MWN stations in the Cape Fear River Basin. The remaining four wells were not sampled due to poor well construction or due to private ownership (*Figure 5-2*). See Chapter 12 for more information regarding the ambient groundwater monitoring well network PFAS sampling. A complete list of the active groundwater monitoring wells, their depth and aquifer placement are included in the Chapter 5 appendix.

The GWRB chloride sampling within the aquifers of North Carolina allows DWR to monitor salinity levels and trends at the freshwater-saltwater interface within each of the major Coastal Plain aquifers (Laughinghouse, 2020). Salinity levels and the location of the interface can change because of sea-level rise, storm surges during hurricanes, groundwater pumping and mine-dewatering. These chloride levels are used to determine if groundwater is freshwater zone (<250 ppm chloride), saltwater zone (>=250 ppm chloride) or transition zone. This transition zone is characterized by a vertical salinity gradient within the aquifer in which salinity increases with depth, from fresh-to-salty (Laughinghouse, 2020). More information about North Carolina's aquifers can also be found on the GWRB's website and later in this chapter. To learn more about DWR's monitoring well network and to view or download data, visit the GWRB's home page and the groundwater quality and groundwater education and information pages.

Figure 5-2: DWR Groundwater Monitoring Wells and Geologic Belts of the Cape Fear River Basin.



5.2.2 Description of the Aquifer System

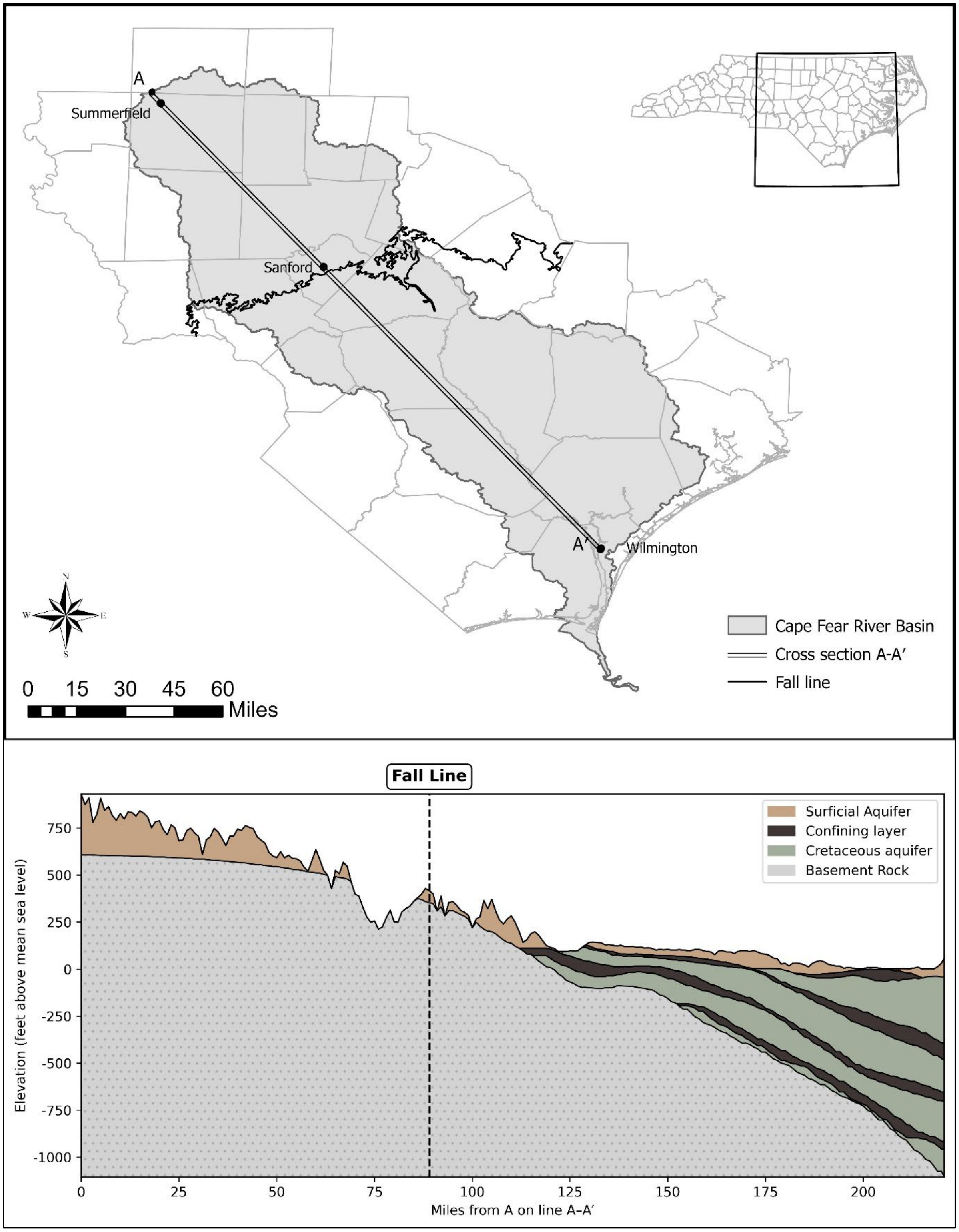
An unconfined aquifer, also called a surficial aquifer, occurs at the land surface. Recharge to a surficial aquifer occurs as direct infiltration across the full extent of the aquifer. The water level, also known as the water table, of surficial aquifers occurs where water pressure is equal to atmospheric pressure, and it rises and falls seasonally in response to variations in precipitation and air temperature. Surficial aquifers also tend to be well-connected to surface water features including streams and lakes. In perennial streams, groundwater is the primary source of flow between precipitation events so any change in the quantity or quality of groundwater stored in a surficial aquifer may directly impact the stream.

A confined aquifer is separated from the land surface and other aquifers by one or more impermeable layers of rock or sediment called an aquitard. Most confined aquifers are sedimentary and in North Carolina, confined aquifers of the Coastal Plain consist of thick, water-saturated sand or limestone layers that are confined on top and bottom by impermeable beds of clay and silt. Water flowing through a confined aquifer is under immense pressure from the weight of overlying water and rock. Although confined aquifers are generally disconnected from surface water resources, exceptions may occur, erosion or structural deformations (folding, faulting, etc.) cut across the upper confining layer and expose the aquifer to the surface. If groundwater is under enough pressure to flow to the land surface at an outcrop, groundwater will discharge to the surface as an artesian spring. Artesian springs commonly occur in stream channels the resulting discharge supplies a portion of stream baseflow. In general, recharge in confined aquifers occurs at much lower rates than in surficial aquifers. Most occurs by direct infiltration where the aquifer outcrops, which can be a narrow window relative to the overall extent of the aquifer. Additional recharge may occur as leakage from adjacent aquifers.

The aquifer system within the Cape Fear River Basin consists of the regolith-bedrock aquifer of the Carolina Slate Belt, the low-permeability sedimentary deposits of the Durham-Sanford Basin and the surficial and confined aquifers of the Coastal Plain. Altogether, these aquifer systems include six regionally significant hydrogeologic units. Only one of these, the surficial aquifer, occurs throughout the entire Cape Fear River Basin. The other five are confined aquifers which only occur in the Coastal Plain. Each of the six hydrogeologic units are discussed below. An image of the unconfined bedrock aquifer and confined Coastal Plain aquifers in the Cape Fear River Basin is shown in *Figure 5-3*.

Four of the confined aquifers in the Coastal Plain were deposited during the Cretaceous period, approximately 130–63 million years ago from bottom to top (oldest to youngest), these aquifers are the Lower Cape Fear, the Upper Cape Fear, the Black Creek and the Peedee. Each is composed of sand and gravel that accumulated in a marginal marine environment as sea levels receded eastward from the present-day fall line.

Figure 5-3: Cross Section of the Surficial and Confined Aquifers in the Cape Fear River Basin.



The Cretaceous aquifers are overlain by thick deposits of shallow marine limestone deposited in the Tertiary period, approximately 63–2 million years ago. From bottom to top (oldest to youngest), these are the Beaufort, Castle Hayne, and Yorktown formations. Moving from bottom to top, the aerial extent of these aquifers grows smaller and shifts to the north. In some coastal areas, overlying confining layers are thin or absent. In these regions, the tertiary aquifers are part of the surficial aquifer system, which is otherwise composed of Quaternary sand and soil deposited in the last 2 million years, and they exchange water with surface water features including streams and estuaries.

Major recharge areas for the Cretaceous aquifers are far from the modern coastline, occurring where the aquifers outcrop at the land surface. Over time, salty water present at the time of deposition has been flushed seaward by the outward flow of freshwater. The modern transition zone between fresh (< 250 ppm chloride) and salty (>= 250 ppm chloride) water is up to 55 miles inland in the Lower Cape Fear aquifer and moves progressively seaward in the younger (shallower) Cretaceous aquifers. In the deeper confined aquifers, freshwater west of the freshwater-saltwater interface has been isolated from anthropogenic impacts for thousands of years. As a result, fresh groundwater in the Cretaceous aquifers typically exhibits high-quality water characteristics (i.e., low in nutrients, metals) and has been values as a source of low-cost, high-quality drinking water for decades.

In coastal counties, fresh water is uncommon in the Cretaceous aquifers. Here, chloride concentrations range from 100 ppm to more than 250 ppm. Although treatment options including reverse osmosis are becoming more common, preference has historically been given to shallower, fresher groundwater of the Castle Hayne or Yorktown aquifers, if present. The Yorktown aquifer is not present in any portion of the Cape Fear River Basin.

As the population of Coastal Plain communities has increased and economic opportunities have expanded, demand for groundwater from the Coastal Plain aquifers has also increased. By the late 1900s, groundwater monitoring indicated that water was being pumped from some portions of the Cretaceous aquifers at rates that exceeded recharge. Over time, large recharge deficits are unsustainable and result in declining water levels and well productivity, dewatering, or saltwater encroachment.

In 2002, North Carolina declared a Central Coastal Plain Capacity Use Area, comprised of 15 counties in the Coastal Plain, and authorized DWR to regulate groundwater withdrawals in these counties per the Water Use Act of 1967. The CCPCUA Rules approved by the Environmental Management Commission (EMC) encouraged large water users to develop alternative sources to reduce reliance on the Cretaceous aquifer system and established a permit program used to monitor and manage water withdrawals within the CCPCUA counties. More information about CCPCUA management in the Cape Fear River Basin is discussed later in this chapter.

5.2.2.1 Surficial Aquifer, Basement Saprolite, and Basement Rock

Surficial aquifer systems are continuous throughout the Cape Fear River Basin and are an important source of potable water, especially in the Piedmont where no deep confined aquifer system exists. In the Carolina Slate Belt and Triassic Basin, bedrock aquifers are overlain by soil and a deeply weathered layer of bedrock called saprolite. Groundwater in saprolite moves through pore and fractures; in deeper bedrock aquifers, it is stored and transmitted through networks of faults and fractures. Production wells in bedrock aquifers must intersect one or more water-bearing fractures, which tend to be more concentrated in valleys.

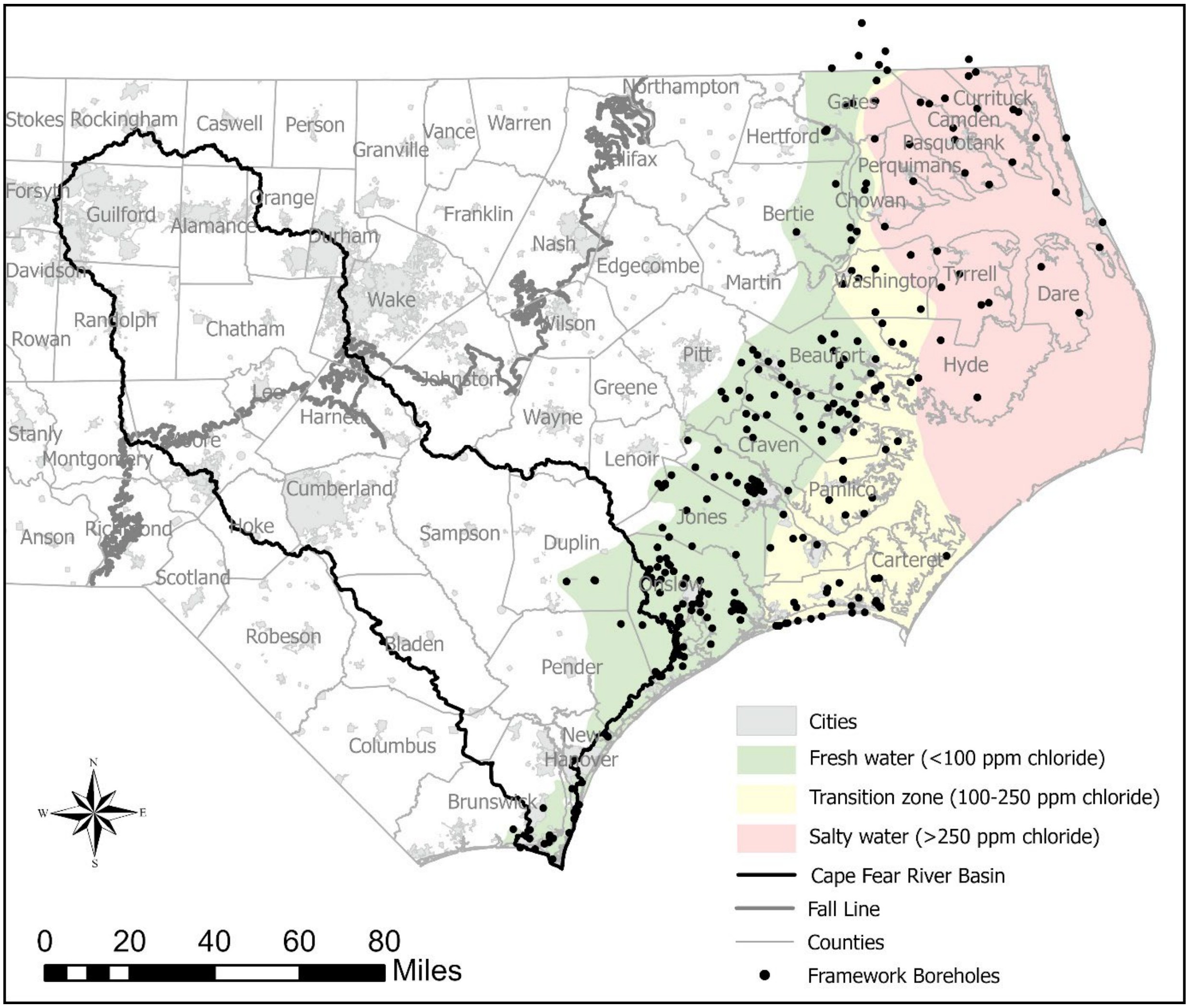
The surficial aquifer system in the Coastal Plain is generally comprised of the uppermost layers of soil and quaternary sands or shallow limestones. Where the Castle Hayne limestone formation outcrops as a surficial aquifer in the coastal regions of Onslow, Pender, Duplin, New Hanover, and Brunswick Counties (see *Figure 5-4*), it is an exceptionally productive resource. Since surficial aquifers are recharged by direct infiltration, groundwater resources in surficial aquifers are sensitive to drought and land-cover changes.

5.2.2.2 Castle Hayne Aquifer

The extent of the Castle Hayne aquifer in the Cape Fear Basin is limited, underlying approximately 817 square miles of the coastal basin, including portions of Brunswick, New Hanover, Pender, Duplin and Onslow counties (*Figure 5-4*). From its western margin, the top of the Castle Hayne dips to the southeast at a rate of about 12 feet per mile, dropping from 8 feet above sea level to 130 feet below sea level. The aquifer also increases in thickness from less than 1 foot in Duplin and Pender counties to over 300 feet in Onslow County.

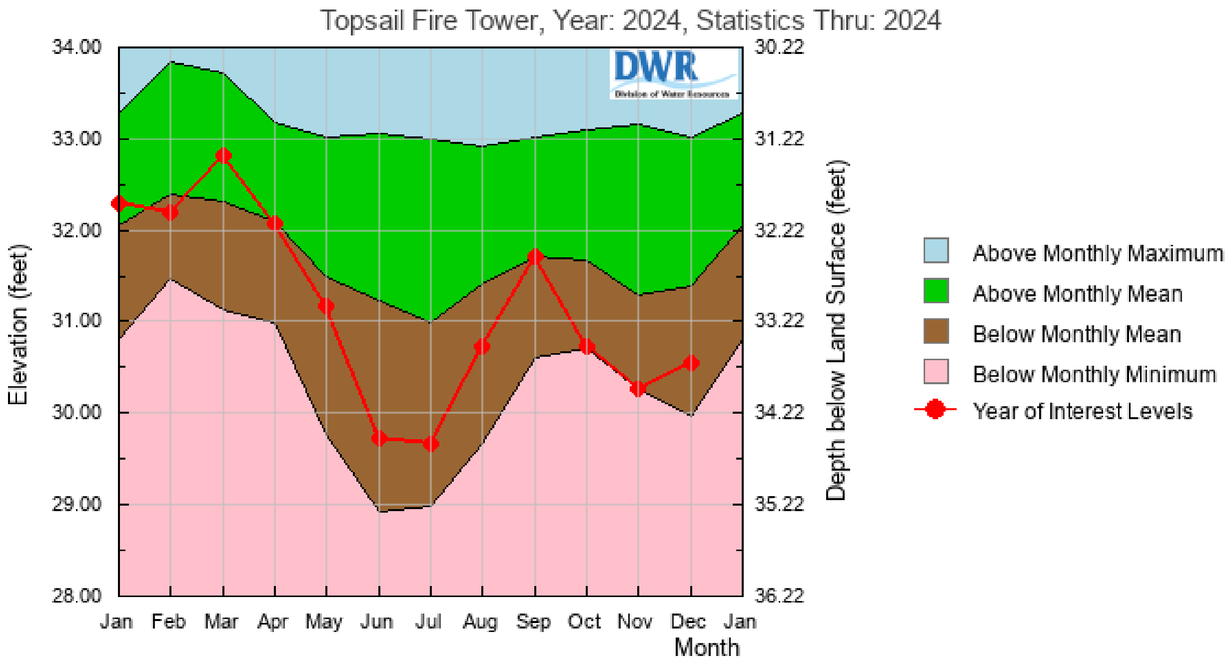
Groundwater flow is to the east/southeast. Most of the aquifer is confined and the majority of recharge occurs at outcrops in the western margin and at the coast. Between outcrops, leakage from the overlying surficial aquifer contributes recharge at a much lower rate. Monitoring data collected from the Holly Ridge, Topsail Beach, and Topsail Fire Tower monitoring stations, show that water levels in the Castle Hayne average about 30 feet above mean sea level (MSL) at the coast. Lower water levels are common in the summer months, but overall seasonal variability is small (± 2 feet, see *Figure 5-5*). Where it is confined, groundwater resources in the Castle Hayne aquifer are vulnerable to over-pumping and salt-water encroachment (in coastal reaches). Drought and land-cover changes may impact water supply or quality at local scales where the aquifer outcrops at the surface. For additional information about monitoring wells, see Section 5.2.1.

Figure 5-4: Castle Hayne Aquifer Map with the Extent of the Fresh, Transitional, and Salty Parts of the Aquifer; the Distribution of Boreholes as Point Data based on 2024 Sampling Events.



Data sources include the following: USGS Open-File 87-690, USGS WRIR 93-4049, 89-4128, & 87-4178; and DWR's Hydrogeologic Assessments of Wilmington Harbor, North Albemarle, CUA #1, Southern Coastal Plain, Central Coastal Plain, East Central Coastal Plain, and the Northwestern Coastal Plain.

Figure 5-5: Statistical Curves Based on the DWR Data of the Record through 2024 for the Topsail Fire Tower Well in the Castle Hayne Aquifer. Red Points are 2024 and Correspond to the Water Level on the Latest Date in each Month.

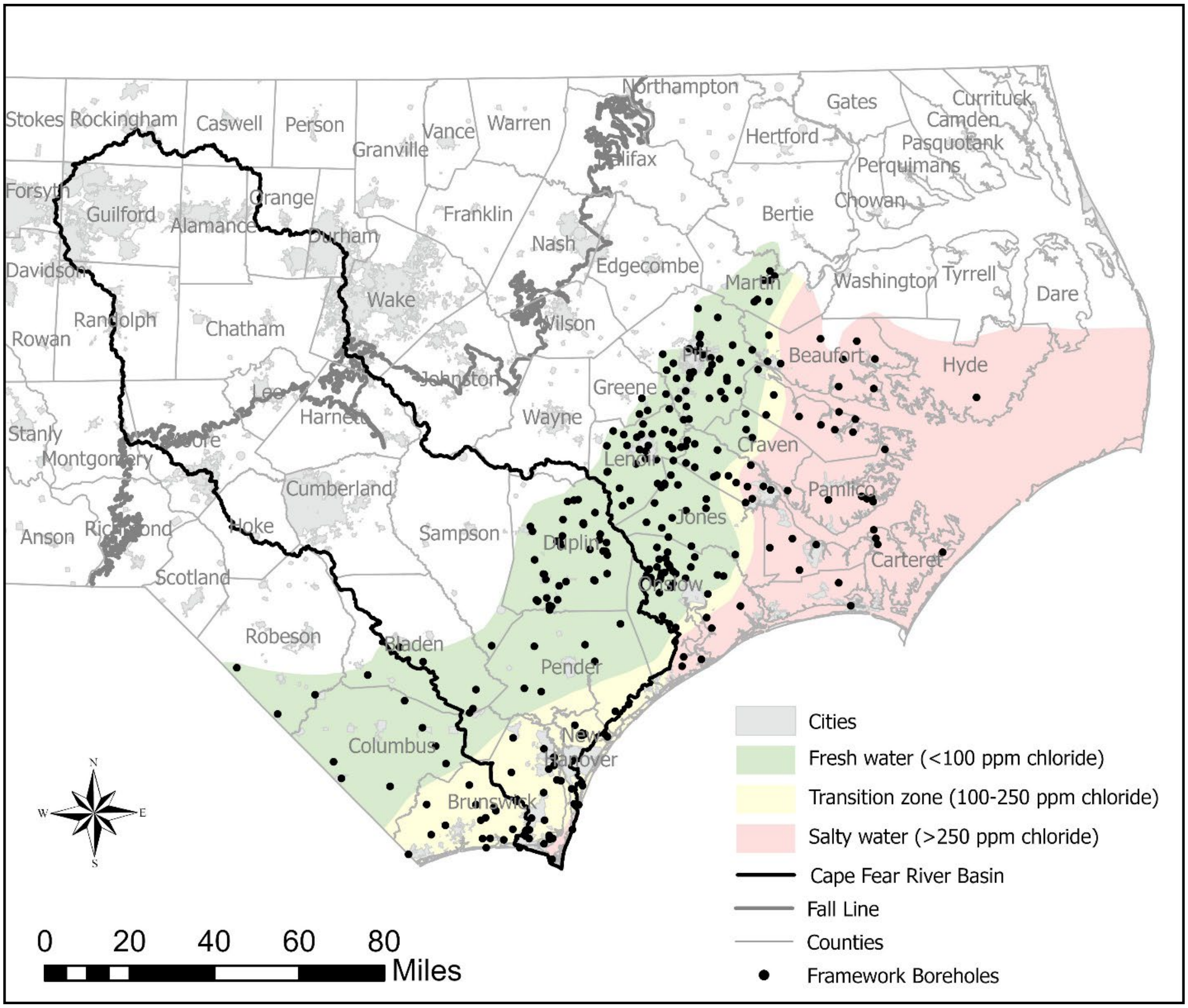


5.2.2.3 Peedee Aquifer

The Peedee aquifer is present in the lower third of Cape Fear River Basin, emerging along a line through central Bladen County, the southern tip of Sampson, and into central Duplin County, based on current interpretation, and continuing east (*Figure 5-6*). The top of the aquifer dips southeast at a rate of 5 feet per mile from its western margin to New Hanover County, where the dip increases to a rate of 24 feet per mile. As it dips, the elevation of the top of the aquifer ranges from about 38 feet above sea level in southern Robeson County to about 220 feet below sea level at Kure Beach in New Hanover County. Available data indicate the upper surface of the Peedee aquifer is hummocky in the central part of the study area, apparently due to an erosional cut and fill surface between Quaternary and Peedee age deposits. The Peedee varies in thickness, reaching up to 400 feet or more in eastern Brunswick County.

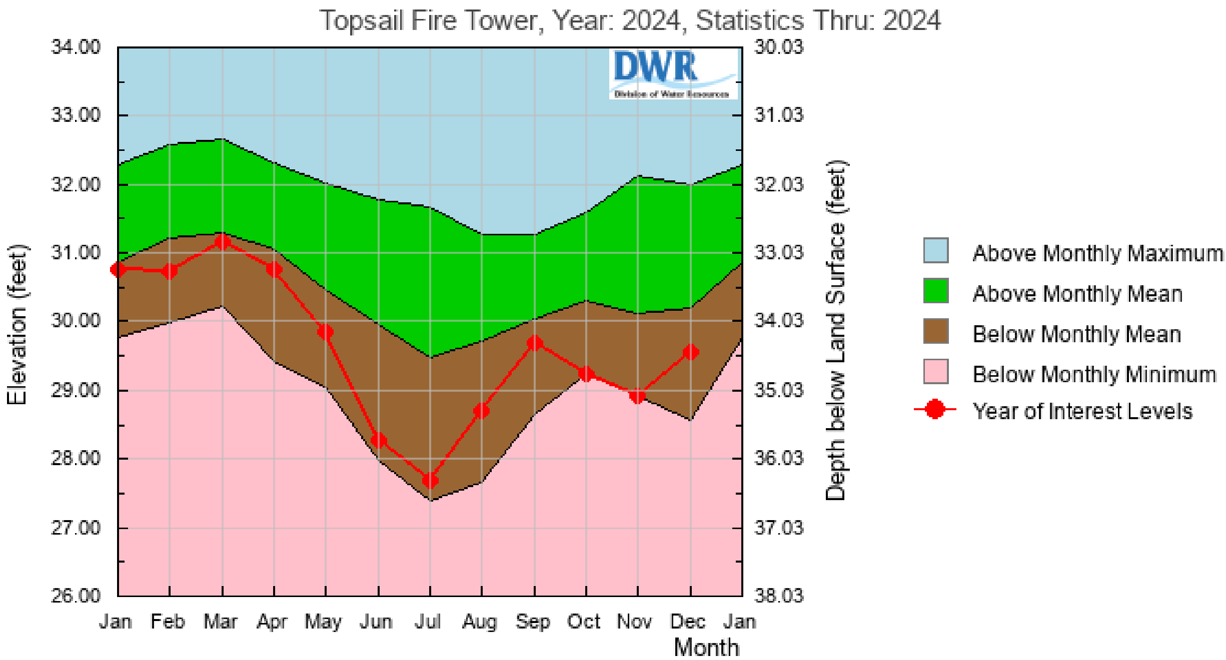
Following recharge, which is limited to narrow outcrops in the aquifer's western margins and leakage from the overlying surficial aquifer, groundwater flows eastward. Water levels along the flow path decline from approximately 100 feet in the west (Bladenboro station) to less than 30 feet at the coast (Topsail Fire Tower Station). Along the flow path, groundwater changes from fresh (<100 ppm chloride) to salty (>250 ppm chloride) along a narrow (~8 mile) transition zone that bisects Bladen, Sampson, and Duplin Counties. Because it is fully confined in the Cape Fear River Basin, there is less than ±2-foot seasonal variability (see *Figure 5-7*), but the Peedee is sensitive to high volumes of groundwater extraction. Drawdown from high pumping rates also increases the risk of saltwater encroachment in wells in or near the transition zone. For additional information about these and other monitoring wells, see Section 5.2.1.

Figure 5-6: Peedee Aquifer Map with the Extent of the Fresh, Transitional and Salty Parts of the Aquifer; the Distribution of Boreholes as Point Data based on 2024 Sampling Events.



Data sources include the following: USGS Open-File 87-690, USGS WRIR 93-4049, 89-4128, & 87-4178; and DWR's Hydrogeologic Assessments of Wilmington Harbor, North Albemarle, CUA #1, Southern Coastal Plain, Central Coastal Plain, East Central Coastal Plain and the Northwestern Coastal Plain.

Figure 5-7: Statistical Curves Based on the DWR Data of the Record through 2024 for the Topsail Fire Tower Well in the PeeDee Aquifer. Red Points are 2024 and Correspond to the Water Level on the Latest Date in each Month.

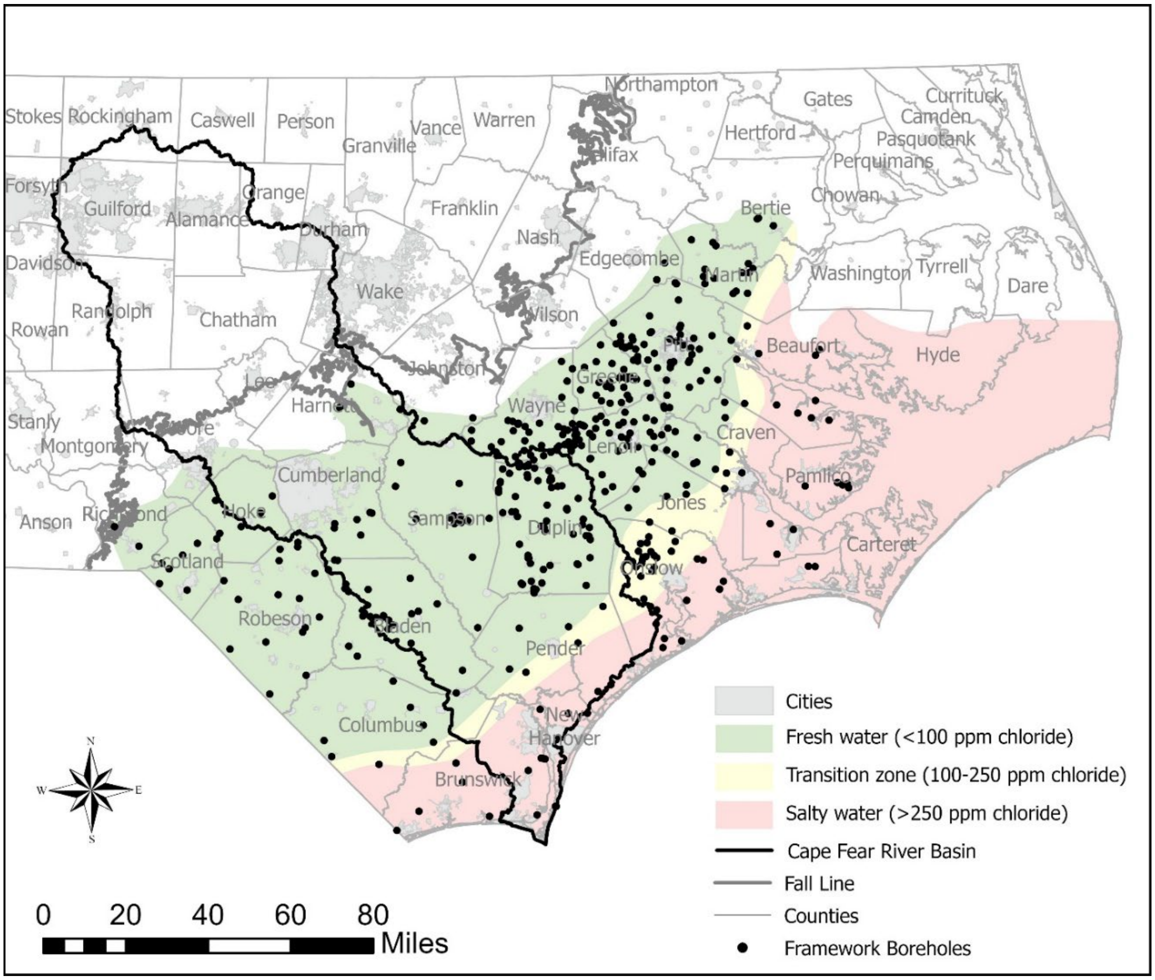


5.2.2.4 Black Creek Aquifer

The Black Creek aquifer is exceptionally productive and yields high-quality groundwater that is valued throughout the Cape Fear River Basin. The Black Creek aquifer is fully confined throughout the Cape Fear River Basin, except a narrow recharge zone where it outcrops in Harnett, Cumberland, and Richmond Counties, between 5 and 25 miles southeast of the Fall Line. From its maximum elevation of about 215 feet, the top of the Black Creek aquifer dips steeply to east-southeast, first at a rate of 17 feet per mile and later increasing to 38 feet per mile (*Figure 5-8*). Thickness of the Black Creek varies considerably throughout the Coastal Plain, but is thickest along the Pender County coast, where it is up to 400 feet thick.

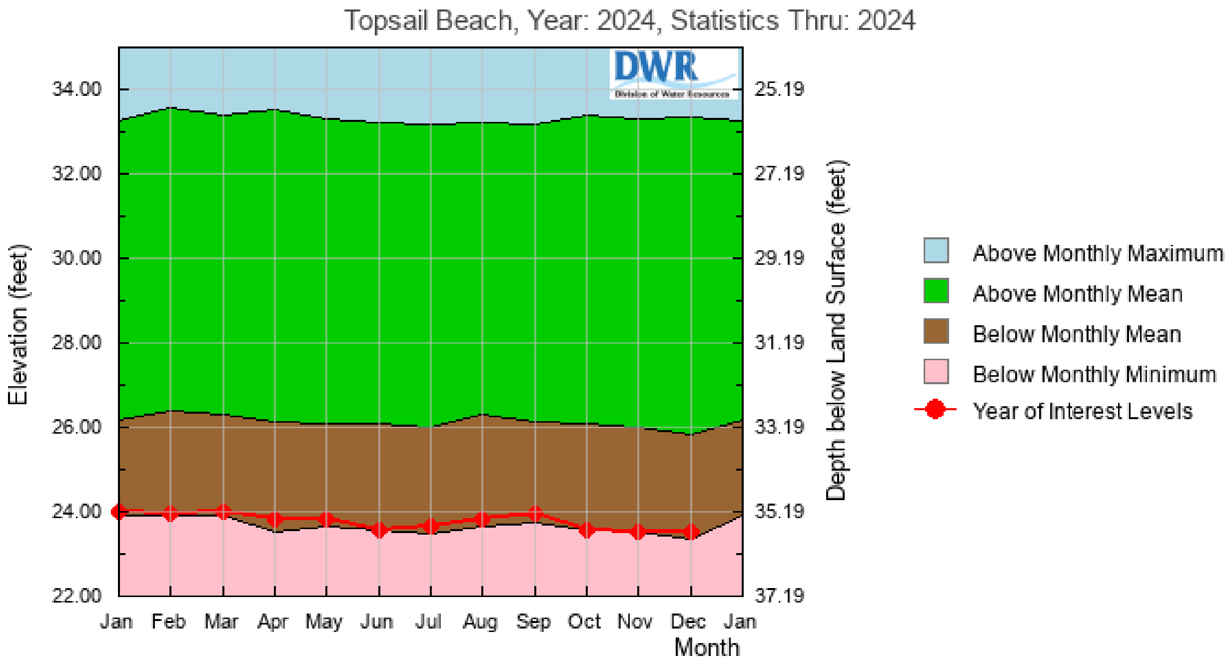
Groundwater in the Black Creek aquifer generally flows east-southeast. Under current conditions, water levels along the flow path decline from an estimated 220 feet above sea level in Harnett County to ~20 feet at the coast and are remarkably consistent year-round (*Figure 5-9*), which is typical for a well-confined aquifer. The fresh-to-saltwater is narrow (~6 miles), cutting across the border between Columbus and Brunswick Counties and bisecting Pender and Onslow Counties. In the lower reaches of the Cape Fear River Basin, recharge to the Black Creek aquifer is limited to leakage from overlying aquifers, enhancing its vulnerability to dewatering and saltwater encroachment, particularly near large population centers. The CCPCUA program, established in 2002, regulates groundwater withdrawals and monitors levels to promote sustainable groundwater development. Four of the fifteen counties regulated are within the Cape Fear River Basin; these include Wayne, Lenoir, Duplin, and Onslow Counties.

Figure 5-8: Black Creek Aquifer Map with the Extent of the Fresh, Transitional and Salty Parts of the Aquifer; the Distribution of Boreholes as Point Data based on 2024 Sampling Events.



Data sources include the following: USGS Open-File 87-690, USGS WRIR 93-4049, 89-4128, & 87-4178; and DWR's Hydrogeologic Assessments of Wilmington Harbor, North Albemarle, CUA #1, Southern Coastal Plain, Central Coastal Plain, East Central Coastal Plain, and the Northwestern Coastal Plain

Figure 5-9: Statistical Curves Based on the DWR Data of the Record through 2024 for the Topsail Beach Well in the Black Creek Aquifer. Red Points are 2024 and Correspond to the Water Level on the Latest Date in each Month.



5.2.2.5 Upper Cape Fear Aquifer

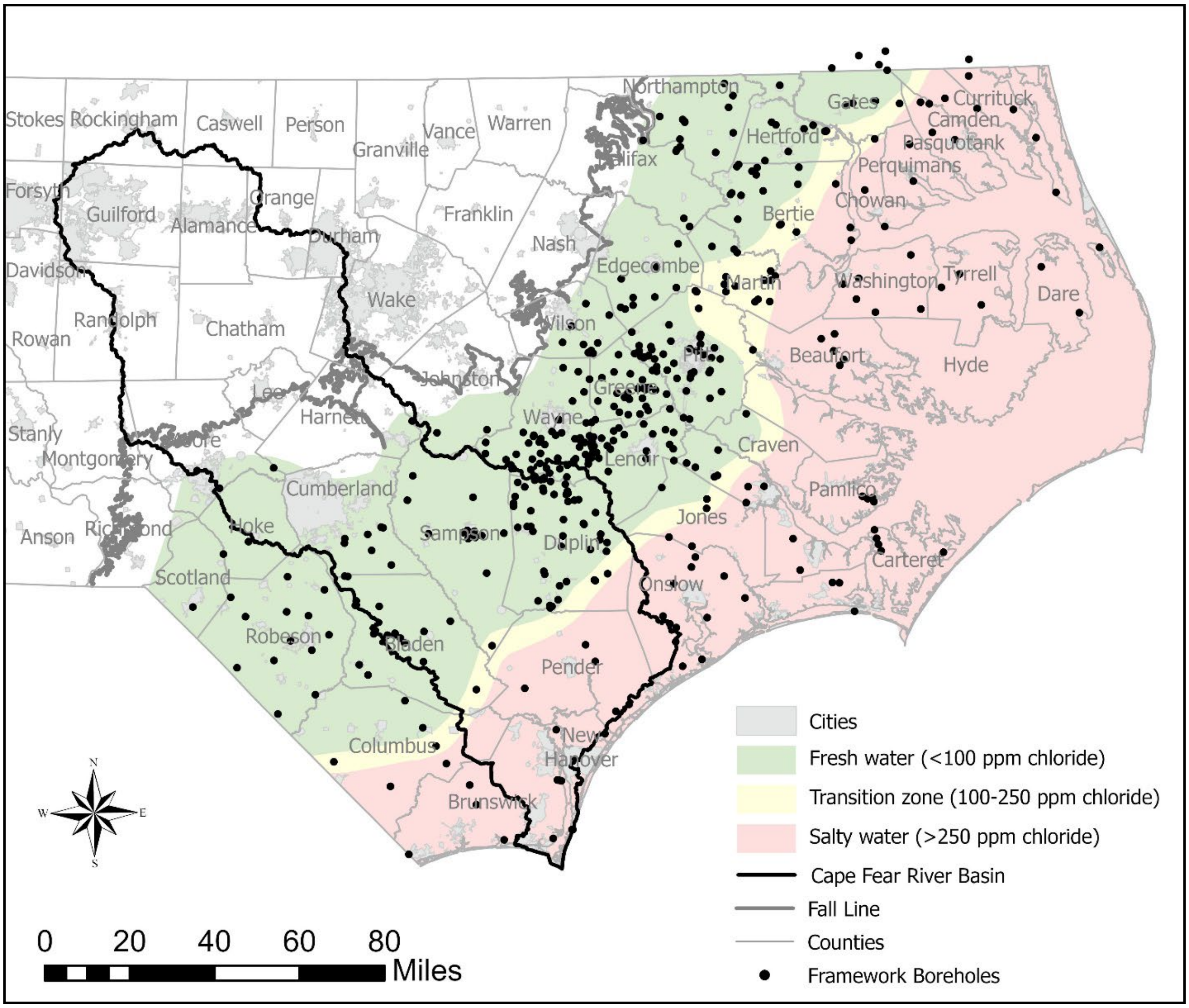
The Upper Cape Fear is a confined aquifer composed of alternating beds of sand, clay and silt of the Upper Cretaceous Cape Fear Formation. The sands are made up of quartz and feldspar, and are fine to coarse grained, subrounded to subangular, poorly sorted with minor to abundant iron oxide staining. Also present are accessory iron oxide minerals such as pyrite, marcasite and siderite. Fine gravel is present in some well samples. Clay and silt beds are generally red and pink to yellowish gray in color.

The aquifer top ranges in elevation from about 40 feet above sea level at its upper extent to 905 feet below sea level at Kure Beach in New Hanover County (*Figure 5-10*). Dip is to the southeast at a rate that varies from about 5 to 30 feet per mile. The aquifer thickens to the east from about 45 feet at its northwestern extent to more than 200 feet in northern New Hanover County.

Pumping of the Upper Cape Fear and overlying Black Creek aquifers near Tar Heel, Elizabethtown and White Lake has produced large cones of depression in both these aquifers. A 2004 agreement between the Lumber River Council of Governments, DWR and the Environmental Management Commission (EMC) pressured Smithfield Foods and other water users to begin planning for use of surface water from the Cape Fear River for their water needs. The recent addition of the Bladen Bluffs surface water supply from the Cape Fear River has since resulted in significant rebound of both the Black Creek and Upper Cape Fear aquifers. Based on the state monitoring network well at Smithfield-McNair House, the water level in the Upper Cape Fear rose 90 feet from 2013 to 2015. See the Chapter 5 Appendix and the GWRB resources in Section 5.2.1 for more information on this topic.

Another area of growing concern is where Upper Cape Fear Aquifer is relied on in the vicinity of Clinton and Mount Olive. Although Mount Olive lies just outside the Cape Fear River Basin, it has a broad cone of depression around it which extends into the Cape Fear River Basin. Clinton, like Mount Olive, does not have a significant source of nearby surface water to use as an alternate water supply and may eventually face a shortage. The fresh-saltwater transition zone in this aquifer is estimated to be in Duplin County, southern Bladen County as well as northwestern Pender County (*Figure 5-10*). Between 2019 and 2022, salinity increases were observed at the Kelly station and decreases in salinity were observed at the Ivanhoe station (Laughinghouse, 2022).

Figure 5-10: Upper Cape Fear Aquifer Map with the Extent of the Fresh, Transitional and Salty Parts of the Aquifer; the Distribution of Boreholes as Point Data based on 2024 Sampling Events.

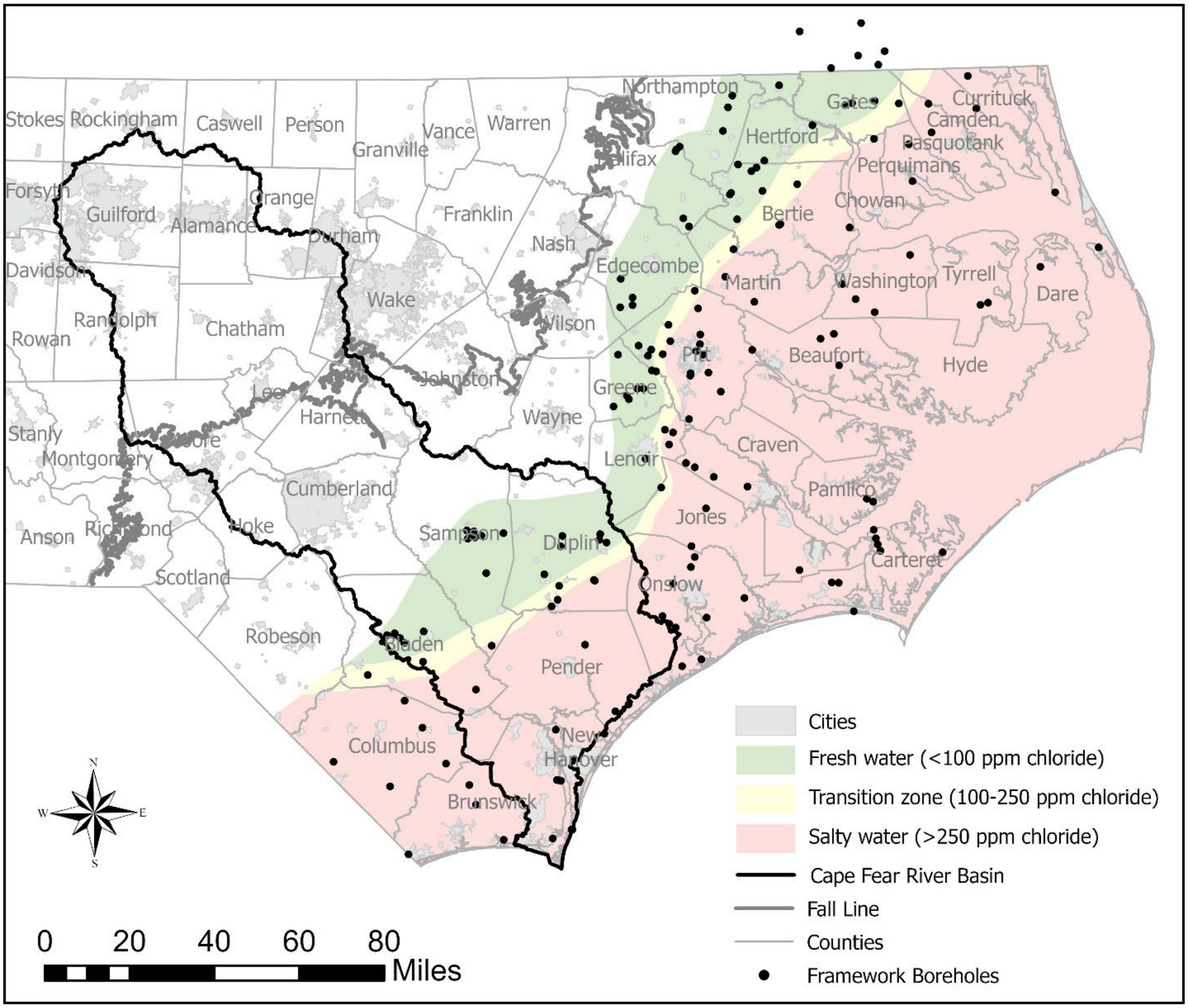


Data sources include the following: USGS Open-File 87-690, USGS WRIR 93-4049, 89-4128, & 87-4178; and DWR's Hydrogeologic Assessments of Wilmington Harbor, North Albemarle, CUA #1, Southern Coastal Plain, Central Coastal Plain, East Central Coastal Plain, and the Northwestern Coastal Plain.

5.2.2.6 Lower Cape Fear Aquifer

The oldest and deepest Coastal Plain aquifer within the study area is the Lower Cape Fear. It lies unconformably on igneous or metamorphic bedrock, or Triassic sedimentary rock, where present. The Lower Cape Fear is lithologically similar to Upper Cape Fear except that the lower section contains reworked material from the underlying bedrock. The aquifer ranges in thickness from less than 1 foot at its northwestern extent to approximately 430 feet near Southport in Brunswick County. West of the saltwater interface, located near the Duplin and Pender County line, the Lower Cape Fear can be a reliable source of potable water (*Figure 5-11*). Between 2019 and 2022, salinity increases were observed at Pink Hill, Six Runs, and Kelly stations (Laughinghouse, 2022).

Figure 5-11: Lower Cape Fear Aquifer Map with the Extent of the Fresh, Transitional, and Salty Parts of the Aquifer; the Distribution of Boreholes as Point Data based on 2024 Sampling Events.



Data sources include the following: USGS Open-File 87-690, USGS WRIR 93-4049, 89-4128, & 87-4178; and DWR's Hydrogeologic Assessments of Wilmington Harbor, North Albemarle, CUA #1, Southern Coastal Plain, Central Coastal Plain, East Central Coastal Plain and the Northwestern Coastal Plain.

5.2.3 Hydraulic fracturing and hydrocarbon extraction

Session Law 2011-276, in part, directed DEQ, then Department of Environment and Natural Resources (DENR), to examine environmental impacts to water resources from the use of drilling and hydraulic fracturing to extract hydrocarbons in the Triassic Basin and other parts of the state (NCDENR and NCDC, 2012). The report was to be submitted to the state legislature's Environmental Review Commission (ERC) by May 1, 2012. The findings of the report were somewhat limited due to the lack of knowledge on hydrocarbon availability in underlying formations throughout the state.

The main focus was on the Triassic geological basin, primarily the Sanford subbasin within the Deep River geological basin, due to previous field investigations. The Sanford subbasin bisects the mid-Cape Fear Basin in a southwest-northeast orientation through eastern Chatham, western Wake, central Moore and Lee counties, generally underlying the lower Deep and Haw River hydrologic subbasins. Core samples and other field studies have shown the formation to have supplies of hydrocarbons for potential extraction. Additionally, this region was mined sporadically for coal in shallow seams between 1832 and 1953 (Clark et al., 2011). The general conclusion of the department was that "[w]ith wise management, adequate water supplies would likely be available to support shale gas extraction in the vicinity of the Triassic Basins in North Carolina" (NCDENR and NCDC, 2012).

Session Law 2012-143 authorized the regulated activities of the hydrocarbon extraction industry in the state (NCGA, 2012). The session law also directed the EMC, the Mining and Energy Commission and the Commission for Public Health to adopt rules to regulate the industry by October 1, 2014. Rules in 15A NCAC 05H provide guidance for the extraction of hydrocarbons. In terms of water resources, the rules established the requirements for both water (surface, ground, purchased and alternatives) and waste management plans and site remediation plans. In addition, there is an annual water use report and an annual exploration and production (E&P) waste management report. Section 15A NCAC 05H .1902, in part, requires surface water withdrawals to identify the affected stream reach, the hydrologic characteristics of the stream reach and the potential impacts on other users and instream flows (NCAC, 2005). An estimate of the 7Q10 flow is required and withdrawals are limited to a flow equivalent to 20% of the 7Q10 flow. During actual surface water withdrawals, if stream flow reaches the 7Q10 flow, then withdrawals must cease until the surface flow reaches 120% of the 7Q10 flow. The flow that equals the 7Q10 is the minimum average flow for a period of seven consecutive days that has an average recurrence of once in 10 years.

Amvest drilled two wells in the Triassic Basin for the purpose of hydraulic fracturing in 1998 (NCDENR and NCDC, 2012). “That fracturing effort was unsuccessful in both wells, but the wells flowed gas and Amvest placed a wellhead containing several pressure shut-off valves (also known as a Christmas tree) on each complete well” (NCDENR and NCDC, 2012). Since the installation of these two wells, North Carolina hasn’t had an oil or gas well drilled (NCDEQ, 2022).

5.2.4 Aquifer Storage and Recovery

Aquifer Storage and Recovery (ASR) is the process of injecting potable water into aquifers below the ground for storage and later recovering that water for use. One common use of ASR is for management of peak demand and raw water supply in public drinking water systems. In this scenario, excess treated drinking water can be injected in periods when supply exceeds demand and can be recovered later when demand exceeds the treatment plant's capacity. If an aquifer is used as the injection zone and the aquifer matrix and native groundwater are chemically compatible with the injected water, the recovered water should be roughly the same quality as when it was injected and thus should require only additional disinfection treatment prior to distribution to the public. An ASR well is a type of Class V Underground Injection Control (UIC) Well and a permit is required to be issued by the DWR prior to construction and operation. In addition to this permit, a water supply well permit is required by the respective regional office, and the Public Water Supply Section of the DWR must approve of the use of the ASR well in a public water system, although issuance of the injection well permit is independent of these approvals.

A single Injection ASR well permit (permit number: WI0800149) was issued to the Cape Fear Public Utility Authority (CFPUA) in 2008 to serve as water for storage when there is insufficient water supply (NCDEQ, 2008). The ASR project installed one ASR well for injection and recovery. CFPUA obtains much of its raw water supply from the Cape Fear River. Treated water from the Cape Fear River was used for injection into the Peedee aquifer for storage in June 2017.

The nature and scope of Chemours' contamination in the Cape Fear River emerged later, with a realization that the source water for CFPUA's water distribution system (and stored in the Pee Dee aquifer at Westbrook ASR) contained Per and Polyfluoroalkyl Substances (PFAS), including Chemours' compound GenX (NCDEQ, 2022). CFPUA responded by ceasing injection and then withdrawing and discharging approximately 50 million gallons of treated drinking water containing GenX stored in the ASR Pee Dee aquifer with discharge to the sanitary sewer (NCDEQ, 2022). CFPUA monitored GenX levels and aquifer response in the vicinity of the Westbrook ASR before, during, and after withdrawal (NCDEQ, 2022). Per a Consent Order between the DEQ and Chemours Company signed February 26, 2019, testing of private water wells in the vicinity of the Chemours plant near Fayetteville and later, sampling of wells in the four downstream counties, was conducted for elevated levels of GenX. Consequently, thousands of private well users were provided alternate water supplies or filtration systems. To address PFAS in the public water system, CFPUA installed a granulated activated carbon system at the Sweeney Water Treatment Plant (WTP). As of January 2023, the plant completed the installation of GAC treatment technologies specifically to remove PFAS from the raw water prior to it being sent into the distribution system.

5.2.5 Groundwater and Surface Water

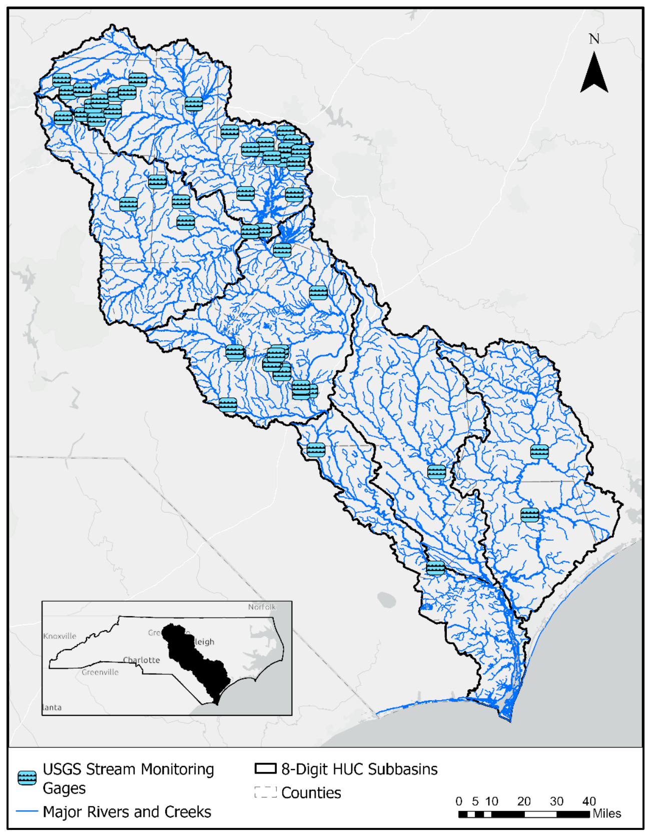
Groundwater and surface water are hydraulically connected, but those connections are often difficult to measure. A surface waterbody can gain water from groundwater (gaining stream), lose water to groundwater (losing stream), or it can gain and lose depending on the streambed, hydrology and geography of the area. In either instance, the interactions between ground and surface water impact water quality and the availability of both (Winter et al., 1998). Major withdrawals from surface water or groundwater can limit the amount of water available for all uses in the basin. GWRB is continually working to update statewide methodologies to calculate groundwater demand and availability to identify future needs and management measures (where applicable).

5.3 Streamflow

Streamflow is monitored by the U.S. Geological Survey (USGS) at gage stations across the state. Insights into the flow characteristics of a stream are aided by the presence of a gage capturing flow measurements that span decades. One of the benefits of a long-term flow record is an understanding of the five critical flow components of a stream's flow regime. These five components are magnitude, frequency, duration, timing and rate of change (Poff et al., 1997).

- **Magnitude** refers to a particular amount, or height of water, within the range of low to high flows at a moment in time at a particular location within a stream channel.
- **Frequency** is how often a particular amount occurs during a designated period of time within a period of recorded flows.
- **Duration** refers to the length of time that the particular amount is sustained during an episode.
- **Timing** refers to the predictability of a particular magnitude during the year or season.
- **Rate of change** refers to the deviation from a particular flow within a given amount of time.

Figure 5-12: Active USGS Gages in the Cape Fear River Basin as of 2023.



Other benefits from established gages are: assisting in early flood warning; helping in the revision of floodplain maps; monitoring drought conditions; informing recreational boaters and anglers; helping determine the assimilative capacity for discharge permits into a receiving waterbody; supporting decisions on water withdrawals for drinking water, irrigation and industry; understanding environmental changes associated with a changing climate; aiding in establishing and monitoring compliance with instream flow requirements based on flow characteristics; and developing hydrologic models. Accurately measuring streamflow and reservoir levels is critical to understanding long-term water availability as well as determining real-time instream and lake/impoundment level conditions. There are 52 active streamflow gages in the Cape Fear River Basin operated by the USGS (*Figure 5-12).* Streamflow measurements are usually available in the form of discharge rate reported as the volume of water per unit of time--represented by the letter "Q"--, typically cubic feet per second (cfs).

5.3.1 Ecological Flow

Critical components of water supply planning and management include calculating the amount of water needed and available to supply existing and future water demands and determining the streamflow required to support the ecological goods and services of the region’s rivers, streams and adjoining riparian zone. Given the increasing off-stream demands on surface waters and the associated flow-altering infrastructure (e.g., intakes and dams), it is unlikely that 100% of the natural flow will remain in some stream channels. The challenge is how much surface water can be removed without impacting the ecosystem services of the contributing water body. Without field studies, the amount of flow that remains in contributing streams is a largely unknown portion of total water demands. It should be considered in any water demand versus available supply analysis and is key to sustaining the state’s water resources for all uses.

In unaltered watersheds, streamflow represents natural flows, ignoring the potential impacts of anthropogenic climate change. Flow-dependent organisms adapt in terms of density and species diversity to the natural flows and deviations associated with the seasons and climatic conditions. However, in a developed watershed with significantly altered water quality and quantity, the diversity and density of normally occurring aquatic organisms become altered based on each species’ ability to adapt. Some species may be lost while others may flourish. More mobile species, such as insects, may reestablish themselves within a few reproduction cycles if quality and quantity conditions improve; however, less mobile species, such as fishes and mussels, may never return to the watershed. To help sustain the density and diversity of aquatic species in streams, a flow regime mimicking unaltered conditions is preferable. Hence, as any activity (dam construction or water withdrawals for agriculture, industry or public uses) significantly alters a stream's existing flow regime, the percentage of the flow regime to sustain the existing biological, physical and chemical processes is also altered.

The term "instream flow" is often used to describe a flow requirement, but it is also used in a more general sense to refer to the amount of water flowing in a stream without providing any established level of protection. A common approach toward establishing an instream flow requirement for a project is the minimum flow, or the amount below which flows must not generally drop. A minimum flow value associated with a water withdrawal, or dam project, is not expected to be the only flow downstream of the project, but the flow below which flows should not drop and, if so, only infrequently and for a brief duration.

The minimum flow is a somewhat antiquated approach based on the reasoning that the minimum flow requirement is protecting the low-flow volumes during naturally occurring drought conditions and that a project won’t have the withdrawal capacity to significantly alter flows above the minimum flow. However, over time, the cumulative impacts of more or expanding demands in the watershed, in addition to changing land uses and climatic patterns that may reduce base flows, the minimum flow may become the only flow in the impacted reach except during storm events. In this situation, a minimum flow requirement will not protect biological integrity because the natural flow regime is either unduly compromised or absent.

The 7Q10 is a flow statistic that has become synonymous with a suitable minimum flow requirement. The flow that equals the 7Q10 is the minimum average flow for a period of seven consecutive days that has an average recurrence of once in ten years. Based on the methodology for determining the 7Q10, and its definition, it is a drought-flow statistic that has historically been used widely to determine wastewater effluent limits such that the pollutant load can still be assimilated and chemical water quality standards maintained during low-flow conditions. A flat drought-flow condition does not support biological integrity as defined or mimic natural flow variability.

Many journal articles have reported the impacts that alterations to streamflow can have on the abundance and diversity of resident aquatic organisms (Freeman and Marcinek, 2006; Phelan et al., 2017; Patterson et al., 2017; McManamay et al., 2013; Driver et al., 2020). A few approaches have been used to examine the relationship of flow alteration to aquatic biota health. One approach is a comparison of fish and macroinvertebrate samples from streams with unaltered and altered flows. An in-depth analysis of North Carolina fish and macroinvertebrate data collected by the state found that there was a 25.1% decrease in the fish species diversity index for the fish guild that favors riffle-run habitat for every 10% decrease in summer ecodeficit (Patterson et al., 2017). Ecodeficit is the area between the unaltered flow duration curve (FDC) and the altered FDC beneath it (Vogel et al., 2007). Invertebrates tended to be more sensitive to changes in flow than the riffle-run fishes (Phelan et al., 2017). For the Ephemeroptera (mayfly)-Plecoptera (stonefly)-Trichoptera (caddisfly) richness metric (EPT), an average decrease of 24.4% was found for each 10% decrease in the ecodeficit flow metric for each of the four seasonal flows, annual flow, and average annual 30-day minimum flow.

Another approach to examine the response of aquatic biota to flow alterations is calculating the withdrawal index. The withdrawal index is the maximum permitted monthly average withdrawal rate, in MGD, divided by the estimated 7Q10 at the withdrawal site (Freeman and Marcinek, 2006). Researchers in Georgia found that when permitted withdrawals exceeded between 0.5 and 1.0 times the volume of water equivalent to the 7Q10 estimate that streams may begin to experience fish species losses (Freeman and Marcinek, 2006). Not only is there a reduction in the number of species, but a shift from fish species that are specialists in utilizing the riffle habitat to the species that are habitat generalists, which flourish in the remaining pool and run habitats (Freeman and Marcinek, 2006). Connecticut fish data showed streams with high water withdrawal rates exhibited lower proportions of fishes needing flowing water to complete a portion of their life history, i.e., fluvial specialists. The same was evident for those fishes that feed on bottom-dwelling insects, i.e., benthic insectivores (Vokoun and Kanno, 2009). These streams had a greater proportion of macrohabitat generalists, such as bluegill, pumpkinseed, yellow perch, chain pickerel and largemouth bass. Increasing withdrawal rates generally accelerated the percent changes from habitat specialists to generalists. Pennsylvania aquatic insect data showed a general decline in the number of EPT genera with increasing withdrawal index in larger drainage areas (Apse et al., 2008). Driver et al. (2020) found that, although increasing water withdrawal rates will likely result in increased loss of fish species richness across a variety of streams and ecoregions, the impacts were generally less severe with a percent-of-flow water withdrawal approach in comparison to a constant rate scenario.

When establishing a suitable flow regime, water temperature is an important water quality parameter to consider, especially for dams constructed on cold-water streams, typically designated as trout waters. Top-water releases over the crest of a dam in summer months may subject cold-water aquatic species to warmer temperatures that may be lethal or reduce reproductive success (Zaidel et al., 1997). In addition, warm water has reduced oxygen solubility that may cumulatively contribute to reduced populations and species diversity. Providing a cold-water release from a dam may prove to be a challenge in the summer when the impoundment is stratified and the cold, bottom water is anoxic with little or no dissolved oxygen due to decaying organic matter near the bottom plus little water circulation (Bevelhimer and Coutant, 2006). Conversely, providing deep cold-water releases from large dams during the wrong seasons, or into warm-water rivers, can suppress the reproductive cycle of mussels and fishes (Gates et al., 2015). A blended flow from the water column may be necessary to provide the most suitable seasonal temperature and dissolved oxygen concentration.

5.3.2 Endangered Species

A number of fishes, mussels, snails, sea turtles and even the manatee are endangered or threatened aquatic species that are residents or occasional visitors to the waters of the Cape Fear River Basin. The state-listed endangered species include some mussels, such as the Atlantic pigtoe and the floaters (barrel, brook and green) as well as snails, such as the magnificent rams-horn. The federally listed species include the sturgeons (shortnose and Atlantic), the sea turtles (Green, Loggerhead, Kemp's ridley and leatherback), the West Indian manatee -- when located in inland fishing waters and the Cape Fear shiner.

The Cape Fear shiner (*Notropis mekistocholas*) is an endangered fish species that is endemic to the Cape Fear River Basin (See Chapter 1 and Chapter 7 for more details on the Cape Fear shiner). The term “endemic” means that the organism is found only in a specific, usually relatively restricted, geographic area. The shiner is found only in the Cape Fear basin. The shiner's habitat preference is the riffles, which have shallower depths and faster water velocities than the pool habitat and the intermediate run habitat. The shiner, when seeking stream cover, tends toward the American water willow (*Justicia americana*) (Hewitt et al., 2009). Microhabitat characteristics most suitable for the shiner are moderate river depths and velocities over gravel substrate and near the water willow. It is common for habitat preference of fish species to shift, depending on life stage and reproductive status; therefore, it is important to maintain a diversity of habitats for successful shiner reproduction and maturation.

Factors that may hinder the recovery of Cape Fear shiner populations are degradation of riparian habitat corridors along the river it occupies, excessive sedimentation that covers suitable gravel spawning areas, the presence of non-native predatory fishes, e.g., flathead catfish (*Pylodictis olivaris*) and Roanoke bass (*Ambloplites cavifrons*), in reaches with existing shiner populations, flow modifications associated with dams and other withdrawals and unsuitable water quality. The re-establishment of shiners into reaches of the Cape Fear basin will be hindered if these issues are not addressed. Proper management and improvements to river corridors, water quality and flow regimes will not only benefit the Cape Fear shiner but other endangered, threatened or locally depauperate species (See Chapter 1 for more details on the state and federal listing status of aquatic taxa).

The extinction of some mussel species in major river basins of the central and eastern United States was caused by the impoundment and inundation of riffle habitat. Dams are also a barrier to fishes that serve as specific hosts for the mussel's young, called glochidia, and, together with increased siltation and industrial and domestic pollution, contribute to the rapid decline of mussel populations in North America (Bogan A. E., 1993). Additionally, water discharged from deep behind a dam will be colder and have less oxygen than the stream below the dam would have naturally, which is stressful or lethal for some mussel species (Neves and Angermeier, 1990). A few of the state’s endangered mussel species are the brook floater (*Alasmidonta varicosa*) and the Carolina creekshell (*Villosa vaughaniana*) (NCWRC, 2022). Both species' ranges include the Cape Fear basin, with the creekshell found in the upper reaches of the basin. The brook floater prefers swift current in run-riffle complexes with clean gravel, sand and cobble substrate. The Carolina creekshell is usually found in silty sand or clay along the banks of small streams. More information regarding biodiversity in the Cape Fear River Basin can be found in Chapter 1.

5.4 Impoundments, Intakes, and Minimum Streamflow

Dams have been constructed throughout North Carolina to provide flood control, hydropower generation, water supply, irrigation, navigation, recreation, fish and wildlife ponds, debris and sediment control and fire protection. Dams affect habitats both upstream and downstream. Upstream habitats may become inaccessible to anadromous fish and downstream habitats receive altered surface water from upstream sources. Many dams in North Carolina are in the upstream portions of estuaries, rivers, and streams. In the Coastal Plain, dams are most abundant in the upper reaches of the Cape Fear (CHPP, 2016). On each of the Deep and Haw rivers, there are presently five hydropower dams, four of which are Federal Energy Regulatory Commission (FERC) licenses. Rockfish Creek in the Upper Cape Fear River subbasin has one FERC-licensed project. A list of previous or existing hydropower dams or licenses can be found in the Chapter 5 appendix. Many of these projects have associated minimum releases, tiered releases and seasonal adjustments.

5.4.1 Hydropower

Like most hydropower in North Carolina, dams were typically constructed to provide mechanical power and fire protection for the textile industry and eventually modernized to provide electrical power to the factories. The dams fell out of favor with the creation of public utilities, which could provide more reliable and cheaper power. Many of the dams were revitalized to provide power to the public utility's network in the early 1980s following the passage of the federal Public Utility Regulatory Policies Act (PURPA) in 1978. Most of the dams fell under the regulatory authority of the FERC. FERC licenses all dams associated with hydropower that meet the conditions of the Federal Power Act (FPA). Dams that do not meet the FPA requirements are regulated jointly by the NC Division of Energy, Mineral and Land Resources' (DEMLR) dam safety program and the NC Utility Commission through the Certification of Public Convenience and Necessity (CPCN).

Most hydropower dams in the state have a bypassed stream reach directly below the dam. Such reaches are usually called the bypassed reach because the producer's interest is to divert as much water as possible through the powerhouse to generate electricity. The water spilling from the dam into the bypassed reach is not used for power generation, hence the amount of water flowing in the bypassed reach is dependent upon the amount of water flowing downstream to the dam, the amount of power generation and the flow requirement contained in the document permitting project operation. The water used for power generation is conveyed downstream to the powerhouse by the use of a canal (or head race) or pipe (or penstock). This conveyance is used to increase the height of falling water through the turbine, which increases the amount of power produced. Hydropower projects that have the powerhouse located at the dam site, with no bypassed reach, depend on the height of the dam to create the height of water drop necessary to generate abundant electricity.

The DEQ Division of Energy Mining and Land Resources (DEMLR) is authorized to administer the Dam Safety Law and the associated administrative rules. One of the purposes of the Dam Safety Law is to ensure maintenance of minimum stream flows below dams. Depending on the flow statistics of the location, conditions may be placed on dam operations specifying mandatory minimum releases in order to maintain adequate quantity and quality of water in the length of a stream affected by an impoundment. The DWR, in conjunction with the Wildlife Resources Commission, recommends conditions relating to release of flows to satisfy minimum instream flow requirements. DEMLR then incorporates the requirements into the dam permits. A description of the FERC-licensed hydropower projects, dams and intakes in the Cape Fear River Basin with minimum releases, tiered releases and seasonal adjustments are described in the following sections and are mapped on *Figure 5-13*. See the Chapter 5 appendix for a complete list of impoundments and their associated minimum releases, tiered releases and seasonal adjustments.

5.4.1.1 Haw River Subbasin (HUC-8: 03030002) Minimum Releases, Tiered Releases, and Seasonal Adjustments for Hydropower Projects or Impoundments

There are five hydropower dams along the Haw River, four of which have FERC licenses. They are the Glencoe Mills Dam (P-7404), Saxapahaw Dam (P-4509), Bynum Dam (P-4093), and B. Everett Jordan Dam (P-11437). The Altamahaw Dam is the only non-FERC licensed hydropower project on the Haw River. Notably, the Bynum Dam project has not been operational since 2007, but the licensee is working toward its revitalization. The Bynum Dam license requires a minimum flow of 120 cubic feet per second (cfs) in its 3,000-foot bypassed reach, except from March 1 through April 30 when the flow is for 240 cfs. The Saxapahaw Dam and Glencoe Mills Dam both have perpetually issued FERC exemptions. The Saxapahaw Dam is required to operate in run-of-river, or non-peaking, mode and has a CPCN states that 10 cfs, or one-quarter of the reservoir inflow, whichever is less, is required in the west channel below the dam. The B. Everett Jordan Dam was issued a 50-year FERC license in 1997. The privately owned project is attached to the spillway tower of the United States Army Corps of Engineers (USACE)-managed reservoir and is only allowed to generate power from USACE releases. Alongside generating hydropower, the B. Everett Jordan Dam serves as water supply source and will be discussed later in this chapter.

Alongside the previously mentioned hydropower projects on the Haw River, there are several impoundments and intakes in the Haw River subbasin with minimum releases, tiered releases and seasonal adjustments. In the Haw River subbasin, there are six river impoundments. These impounded rivers are Back Creek, Big Alamance Creek, Reedy Fork, Cane Creek, Wilson Creek and an unnamed tributary to Troublesome Creek. Additionally, the City of Greensboro has an emergency intake on the Haw River just upstream of Brooks Bridge Road (SR 2712) that is used during drought conditions. Based on previous studies and the 2002 addendum to the city's Local Water Supply Plan, a flow-by of 23.2 cfs is required below the intake during pumping. The minimum releases, drainage area, tiered releases and seasonal adjustments for these projects and others in the Haw River subbasin are provided in the Chapter 5 appendix.

5.4.1.2 Deep River Subbasin (HUC-8: 03030003) Minimum Releases, Tiered Releases, and Seasonal Adjustments for Hydropower Projects or Impoundments

Along the Deep River several dams have either terminated or surrendered their project license while one dam was removed. The Worthville Dam had its license terminated in 2011 by FERC due to inactivity. The dam passes streamflow unimpeded. The Cedar Falls Dam, licensed to Piedmont Triad Regional Water Authority (PTRWA), was terminated in 2013 due to inactivity and was once considered for removal. This dam has a 2,112-foot bypassed reach and water flows over the dam unimpeded. Ramseur Dam had its license surrendered in 2011 and is a potential candidate for removal. Streamflow passes over the dam unimpeded. The Carbonton dam was removed in 2006 while the powerhouse structure still sits on the riverbank.

There are five hydropower dams along the Deep River, four of which have FERC licenses. They are Cox Lake Dam (P-6559), Coleridge Dam (P-7478), High Falls Dam (P-7987), Lockville Dam (P-6276) and the one non-FERC licensed hydropower project, Randolph Mills Dam. All the FERC-licensed projects on the Deep River have perpetually issued FERC exemptions and are required to provide minimum flows. The owner of the High Fall Dam has documented an interest in surrendering its license, and the dam is a possible candidate for removal. There are four impoundments in the Deep River subbasin with minimum releases, tiered releases, or seasonal adjustments. These waterways include the Rocky River, Pocket Creek, Deep River and an unnamed tributary to Mclendons Creek.

Notably, the PTRWA's Randleman Reservoir Dam on the Deep River serves the cities of Greensboro and High Point. The reservoir has a tiered minimum release ranging from a high of 30 cfs at full pool, 20 cfs when below 60% full pool and 10 cfs when below 30% of full pool. The minimum flow recommendations are based on a wetted perimeter study which compares the water elevation to the area of wetted stream channel. The project diverts up to 30.5 MGD (47.1 cfs). The environmental review of the project recognized that the diversion would reduce the average annual flow; however, the natural low flows in the lower Deep River would be increased by the minimum flow releases. The diversion in part is considered an interbasin transfer. Randleman Reservoir impacts hydropower generation in the Deep River. The DWR estimated that hydropower generation would be reduced by 5% to 15%, depending on the amount of withdrawal from the reservoir, proximity of the generation facility to Randleman and the minimum flow requirement at each project. The PTRWA lost a court case brought by the small hydropower producers on the Deep River on the basis of taking without compensation due to the removal of water from the Deep River watershed and the associated loss of potential power production. The minimum releases, drainage area, tiered releases, and seasonal adjustments for these projects and others in the Deep River subbasin are provided in the Chapter 5 appendix.

5.4.1.3 Upper Cape Fear River Subbasin (HUC-8: 03030004) Minimum Releases, Tiered Releases, and Seasonal Adjustments for Hydropower Projects or Impoundments

Raeford Dam (P-6619) on Rockfish Creek has no minimum release requirement in its perpetually issued FERC exemption. The project is to operate in a run-of-river, or non-peaking, mode and it has no bypass reach. The dam is west of Hope Mills with a drainage area of 179 square miles (mi^2). There are an additional 12 impoundments in the Upper Cape Fear River subbasin with minimum releases, tiered releases or seasonal adjustments. These are Branson Creek, Little Cross Creek, Little Rockfish Creek, Bones

Creek, Buffalo Meadows Creek, Mill Creek, Crane Creek, Kit Creek, Upper Little River, Juniper Branch, as well as unnamed tributaries to Stewarts Creek and Nicholson Creek. Additionally, the Town of Carthage was granted permission for an increase of its run-of-river withdrawal from 0.5 MGD to 1 MGD with no flow requirement in Nick's Creek based on an instream flow study. Carthage reconstructed the breached dam upstream of the water supply intake. The intake structure is now located in the impoundment. Downstream flows are maintained by setting the water intake weir higher than the fish passage structure, based on terms established in the project's 401 Certification. The town is also to maintain a rated staff gage for use to trigger drought response protocols.

5.4.2 Lock and Dam

The three Lock and Dam (LD) structures were built between 1910 and 1935 to provide commercial navigation on the Cape Fear River between Wilmington and Fayetteville. The last known commercial passage was in 1995. The three facilities have also been used to pass recreational vessels and to lock through diadromous fishes. The land parcels adjacent to the LDs also provide recreational facilities. Although not a federally authorized use of the facilities, water suppliers have taken advantage of the available storage behind the dams and located water intakes in each of the LD's impounded waters.

In 2020, the USACE produced a draft Section 216, Disposition Study, and an environmental assessment for the three LDs. The study was to determine the fate of the three LDs: maintain at the current level of condition; de-authorize and remove the structures; or de-authorize and transfer ownership to a willing recipient. The most favorable outcome, according to the draft document, was to transfer the LDs to a willing recipient. The NC General Assembly passed Session Law 2008-186 authorizing the state to acquire the three LDs if refurbished and providing fish passage; therefore, the state has documented its interest in assuming ownership of the LDs. Presently, LD1 is the only one with modifications in place to allow anadromous fish, such as shad, river herring, striped bass, and both Atlantic and shortnose sturgeon, to pass unimpeded upstream.

5.4.3 Cape Fear River and the Sustainable Rivers Program (SRP).

The Cape Fear River is formed at the confluence of the Haw and Deep rivers, 4.2 miles downstream of the Jordan Dam. The Deep River's drainage area is approximately 1,440 mi^2 at the confluence with the Haw River. The Haw River's drainage area is approximately 1,690 mi^2 at the Jordan Dam. The USACE owns and operates B. Everett Jordan Dam as well as three downstream lock and dams. Their water control manual stipulates their flow release guidance and includes minimum flow thresholds at Lillington.

In 2002, USACE and The Nature Conservancy (TNC) launched the Sustainable Rivers Program (SRP) (Opperman, 2008). The goal of the SRP is to restore, protect and sustain riverine and floodplain habitats by modifying the operations of USACE infrastructure while still accomplishing authorized project purposes (Winget, 2020). In 2016, the Cape Fear River was proposed for inclusion in the SRP, and in 2017, the TNC and USACE officially included the river into the program. Justifications for inclusion were the complex human-ecology relationships in the watershed, the abundant number of enthusiastic stakeholders and the potential for B. Everett Jordan Dam releases to enhance natural resources like fish and wildlife habitat and water quality (TNC and USACE, 2019).

The first step of the SRP process was for basin experts to identify the threats, opportunities and targets in the system. A launch meeting occurred at B. Everett Jordan Dam in 2017 with the results that TNC and the USACE would write a literature review and conduct data analysis on three themes- rare and diadromous fish, healthy floodplains, and improving water quality. The Nature Conservancy and USACE then completed a literature review synthesis and analysis of hydrology in the river pre-and post- dam based on the themes. Modeling was completed to look at river channel elevations with flow-stage relationships. This literature review was the precursor to an expert ecological flows meeting to craft flow prescriptions for the river. The e-flows meeting occurred in 2019, whereby participants drafted ecological flows recommendations for fish, floodplains and water quality. General interests were to provide flows to overtop the three downstream LDs to provide fish passage for diadromous fishes; provide biological cues to facilitate upstream fish movement; downstream transport of eggs and fry; timely inundation of adjacent floodplain to support riparian flora and fauna and to break up potential stratification behind the LDs during summer low-flow periods to reduce the potential for algal blooms and low dissolved oxygen.

Assembling an ecological flow regime strategy downstream of the B. Everett Jordan Dam is complicated due to many factors. The Haw River has lake-like characteristics, or is lentic, between the dam and Buckhorn Dam. The Cape Fear River exhibits river-like characteristics, or is lotic, between Buckhorn Dam and Erwin. The Cape Fear River returns to lentic characteristics behind each of the three LDs. Downstream of LD1 to the confluence with the Atlantic Ocean, the Cape Fear River becomes increasingly more tidally influenced and saline. During wet, moderate, or dry years, the characteristics of the lentic and lotic reach boundaries expand or contract depending on intervening drainage contributions and releases from the B. Everett Jordan Dam. There are differing seasonal biologic requirements in the river associated with fish migration, spawning and transport of eggs and larvae. Differing seasonal water quality parameter requirements need managing to maintain nutrient transport and to prevent stratification behind the LDs during low-flow periods. The travel time to get desirable amounts of water to desired locations within a desired time frame differs depending on whether it is a wet, dry, or moderate season.

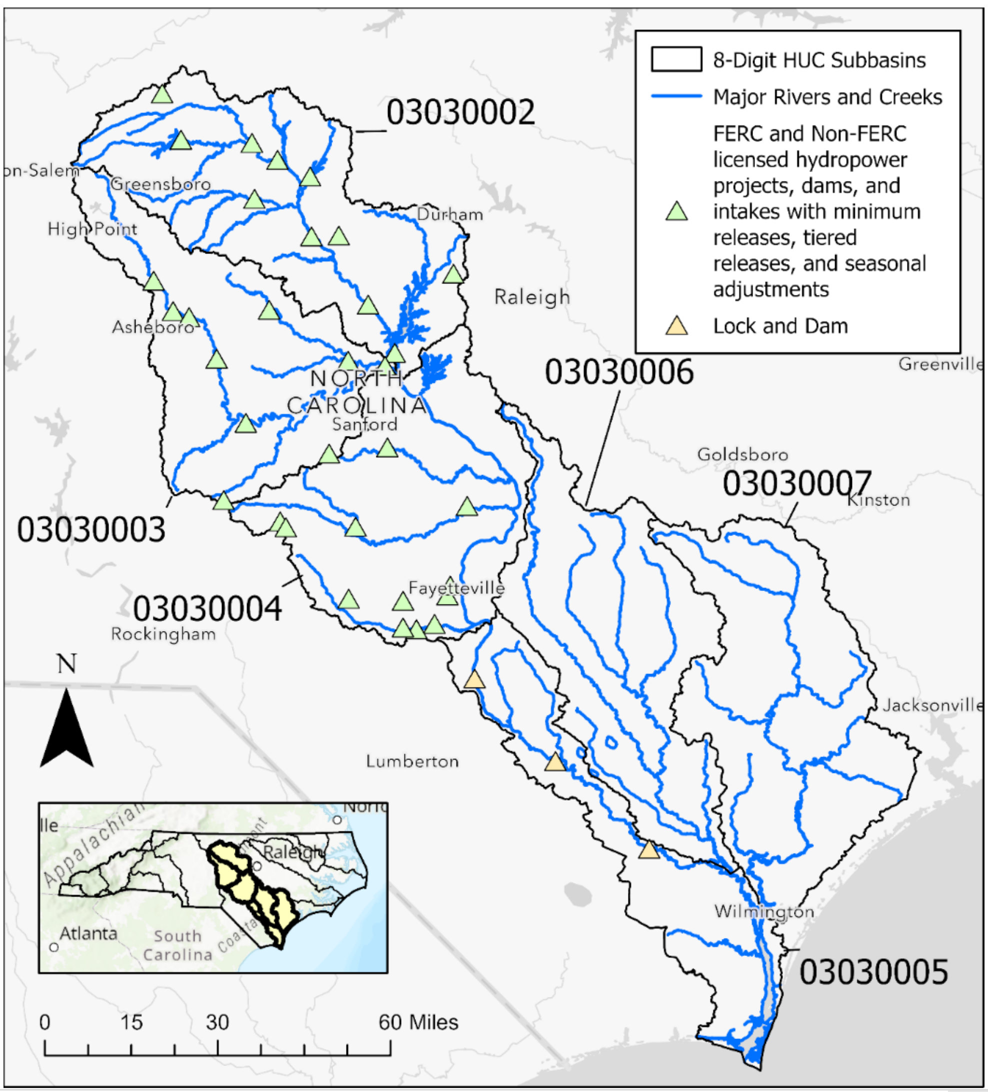
Participants in the ecological flows meeting were encouraged to describe the needed flow regime without focusing on constraints in the system. A summary of the meeting and the flow prescriptions is on the USACE website. After the meeting, USACE and TNC took the winter of 2020 to determine which flow strategies could be accomplished (1) without negatively impacting people (especially housing), (2) within the USACE operational flexibility, and (3) which continued to maintain the authorized purposes of B. Everett Jordan Dam.

After analysis and further modeling, it was determined that pulses could be attempted for any ecological theme that kept flows below 20,000 cfs at Fayetteville. This threshold is identified in the Jordan Lake USACE's Water Control Manual as a limit to avoid flooding people. Fayetteville is in the middle of the basin, thus the team assumed that downstream flows at LD3 could be slightly higher.

TNC and the Corps concluded that February through early June would represent the timing of "fish pulses" whereby the goal is to submerge the downstream locks and dams when diadromous fish are swimming upstream to spawn. It was estimated that a flow of 20,000 cfs at LD3 could accomplish this goal. From June through October, the pulses would change to "water quality and juvenile fish pulses" whereby releases from B. Everett Jordan Dam would shift to mini-pulses to mix the downstream water column, reduce the potential for algal blooms, and help push eggs/juveniles slowly downstream. It was estimated that flows of 2,000-5,000 cfs could accomplish these goals.

Testing of ecological flows began in the spring of 2020. Since 2020, yearly test pulses have occurred for both fish passage and water quality purposes. Simultaneously, TNC and the Wilmington District of the USACE have received multiple grants to study the efficacy of pulses, bringing on academic, state and federal research partners. The test pulses have been successful at submerging the downstream locks and dams and enabling fish to pass. The water quality pulses have also been successful at mixing the water column all the way down to LD1. TNC, USACE, and the research team continue to refine the understanding of flow releases out of B. Everett Jordan Dam. Updates to the project are posted on [the USACE website](), with the long-term goal to formalize the ecological flows strategies in the Water Control Manual.

Figure 5-13: FERC and Non-FERC Licensed Hydropower Projects, Dams, and Intakes, with Minimum Releases, Tiered Releases and Seasonal Adjustments in the Cape Fear River Basin and Lock and Dam Structures.



5.5 Water Use

5.5.1 Public Water Systems

It is the responsibility of DWR's Public Water Supply Section to regulate public water supply (PWS) systems within the state under the authority of General Statute 130A Article 10: North Carolina Drinking Water Act. Public water supply systems are those that provide piped drinking water to 15 or more service connections or 25 or more people for 60 or more days per year (*Table 5-1*). A PWS system is identified by the number of people served or number of connections and the number of days or months of the year that the population is served. As of 2021, there were 844 PWS system sources located in the Cape Fear River Basin that includes 820 groundwater sources, 22 surface water sources, and 2 community water systems using both surface water and groundwater sources (*Table 5-1*).

The Cape Fear River Basin is a water supply resource for PWS systems that depend on surface water from several waterways that dissect the landscape including the Deep, Haw and Cape Fear rivers, (*Figure 5-14*) as well as systems that use groundwater resources located under the Piedmont and Coastal Plain (*Figure 5-15*). As described throughout this river basin planning document, managing the impacts from both point and nonpoint sources of pollution is critical to ensuring the reliance on these water resources as a drinking water source is protected for the future. It is vitally important to communicate that upstream pollution sources impact both the local and downstream communities drinking water supplies through increased drinking water treatment costs, emerging contaminants removal, reduced flows, and/or ecological responses (i.e., algal blooms). Several protection programs including the Water Supply Watershed Protection Program, Source Water Assessment Program, Surface Water Protection Program, and Wellhead Protection Program aim to protect public drinking water supplies. The DEQ will continue to work with all water users to address their concerns regarding water use and water quality.

In late 2022, NCDEQ performed three months of sampling at 50 municipal and county water systems identified in the 2019 PFAS Testing (PFAST) Network study with PFOA and/or PFOS detections above 4 ppt. Those results have been provided to the water systems and are available online. Some public water systems in North Carolina are currently monitoring for PFAS voluntarily. DEQ has recommended that these water systems share PFAS results with their customers. Customers can also contact their specific water provider for more information. See Chapter 2 for more details regarding PFAS.

Table 5-1: Types of Public Water Systems (PWS) (2021).

Public Water System (PWS) Type	Source Water	Number	Total	Description
Community	Groundwater	**258**	**279**	Regularly serves 25 or more year-round residents or has 15 or more connections. Examples include subdivisions, mobile home parks, prisons and assisted living centers.
	Surface Water	**19**		
	Groundwater and Surface Water	**2**		

Public Water System (PWS) Type	Source Water	Number	Total	Description
Adjacent	Groundwater	**27**	**27**	Two or more water systems that are adjacent and are owned or operated by the same supplier of water and that together serve 15 or more service connections or 25 or more persons. An example of an adjacent water system is adjoining mobile home parks that together meet the community water system definition.
Transient Non-Community	Groundwater	**453**	**453**	Serves 25 or more people at any given time at least 60 days per year. Examples include restaurants, gas stations, rest areas and campgrounds.
Non-Transient, Non-Community	Groundwater	**82**	**85**	Serves at least 25 of the same persons, six or more months per year. Examples include schools, daycares, and industries.
	Surface Water	**3**		
Total PWS		**844**		

5.5.2 Water Supply Watershed Protection Program

The purpose of the Water Supply Watershed Protection (WSWP) program is to protect North Carolina's surface water drinking supplies. The program requires minimizing the volume and pollutant load of stormwater runoff, limiting built-upon area (BUA) (i.e., impervious cover), providing vegetated areas setbacks along streams (i.e., buffers), and prohibiting certain activities based on the water supply watershed classification (Factsheet). This program is for both water supply reservoirs and run-of-river water supply intakes. As of 2023, there are 290 WSWP programs across the state. Local governments are responsible for the watershed protection ordinance, development and maintenance of maps, reviews of projects for compliance, interlocal agreements, record keeping and reporting, maintenance of stormwater control measures and variances. Local governments that implement a WSWP program are encouraged to complete the WSWP Program Survey. *Figure 5-14* shows the water supply watersheds mapped alongside the balance of watershed and critical area as described in the WSWP Program.

Figure 5-14: Public Water Systems using Surface Water Sources and Associated Water Supply Watersheds as of 2021.

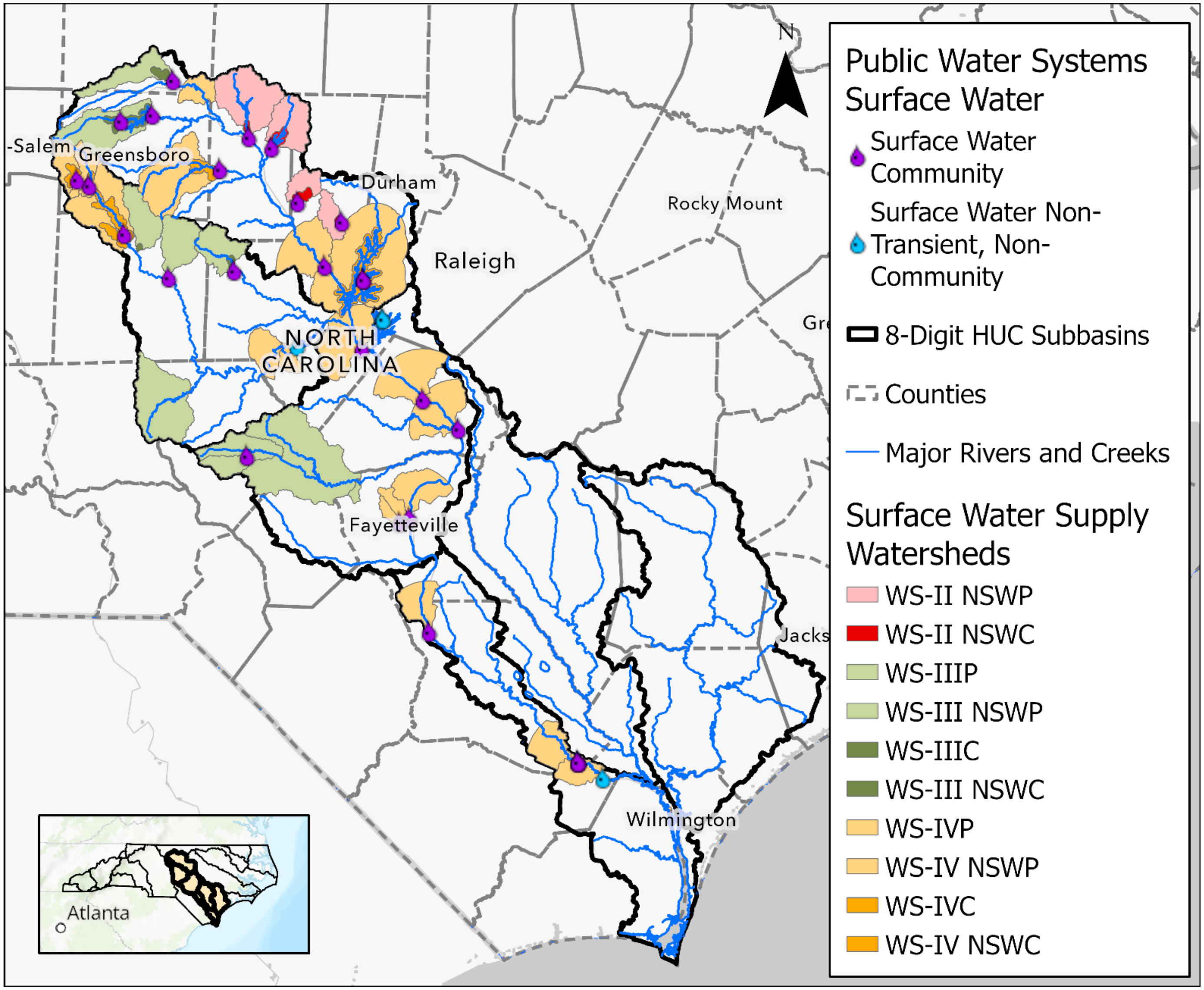
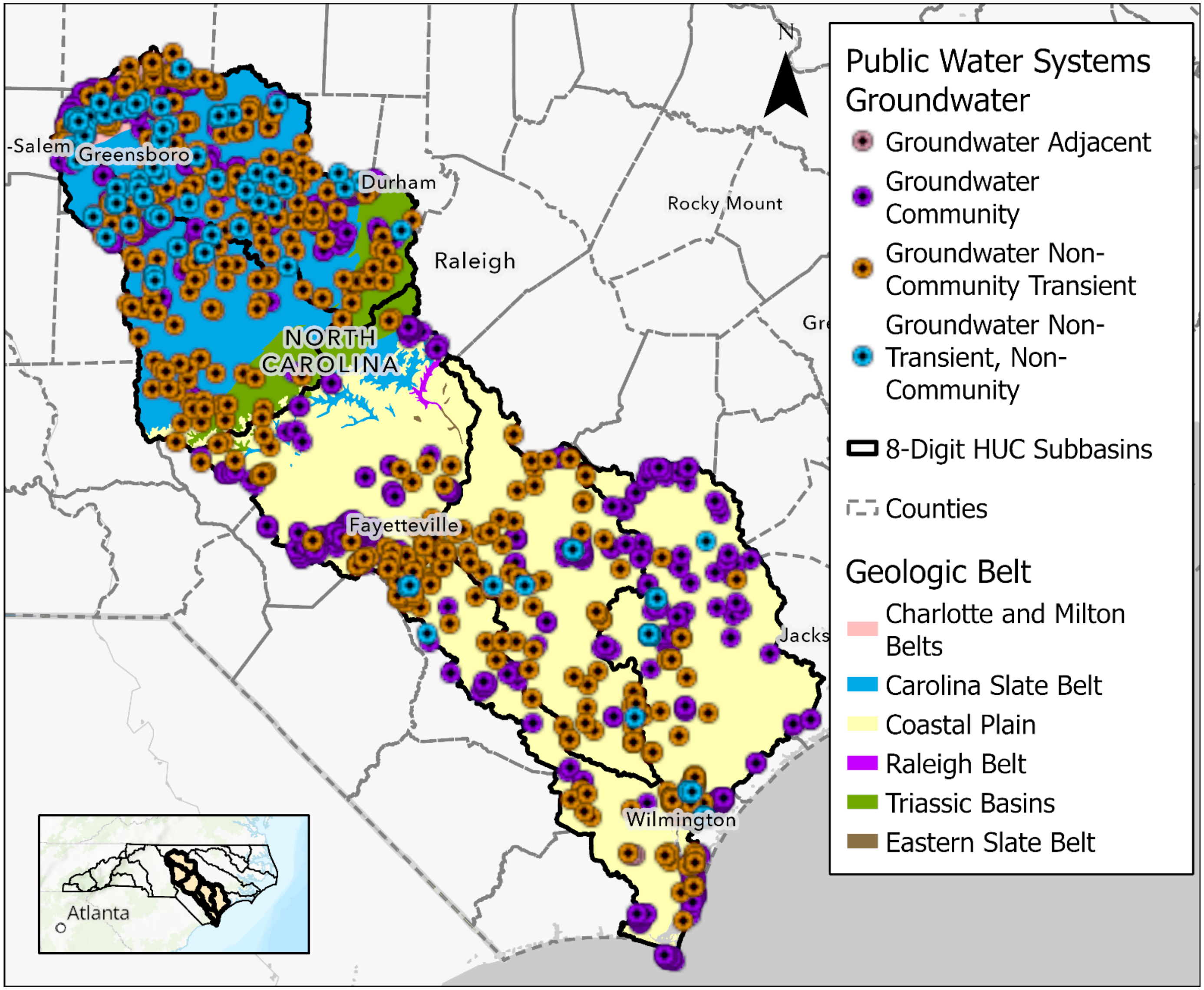


Figure 5-15: Public Water Systems using Groundwater Sources as of 2021.



5.5.3 Surface Water Protection Planning Rule and Surface Water Protection Program

On January 1, 2019, a new rule went into effect that mandates source water protection (SWP) planning for all public water supply systems that treat and supply water from surface sources. Prior to rule adoption, SWP planning in North Carolina was voluntary (additional information can be found in the SWP Planning Brochure). The new and expanded SWP planning model includes proactive activities to identify and reduce the risk of contamination, with additional emphasis on reactive emergency response mechanisms. Although SWP planning does not guarantee the absence of contamination, it is an important step for a utility to assess vulnerabilities and to identify strategies that could better protect public health.

- Source Water Protection Planning Rule (15A NCAC 18C .1305) - Effective April 1, 2020
- SWRRP Certification Form
- Information on Potential Contaminant Source (PCS) Data Sets

Surface water refers to the streams, rivers and lakes that are used as sources of public drinking water. In North Carolina, more than four million residents rely on surface water for safe and reliable drinking water. Our state's surface waters face a variety of threats, including agriculture pressures, stormwater runoff, development and emerging contaminants. The North Carolina SWP planning program serves the state by initiating proactive protection strategies to identify and mitigate these threats. DWR worked in partnership with a variety of other agencies and programs to promote local drinking water protection in local communities across North Carolina.

5.5.4 Source Water Assessment Program (SWAP)

Pollution prevention is recognized as the most effective approach for ensuring a reliable, long-term and safe public drinking water supply. The Safe Drinking Water Act (SDWA) amendments of 1996 required that all states establish a Source Water Assessment Program (SWAP). SWAP allows the state to systematically identify potential contaminants and delineate source water protection areas by using existing data from established federal and state environmental programs.

The primary goal of SWAP is to protect public drinking water supplies. Detailed assessments of all public drinking water intakes are available for review and can be used as a planning tool to protect public drinking water sources. The susceptibility rating is based on a contaminant rating and an inherent vulnerability rating and indicates the potential for a drinking water source to become contaminated. It should be noted that the susceptibility rating is not an indicator of water quality, but rather, the potential for a water source to be impacted by the identified contaminants within the assessment area.

5.5.5 Wellhead Protection (WHP) Program

In 1986, amendments to the SDWA established requirements for states to develop programs. The Wellhead Protection (WHP) Program was intended by Congress to be a key part of a national groundwater protection strategy to prevent contamination of groundwater used for public drinking water supplies. In North Carolina, development of a local WHP plan is not mandatory but is encouraged and viewed as a valuable supplement to existing groundwater protection programs. North Carolina's program is designed for city and county governments and water supply operators who wish to provide added protection to their local groundwater supplies. The WHP plan identifies the wellhead protection area (WHPA). A WHPA is defined as “the surface and subsurface area surrounding a water well or well field, supplying a public water system, through which contaminants are reasonable likely to move toward and reach such water well or well fields.” Once implemented, the WHP plan reduces, but does not eliminate, the susceptibility of wells to contaminants.

5.6 Water Use Reported in the Cape Fear River Basin

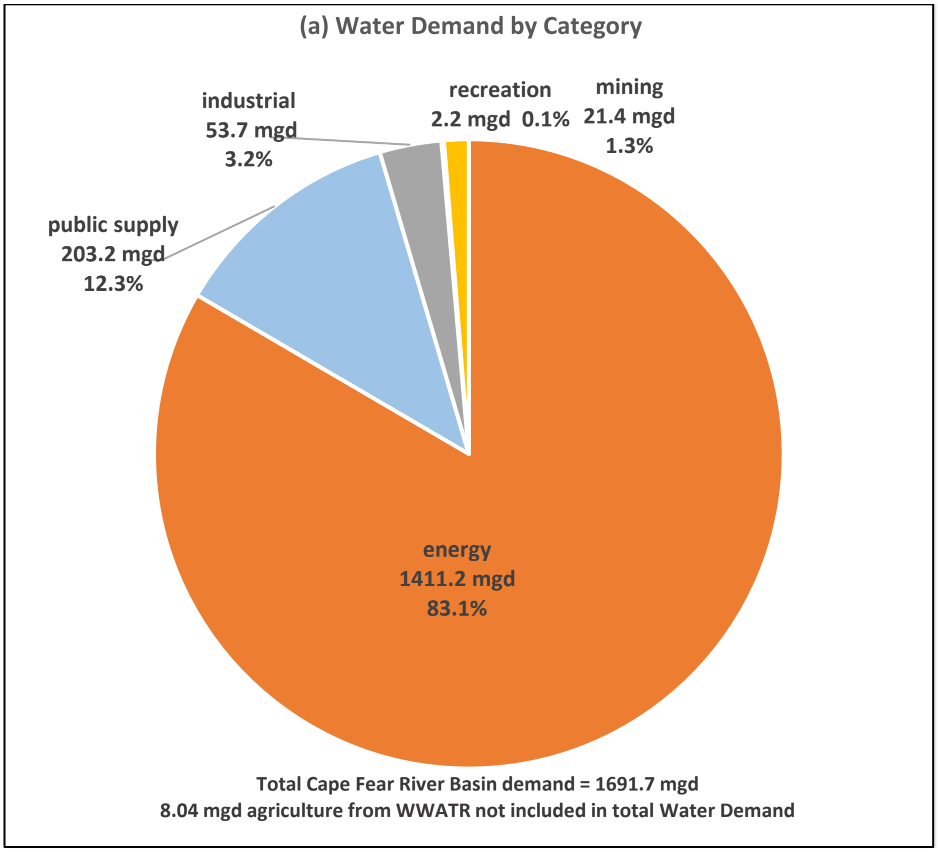
The Cape Fear River Basin encompasses approximately 9,164 square miles in central North Carolina. The boundary extends from southern Rockingham and Caswell counties to the Cape Fear River Estuary in New Hanover and Brunswick counties. Understanding the total amount of water being used for all activities across this river basin is critical for helping agricultural producers, manufacturers, municipalities and utilities plan for future water use, while also maintaining or protecting water quality and the ecological integrity of waterbodies throughout the region.

The information presented in this chapter quantifies water demand on a river basin scale and describes pertinent water-quantity information needed to evaluate water use and conditions in the Cape Fear River Basin. Data was collected from several programs within DWR, as well as the NCDA&CS. The information and data contained within this section is provided by DWR as a service to the public and to stakeholders within the river basin. DWR staff does not field verify nor validate the accuracy of the data provided by water systems in their LWSPs. DWR does, however, conduct technical reviews of the LWSPs submitted by the PWS systems for apparent abnormalities in the data. Neither DWR nor any other party involved in the preparation of this data attests that the data is free of errors and/or omissions. Furthermore, data users are cautioned to use the information in this section for planning purposes only and not regulatory compliance. Questions regarding the accuracy or limitations of using this data should be directed to the individual PWS system, registrant, and/or DWR.

5.6.1 Total Water Demand and Withdrawals Reported by DWR Programs

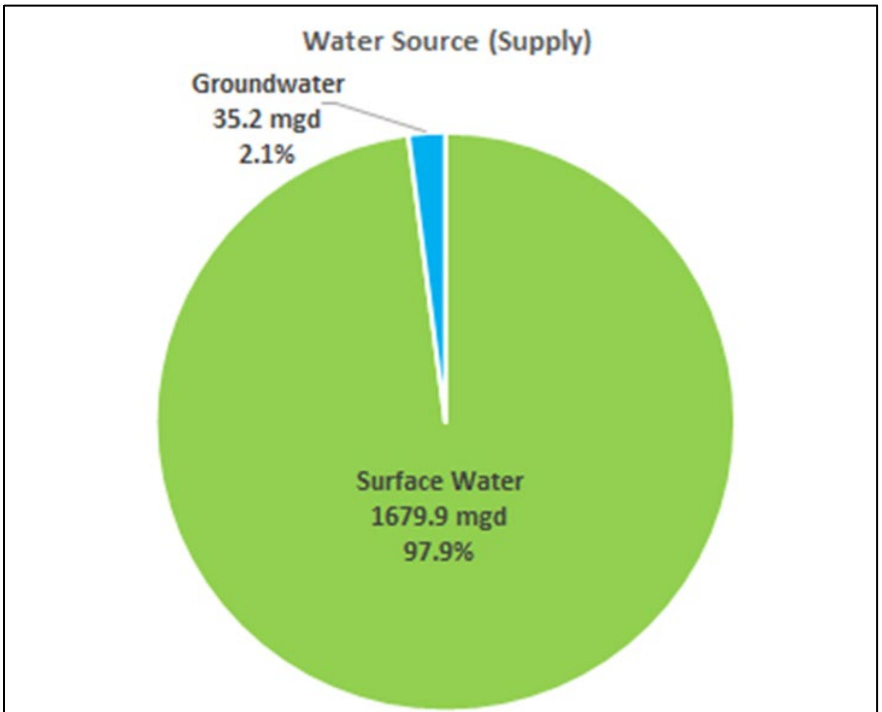
Service area water demand reported in the Cape Fear River Basin totaled 1,691.7 million gallons per day (MGD) in 2020 (*Figure 5-16*). This total includes 201.7 MGD reported for public water system use in the LWSPs, plus those demands reported in the Water Withdrawal and Transfer Registration (WWATR) Program for public water system use (1.5 MGD), industrial self-supply (53.7 MGD), recreation (2.2 MGD), mining (21.4 MGD) and energy (1411.2 MGD). The 201.7 MGD reported in the LWSPs was used to meet residential, commercial, industrial, institutional and system process water service-area demands. This total also includes system water losses. Agricultural use was reported to the WWATR as 8.04 MGD in 2020; however, because of the lack of complete and discernable data from the NCDA&CS for the Cape Fear River Basin, the total usage, which would be a combination of the two data sources, has not been included in the Cape Fear River Basin total service area water demand and *Figure 5-16*.

Figure 5-16: Total Water Demand Reported in the Cape Fear River Basin for the Year 2020.



Water used to meet demands was extracted from surface water and groundwater sources, 1679.9 MGD and 35.2 MGD, respectively (*Figure 5-17*). Included in these totals is the 225.1 MGD reported in the LWSPs (196.2 MGD surface water and 28.9 MGD groundwater), and the 1490.0 MGD reported by the WWATR Program (1483.7 MGD surface water and 6.3 MGD groundwater). An additional 71.1 MGD of water was purchased or exchanged between water systems in the basin. Although reported as part of the total supply in the LWSPs, purchased water is not included in the Cape Fear River Basin water withdrawn total and *Figure 5-17* because the figure is intended to quantify the physical water withdrawals using the basin's surface water (i.e., rivers and reservoirs) and groundwater (i.e., aquifers) resources. Including purchased water into the surface water and groundwater components of the basin's withdrawal total would be redundant. Also, given that Cape Fear River Basin water withdrawal total and *Figure 5-17* quantify only Cape Fear River basin-imposed stresses, 73.9 MGD of surface water contributed from sources in adjacent basins is not included in the Cape Fear River Basin water withdrawn total. Outside surface water contributors in 2020 included Asheboro (5.1 MGD), Durham (27.4 MGD), Montgomery County (2.6 MGD), Southern Pines (3.2 MGD), and Winston-Salem (35.6 MGD). All groundwater withdrawals are assumed to have come from wells located within the basin. Notably, the total Cape Fear River Basin demand was 1,691.7 MGD and water withdrawn from the Cape Fear River Basin to meet this demand was 1,715.1 MGD. The difference between these numbers is 23.4 MGD, which is the amount of water that went outside the basin to meet demand.

Figure 5-17: Total Water Withdrawn Reported in the Cape Fear River Basin for the Year 2020



71.1 mgd of water was purchased or exchanged between water systems in the basin and 8.04 mgd of water agriculture from WWATR not included in supply total.

5.7 Public Water Supply Availability and Demand

5.7.1 Local Water Supply Plans (LWSP)

Per North Carolina General Statute §143-355 (l), the Local Water Supply Planning Program applies to units of local governments and community water systems that regularly serve 3,000 or more individuals or have 1,000 or more service connections. One hundred and twenty-two (122) PWS systems are required to submit LWSPs to DWR in the Cape Fear River Basin. Combined, these systems provided approximately 201.7 MGD to an estimated service population of 1.93 million in 2020 (*Table 5-2* and *Table 5-3*). The City of Winston-Salem has the largest water system in the basin and represents about 13% of the total service population, with 377,772 customers being served. However, most of Winston-Salem's population (91%) is in the Yadkin Pee Dee River basin. Winston-Salem is included in this study because it has a portion of its service area in the Cape Fear River Basin. Section 5.7.2 discusses how a water system's service area demands were quantified based on the percentage of the system's service area within the Cape Fear River Basin.

A total of 122 public water supply systems submitted LWSPs in the Cape Fear River Basin. The information presented in this section quantifies water demand/use, available water supply, and residential use on a subbasin and basin scale. The data includes historic (2012 and 2017), current (2020), and projected (2030 to 2070) demand in 10-year increments. Data is presented on basinwide and HUC8 subbasin scales. Data reported in the LWSPs indicate that all the HUC8 subbasins, as well as the individual water systems in the Cape Fear River Basin, will be able to meet currently projected water demands.

5.7.2 Data Qualifications and Methodology

The DWR provides the data contained within this document as a service to our customers. DWR staff does not field verify nor validate the accuracy of the data provided by water systems in their LWSPs. DWR does, however, conduct technical reviews of the LWSPs submitted by the PWS systems for apparent abnormalities in the data. Furthermore, data users are cautioned to use the information in this document for planning purposes only and not regulatory compliance. Questions regarding the accuracy or limitations of using this data should be directed to the individual PWS system, registrant, and/or DWR. Water-use estimates presented in this document are based on information included in the LWSPs. Water systems with either their intake and/or a portion of their service area in the Cape Fear River Basin were used when calculating water-use summaries for this report. The LWSP service area information was verified using ArcMap software, with any discrepancies corrected.

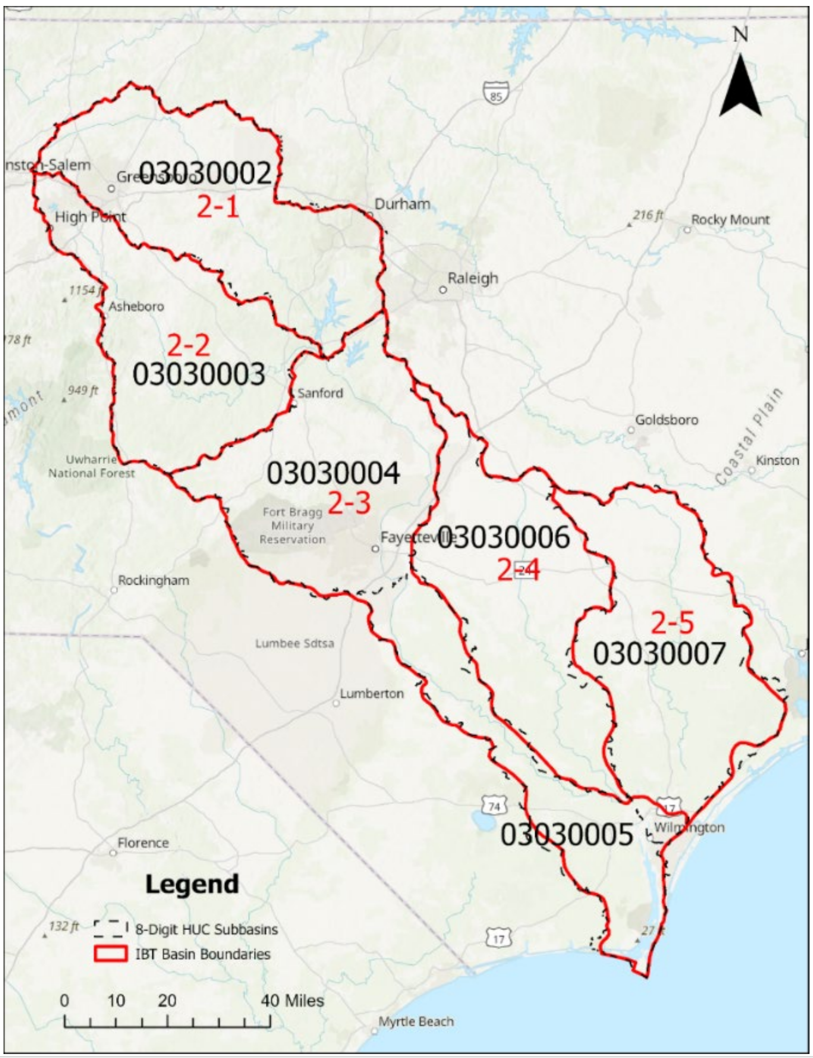
ArcMap software was also used to determine where PWS systems are located spatially to accurately determine their appropriate hydrologic unit code (HUC). The HUCs are delineated by the USGS and are used by DWR to define subbasin characteristics. Six subbasins (HUC8) contain the 122 public water supply systems in the Cape Fear River Basin. Based on 2020 water demand, the largest of these is the Haw River subbasin (HUC8: 03030002) (81.28 MGD) and the smallest is the Northeast Cape Fear River subbasin (HUC8: 03030007) (6.09 MGD). Using ArcMap and information reported in the LWSPs, water demands, available supply, service area percentage and future projections were calculated for each subbasin.

Service-area demands were quantified based on the percentage of a system's service area within the Cape Fear River Basin. Most systems included in this report have service areas located solely within the Cape Fear River Basin, so 100% of reported service-area demands were applied to the Cape Fear River Basin. However, for 23 systems with service areas divided between the Cape Fear River Basin and an adjacent basin (Angier, Apex, Archdale, Asheboro, Benson, Cary, Dunn, Durham, Fuquay-Varina, High Point, Hoke County Regional, Holly Springs, Montgomery County, Moore County - Seven Lakes, Mt. Olive, Oak Island, Orange Alamance, Pender County, Reidsville, Rockingham County, Seagrove Water District, Southern Pines and Winston-Salem), the Cape Fear River Basin demand was estimated by multiplying the total demand by the percentage of the Cape Fear River Basin service area. The City of Durham, for example, has service areas in both the Cape Fear River Basin (49%) and the Neuse River basin (51%), so only 13.4 MGD of Durham's 27.3 MGD service-area demand was included in the Cape Fear River Basin total. Basin percentages are provided and quantified in the LWSPs.

The LWSPs provide basin service area percentages based on interbasin transfer (IBT) basin boundaries. The IBT basin boundaries overlap reasonably well with the HUC8 subbasin boundaries (*Figure 5-18*). This report describes water demands and service area percentages by HUC8 subbasin using the basin service area percentage based on IBT basin boundaries. This approach was taken to provide consistency with other programs' data, as well as other chapters of this report. While errors may exist using this method to calculate the basin service area percentages and associated demands, this method provides the most accurate estimates for water use and conditions for each HUC8 based on information provided by the PWS systems. The water system's basin service area provided through LWSPs could also have errors and/or change over time which would be reflected in future LWSPs provided by the PWS system.

Another potential source of error for surface water sources could be the use of estimations of stream flows in areas that lack adequate stream gaging. Accurately measuring stream flows and reservoir levels is critical to understanding long-term water availability as well as determining real-time supply and instream conditions. Adding to these gauging issues, water withdrawers and dischargers are, in certain situations, required to determine the 7Q10 statistic for permitting of the water use activity. Without proper gauging, estimations are required, and even with proper gauging, state-wide or regional calculations of the stream flow statistics often go decades before being revised. The potential inaccuracy of these older estimates makes it difficult to calculate an accurate 7Q10 low flow estimate for ungauged locations going forward. The following sections include charts displaying water supply, demand, population growth and residential consumption rates. They also review any existing issues within the basin that are known to DWR that are in various stages of resolution. Because water supply issues and associated solutions are often regional in scope, discussion beyond the boundaries of the basin may be necessary.

Figure 5-18: Spatial Extents of the Cape Fear River Basin by Interbasin Transfer (IBT) and Subbasin (HUC8) Boundaries.



5.7.3 Basinwide Summary of Water Use and Availability Reported in LWSPs

Basinwide data for historic (2012-2017), current (2020) and projected (2030-2070) water demands, and population are presented in *Table 5-2* and *Table 5-3*, and graphically in *Figure 5-19* and *Figure 5-20*. Similar figures for each subbasin are presented in the subsequent subbasin sections. *Table 5-4* also ranks the subbasin in the Cape Fear River Basin from largest to smallest based on 2020 water demand. Basinwide, water demand is projected to increase with population. However, the residential consumption rate (Res CR), or per capita demand, increases modestly, but is not egregious. It should be noted that considerable changes in demand, population and/or residential consumption rate on a basinwide level are not evenly distributed among the 122 PWS systems but rather influenced by changes reported by one or more of the larger systems.

Table 5-3 shows that for data collection year 2020, the Cape Fear River Basin population served by PWS systems was estimated to be more than 1.93 million. This includes population estimates of 1.26 million using surface water sources; 116,945 using groundwater sources; 342,860 using purchased water sources; and 208,270 using a combination of surface water, groundwater, and/or purchased water sources (*Table 5-5*). The 122 PWS systems in the Cape Fear River Basin had a combined average daily water demand of 201.7 MGD in 2020. Comparing this to the total available supply of all 122 PWS systems in 2020 (*Table 5-2*) of 626.84 MGD, the combined average daily demand of the public water supply systems in the basin used about 32% of available supply. Often surface water sources, such as reservoirs, were constructed decades ago and grandfathered into the DEQ permitting system. The result is that water systems sometimes do not have an accurate assessment of the current available supply, be it surface or groundwater. Therefore, some error in the total available supply for a basin and subbasin should be expected.

Combined, all 122 PWS systems showed a positive correlation between historic and projected population growth and water demand (*Table 5-3*). However, *Table 5-3* shows a large increase in demand from 2020 to 2030. This jump in demand can be mostly attributed to the Lower Cape Fear Water and Sewer Authority (LCFWSA) – Kings Bluff in the Lower Cape Fear River subbasin (HUC8: 03030005). A significant available supply is allocated by the LCFWSA – Kings Bluff as future sales to its partnering systems, which is counted as demand. However, current demand projections of the partnering systems show the full amount of the allocation would not be used in the foreseeable future.

Figure 5-20 shows a dip in the residential consumption rate (Res CR) for 2017 and 2020. This dip in the Res CR can be mostly attributed to water conservation efforts by customers and water efficiency improvements by the water systems subbasin-wide. With appliance efficiencies and water system conservation measures in place, it is expected that the projected Res CR will not increase significantly but may even decrease. However, it should be reiterated that population and residential demand projections are subject to errors that can skew the Res CR up or down. The combined average daily demand (384.0 MGD) of the 122 PWS systems in the Cape Fear River Basin is estimated to be about 56% of available supply (683.4 MGD) in 2070. It should be noted that the projected demand is based on the same proportion of service area in the Cape Fear River Basin for the 122 PWS systems, as determined for the 2020 plan year.

Table 5-2: Water Supply and Demand for Cape Fear River Basin, 2012 – 2070.

HUC8 number		03030002	03030003	03030004	03030005	03030006	03030007	Cape Fear River Basin
Number of systems		21	21	28	20	18	14	122
2012	**Demand**	80.22	18.82	51.51	25.60	4.98	5.66	186.79
	Supply	177.74	80.61	182.54	177.92	20.35	15.83	654.99
	D/S	0.45	0.23	0.28	0.14	0.24	0.36	1.73
	Res CR	52.28	52.93	50.78	61.10	56.17	55.44	327.99
2017	**Demand**	85.45	21.20	54.46	28.11	6.09	5.57	200.89
	Supply	172.55	86.60	180.52	193.63	21.26	21.74	676.29
	D/S	0.50	0.24	0.30	0.15	0.29	0.26	1.75
	Res CR	52.44	50.38	47.38	58.14	51.64	48.15	306.92
2020	**Demand**	81.28	22.05	57.58	27.78	6.97	6.09	201.75
	Supply	179.55	99.40	170.91	137.93	22.54	16.50	626.84
	D/S	0.45	0.22	0.34	0.20	0.31	0.37	1.91
	Res CR	49.36	47.99	49.61	64.47	46.10	46.59	303.54
2030	**Demand**	100.34	22.23	80.74	32.61	7.21	6.73	249.87
	Supply	193.55	99.40	195.92	148.81	23.94	16.76	678.38
	D/S	0.52	0.22	0.41	0.22	0.30	0.40	2.11
	Res CR	51.24	48.50	50.18	63.73	46.36	46.83	306.17
2040	**Demand**	117.16	23.89	96.10	37.11	7.96	6.79	289.01
	Supply	209.55	99.40	198.55	148.81	23.94	16.76	697.01
	D/S	0.56	0.24	0.48	0.25	0.33	0.41	2.31
	Res CR	51.77	49.18	50.48	65.01	47.40	47.26	310.19
2050	**Demand**	132.84	25.77	109.02	42.27	8.70	6.87	325.46
	Supply	213.55	99.40	199.18	148.81	24.37	16.76	702.08
	D/S	0.62	0.26	0.55	0.28	0.36	0.41	2.52
	Res CR	52.24	49.44	50.59	66.35	48.35	47.51	313.47
2060	**Demand**	146.97	27.24	123.07	48.26	9.48	6.93	361.95
	Supply	215.55	99.40	200.08	148.81	24.37	16.76	704.98
	D/S	0.68	0.27	0.62	0.32	0.39	0.41	2.75
	Res CR	52.69	49.73	50.67	74.09	48.74	47.66	322.45
2070	**Demand**	150.56	28.49	132.83	55.55	10.06	6.46	383.94
	Supply	203.55	99.40	192.41	148.81	24.13	15.08	683.39
	D/S	0.74	0.29	0.69	0.37	0.42	0.43	3.00
	Res CR	52.44	49.38	51.55	70.58	47.27	47.58	318.86
Largest System User (2020)	**System Name**	Greensboro	High Point	Fayetteville	Cape Fear Public Utility Authority - Wilmington	Clinton	Duplin Co	-
	Demand	32.86	9.66	25.54	11.96	1.68	1.76	-

Demand, average daily water demand in million gallons per day (MGD);
Supply, water supplied in MGD;
D/S, demand-to-supply ratio;
Res CR, residential consumption rate (gallons per capita per day, calculated as the total residential demand divided by the service area population)

Table 5-3: Population and Demand for Cape Fear River Basin, 2012 – 2070. Total Values May Not Equal the Sum of Individual Entries due to Rounding.

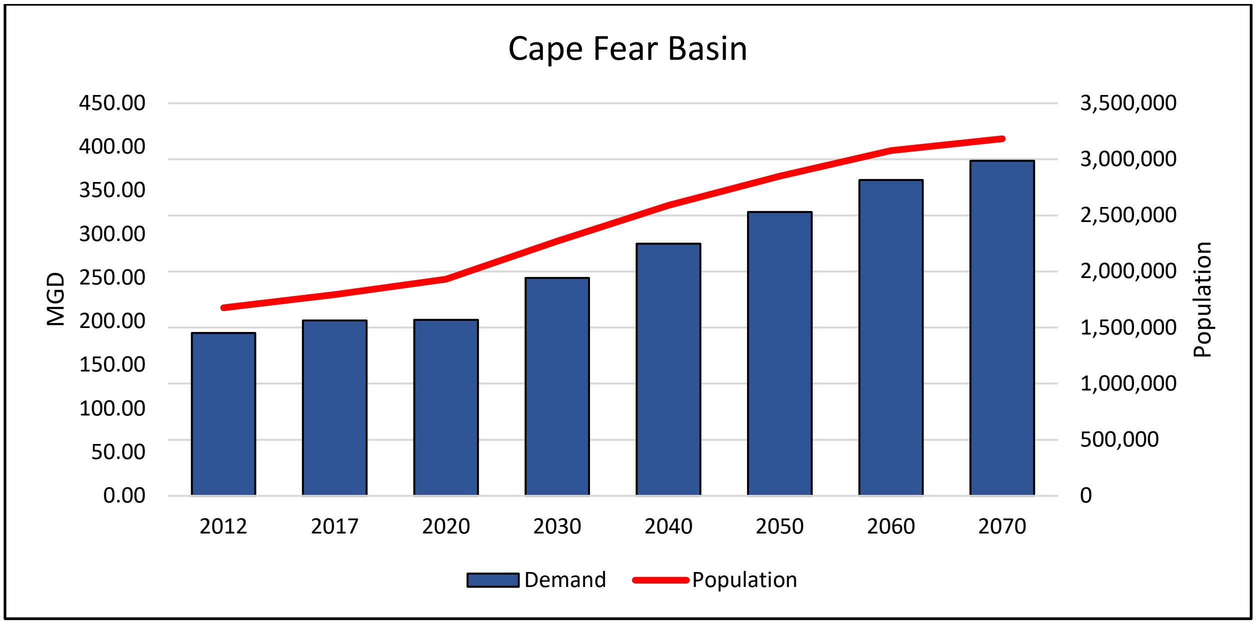
HUC8 number		3030002	3030003	3030004	3030005	3030006	3030007	Cape Fear River Basin
Number of systems		21	21	28	20	18	14	122
2012	**Demand**	80.22	18.82	51.51	25.6	4.98	5.66	186.79
	Population	698,052	160,654	511,156	216,779	38,341	51,368	1,676,350
2017	**Demand**	85.45	21.20	54.46	28.11	6.09	5.57	200.89
	Population	750,220	168,940	548,254	221,085	48,827	56,263	1,793,589
2020	**Demand**	81.28	22.05	57.58	27.78	6.97	6.09	201.75
	Population	825,481	171,499	564,421	249,747	54,893	64,006	1,930,047
2030	**Demand**	100.34	22.23	80.74	32.61	7.21	6.73	249.87
	Population	965,996	181,101	715,068	280,922	60,846	65,350	2,269,283
2040	**Demand**	117.16	23.89	96.10	37.11	7.96	6.79	289.01
	Population	1,135,489	191,536	816,439	314,302	67,565	65,931	2,591,262
2050	**Demand**	132.84	25.77	109.02	42.27	8.7	6.87	325.46
	Population	1,271,240	203,994	882,966	349,863	74,560	66,889	2,849,512
2060	**Demand**	146.97	27.24	123.07	48.26	9.48	6.93	361.95
	Population	1,404,441	216,529	951,106	355,252	82,011	67,685	3,077,024
2070	**Demand**	150.56	28.49	132.83	55.55	10.06	6.46	383.94
	Population	1,415,571	221,359	962,566	426,217	90,093	67,008	3,182,814
Largest System User (2020)	**System Name**	Greensboro	High Point	Fayetteville	Cape Fear Public Utility Authority - Wilmington	Clinton	Duplin Co	-
	Demand	32.86	9.66	25.54	11.96	1.68	1.76	-

Demand, average daily water demand in million gallons per day (MGD);

Table 5-4: Subbasin Ranking Based on 2020 Demand for Cape Fear River Basin.

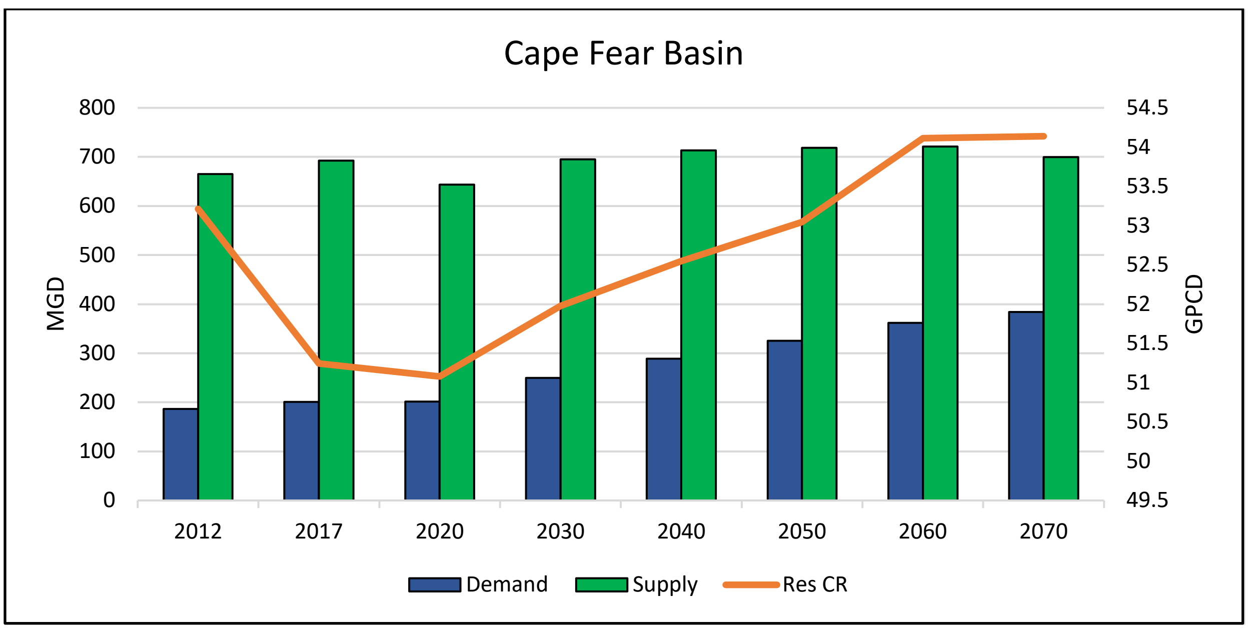
HUC Watershed	Demand (MGD)	Ranking
Haw (03030002)	81.28	1
Upper Cape Fear River (03030004)	57.58	2
Lower Cape Fear River (03030005)	27.78	4
Deep River (03030003)	22.05	3
Black River (03030006)	6.97	5
Northeast Cape Fear River (03030007)	6.09	6
Total	**201.75**	

Figure 5-19: Water Demand and Service-area Population for the Cape Fear River Basin, 2012-2070.



Note: Relatively large changes in demand and/or population are not evenly distributed among the 122 public water supply systems in the basin but are influenced more by changes reported by one or more of the larger systems.

Figure 5-20: Water Supply, Demand, and Residential Consumption Rate for the Cape Fear River Basin, 2012-2070.



Note: Relatively large changes in supply, demand and/or residential consumption rates are not evenly distributed among the 122 public water supply systems in the basin but are influenced more by changes reported by the larger systems. A value of the residential consumption rate (Res CR) being higher than the supply value does not mean that supply is insufficient.

Table 5-5: Breakdown of Local Water Supply Plan 2020 Population by Water Use Sources for Cape Fear River Basin. Total Values May Not Equal the Sum of Individual Entries due to Rounding.

HUC-8	Surface Water Use Population	Groundwater Water Use Population	Purchased Water Use Population	Mixed Sources (Surface, Groundwater, and/or Purchased) Water Use Population	HUC8 Totals
03030002	771,070	-	48,261	6,150	825,481
03030003	124,062	2,655	36,282	8,501	171,499
03030004	356,850	37,259	135,205	35,107	564,421
03030005	-	36,442	102,541	110,764	249,747
03030006	9,991	14,914	20,172	9,816	54,893
03030007	-	25,675	400	37,931	64,006
Totals	1,261,972	116,945	342,861	208,270	1,930,047

5.7.4 Haw River Subbasin (HUC8 03030002)

Twenty-one water systems are included in the Haw River subbasin. Based on the information reported by users, not including ecological flow, domestic users, non-reporters, and other unknown usages, there are no apparent water supply issues in the Haw River subbasin. Based on 2020 data, the Haw River subbasin has the greatest demand of any subbasin within the larger Cape Fear River Basin. Water demand and population are projected to increase throughout the study period as population growth in central North Carolina continues. Future water demand and population growth resulting from future economic development is beyond the scope of this document.

Table 5-3 shows that for data collection year 2020, the Haw River subbasin population served by public water supply systems was 825,481. The public water supply systems in this subbasin had a combined average daily water demand of 81.3 MGD in 2020. Comparing this to the total available supply in 2020 of 179.6 MGD (*Table 5-2*), the combined average daily demand of the public water supply systems in the Haw River subbasin was about 45% of available supply.

Figure 5-21 depicts steady increases for both population and demand over the study period; however, there is a significant jump in demand between 2020 and 2030. This is due to projected demands in the LWSP by large water systems in the subbasin. It should be noted, because of Session Law 2011-374, water systems must now include a plan to reduce long-term per capita water demand within their jurisdiction as part of the LWSP submittal.

Figure 5-22 shows a decrease in the calculated Res CR in 2020, this was likely attributed to the service population's temporary lifestyle changes during the pandemic. It is important to note that this represents a decrease of approximately three gallons per capita per day (gpcd) from 2017. The combined average daily demand of public water supply systems in the Haw River subbasin is estimated to be approximately 74% of available supply in 2070. It should be noted that projected demands for water systems in this subbasin are based on the same proportions of service area in the Cape Fear River Basin, as determined for the 2020 plan year.

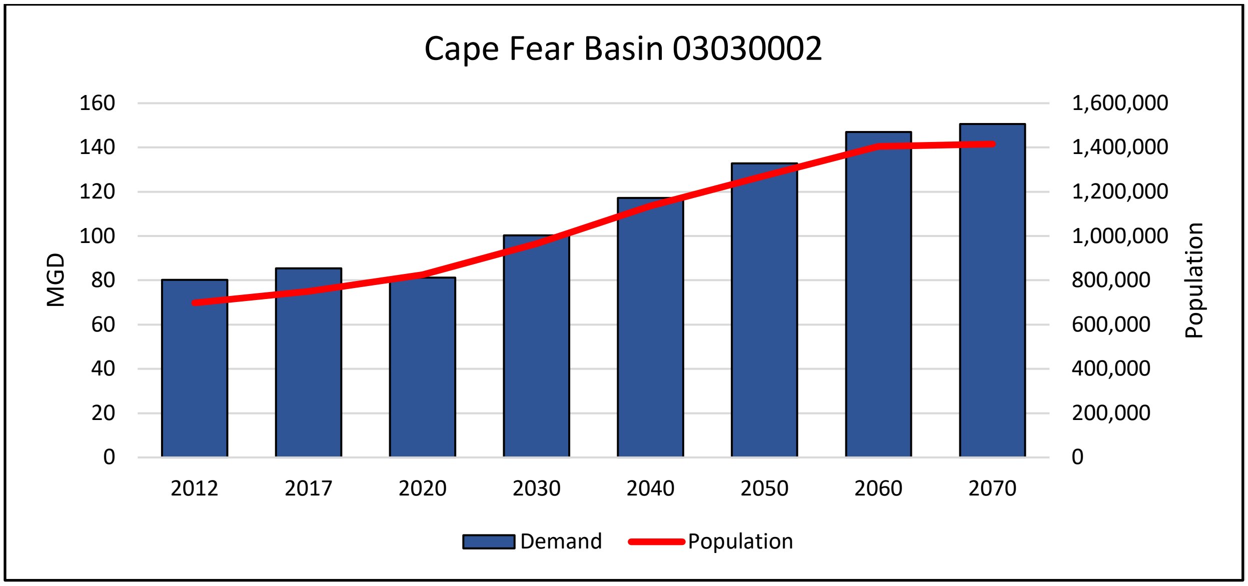
To use the best available LWSP data, the 2019 plan year was used, instead of 2020, for the Town of Gibsonville and the Town of Pittsboro (alternate year systems). Since the LWSP projections only went through 2060 for the alternate year systems, it caused a slight decrease in population, supply and demand for projection year 2070. For the alternate year systems, the projected 2020 demand (from the 2019 LWSP) was 1.18 MGD, or about 1.5% of the combined subbasin demand for 2020. Although 2070 projected demand and supply for the alternate year systems was not included, it is not considered a significant factor in the overall water quantity condition of the subbasin. Nonetheless, the available supply for the Town of Pittsboro not represented in the 2070 projections appears to result in a slight decrease in available supply in 2070.

The City of Greensboro is the largest system in the subbasin. The average daily water demand for Greensboro in 2020 was 32.9 MGD, or about 40% of the combined subbasin demand. Significant upgrades are underway by the city at both the Mitchell Water Treatment Plant and the Townsend Water Treatment Plant to increase and sustain plant capacity while significantly improving water quality. Notably, the Town of Pittsboro WTP completed the installation of GAC treatment technologies specifically installed to remove PFAS from the raw water prior to distribution.

The City of Durham along with Orange Water and Sewer Authority (OWASA) (i.e., Partners) have formally formed the Western Intake Partnership (WIP) for a proposed water supply intake on the western side of Jordan Lake. This proposed intake would provide direct access to water supply in B. Everett Jordan Lake that was allocated to the Partners by the EMC. Access to this water supply is critically needed to keep pace with the continual population growth and associated water demands in the Triangle region.

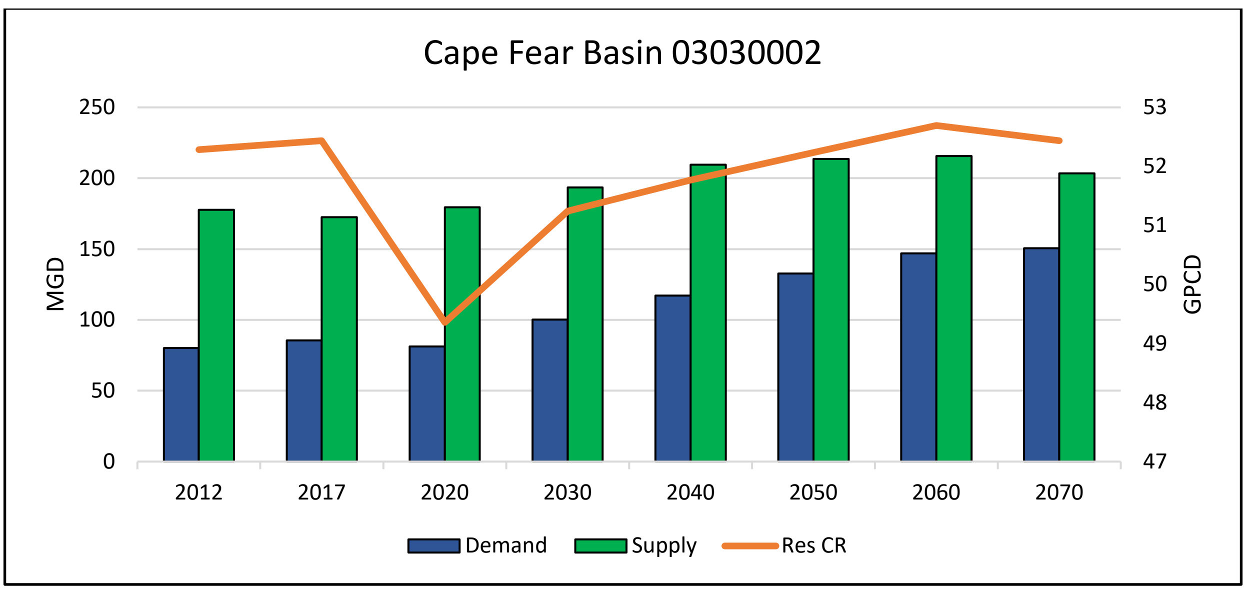
Included in this review of the Haw River subbasin is the Town of Cary and the City of Durham, both of which have the majority of their service areas in subbasins outside the Haw River subbasin. The majority service areas for both of these water systems lie within the Neuse River basin; therefore, only the portion of the systems demand in the Haw River subbasin are included in this review. The Town of Cary receives all of its water supply from B. Everett Jordan Lake (Haw River subbasin) while the water supply sources for the City of Durham are Lake Michie and Little River Reservoir (Neuse River Basin). Durham currently has a 16.5 MGD water supply allocation from B. Everett Jordan Lake and will serve as an important additional source of water as the city's population continues to grow.

Figure 5-21: Water Demand and Service-area Population for HUC 03030002, 2012 – 2070.



Note: relatively large changes in demand and/or population are not evenly distributed among the 21 water systems in the HUC but are more influenced by changes reported by one or more of the larger systems.

Figure 5-22: Water Supply, Demand and Residential Consumption Rate for HUC 03030002, 2012 – 2070.



Note: relatively large changes in supply, demand and/or residential consumption rates are not evenly distributed among the 21 water systems in the HUC but are more influenced by changes reported by one or more of the larger systems. A value of the residential consumption rate (Res CR) being higher than the supply value does not mean that supply is insufficient.

5.7.5 Deep River Subbasin (HUC8 03030003)

Twenty-one water systems are included in the Deep River subbasin. Based on the information reported by users, not including ecological flow, domestic users, non-reporters and other unknown usages, there are no apparent water supply issues in the Deep River subbasin. Water demand and population are projected to increase throughout the study period as population growth in central North Carolina continues. It should be noted that future water demand and population growth resulting from future economic development is beyond the scope of this document.

Table 5-3 shows that for data collection year 2020, the Deep River subbasin population served by public water supply systems was 171,499. The public water supply systems in this subbasin had a combined average daily water demand of 22.05 MGD in 2020. Comparing this to the total available supply in 2020 of 99.40 MGD (*Table 5-2*), the combined average daily demand of the public water supply systems in the Deep River Subbasin was about 22% of available supply.

Figure 5-23 depicts steady increases for both population and demand over the study period. The combined average daily demand of public water supply systems in the Deep River subbasin is estimated to be about 29% of available supply in 2070. Projected demands for water systems in this subbasin are based on the same proportions of service area in the Cape Fear River Basin, as determined for the 2020 plan year.

The decrease in the calculated Res CR values, as depicted in *Figure 5-24*, from approximately 53 gpcd in 2012 to 48 gpcd in 2020 can be attributed to water conservation efforts by customers and water efficiency improvements by the water systems subbasin-wide. The City of High Point alone reduced their calculated Res CR value from 53 gpcd in 2012 to 48 gpcd in 2020. As the water system with the highest daily average demand in 2020 (9.66 MGD, or approximately 34% of the total subbasin demand), water conservation and efficiency efforts by High Point can have significant impacts on the Res CR values throughout the subbasin. The projected Res CR values (post-2020) depict slight increases over the study period. This increase could potentially be avoided through the continued implementation of strong water conservation and efficiency measures subbasin-wide. Because of Session Law 2011-374, water systems must now include a plan to reduce long-term per capita water demand within their jurisdiction as part of the LWSP submittal.

Included in this review of the Deep River subbasin is Montgomery County and the City of Winston-Salem, both of which have the majority of their service areas in subbasins outside the Deep River subbasin. Montgomery County has only a small portion of its service area in the Deep River subbasin, with the majority of its service area in the Yadkin-Pee Dee River basin. Montgomery County's sole source of water supply is from Lake Tillery in the Yadkin-Pee Dee River basin. Additionally, Montgomery County sells finished drinking water to the Town of Robbins in Moore County, which lies entirely within the Deep River subbasin. The majority of the service area for Winston-Salem is located within the Yadkin–Pee Dee River Basin; however, approximately 2% of its service area is in the Deep River subbasin and another 1% of its service area is in the Haw River subbasin.

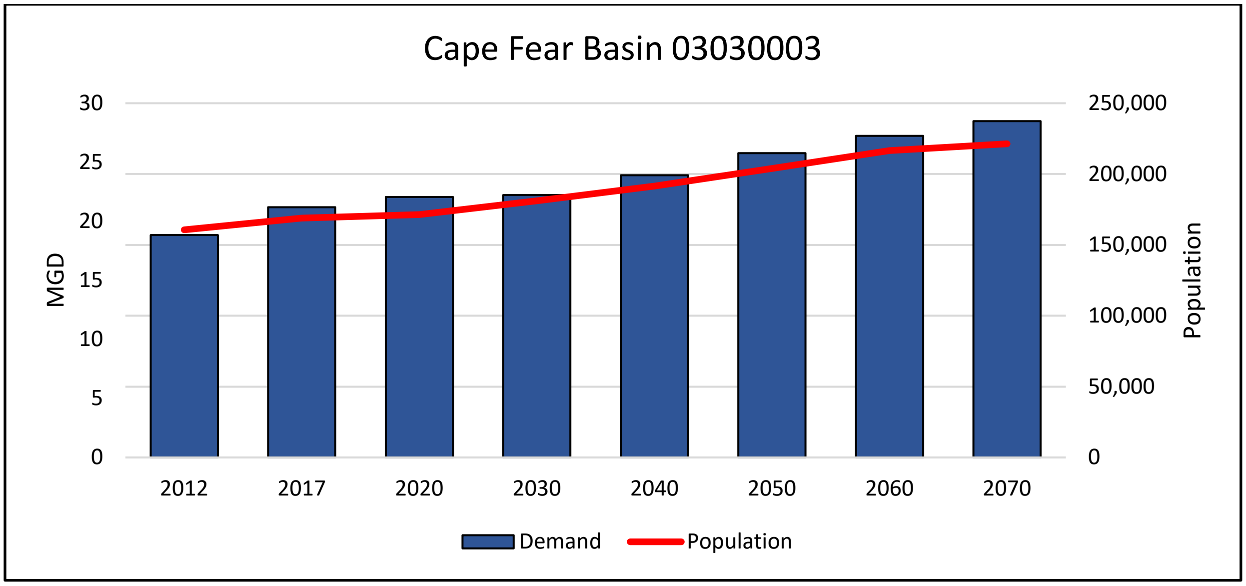
The service area for the Moore County - Seven Lakes water system is located within the headwaters of the Deep River subbasin, Upper Cape Fear River subbasin and the Lumber River basin, with approximately two-thirds of the service area in the Cape Fear River Basin. Largely due to its location in the headwaters and relatively small customer base, the Moore County - Seven Lakes water system depends upon groundwater for its water supply.

The majority of the service area for the City of Asheboro is in the Deep River subbasin, however, the water supply for Asheboro is entirely within a series of reservoirs in the Uwharrie River subbasin (Yadkin-Pee Dee River basin). Completed in 1993, Randleman Reservoir serves as a major water supply source for the cities of Greensboro and High Point, and the towns of Archdale and Randleman. The reservoir is owned and managed by the Piedmont Triad Regional Water Authority (PTRWA), which does not have a direct service population, but sells finished water to nearby water systems.

The City of Sanford has proposed a major WTP expansion to not only meet projected demands, but also to sell finished water to the Town of Fuquay-Varina and portions of Chatham County. The proposed sale of finished water to Fuquay-Varina requires procurement of an IBT Certificate by the town. The town is currently in the process to secure an IBT Certificate from the EMC.

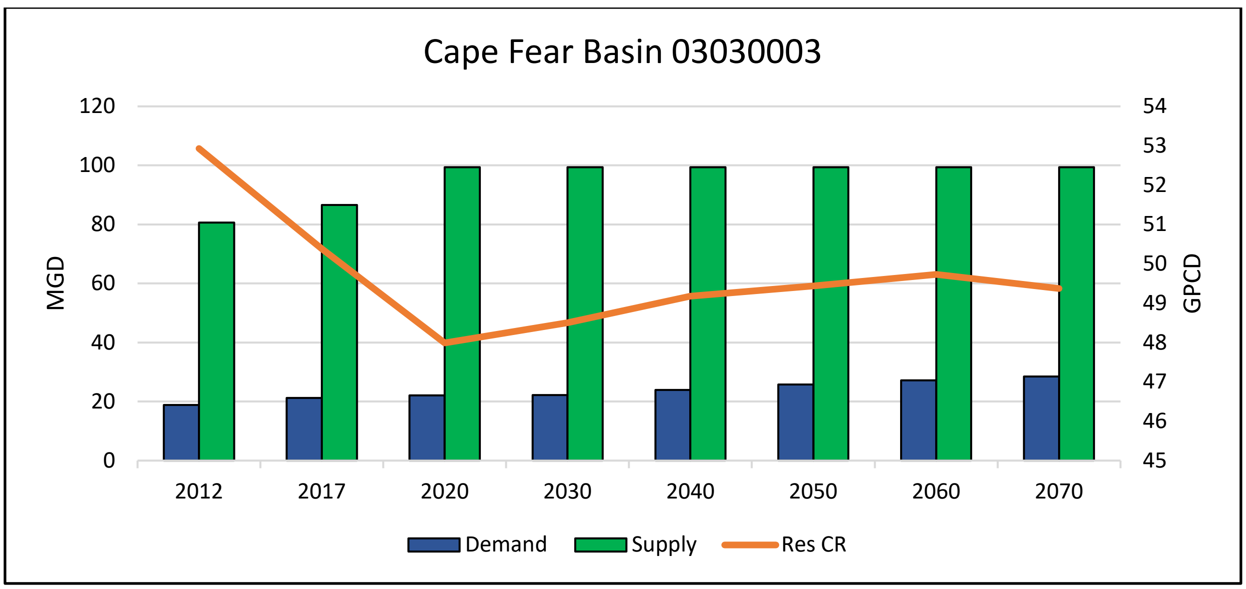
In 2021, an interlocal agreement was reached between the City of Sanford and Pittsboro, Chatham County, Holly Springs, and Fuquay-Varina to study, design, and complete construction of an additional 18-million gallon per day water treatment facility upgrade in Sanford to meet the water supply needs of all five partners. This will increase the current treatment capacity from 12 MGD to 30 MGD when complete. The expansion of water plant was started on October 29, 2024, with an anticipated completion in 2028. In March 2024, the City of Sanford announced it was intending to provide regional water utilities to surrounding towns and counties under the name TriRiver Water (https://www.tririverwater.com/). This information will be included in future local water supply plans.

Figure 5-23: Water Demand and Service-area Population for HUC 03030003, 2012 – 2070.



Note: relatively large changes in demand and/or population are not evenly distributed among the 22 water systems in the HUC but are more influenced by changes reported by one or more of the larger systems.

Figure 5-24: Water Supply, Demand and Residential Consumption Rate for HUC 03030003, 2012 – 2070.



Note: relatively large changes in supply, demand and/or residential consumption rates are not evenly distributed among the 22 water systems in the HUC but are more influenced by changes reported by one or more of the larger systems. A value of the residential consumption rate (Res CR) being higher than the supply value does not mean that supply is insufficient.

5.7.6 Upper Cape Fear River Subbasin (HUC8 03030004)

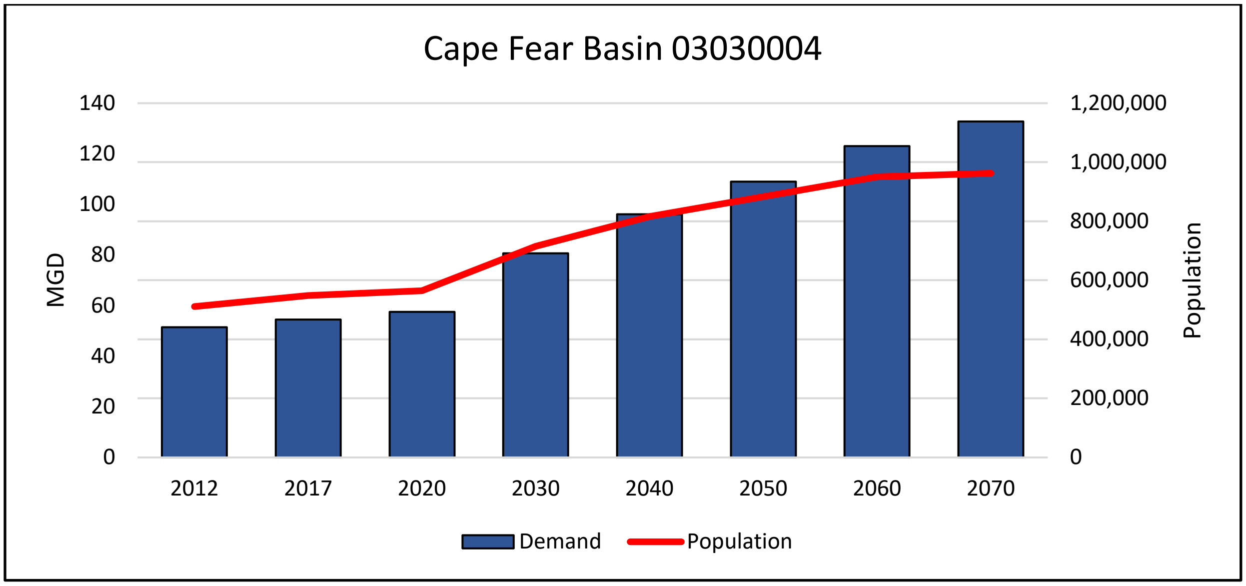
Twenty-eight water systems are included in the Upper Cape Fear River subbasin. The Upper Cape Fear River subbasin contains more water systems than any other subbasin in the Cape Fear River Basin. Based on the information reported by users, not including ecological flow, domestic users, non-reporters and other unknown usages, there are no apparent water supply issues in the Upper Cape Fear River subbasin. Water demand and population are projected to increase throughout the study period as population growth in central North Carolina continues. Future water demand and population growth resulting from future economic development is beyond the scope of this document.

Table 5-3 shows that for data collection year 2020, the Upper Cape Fear River subbasin population served by public water supply systems was 564,421. The public water supply systems in this subbasin had a combined average daily water demand of 57.58 MGD in 2020. Comparing this to the total available supply in 2020 of 170.91 MGD (*Table 5-2*), the combined average daily demand of the public water supply systems in the Upper Cape Fear River Subbasin was approximately 34% of the available supply. *Figure 5-25* depicts steady increases for both population and demand over the study period; however, there is a significant jump in demand between 2020 and 2030. This is due to projected demands in the LWSP by large water systems in the subbasin.

The decrease in calculated Res CR values, as depicted in *Figure 5-26*, from approximately 51 gpcd in 2012 to 47 gpcd in 2017, then back up to 50 gpcd in 2020 can be attributed to the City of Fayetteville's calculated reduction in Res CR values in 2017 (48 gpcd), while both 2012 and 2020 have calculated Res CR values of 53 gpcd. Since Res CR is a calculated value using reported population and residential demand values, the reduction in 2017 is caused by a slight increase in the reported population in 2017 and a slight increase in the reported demand in 2020. While the population and demand values reported in 2012 and 2020 are somewhat similar, it is important to note that increased demand is expected as the population increases. However, when one factor increases or decreases incommensurably with the other, the calculated Res CR will vary accordingly. The projected Res CR values (post-2020) depict slight increases over the study period. This increase could potentially be avoided through the implementation of stronger water conservation and efficiency measures subbasin-wide. Because of Session Law 2011-374, water systems must now include a plan to reduce long-term per capita water demand within their jurisdiction as part of the LWSP submittal.

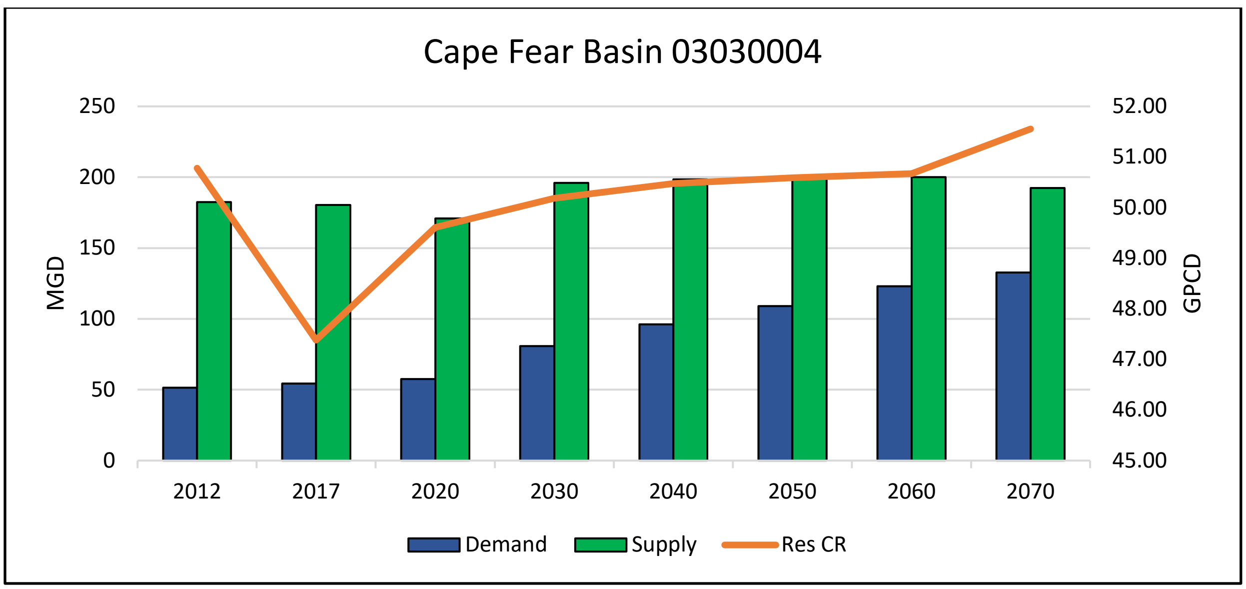
The combined average daily demand of public water supply systems in the Upper Cape Fear River subbasin is estimated to be about 69% of available supply in 2070. Projected demands for water systems in this subbasin are based on the same proportions of service area in the Cape Fear River Basin, as determined for the 2020 plan year. To use the best available LWSP data, the 2019 plan year was used, instead of 2020, for several water systems in the Upper Cape Fear River subbasin. The alternate year systems include the towns of Broadway, Cameron, Carthage, Godwin, Wade and the Hoke County Regional Water System. Alternate year plans are used when systems do not submit or insufficiently complete a 2020 LWSP. Since the LWSP projection only went through 2060 for the alternate year systems, it caused a slight decrease in population, supply and demand for projection year 2070. These water systems represent a small portion, approximately 3%, of the total subbasin demand; therefore, it is not considered a significant factor in the overall water quantity condition of the subbasin when estimating projections out to 2070.

Figure 5-25: Water Demand and Service-area Population for HUC 03030004, 2012 – 2070.



Note: relatively large changes in demand and/or population are not evenly distributed among the 27 water systems in the HUC but are more influenced by changes reported by one or more of the larger systems.

Figure 5-26: Water Supply, Demand and Residential Consumption Rate for HUC 03030004, 2012 – 2070.



Note: relatively large changes in supply, demand and/or residential consumption rates are not evenly distributed among the 27 water systems in the HUC but are more influenced by changes reported by one or more of the larger systems. A value of the residential consumption rate (Res CR) being higher than the supply value does not mean that supply is insufficient.

The City of Fayetteville is the largest water system in the subbasin. The average daily water demand for the city in 2020 was 25.54 MGD, or approximately 44% of the total subbasin demand from public water supply systems. Fayetteville has proposed to expand the PO Hoffer Water Treatment Plant from 39.5 MGD to 55.5 MGD by 2028 to meet projected demands.

Included in this review of the Upper Cape Fear River subbasin is the Town of Fuquay-Varina and Moore County – Pinehurst, both of which have the majority of their service areas in subbasins outside the Upper Cape Fear River subbasin. The service area for Fuquay-Varina is split nearly evenly between the Upper Cape Fear subbasin and the Upper Neuse River subbasin (HUC8 03020201). Fuquay-Varina has requested an IBT Certificate from the EMC and is currently proceeding through the regulatory process. The majority of the Moore County – Pinehurst water system is within the Lumber River basin (approximately 70%), with the remaining in the Upper Cape Fear River subbasin. The Moore County – Pinehurst water system is primarily supplied by groundwater through approximately 17 wells. The water system also purchases a significant portion of its supply from the towns of Aberdeen and Southern Pines and the East Moore Water District.

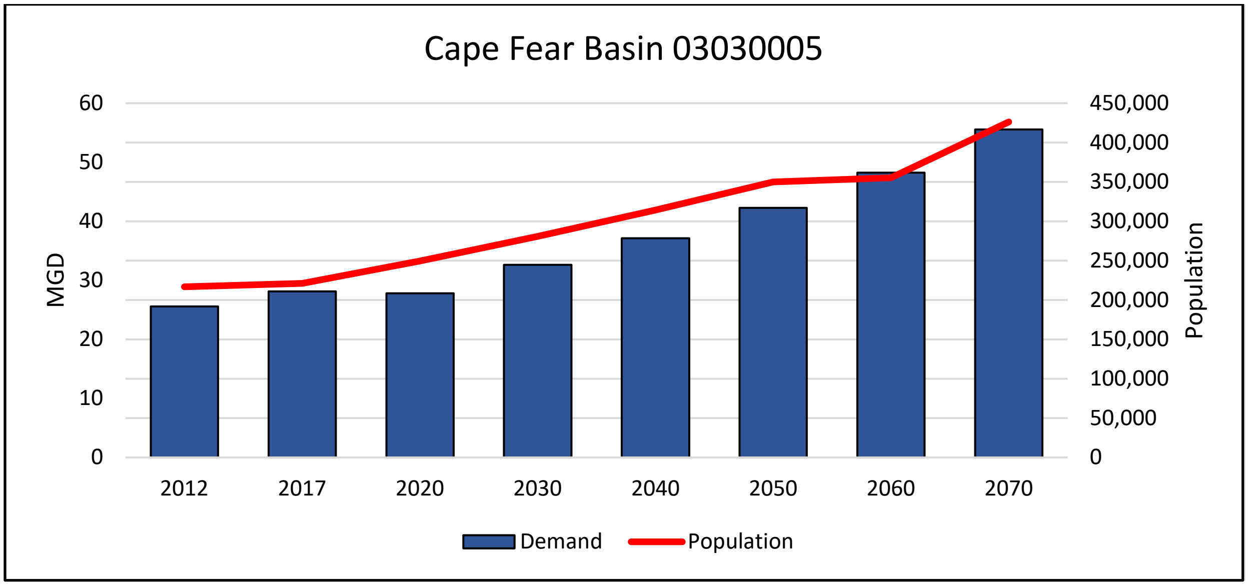
5.7.7 Lower Cape Fear River Subbasin (HUC8 03030005)

Twenty water systems are included in the Lower Cape Fear River subbasin. Based on the information reported by users, not including ecological flow, domestic users, non-reporters and other unknown usages, there are no apparent water supply issues in the Lower Cape Fear River subbasin. As shown in *Figure 5-27*, water demand and population are projected to increase throughout the study period as population growth in southeastern North Carolina continues. However, *Figure 5-27* does show a dip in population between 2050 and 2070. This is mainly due to growth projections of the Brunswick County water system and the Brunswick Regional Water and Sewer District. Future water demand and population growth resulting from future economic development is beyond the scope of this document.

Table 5-3 shows that for data collection year 2020, the Lower Cape Fear River subbasin population served by public water supply systems was 249,747. The public water supply systems in this subbasin had a combined average daily water demand of 27.78 MGD in 2020. Comparing this to the total available supply in 2020 of 137.93 MGD (*Table 5-2*), the combined average daily demand of the public water supply systems in the Lower Cape Fear River subbasin was approximately 20% of available supply. The combined average daily demand of public water supply systems in the Lower Cape Fear River subbasin is estimated to be about 37% of available supply in 2070. This can be attributed to the contractual obligations of the LCFWSA – Kings Bluff water system as described previously in this chapter. Projected demands for water systems in this subbasin are based on the same proportions of service area in the Cape Fear River Basin as determined for the 2020 plan year. *Figure 5-27* depicts steady increases for both population and demand over the study period.

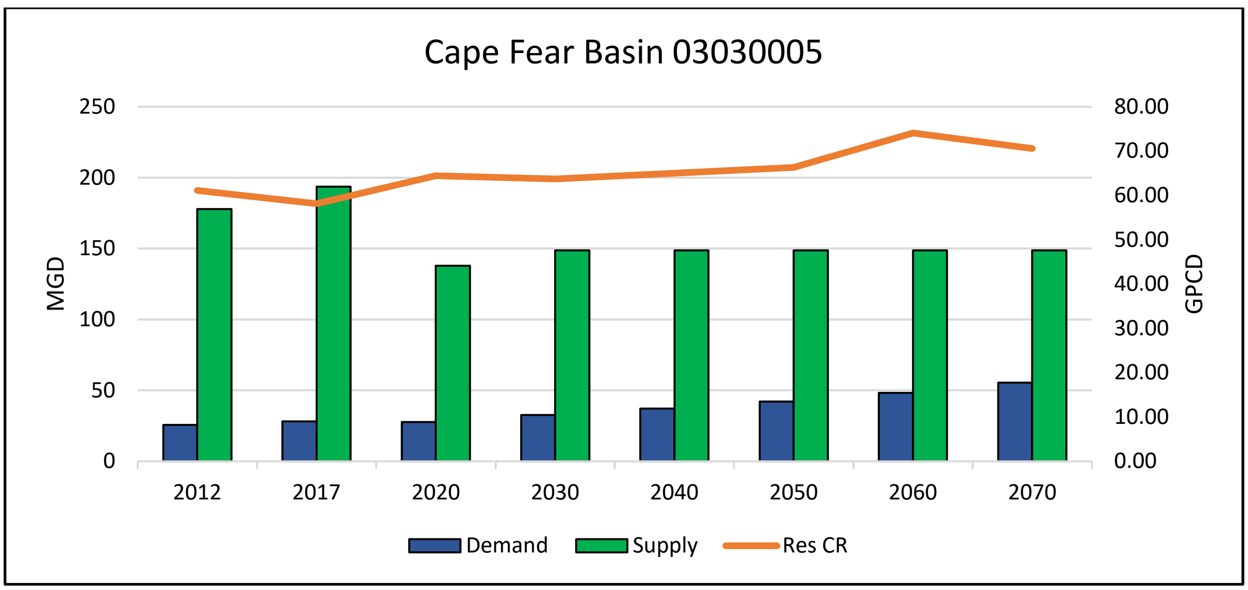
Figure 5-28 depicts steady growth in Res CR throughout the planning period, suggesting a lack of effective water conservation and efficiency measures by water systems and their customers in the subbasin. This is common in areas of the state with high tourist populations as observed along the coast. Because of Session Law 2011-374, water systems must now include a plan to reduce long-term per capita water demand within their jurisdiction as part of the LWSP submittal. The decrease in available supply between 2017 and 2020, depicted in *Figure 5-28*, is largely the result of changes in the LWSP for Cape Fear Public Utility Authority - Wilmington.

Figure 5-27: Water Demand and Service-area Population for HUC 03030005, 2012 – 2070



Note: relatively large changes in demand and/or population are not evenly distributed among the 20 water systems in the HUC but are more influenced by changes reported by one or more of the larger systems.

Figure 5-28: Water Supply, Demand and Residential Consumption Rate for HUC 03030005, 2012 - 2070



Note: relatively large changes in supply, demand and/or residential consumption rates are not evenly distributed among the 20 water systems in the HUC but are more influenced by changes reported by a one or more of the larger systems. A value of the residential consumption rate (Res CR) being higher than the supply value does not mean that supply is insufficient.

The Cape Fear Public Utility Authority – Wilmington is the largest system in the subbasin. The average daily water demand for Cape Fear Public Utility Authority – Wilmington in 2020 was 12.0 MGD, or approximately 43% of the combined subbasin demand. Cape Fear Public Utility Authority – Wilmington does not have the majority of its service area in any single subbasin. Instead, the service area of CFPUA is split between the Lower Cape Fear River subbasin (42%), the New River subbasin (41%), and the Northeast Cape Fear River subbasin (17%). As of January 2023, the CFPUA completed a major expansion of the Sweeney WTP. This expansion will increase the plant treatment capacity from 35 MGD to 44 MGD. The updated plant also includes GAC treatment technologies specifically installed to remove PFAS from the raw water prior to distribution to customers.

Brunswick County has a considerable portion of its service area outside the Lower Cape Fear River subbasin: Shallotte River subbasin (43%) and Waccamaw River subbasin (2%). With the service area split between several subbasins and increasing demand, Brunswick County was granted an IBT Certificate in 2012. To meet the demands of its growing service population, the Northwest WTP is currently under construction to expand its capacity from 24 MGD to 48 MGD and install a low-pressure reverse osmosis system to treat and remove GenX, 1,4 dioxane, and other PFAS.

5.7.8 Black River Subbasin (HUC8 03030006)

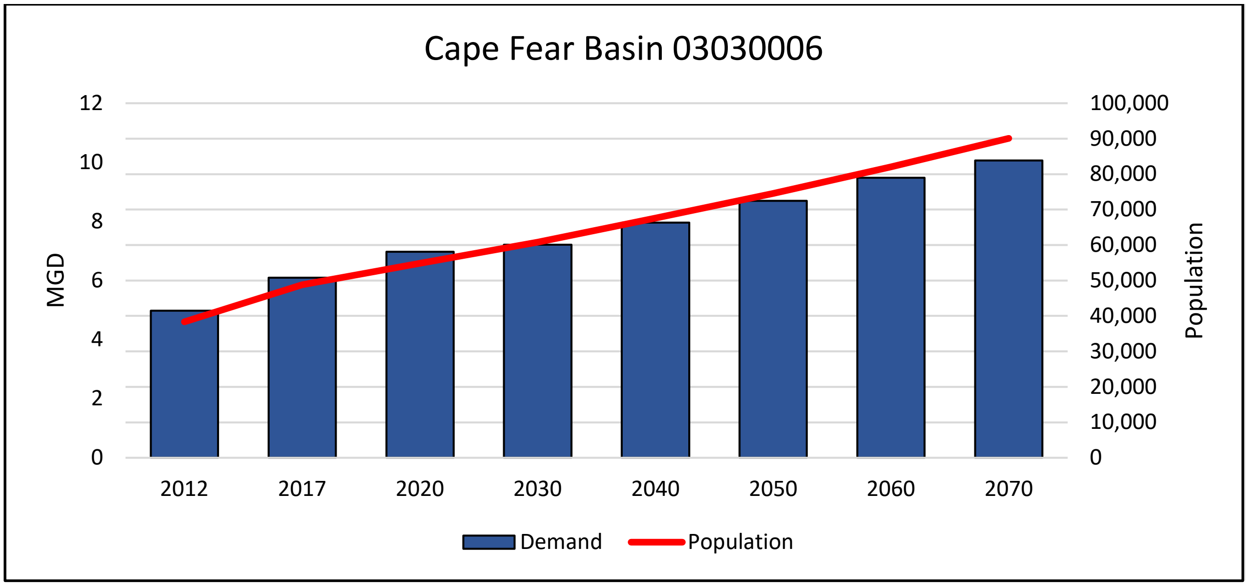
Eighteen water systems are included in the Black River subbasin. Based on the information reported by users, not including ecological flow, domestic users, non-reporters, and other unknown usages, there are no apparent water supply issues in the Black River subbasin. Water demand and population are projected to increase throughout the study period as population growth in central North Carolina continues. Future water demand and population growth resulting from future economic development is beyond the scope of this document.

Table 5-3 shows that for data collection year 2020, the Black River subbasin population served by public water supply systems was 54,893. The public water supply systems in this subbasin had a combined average daily water demand of 6.97 MGD in 2020. Comparing this to the total available supply in 2020 of 22.54 MGD (*Table 5-2*), the combined average daily demand of the public water supply systems in the Black River subbasin was approximately 31% of available supply.

Figure 5-29 depicts steady increases for both population and demand over the study period. Out of all the systems in the Black River subbasin, the Town of Angier and Sampson County Water District II – Dunn, have projected the largest increases in population over the study period. *Figure 5-30* shows a significant decline in Res CR from 2012 to 2020. This decline can be attributed to water conservation efforts by customers and water efficiency improvements by the water systems. The combined average daily demand of public water supply systems in the Black River subbasin is estimated to be about 42% of available supply in 2070. Projected demands for water systems in this subbasin are based on the same proportions of service area in the Cape Fear River Basin as reported in the 2020 plan year.

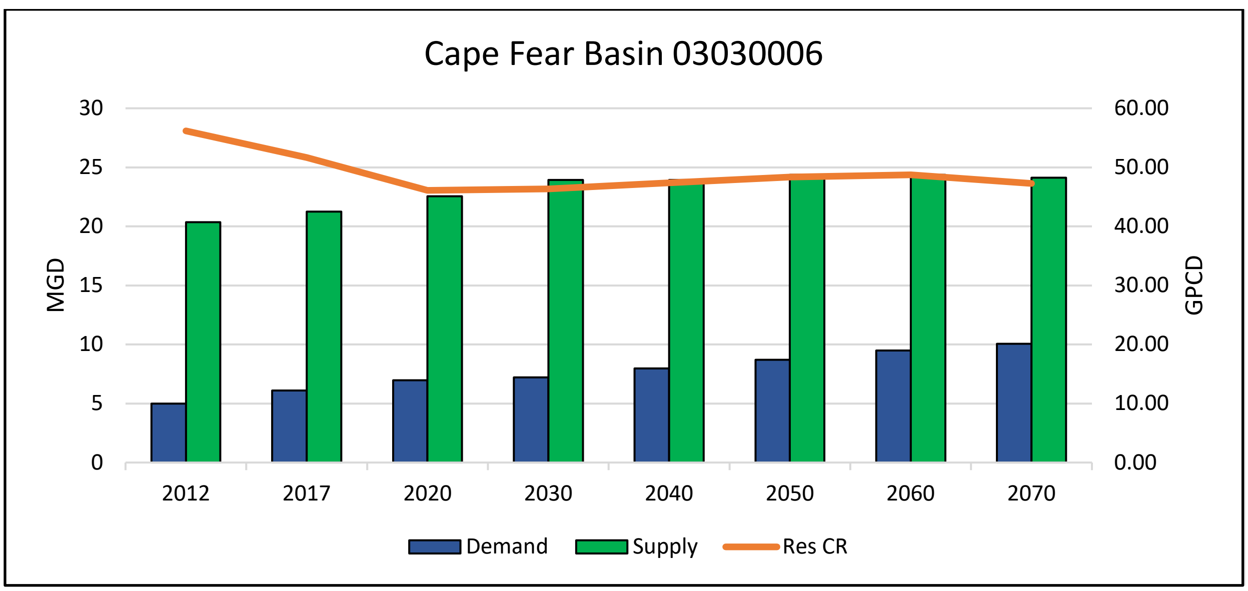
The City of Clinton is the largest system in the subbasin, with an average daily water demand in 2020 of 1.68 MGD, or approximately 24% of the combined subbasin demand. The City of Dunn withdraws its water from the Cape Fear River and sells finished water to several neighboring communities. The water treatment plant associated with this withdrawal is nearing the end of its useful life and the city intends to pursue state and federal funding to replace the existing water plant within the next five years. One of the communities that purchases finished water from Dunn is the Town of Benson. Benson has a portion of its service area in the Upper Neuse River subbasin.

Figure 5-29: Water Demand and Service-area Population for HUC 03030006, 2012 – 2070



Note: relatively large changes in demand and/or population are not evenly distributed among the 18 water systems in the HUC but are more influenced by changes reported by one or more of the larger systems.

Figure 5-30: Water Supply, Demand and Residential Consumption Rate for HUC 03030006, 2012 – 2070



Note: relatively large changes in supply, demand and/or residential consumption rates are not evenly distributed among the 18 water systems in the HUC but are more influenced by changes reported by a one or more of the larger systems. A value of the residential consumption rate (Res CR) being higher than the supply value does not mean that supply is insufficient.

5.7.9 Northeast Cape Fear River Subbasin (HUC8 03030007)

Fourteen water systems are included in the Northeast Cape Fear River subbasin. Based on the information reported by users, not including ecological flow, domestic users, non-reporters and other unknown usages, there are no apparent water supply issues in the Northeast Cape Fear River subbasin. Water demand and population are projected to increase throughout the study period as population growth in southeastern North Carolina continues. Future water demand and population growth resulting from future economic development is beyond the scope of this document.

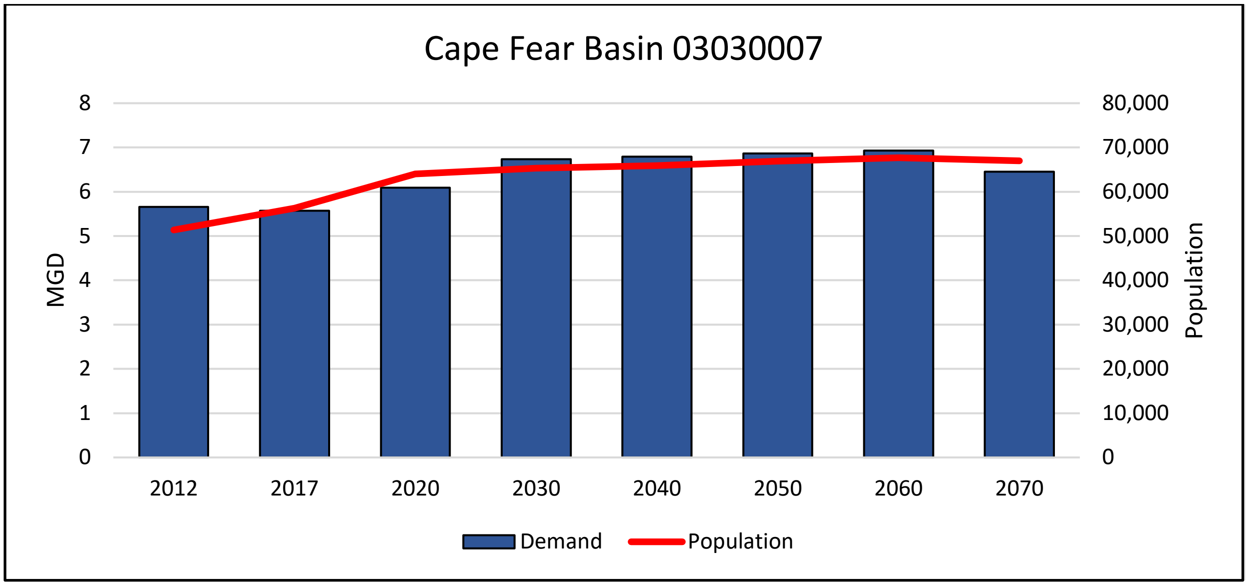
Table 5-3 shows that for data collection year 2020, the Northeast Cape Fear River subbasin population served by public water supply systems was 64,006. The public water supply systems in this subbasin had a combined average daily water demand of 6.09 MGD in 2020. Comparing this to the total available supply in 2020 of 16.5 MGD (*Table 5-2*), the combined average daily demand of the public water supply systems in the Northeast Cape Fear River subbasin was approximately 37% of available supply.

Figure 5-31 depicts increases for both population and demand over most of the study period. Out of all the systems in the Northeast Cape Fear River subbasin, the Duplin County water system and Pender County Utilities have projected the largest increases in population over the study period. For the period 2012 – 2020, both systems reported larger population growth rates than what is projected. As a result, the slope of the historical population line is noticeably steeper than it is for the projected population.

Figure 5-32 shows a slight decline in the Res CR between 2012 and 2020. This decline can be attributed to water conservation efforts by customers and water efficiency improvements by the water systems. It should be noted that the 2019 plan year was used, instead of 2020, for the towns of Faison and Teachey, due to questionable 2020 LWSP data. As a result, the LWSP projection is only through 2060, causing a slight decrease in the 2070 population, demand and supply for the study period. These water systems represent approximately 9% of the total subbasin demand. Although 2070 projected demand and supply for the alternate year systems was not included, it is not considered a significant factor in the overall water quantity condition of the subbasin. The combined average daily demand of public water supply systems in the Northeast Cape Fear River subbasin is estimated to be about 43% of available supply in 2070. Projected demands for water systems in this subbasin are based on the same proportions of service area in the Cape Fear River Basin as reported in the 2020 plan year.

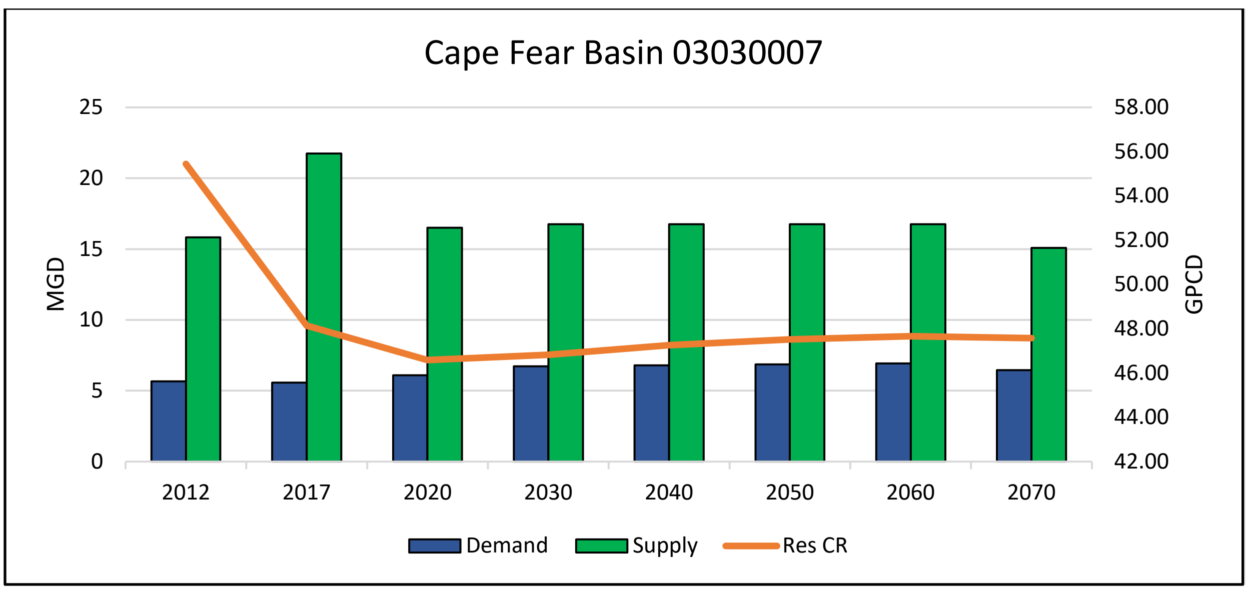
The Duplin County Water System and Pender County Utilities have the largest demands for water systems in the subbasin. Duplin County depends upon groundwater as its source and is within the CCPCUA. Pender County also has groundwater wells, but most of its raw water is purchased from LCFWASA, with a small amount purchased from the Town of Wallace. The average daily water demand for both Duplin County and Pender County Utilities in 2020 was approximately 3.26 MGD. Combined, this constitutes approximately 54% of the subbasin demand. Pender County Utilities was granted an IBT Certificate in 2018 for the purchase of water from LCFWASA.

Figure 5-31: Water Demand and Service-area Population for HUC 03030007, 2012 – 2070



Note: relatively large changes in demand and/or population are not evenly distributed among the 14 water systems in the HUC but are more influenced by changes reported by one or more of the larger systems.

Figure 5-32: Water Supply, Demand and Residential Consumption Rate for HUC 03030007, 2012 – 2070



Note: relatively large changes in supply, demand and/or residential consumption rates are not evenly distributed among the 14 water systems in the HUC but are more influenced by changes reported by a one or more of the larger systems. A value of the residential consumption rate (Res CR) being higher than the supply value does not mean that supply is insufficient.

5.7.10 Water Shortage Response Plan (WSRP)

A Water Shortage Response Plan (WSRP) is a document prepared by the water system that describes how the water system will respond to drought and other water shortage emergencies and continue to meet essential public water supply needs during the emergency. It establishes authority for declaration of a water shortage, defines different phases of water shortage severity and outlines appropriate responses for each phase. A WSRP is required by statute (G.S. 143-355(l)) for all large community water systems or those required to submit a LWSP. To ensure effectiveness and meet statutory requirements, an updated WSRP must be approved by the associated local governing board and resubmitted for approval to the DWR at least every five years. DWR is unaware of any implementation issues among water systems in the Cape Fear River Basin.

5.8 Water Withdrawal and Transfer Registration (WWATR) Program

North Carolina General Statute §143-215.22H requires any person who withdraws or transfers 1,000,000 gallons per day (GPD) or more of water for activities directly related or incidental to agricultural production or to the creation or maintenance of waterfowl impoundments and any person who withdraws 100,000 GPD or more of water from the surface or groundwater, or who transfers 100,000 GPD or more of water from one river basin to another, to register the withdrawal or transfer with the DWR.

In 2020, 169 facilities reported to the Water Withdrawal and Transfer Registration (WWATR) program in the Cape Fear River Basin. Combined, these facilities withdraw an annual daily average of 1,498.011 MGD from 346 different surface water and groundwater sources. Of the total reported, 1,491.091 MGD was withdrawn from 84 different surface water sources and 6.920 MGD was withdrawn from 262 groundwater sources. Categorical uses included in the WWATR Program report are shown in *Table 5-6*. The table only includes data collected directly by the WWATR Program. It does not include data from the DWR Local Water Supply Plans (Section 5.7.1) or the NC Agricultural Water Use Report by NCDA&CS (Section 5.9). The public water supply systems represented in the table are limited to small, privately-owned systems, primarily comprised of systems owned by Aqua and Carolina Water.

Though compliance with the WWATR appears to be reasonably effective at capturing major water withdrawals for most of the water use sectors, the lack of water withdrawal permitting in North Carolina creates a difficult scenario for DWR to confidently provide assurances to all corners of the state to ensure the long-term sustainability of the water resources for all. Furthermore, the amount of water needed to support and sustain the aquatic life present in rivers and streams needs to be considered simultaneously with water withdrawal planning, management, and any current or future permitting.

It is important to note that groundwater resources are a finite source of water that in most areas across the state recharge very slowly. Unlike surface water sources, the state currently has no effective means for quantifying sustainable yields for withdrawal rates for water users. Comprehensive groundwater assessment/modeling programs are needed by water-resource managers to make more informed decisions regarding groundwater availability and allocations.

Table 5-6: Water Withdrawal and Transfer Registration 2020 Data.

WWATR Category	Total Annual Average Daily Use (MGD)	Annual Average Daily Groundwater (MGD)	Annual Average Daily Surface Water (MGD)	Number of Facilities	Total Ground and Surface Water Sources
Industrial	53.658	2.821	50.837	14	59
Energy	1411.249	1.691	1409.558	4	16
Public Water Supply	1.496	1.496	0.000	99	181
Agriculture	8.036	0.605	7.431	4	12
Recreation	2.223	0.274	1.949	23	48
Mining	21.349	0.033	21.316	25	30
Total	**1498.011**	**6.920**	**1491.091**	**169**	**346**

5.9 Agricultural Water Use Survey (NCDA&CS)

The North Carolina Department of Agriculture & Consumer Services (NCDA&CS) is required per Session Law 2008-0143 to collect water use information from farms withdrawing 10,000 gallons per day (GPD) or more from surface or groundwater sources. The data is collected by NCDA&CS Agricultural Statistics Division. The data is compiled and used to report agricultural water use biennially by July 25 (NCDA&CS, 2020). (See link: https://www.ncagr.gov/). Individual responses are kept confidential and are only used in combination with other reports as well as produce and livestock totals. Reported information is published as total monthly groundwater use, total monthly surface water use, amount used by crop or animal type, daily demand on the days water was used or applied to cropland, use by county, use by watershed or HUC, and water used in the CCPCUA (NCDA&CS, 2020). Farms with water usage exceeding 1,000,000 GPD are required to report usage directly to DWR under the WWATR program (NCDA&CS, 2020). This aggregation of data based on county and watershed coupled with the USDA's legal confidentiality requirements has resulted in the inability to discern water quantity issues related to agricultural operations through their water use dataset, as shown in *Table 5-7*.

According to the 2020 NCDA&CS Agricultural Water Use Survey, 852 farms statewide withdrew at least 10,000 GPD. Collectively, these farms had an average daily water use of 50.2 MGD and an annual withdrawal capacity that totaled 1.2 billion gallons. In the Cape Fear River Basin, there were 294 unique operations that participated in the survey. Total average daily water use from both surface and groundwater was 6.331 MGD. The daily withdrawal capacity was reported to be 267.330 MGD. Limited data was available for five of the six HUCs located in the Cape Fear River Basin (*Table 5-7*). It is important to note that the data available did not include the Deep River subbasin (HUC 8: 03030003), which includes areas of Guilford, Randolph, Chatham, Moore and Lee counties.

Table 5-7: Available Agricultural Water Use Survey in the Cape Fear River Basin (NCDA&CS, 2020).

HUC	Unique Operations[1]	Annual Average Daily Ground[2] (MGD)	Annual Average Daily Surface[2] (MGD)	Annual Average Daily Total (MGD)	Daily Withdrawal Capacity[3] (MGD)
03030002	32	*	1.310	1.310*	29.130
03030003	ND	ND	ND	ND	ND
03030004	22	0.172	*	0.172*	11.455
03030005	15	0.228	*	0.228*	*
03030006	107	1.828	0.467	2.295	68.146
03030007	118	2.326	*	2.326*	158.599
Basin Total	**294**	**4.554**	**1.777**	**6.331**	**267.330**

ND - Nondisclosed data for HUC's grouped in 2020 NC Agricultural Water Use report.
* Disclosure - one operation is greater than 60% of total or less than 3 operations reported.
[1] represents the unique number of operations which withdrew surface and or groundwater
[2] represents the average across all days of the year
[3] includes ground and surface

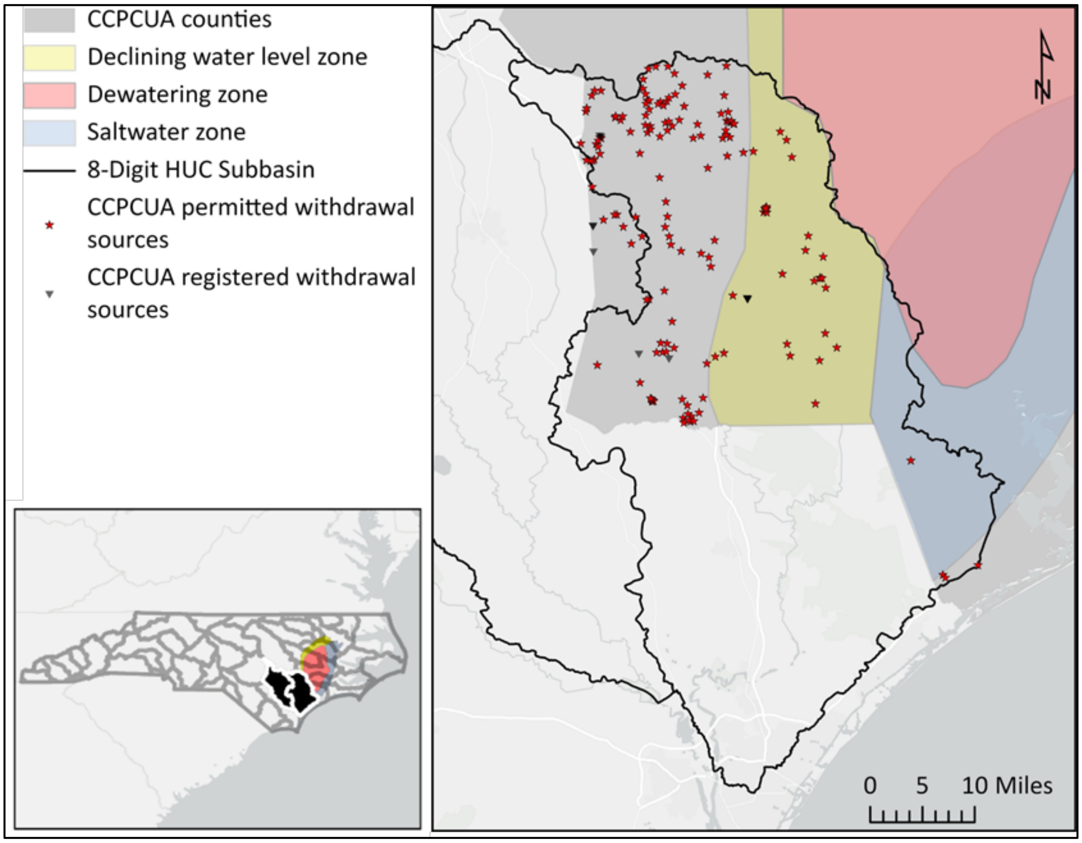
5.10 Central Coastal Plain Capacity Use Area (CCPCUA)

The CCPCUA is a 15-county region where water use is regulated under the 15 NCAC O2E Water Use Registration and Allocation rules. Designation of the CCPCUA was due to over-pumping of groundwater in the Cretaceous-age confined aquifers (Black Creek and Upper Cape Fear). The CCPCUA rules require groundwater users of more than 100,000 GPD to obtain a water withdrawal permit. Also, registration and annual reporting is required of entities and facilities that use more than 10,000 GPD of surface water or groundwater.

In the Cape Fear River Basin, water users located in Duplin, Wayne and Onslow counties are subject to the rules associated with the CCPCUA. A portion of Duplin and Wayne counties are in the CCPCUA designated "Declining Water Level Zone" where water users were faced with an overall 30% reduction in groundwater withdrawals phased in from 2008 to 2018 (*Figure 5-33*). Onslow County is located in the CCPCUA designated "Dewatering and Salt Water Zones," where water users were faced with an overall 75% reduction in groundwater withdrawals phased in from 2008 to 2018.

In 2020, 60 facilities were permitted and 6 were registered with the CCPCUA program within the Cape Fear River Basin. The permit holders and registrants included 41 agricultural facilities, 14 public water suppliers, 9 industries and 2 mining operations. Reported annual average water use for permit holders in agriculture, public water supply and industry ranged from 0 to 1.8 MGD. Reported annual average water use for registrants in agriculture, industry, and mining ranged from 4.1 to 221.1 GPD. Total reported groundwater use was 3,940,803,600 gallons in 2020 with approximately 61.7% public water supply, 28.2% industry, 10.1% agriculture, and a minor percentage was mining operations. A list of permitted and registered facilities and reported average daily water use can be found in the Chapter 5 appendix.

Figure 5-33: Central Coastal Plain Capacity Use Area Wells and their Locations in the Cape Fear River Basin.



5.11 Estimates of Self-Supplied Domestic Well Use (Private Well Owners)

Self-supplied domestic water use is primarily household water used by people not serviced by a water supply system. Instead, groundwater well(s) located on the homeowner's property supply groundwater to the residence and associated activities (farm or other commercial business). Water use from individual private wells for household use does not reach the quantities necessary to require reporting to DWR and is, therefore, not included in the overall demand calculated in the summaries included in this report. DWR, however, recognizes this water usage is likely significant considering the large rural population across North Carolina.

An analysis to estimate the population not served by water systems that submit LWSP was completed using the Apportion method in ArcGIS software with the 2020 US Census Block, LWSP service area boundaries, and HUC-8 basin boundary spatial data layers. Please note there are potential issues with the estimated population not serviced by a system that submits a LWSP including, but not limited to, errors in population served, inaccurate basin splits, population density across a service area, boundaries being incorrectly georeferenced, numerous overlaps in boundaries, and different levels of detail. With these potential issues noted, the analysis resulted in an estimated population of 579,334 relying on a water source or system that do not submit a LWSP (*Table 5-8*). This was a desktop analysis based solely on spatial datasets available to DWR, unlike the other population analyses presented in this chapter which relied on information provided in LWSPs, and these estimates may not accurately reflect the population serviced in the Cape Fear River Basin subbasins (HUC8). Further refinement of these estimates might be possible using voluntary response surveys from citizens in the river basin.

A separate analysis using the following methodology was undertaken to determine self-supplied domestic water use for North Carolina counties. This methodology was to subtract the population reported in 2020 LWSPs served from the 2020 US Census County population and multiplying that result by a per capita water use value of 70 GPD per capita. The 70 GPD per capita estimate is based on the most recent 2015 water use report by the USGS (USGS, 2018).

Table 5-8: Estimate of Population Serviced by Systems that Submit a LWSP and Estimated Population not Serviced by a Water Source or a System that Submit a LWSP Based on the 2020 US Census Block Data and the HUC-8 Subbasin Boundaries.

2020 Census Block Population Data by HUC-8 (Apportion Method)		**2020 Population on public water supply or community groundwater**		**Estimated population not serviced by a water system that submit a LWSP***
HUC-8 Basin Boundary	**2020 Population**	**HUC-8 Basin Boundary**	**2020 Population on water systems**	**Total**
03030002	1,030,623	03030002	786,675	243,948
03030003	336,328	03030003	211,339	124,989
03030004	603,835	03030004	535,035	68,800
03030005	183,131	03030005	133,511	49,620
03030006	117,771	03030006	94,182	23,589
03030007	177,614	03030007	109,226	68,388
Total	**2,449,302**	**Total**	**1,869,968**	**579,334**

*This analysis does not distinguish between systems not required to submit a LWSP, register with the Water Withdrawal and Transfer program, or domestic self-supplied populations.

Table 5-9: Self-Supplied Domestic Water Use Estimates by County.

County	2020 Census	2020 Population on public surface water supply or community groundwater	2020 Population on private groundwater	Self-supplied water use (gal/day)	2015 USGS domestic self-supplied withdrawals (gal/day)
Alamance	171,415	110,185	61,230	4,286,100	3,490,000
Bladen	29,606	17,007	12,599	881,930	1,290,000
Brunswick	136,693	125,951	10,742	751,940	430,000
Caswell	22,736	2,618	20,118	1,408,260	1,360,000
Chatham	76,285	55,301	20,984	1,468,880	2,020,000
Columbus	50,623	26,084	24,539	1,717,730	2,000,000
Cumberland	334,728	299,094	35,634	2,494,380	1,300,000
Duplin	48,715	40,273	8,442	590,940	1,530,000
Durham	324,833	296,305	28,528	1,996,960	1,780,000
Forsyth	382,590	387,412	Minimal	Minimal	6,060,000
Guilford	541,299	451,112	90,187	6,313,090	7,070,000
Harnett	133,568	124,688	8,880	621,600	2,030,000
Hoke	52,082	57,480	Minimal	Minimal	680,000
Johnston	215,999	155,004	60,995	4,269,650	3,240,000
Jones	9,172	10,523	Minimal	Minimal	40,000
Lee	63,285	55,725	7,560	529,200	660,000
Lenoir	55,122	53,021	2,101	147,070	200,000
Montgomery	25,751	25,223	528	36,960	50,000
Moore	99,727	70,383	29,344	2,054,080	1,720,000
New Hanover	225,702	219,434	6,268	438,760	3,960,000
Onslow	204,576	201,613	2,963	207,410	1,130,000
Orange	148,696	108,449	40,247	2,817,290	2,640,000
Pender	60,203	41,699	18,504	1,295,280	1,980,000
Randolph	144,171	81,074	63,097	4,416,790	4,210,000
Robeson	116,530	124,088	Minimal	Minimal	1,620,000
Rockingham	91,096	54,324	36,772	2,574,040	2,720,000
Sampson	59,036	33,745	25,291	1,770,370	2,250,000
Wake	1,129,410	990,202	139,208	9,744,560	9,620,000
Wayne	117,333	101,851	15,482	1,083,740	410,000

*This analysis does not distinguish between systems not required to submit a LWSP, register with the Water Withdrawal and Transfer program, or domestic self-supplied populations.

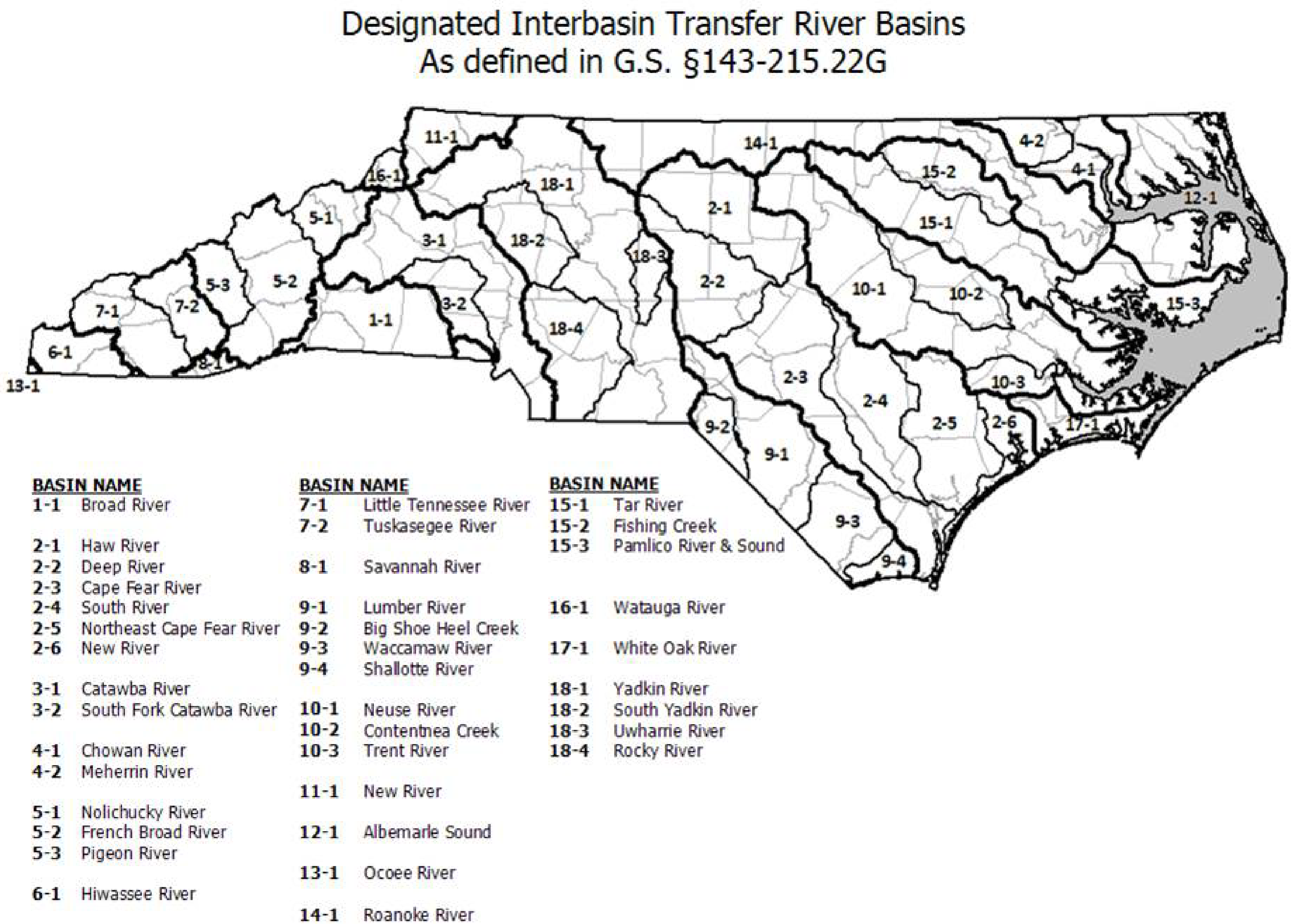
There is uncertainty when using this approach to estimate self-supplied water use. Notably, there were many counties that reported negative values when subtracting the population served by the public or community water systems from the 2020 county census population (e.g., Forsyth, Hoke, Jones, and Robeson counties). A possible explanation for this error is that some water systems also supply water to areas outside their own counties, resulting in an overestimate of how many in-county users are served by public water supply. The system may also overestimate the population serviced by community or public water service compared to the 2020 US Census County populations. Another source of error is the service area boundaries layer used to estimate the percentage of a municipality that is within a county. Use of these boundaries assumes that the population is evenly distributed within a system boundary. In addition, the boundaries have inaccuracies that will affect the calculations. The 2015 USGS self-supplied domestic water use estimates were included in *Table 5-9* for comparison purposes. DWR is continually working on a methodology that would help better estimate the amount of water being withdrawn via self-supplied domestic wells in North Carolina.

5.12 Interbasin Transfer (IBT) Certificates

The North Carolina Legislature adopted the Regulation of Surface Water Transfers Act (NCGS §143-215.22L) in 1993. The intent of the law is to regulate large surface water transfers between river basins by requiring a certificate from the EMC. NCGS §143-215.22G established 38 Interbasin Transfer (IBT) basins. An IBT certificate is required for a transfer greater than 2.0 MGD between any of the defined IBT river basins. Across North Carolina, there are approximately 133 public water supply (PWS) systems known to transfer surface water across IBT river basins. There are approximately 38 systems that transfer less than 100,000 GPD, 68 systems that transfer between 100,000 GPD and 1.0 MGD, and 27 systems that transfer more than 1.0 MGD. Eleven of those 27 systems are regulated under the nine IBT certificates issued by the EMC. Ten water systems exceed the 2.0 MGD threshold that requires an IBT certificate, but have a pre-existing transfer (i.e., grandfathered) allowance for the surface water transfer because their system infrastructure existed or was under construction prior to July 1, 1993 (as established in NCGS §143-215.22L). Six systems are transferring between 1.0 and 2.0 MGD. Surface water movement between statutorily defined IBT basins by water systems or other entities that do not meet the threshold for an IBT certificate are commonly referred to simply as a "surface water transfer."

In the Cape Fear River Basin, there are six IBT river basins: Haw River (2-1), Deep River (2-2), Cape Fear River (2-3), South River (2-4), Northeast Cape Fear River (2-5), and New River (2-6) (*Figure 5-34*). There are approximately 35 systems that are known to transfer water across IBT basin boundaries. This includes systems transferring Cape Fear River Basin "source" water to another "receiving" basin or transferring water from another basin to the Cape Fear River Basin or moving water within the Cape Fear River subbasins. Of the smaller basin transfers in the Cape Fear River Basin that are not regulated by an IBT certificate, there are an estimated six water systems that transfer less than 10,000 GPD, five water systems that transfer more than 10,000 GPD, but less than 100,000 GPD, 10 water systems that transfer between 100,000 GPD and 1.0 MGD, and four water systems that transfer more than 1.0 MGD, but less than 2.0 MGD. There are five water systems that have pre-existing transfer allowances (prior to July 1, 1993) to transfer more than 2.0 MGD based on their water system capacity in July 1993. There are four IBT certificates that regulate large surface water transfers in the Cape Fear River Basin.

Figure 5-34: Spatial Extents of the IBT Basins.



The first IBT certificate was issued in 1991 to the Piedmont Triad Regional Water Authority under previous statutes (NCGS § 162A-7 and § 153A-285). The Piedmont Triad Certificate allowances are used primarily by the City of Greensboro to transfer water between the Deep River and Haw River within their distribution system. Three IBT certificates have been issued under the current statute (NCGS §143-215.22L) to water systems that have service areas within the Cape Fear River Basin. They are: Brunswick County, issued in 2013; Wake County (Cary, Apex, and Morrisville) issued in 2001 and modified in 2015; and Pender County, issued in 2018 (*Table 5-10*).

Table 5-10: Cape Fear River Basin Interbasin Transfer Certificates.

Interbasin Transfer Certificate[1]	Year	Source IBT Basin	Receiving IBT Basin	Maximum Allowable Amount (MGD)	Annual Average IBT Basin Transfer (MGD) (2020)
Piedmont Triad Regional Water Authority[2]	1991	Deep River (2-2)	Yadkin (18-1)	2.0	-
			Haw (2-1)	28.5	-
Brunswick County	2013	Cape Fear (2-3)	Shallotte River (9-4)	17	7.228
			Waccamaw River (9-3)		1.515
Wake County (Cary, Apex, and Morrisville)	2015	Haw (2-1)	Neuse (10-1)	31	15.9
			Cape Fear (2-3)	2	0.09
Pender County Utilities and Towns of Burgaw, Topsail Beach, Surf City and Wallace and Utilities, Inc.	2018	Cape Fear (2-3)	South River (2-4)	14.5	1.28
			Northeast Cape Fear (2-5)		
			New River (2-6)		

[1]Table does not include facilities that were grandfathered for their transfer amount prior to the implementation of G.S. 143-215.22I in 1993. IBT Certificates are not required for facilities that existed or were under construction prior to July 1, 1993, up to the full capacity of that facility to transfer water on that date, regardless of the transfer amount.
[2]The Piedmont Triad Regional Water Authority's IBT certificate, issued under G.S. 162A-7 and 153A-285, did not require the submittal of Annual Reports.

The Town of Fuquay-Varina has requested an IBT Certificate from the EMC and is currently proceeding through the regulatory process. The town issued a Notice of Intent (NOI) to the Environmental Management Commission (EMC) in September 2020 that they will be pursuing an IBT Certificate to allow the transfer of 4.0 MGD from the Cape Fear River IBT basin to the Neuse River IBT basin. The proposal involves transferring water from the City of Sanford's intake on the Cape Fear River to Fuquay-Varina's service area, which is approximately split evenly between the Cape Fear River IBT basin and the Neuse River IBT basin. The town owns and maintains a wastewater treatment plant (WWTP) that discharges directly into Terrible Creek in the Neuse River Basin. The current capacity of the Terrible Creek WWTP is 3 MGD; however, the town has a permitted NPDES allowance to discharge up to 6 MGD, once improved treatment technology is implemented. As a statutory requirement for the IBT proposal, the town has issued a draft Environmental Impact Statement (EIS) for agency, concerned parties and public review.

DWR is accepting comments on the draft EIS through April 1, 2026. The comments received will be addressed in the EMC's hearing officers report. Subsequently, the EMC will make a determination on the issuance of the requested IBT Certificate following additional public hearings per statutory draft determination requirements. For additional information on the Fuquay-Varina IBT process see DWR Interbasin Transfer Certification website.

5.13 Summary of Water Use Reporting

A summary of the information provided in the water use reported sections of this report is in *Table 5-11*. This includes the total water used to meet demands reported to the LWSP, WWATR, CCPCUA, Agriculture Water Use Survey, self-supplied and interbasin transfers. While these programs all report water use, there is an overlap in reporting by water systems that report to both the 15-county CCPCUA and LWSP programs. Additionally, there is an overlap between water use reporting to Agricultural Water Use Survey and the WWATR program when a system withdrawal is over 1 MGD. Self-supplied domestic water use is estimated at the county-scale and county boundaries may not conform to hydrologic unit code (HUC8) boundaries. More information about each of these water use reporting programs is included in the above sections.

Table 5-11: Summary of the Water Use Reported and Estimated.

Category*	Total Annual Average Use (MGD)	Annual Average Groundwater (MGD)	Annual Average Surface Water (MGD)	Number of Facilities	Transferred out of the Basin (MGD)	Annual Average IBT Transfers out of the basin (MGD)	Annual Average IBT Transfers within the basin (MGD)
LWSP*	225.1	28.9	196.2	122	23.4	-	-
WWATR*	1490.0	6.3	1483.7	169	-	-	-
WWATR – Agriculture*	8.0	0.6	7.4	4	-	-	-
CCPCUA[1]*	10.8	10.8	-	66	-	-	-
Agriculture Water Use[2]*	6.3	4.6	1.8	294	-	-	-
Self-Supplied[3,4]*	40.6	-	-	-	-	-	-
IBT[5]*	-	-	-	-	-	23.128	2.885

*Note: These numbers are **NOT** additive. Public Water Supply Systems may report to both the CCPCUA and LWSP programs. The agriculture water use survey information can overlap with the WWATR or CCPCUA records. Self-supplied is estimated using a desktop analysis and may not be accurate.

[1] For planning purposes, the total annual water use was divided by 365 days to align with annual reported average values from other water use programs in DEQ. This differs from the CCPCUA program which establishes maximum daily withdrawal limits. For compliance monitoring, average daily use reported on the public CCPCUA website is calculated as the total annual water use divided by # of days of use.

[2] non-disclosures associated with data

[3] desktop analysis based on spatial datasets available to DWR

[4] 70 GPD per capita estimate is based on the most recent 2015 water use report by the USGS (USGS, 2018)

[5] based on IBT Basin Boundaries

5.14 Basinwide Water Supply Planning

5.14.1 Basinwide Hydrologic Model Purpose and Scope

In 2010, recognizing the need for tools to assist with water resources planning, the North Carolina General Assembly directed DEQ to develop hydrologic models for North Carolina's 17 major river basins (G.S. 143-355(o)). A basinwide hydrologic model is a mass balance, water resources simulation, and optimization model for the finest practical geographic resolution and timestep. The model calculates surface water movement in a river network at pre-determined nodes. The calculations are based on local historic streamflow data at USGS gages, surface water withdrawals, permitted wastewater return flows and reservoir operation models, which include evaporation rates, drainage area, bathymetry and required releases, if any. The basinwide hydrologic model also includes instream flow requirements associated with permits and licenses. The instream flow requirements included in the model are typically associated with permitted intakes or dams used for public water supply or hydropower. The instream flow requirements are based on desktop calculations or site-specific field studies, depending on the regulatory authority, guiding statutes and anticipated impacts to natural resources.

Hydrologic models can process large amounts of data and are powerful planning tools to evaluate water supply dependability, reservoir management strategies, streamflow variability and hydropower generation in river basins with growing populations and water demands. A hydrologic model's capabilities assist in evaluating the potential flow impacts from proposed projects by identifying flow conditions that could produce water shortages and limit the ability to meet both in- and off-stream demands. Such projects include new or expanding water supply sources, interbasin transfers, and hydropower relicensing. The model's output is a hypothetical record of streamflow and reservoir storage conditions at each node in the basin's stream network under various modelled conditions to evaluate the potential effects on surface water availability and the possible magnitude of water shortages.

The hydrologic model does not account for climate change. There is no easy direct climate change scenario set up in the model as this is not a rainfall/runoff model. There is no option of changing seasonal or location wise variations/extreme hydrologic condition modification in any single year. It can be done for the overall change in hydrology by a multiplying factor, which can either reduce or increase the inflow at all locations into the entire basin for the whole period of record or the demand can be reduced or increased by multiplying factors for all demands except agriculture. That means it can do the overall sensitivity test only, but it cannot change the inflow based on the change in intensity of rainfall or temperature as is expected by any climate change scenarios.

5.14.2 Hydrologic Models and Ecological Flows

The 2010 law also directed the creation of an Ecological Flows Science Advisory Board (EFSAB) to assist DEQ in characterizing the ecology of the state's river basins and identifying the flows necessary to maintain ecological integrity (G.S. 143-355(o)). A flow regime that protects ecological integrity is often referred to as an "ecological flow." Ecological integrity is defined in a North Carolina G.S. 143-355(o) as "the ability of an aquatic system to support and maintain a balanced, integrated, adaptive community of organisms having a species composition, diversity and functional organization comparable to prevailing ecological conditions and, when subject to disruption, to recover and continue to provide the natural goods and services that normally accrue from the system." Ecological flow regimes maintain a suitable environment for organisms, their habitats, their various life stages and their life-sustaining prey.

Another G.S. 143-355(o) requirement of each model's functionality is to specifically be designed to predict the place, time, frequency and interval when yields can't meet all needs and essential uses and ecological flows are adversely impacted. The modeling statute also instructed that a hydrologic model was not a rule, not requiring a rule-making process, and that any findings based on modeling output would not vary any existing requirements associated with water quality or quantity nor impose any new requirements. DWR interpreted this to mean that the modeling efforts and conclusions derived from the models were for planning purposes only.

The hydrologic model routes water through the stream network but lacks the capability to evaluate the suitability of various habitats in the river channel for various aquatic species. The model is not an acceptable substitute for a site-specific field study when evaluating the impacts to aquatic habitat from alterations of existing flow conditions. The model is suitable for determining whether site-specific flow requirements can be met and their impact on other water demands.

In each hydrologic model, the ecological flows for inclusion were determined by DWR to be 85% of streamflow at each model node. *The percent flow-by approach was based on an EFSAB recommendation of between 80 and 90% flow-by.* The recommendations of the EFSAB, contained in its 2014 peer-reviewed report, were based on a review of the relevant literature, in-depth analysis of fish and aquatic macroinvertebrate samples collected by the state in wadeable streams, and impacts to aquatic habitat by re-analysis of historical site-specific field studies (NCEFSAB, 2013).

In addition to the percent flow-by, the EFSAB recommended incorporating a critical low-flow component to identify when additional actions may be needed to protect ecological integrity. The critical low-flow component was envisioned as a threshold below which further review was required in order to minimize increases in the magnitude and duration of extreme low flows during drought conditions. Additionally, the EFSAB recommended a biological-response strategy of 5-to-10% reduction in biological conditions to evaluate the effects of the percent flow-by strategy on changes in the most sensitive and susceptible fish and macroinvertebrate communities. The EFSAB also recommended the use of adaptive management to protect the ecological integrity of the state's streams. This recommendation was based on the realization that the supporting science behind ecological flow will advance as more research examines the flow-ecology relationship at various spatial and temporal scales. An adaptive management approach would anticipate changes in the state's climate, land cover, precipitation and runoff patterns, as well as potential shifts in air and water temperature. Additionally, with time and lessons learned, the percent flow and biological criteria recommendations would require periodic reevaluation to assess their efficacy. Finally, adaptive management was a recognition of the data gaps that exist concerning headwater streams less than 4 square miles and tidally influenced coastal waters.

Except for the percent flow-by, the remainder of the EFSAB's recommendations required further consideration by DWR or were deemed to be beyond the scope of the hydrologic models. Additionally, the use of ecological flows in the hydrologic models is on hold due to a resolution passed by the NC Environmental Management Commission in 2014 to resolve its concerns with the statute.

5.14.3 Cape Fear – Neuse River Combined OASIS Model

The DWR currently hosts hydrologic models with the OASIS (Operational Analysis and Simulation of Integrated Systems) platform for the Tar-Pamlico, Roanoke, Broad and French Broad River basins and combined basin models for the Yadkin-Pee Dee-Lumber, New-Watauga and Cape Fear-Neuse River basins. In the Catawba River Basin, the CHEOPS (Computerized Hydroelectric Operations Software) model is available to the public and is hosted by Duke Energy. The OASIS model is not designed to account for tidally included surface waters.

The Cape Fear-Neuse River Combined OASIS model was developed in consultation with the major water withdrawers in the basin and representatives of state and federal resource management agencies. The model development process started in 2011 with a kickoff meeting to outline the needs and scope of the combined model for Cape Fear and Neuse River basins, followed by more stakeholder meetings to present the model schematic, collect data, and review of the data used in the current condition scenario, and finally training to use the model. There were technical review committee meetings apart from the stakeholder meetings to discuss critical and technical issues related to basinwide water supply, interbasin water transfer, water management and drought protocol or management, and to address any other concerns identified by the technical review committee members. More information on the model and its development is available on the DWR website.

The geographic scope of the Cape Fear portion of the model extends from the headwaters of the Deep and Haw rivers to LD1 on the lower Cape Fear River. The Cape Fear component of the model also does not include the Black River or Northeast Cape Fear River due to their confluence with the Cape Fear River below LD1. The Neuse portion of the model extends from the headwaters of the Eno, Flat and Little Rivers to near the mouth of the Neuse River at New Bern. The model is divided into several "subbasins" based on the locations of the reservoirs and junction of the other subbasins for both the Cape Fear and Neuse river basins. The model uses a map-based schematic that includes nodes for surface water withdrawals (agricultural, municipal, and industrial), discharges (municipal and industrial), reservoirs, gage locations, flow requirements associated with dams or run-of-the-river intakes, and points along the rivers where flows are of interest. The following schematic map of the basins shows the geographic coverage of the combined model and the relative locations of the various model nodes (*Figure 5-35*). The red triangles represent reservoirs or lakes, the blue squares are the water withdrawal or demand nodes, the yellow ovals are the junction nodes, the yellow ovals with purple arrows are the gages or local inflow locations and the ovals with brown arrows are the wastewater discharge nodes. The color-coded arcs connect the nodes to represent the different types of flows from the nodes along the river reaches. The black arcs are regular flows along the river or between two withdrawals for regular connections, the red arcs for emergency connections and green arcs for two-way connections. The list of different types of nodes to interconnect the nodes and different water users are presented in *Table 5-12*.

Table 5-12: Cape Fear – Neuse River Combined OASIS Model Nodes.

Types of Nodes	Cape Fear River Basin	Neuse River Basin	Total
Geographic Boundary (Subbasin)	4*	3	10
Total Nodes	212	117	329
Gage Node	14	8	22
Reservoir Node	17	33	50
Demand Node	95	30	125
Municipal	45	13	58
Industrial	7	3	10
Agricultural	43	14	57
WTP Discharge Node	7		7
WWTP Discharge Node	34	22	56
Junction Node	100	54	154

Types of Nodes	Cape Fear River Basin	Neuse River Basin	Total
Travel time Reservoir Node	2	2	4
Terminal Node	1	1	2

*The Black River and Northeast Cape Fear River subbasins are not included in the hydrologic model although interconnections outside of the Black River subbasin are included.

Water withdrawals at demand nodes can be for municipal (public) water supply systems, industrial water users, or agricultural water users. Municipal and industrial water withdrawals are limited to use of 100,000 GPD or more. Agricultural withdrawal is limited to 1,000,000 GPD or more. Municipal water supply withdrawals are based on Local Water Supply Plan (LWSP) data submitted to DWR by local water utilities. Self-supplied industrial water withdrawals were derived from data submitted under DWR's Water Withdrawal and Transfer Registration (WWATR) program. For self-supplied industries, it was assumed that future withdrawals will be the same in the future, as in the 2014 base-case scenario, unless additional information was available to justify changes in projections.

The model uses an estimated daily natural inflow data set that extends from January 1930 to September 2011 to characterize the water entering the river system adjusted for known historical withdrawals, discharges, and reservoir operations. The input data for the model comes in three forms:

- static and pattern data - data contained in the model's graphic user interface (GUI) and represent data that do not change during the model simulation (e.g., physical data like reservoir elevation-storage-area relationships) or repeating data that occurs every year in the simulation (e.g., monthly demand patterns or seasonal minimum release patterns).
- time series data - data that change with each day in the simulation record and typically consist of inflows and reservoir net evaporation.
- user-defined data – data that uses operations control language (OCL). OCL allows the user to define more elaborate operating rules than are permitted from the graphic user interface (GUI).
- A more detailed and technical description of the Cape Fear – Neuse River Combined OASIS Model is provided on the Cape Fear - Neuse Combined River Basin Model website that includes a discussion of model demand nodes, model input data, the GUI, and module run configurations.

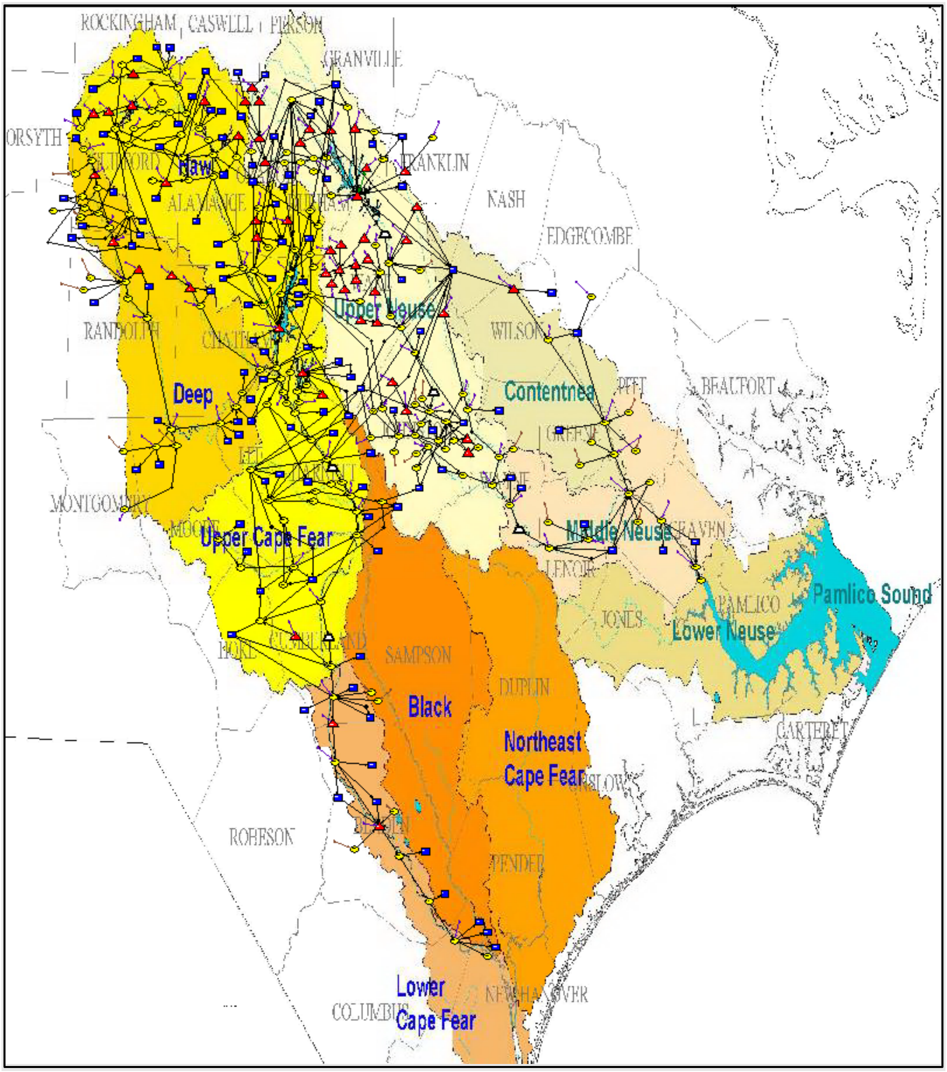
5.14.4 Updating the Cape Fear – Neuse Combined Model

As time and resources allow, the Cape Fear-Neuse Combined River Basin Model should be updated to reflect changes that have occurred throughout the river basin since 2014. This includes updates to hydrology, municipal system operations, water demand and discharge data, water shortage response plans, demand projections, and other model inputs. Some of the expected changes to the OASIS model are discussed below, including the Jordan Lake Round 4 Allocation, as well as the proposed Jordan Lake Western Intake, and the City of Durham's Teer Quarry.

5.14.4.1 Jordan Lake Round 4 Allocation

The water supply storage pool of B. Everett Jordan Reservoir was designed to reliably provide 100 million gallons per day of water supply. The NC General Assembly delegated authority to allocate water supply to the EMC. Allocations are made as a percentage of the water supply pool to address documented needs for 30 years into the future. The EMC is mandated by rule to limit allocations that would result in a diversion of water off the Jordan Lake watershed to 50% of the water supply pool (NC DEQ-DWR, 2016).

Figure 5-35: Cape Fear-Neuse River Combined OASIS Model Schematic.



In 2016, the Environmental Management Commission approved the fourth round of water supply allocation for Jordan Lake. During the decision-making process, the Division of Water Resources produced two reports: [Cape Fear River Surface Water Supply Evaluation] (CFRSWSE) and [Jordan Lake Water Supply Allocation Recommendations] (JLWSAR). Both reports used the OASIS hydrologic river basin modeling to simulate the routing of water in the Cape Fear River Basin above William O' Huske Lock and Dam 3. These reports represent the most recent DWR effort to update and run the Cape Fear-Neuse River Combined OASIS model to determine if there is likely to be a sufficient quantity of water available at specific water supply intakes to cover the expected withdrawals needed to meet specific water demand levels, whenever they occur. The CFRSWSE analysis was limited to public water systems and other self-supplied industrial facilities that use surface water and the neighboring water systems that depend on them. The JLWSAR analysis focused on the information relevant to the decisions concerning the allocation of water supply storage from Jordan Lake (NCDEQ, 2016). All documents related to the fourth round of Jordan Lake allocations are available on the DWR basin planning Jordan Lake Water Supply Allocation Round 4 website. The JLWSAR includes Cary, Apex, Morrisville, Wake County – Research Triangle Park, Pittsboro, Chatham County-North Water System, Durham, Orange Water and Sewer Authority, City of Raleigh Public Utilities Department, Orange County, Hillsborough, Holly Springs and Fayetteville Public Works Commission. These applicants received the following allocations, totaling 95.9% of the water supply pool in Jordan Lake (*Table 5-13*). The City of Raleigh rescinded their 4.7% allocation in 2019, making the final round-4 allocation total 91.2% of the water supply pool.

Table 5-13: Jordan Lake Water Supply Allocation Pool.

Allocation of Jordan Lake Water Supply Pool		
Applicant	Jordan Lake Round 4 Requested Allocation	Jordan Lake Round 4 Approved Allocation
	Allocation Percent	Allocation Percent
Cary Apex Morrisville RTP	46.2	46.2
Chatham County - North	13	13
Durham*	16.5	16.5
Fayetteville PWC	10	0
Hillsborough	1	1
Holly Springs	2	2
Orange County	1.5	1.5
Orange Water and Sewer Authority*	5	5
Pittsboro	6	6
Raleigh+	4.7	4.7
Total	105.9	95.9

*Western Intake Partner
+Rescinded EMC-approved allocation percentage as of 2019 (City of Raleigh, 2019 - link)

5.14.4.2 Western Intake Partnership

The City of Durham and the Orange Water and Sewer Authority partnered together to form the Western Intake Partnership (WIP). The WIP has been working together on a proposal to construct a new intake and water treatment plant on the western side of Jordan Lake. The Jordan Lake Round 4 allocation provided a guaranteed source of water enabling potential success with this cooperative project. The new facilities would allow these systems to access their Jordan Lake allocations and provide the ability to fully utilize the water supply storage in Jordan Lake reservoir. Development of a new intake, treatment plant and transmission pipelines face an extensive review and approval process. The new facility is expected to be operational by 2035. With the 80 MGD limit on the existing raw water intake, an additional intake will be required if the state is to reap the maximum benefits of the water supply storage in Jordan Lake reservoir. As currently envisioned, the project would include a new raw water intake and pump station in or adjacent to the reservoir, a treatment plant constructed on land owned by the Orange Water and Sewer Authority adjacent to the US Army Corps of Engineers property and finished water pumping and transmission facilities to deliver water to the project partners. Once this project is operational, this water intake will need to be included in the updated Cape Fear – Neuse Combined River Basin OASIS Model maintained by the DEQ.

5.14.4.3 Durham County Teer Quarry

The City of Durham has requested that Teer Quarry and an Eno River segment in Durham County (Neuse River Basin) be reclassified. These waters are proposed to be reclassified from being in a Class Water Supply-IV (WS-IV) (Protected Area or PA) to the Class WS-IV Critical (CA) designation. This reclassification is needed because the City of Durham seeks to construct a new intake in the river, pump water from the intake to the quarry, and utilize the quarry's waters as a public water supply. Teer quarry is located adjacent to the southern side of the Eno River, approximately five miles west of Falls Lake.

DWR staff worked with the NC Wildlife Resources Commission (WRC) and City of Durham staff to come to an agreement in 2019 regarding the conditions pertaining to water quantity by which the City of Durham would be allowed to (1) withdraw water for water supply purposes from the Eno River as well as Lake Michie and Little River Reservoir and transfer those waters into the Teer quarry, and (2) use water in the Teer quarry for water supply. If Durham's Teer Quarry Storage Project goes online, they will draw on that storage beginning at the first stage of their WSRP. Once this project is operational, this water intake and reservoir will need to be included in the updated Cape Fear – Neuse Combined River Basin OASIS Model maintained by the DEQ.

5.15 Management Under Drought Conditions

Droughts and floods are natural processes; however, their severity can be exacerbated by surrounding land-use activities. Water quality problems associated with rain events usually involve degradation of aquatic habitat from the transport of matter that is either toxic or in such quantities that the system is incapable of accommodating it (e.g., metals, oils, pesticides, sediment, organic material, bacteria, nutrients). These substances can be toxic to aquatic life like fishes and insects, cause oxygen depletion or smother critical habitat with excessive sediment.

Droughts challenge the management of aquatic resources and highlight the important relationship between water quantity and quality in streams. During drought conditions, the assimilative capacity of streams decreases with flow and these pollutants can become more concentrated, constituting a larger percentage of streamflow. During 2002 and 2007, North Carolina was impacted by exceptional drought conditions (***Figure 5-36***), and the Cape Fear River Basin was impacted similarly (***Figure 5-37***). Summer months are generally the most critical months for preserving acceptable water quality. Dissolved oxygen concentrations are naturally lower due to higher temperatures, algal growth increases from longer periods of sunlight and stream flows are reduced. In long-term droughts, these problems can be greatly exacerbated and increase the potential for water quality problems to become catastrophic. The frequency of acute impacts from nonpoint source pollution, or runoff, is minimized during lower flows or drought conditions due to lack of rainfall; however, when rain events do occur, pollutants that have been collecting on impervious surfaces are quickly transported to streams.

Point sources may also have water quality impacts during drought conditions even though permit limits are met. Facilities that discharge wastewater have permit limits that are based on a statistical low-flow condition, often the 7Q10. However, receiving streams with a 7Q10 of zero are not necessarily precluded from receiving permitted discharges, although with stricter permit limits. During droughts, these wastewater discharges

Figure 5-36: Historical Drought Conditions for the State of North Carolina between 2000 and 2022 (link: North Carolina | Drought.gov).

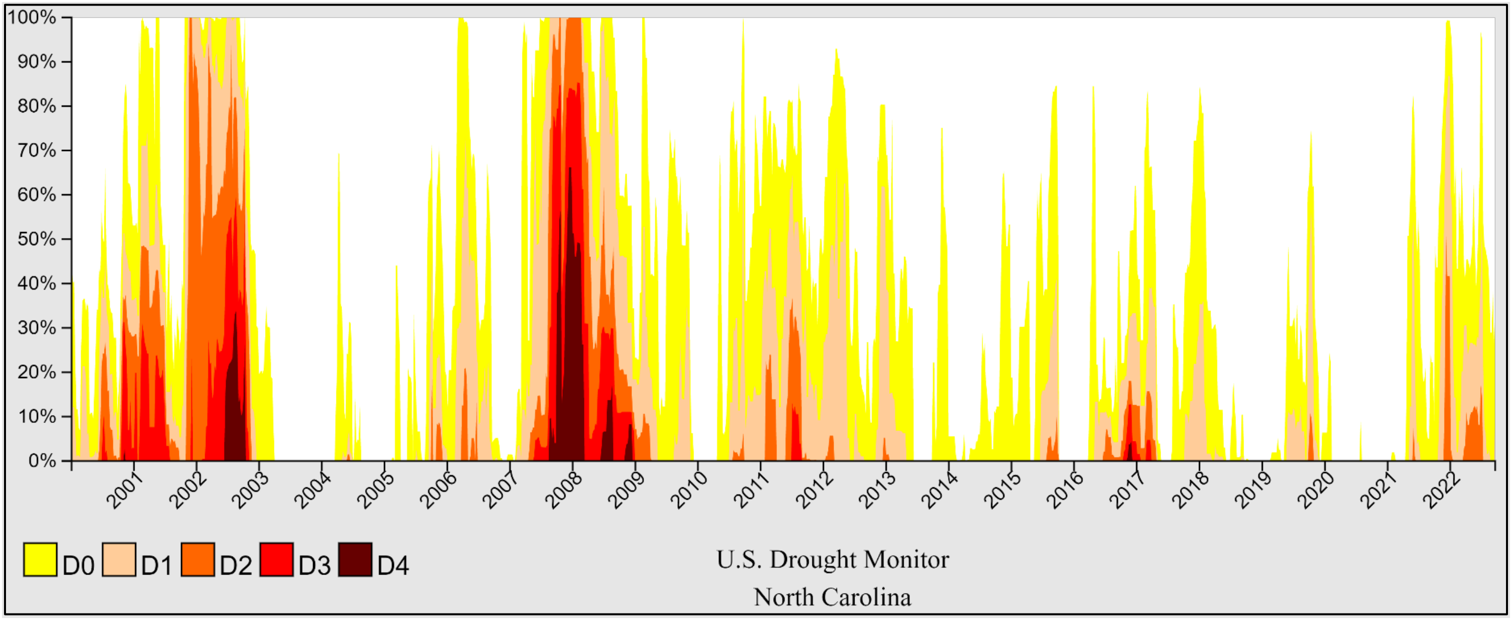
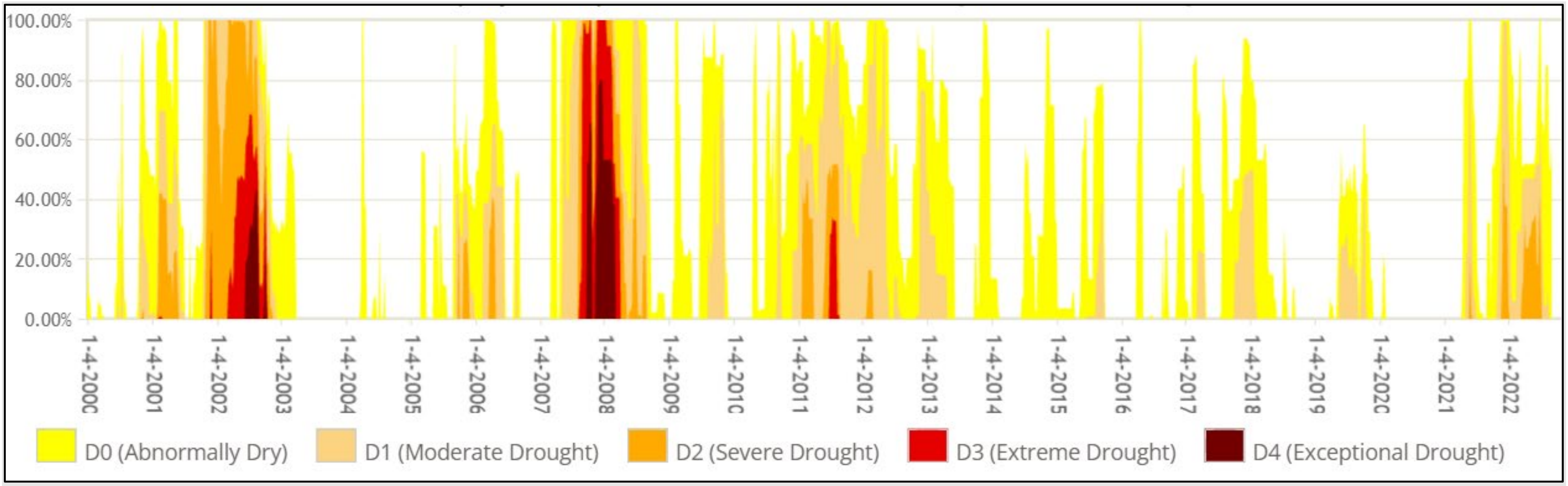


Figure 5-37: Historical Drought Conditions for the Cape Fear River Basin between 2000 and 2022 (Time Series | U.S. Drought Monitor (unl.edu)).



make up a larger percentage of the receiving waters than usual and might contribute to lower dissolved oxygen concentrations and increased levels of other pollutants. During dry periods and droughts, less water is available for off-stream uses like public water supplies and irrigation. As streamflow decreases, the channel is dewatered and less habitat is available for aquatic insects and fishes, particularly in riffle habitat. The dry conditions and increased off-stream removal of water for these other uses further increases stressors on the biological resources. With less habitat, lower dissolved oxygen levels and higher water temperatures, these conditions may stress the biota to the point where it becomes more susceptible to disease and other stresses that normally would not be harmful, resulting in higher mortality for fishes, mussels, and aquatic insects.

Drought Classification
D0 - Abnormally Dry
D1 - Moderate Drought
D2 - Severe Drought
D3 - Extreme Drought
D4 - Exceptional Drought

The North Carolina Drought Management Advisory Council (NCDMAC) has been monitoring drought conditions weekly since 2000 and was given official statutory status and assigned the responsibility for issuing drought advisories in 2003. The NCDMAC assesses drought conditions based on several indices, including streamflow, groundwater levels, rainfall, reservoir levels and soil moisture and then issues advisories on a county-by-county basis. The council provides consistent and accurate information as it relates to drought and includes representatives from surface water and groundwater hydrology, meteorology, water system operation and management, reservoir management, emergency response as well as local governments, agriculture and agribusiness, forestry, manufacturing and water utilities. Five drought designations, or classifications, were established by the NCDMAC. A drought classification is applied to a county when at least 25% of the land area of the county is impacted. A statewide subset of the national drought monitor map is published every Thursday, available online.

Droughts are unpredictable, but their occurrence is inevitable. A drought plan, or water shortage response plan (WSRP), can help reduce the impacts to water resources and minimize disruptions to water withdraws. A WSRP establishes authority for declaring a water shortage, defines different stages of water shortage severity and outlines appropriate responses for each stage. All public and privately-owned water systems subject to General Statute 143-355 (l) are required to prepare and submit a WSRP as part of their LWSP. WSRPs are updated every five years but can be updated more often to address changes to population, water sources and/or additional demands. The plans can also be updated to address any issues that may have been identified when implementing or evaluating the effectiveness of the plan.

5.16 Water Conservation

Alongside WSRPs, demand management and water conservation programs provide valuable tools to manage the average and peak demands experienced by a water system, especially during times of drought. A water conservation program can include the following elements:

- Water conservation policy or ordinance
- Water conservation pricing
- Leak detection and repair
- Annual water audits
- Public education program, including a specific outdoor water use education program
- Evaluation of plumbing retro-fit program to replace older less efficient water fixtures

- Evaluation of the potential to use reclaimed water

The DWR maintains an online reporting tool for the status of conservation requirements by public water systems. This tool provides a consistent way to document and track the status of and impacts to public water systems. This system currently tracks 555 water systems statewide and can be accessed through: https://www.ncwater.org/WUDC/conservation-status.

5.17 Protecting Water Resources

Agricultural Data

In the Cape Fear River Basin, there were 294 unique operations that participated in the 2020 NCDA&CS Agricultural Water Use Survey. Total average daily water use from both surface and groundwater was 6.331 MGD. The daily withdrawal capacity was reported to be 267.330 MGD. Limited data was available for five of the six HUCs located in the basin. Due to confidentiality restrictions surrounding agricultural data, the water use datasets currently available through USGS, USDA, and NCDA&CS can only be used for statistical purposes, not planning purposes. The dataset is aggregated and cannot be used to model local conditions or to report local or total water use of groundwater or surface water resources in the basin. Understanding how water is being used by all sectors in the basin can help state and county engineers or planning managers plan for future growth and long-term sustainability, ensure commercial, industrial, agriculture and drinking water users are accounted for and that those uses are protected, and allow for better management during drought conditions. *DWR will continue to work collaboratively with federal, state, and local agencies as well as stakeholders in the basin to identify information sharing opportunities to understand and protect water resources for all needs in the Cape Fear River Basin.*

Groundwater Availability and Trends

North Carolina places considerable demands on its groundwater resources, including domestic drinking-water supplies (i.e., self-supplied private wells), numerous public water-supply systems, irrigation, livestock, mining, and self-supplied commercial and industrial uses. However, this resource is finite and needs to be properly managed to ensure that present withdrawals are sustainable and that ever-increasing projected future demands can be met. *To understand changing groundwater levels and quality, it is critical to retain the existing groundwater monitoring network where feasible. It is recommended that federal, state and local resources agencies continue to fund and expand the well network and water quality sampling efforts throughout the state.*

A key element of properly managing any regional groundwater system is quantifying just how much water can be extracted from contributing aquifers without inducing adverse effects, such as aquifer dewatering, water-quality degradation and/or ecological damage. Quantifying sustainable yields, however, is a challenging task and, at present, the state lacks the kind of comprehensive groundwater modeling program needed by water-resource managers to make more informed decisions regarding groundwater availability. *Given that the resource will be further stressed to meet the demands of a growing population, as well as to replace/augment currently stressed surface water supplies, it is crucial that North Carolina conduct regional scale groundwater availability studies required to determine sustainable yields and more efficiently manage the resource.*

Verification of Available Yield

Often, surface water sources, such as reservoirs, were constructed decades ago and grandfathered into the NCDEQ permitting system. The result is that water systems sometimes do not have an accurate assessment of the current available supply for many of these projects. Therefore, some error in the total available supply for a basin and watershed should be expected. Each unit of local government and large community water system should verify the available raw water supply (surface and/or groundwater) in the LWSP at least every 10 years or as reasonably determined by the water system, by testing, evaluation, or by other means acceptable to the Department.

River and Reservoir Gages

Accurately measuring stream flows and reservoir levels is critical to understanding long-term water availability as well as determining real-time instream and lake/impoundment level conditions. Funding for gages has decreased over time, resulting in a more limited ability to monitor conditions at a time when a more comprehensive network is needed. As water resources face greater pressures from multiple demands, a more extensive gage measurement system is needed. *To understand impacts of changing stream flow and watershed flooding, it is critical to retain existing USGS flow gages. It is recommended that federal, state and local resources agencies continue to fund and expand the flow gage network throughout the state.*

Update Long-term Streamflow Calculations

Many federal and state permitting programs and agency policies rely on low flow statistics particularly the 7Q10. The last statewide assessment of 7Q10 values was conducted in the early 1990s by the USGS and published in 1993 (USGS, *Low-flow characteristics of streams in North Carolina*, 1993). The most recently conducted assessment of 7Q10 values by USGS in North Carolina focused on select sites in 2015. The resulting document, *Low-Flow Characteristics and Flow-Duration Statistics for Selected USGS Continuous-Record Stream gaging Stations in North Carolina Through 2012,* suggests that 7Q10 values across North Carolina have been declining, some significantly, over time. As a result, streams may have lower baseflows directly impacting such things as assimilative capacity for point and nonpoint discharges and the estimated available yield. In addition, the potential inaccuracy of these older estimates makes it difficult to calculate an accurate 7Q10 for ungaged locations in the future. In coordination with the NC DWR and with support from the North Carolina Office of Recovery and Resilience, the USGS has initiated an effort to update the low flow statistics for North Carolina. Scheduled to be completed in 2026, the project will recalculate the low-flow statistics at USGS gages, including data through the 2021 water year (October - September). The effort will also develop regression equations that will be included in the USGS StreamStats program. Streamstats allows users to select any location along a stream and obtain the drainage-basin boundary, basin characteristics, and estimates of streamflow statistics for the location (Ries et. al. 2008). *As the USGS updates the low-flow statistics, federal, state and local resource agencies should utilize the updated information to improve protections of aquatic resources.*

Water Withdrawal Challenges

North Carolina General Statute §143-355 requires DWR to assure the availability of adequate supplies of water to protect public health and support economic growth. Water supply planning and management requires a basic understanding of both the available water resources and all the demands being placed on those resources. Understanding the demands will help identify potential conflicts, identify strategies for managing supplies during extreme weather events and identify ways to protect public health, recreational use, economic growth and aquatic health. Two examples of this include the CCPCUAs that provide a framework for permitting surface water and groundwater in 15 counties of the Coastal Plain and the Eno River area. Notably, only three counties (Duplin, Onslow, and Wayne) in the Cape Fear River Basin are managed under the CCPCUA program, limiting DWRs ability to effectively manage our water resources for long-term sustainability. According to a 2010 Water Allocation Study for the Environmental Review Commission, "The PIs [Primary Investigators] found that only NC [North Carolina] and one or two other states do not require permits for large water withdrawals." To ensure future water supply needs can be met across the basin, *DWR will continue to work collaboratively with federal, state, and local agencies as well as stakeholders in the basin to identify information sharing opportunities to understand and protect water use for all users in the Cape Fear River Basin.*

Ecological Flow

A critical component of water supply planning and management is the determination of how much flow is needed to support and sustain the aquatic life present in specific rivers and streams. This key demand placed on water resources is known as ecological flow, also known as instream flow needs. It is defined as the amount of water needed to sustain the diversity of aquatic life and the functioning ecosystem in a river or stream. This given amount of water is needed in a river or stream to adequately provide for downstream ecological uses occurring within the stream channel. This is a largely unknown portion of the overall water demand and should be considered in any water demand versus available supply analysis, key to the sustainability of North Carolina's water resources.

Aquatic Barrier Removal

Basin planning supports the removal of dams or other man-made barriers where appropriate and economically feasible or the installation of fish ladders or stream bypass channels to encourage the passage of migratory fish and promote biodiversity and the sustainability of healthy fish populations. A useful resource to pursue this recommendation is the Southeast Aquatic Resources Partnership, Assessing Road Stream Crossing Barriers in the United States web application (https://fws.maps.arcgis.com/apps/instant/attachmentviewer/index.html?appid=0e60c1c7da4d469d9cb7fd07aa6dd6af).

United States Geological Survey Coastal Carolina Focus Area Study

In 2015, the USGS National Water Census Focus Area Study Work Plan for *Water Availability and Use to Meet Competing Societal and Ecological Needs in Southeastern Atlantic Coastal Basins of the Carolinas*, the Coastal Carolina Focus Area Study was developed (Wagner et al., 2015). The work plan proposed projects which aimed to provide data and develop tools to confront the challenges faced by water managers across several states (Wagner et al., 2015). A series of publications and data releases were produced because of this study including:

Publications:

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The DWR had provided a letter of support for a project proposal to create a web-based application to better access the Coastal Carolina Focus Area Study Data Product information. More information regarding the Coastal Carolinas Focus Area Study can be found on their project webpage: https://www.sciencebase.gov/catalog/item/550b2a87e4b02e76d7593fb9.

NC Wildlife Resources Commission's Wildlife Action Plan

The NC Wildlife Resources Commission's Wildlife Action Plan is a comprehensive planning document to educate and provide guidance toward the conservation and enhancement of the state's wildlife and their habitat. *Some of the Wildlife Action Plan recommendations related to water include:*

- Manage riverine habitat to promote the presence of adequate woody and rocky structures and natural processes like bank dynamics, channel meanders, and flood regimes.
- Modify discharge permits when base flow conditions decrease and the 7Q10 is lowered as part of a drought management program.
- Augment instream habitat to enhance its structural complexity to increase fish community abundance, biomass, and diversity (Hrodey and Sutton, 2008).
- Restore stream flows that promote controlled overbank flows and hydrological connectivity between the river and the floodplain in managed rivers.
- Protect potential migration corridors and preserve connectivity that allows for species and ecosystem migration.
- Undertake immediate and continuing efforts to limit water quality deterioration from both point and nonpoint sources of pollution.

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