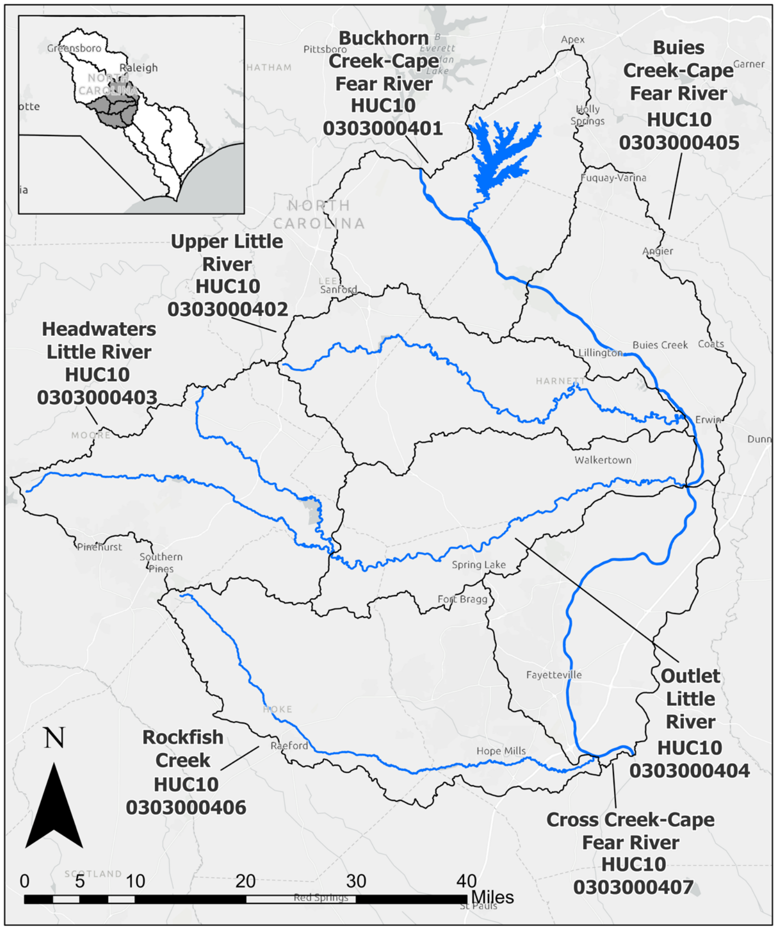

DRAFT
Chapter 8 –
Upper Cap Fear River Subbasin
HUC 03030004

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

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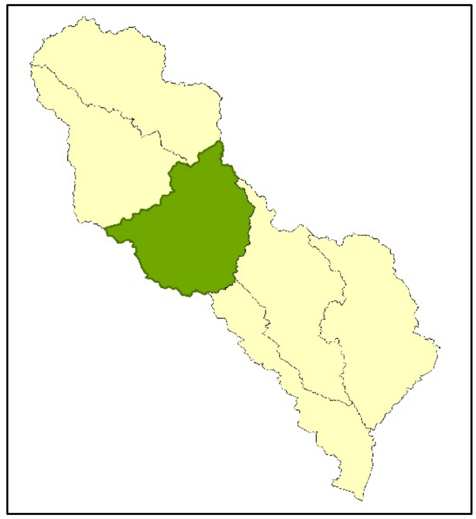
8 Upper Cape Fear River Subbasin (HUC8 03030004)

8.1 General Description



The Upper Cape Fear River subbasin 8-digit hydrologic unit code (HUC) boundary (03030004) is the largest subbasin in the Cape Fear River Basin, covering 1,630 mi^2, or 1.04 million acres, and has 1,367 miles classified as freshwater (FW)--the most waterway miles of all the subbasins. The subbasin lies in parts of Wake, Chatham, Lee, Harnett, Moore, Cumberland, Hoke and Robeson counties. The Upper Cape Fear River subbasin encompasses the Cape Fear River from its origin at the confluence of the Deep and Haw rivers downstream to half-way between Rockfish and Cedar creeks, south of I-95. The Upper Cape Fear River subbasin is sub-divided into eight HUC10 watersheds. Major tributaries in Upper Cape Fear River include Lick, Buckhorn, Neills, Buies, Rockfish, Cranes, and Cross creeks, as well as the Upper Little and (Lower) Little rivers. The largest impoundment in the Upper Cape Fear River subbasin is Shearon Harris Lake (4,151 acres), which provides cooling water for Duke Energy's Shearon Harris nuclear power station.

The Upper Cape Fear River subbasin contains two state parks, Raven Rock and Carvers Creek, as well as two large county parks, Anderson Creek, and Shearon Harris. There are five parcels of land that are managed by the North Carolina Wildlife Resources Commission (NCWRC) as game lands that total nearly 19,400 acres: Harris, Chatham, Lee, Rockfish Creek, and Nicholson Creek (NCWRC 2023a). The Fort Liberty Military Reservation, one of the largest U.S. Army bases, is within the Upper Cape Fear River subbasin and spans four of the HUC10 watersheds, covering over 15% of the Upper Cape Fear River subbasin watersheds. Some of the larger municipalities that lie wholly or partially within the Upper Cape Fear River subbasin are Apex, Fayetteville, Fuquay-Varina, Holly Springs, Hope Mills, Lillington, Sanford, Southern Pines, and Spring Lake. A general map showing permitted facilities and monitoring stations in the Upper Cape Fear River subbasin is shown in *Figure 8-1* to *Figure 8-3*.

Based on the Level III Ecoregions classifications, the Upper Cape Fear River subbasin represents a transition zone, known as the Southeastern Plains, between the Piedmont and the Coastal Plain (Griffith et al. 2002). The "Fall Line" is the demarcation between the Piedmont and the Southeastern Plains ecoregions in the Upper Cape Fear River subbasin, with erosion-resistant metamorphic rock to the west and more erodible sedimentary rock to the east. The Fall Line is evident by rocky outcrops in creek and river channels near the town of Lillington. On a finer scale (Level IV Ecoregions) the Upper Cape Fear River subbasin lies in the Sand Hills, Atlantic Southern Loam Plains, and Southeastern Floodplains and Low Terraces.

Monitoring data were available for 41% of the 1,367.7 miles of FW streams in the Upper Cape Fear River subbasin and 74% of the 5,867.7 FW acres for the 2022 Integrated Report (IR) (*Table 8-1*). Of the total FW miles sampled, 28% were meeting criteria, 64% had inconclusive results, and 7% were exceeding criteria.

The causes for stream impairment were largely due to stressed fish and benthos communities, as well as exceedances of the dissolved oxygen and turbidity water quality standards (*Table 8-2*). Notably, an unnamed tributary to Locks Creek near the city of Fayetteville exceeded the dissolved copper, mercury, and pH water quality standards.

There have been several concerning water resource-related issues and DEQ actions taken in the Upper Cape Fear River subbasin during the timeframe of this plan, 2002 to 2020:

- Several impairments consisting of stressed benthos and fish communities, chlorophyll *a*, chronic dissolved copper, dissolved oxygen, mercury, pH, turbidity (Section 8.1), as well as water quality concerns related to nutrients (nitrogen and phosphorus), noxious aquatic plants, and eutrophication (Section 8.7.1).

- Rapid population growth and development in the Upper Cape Fear River subbasin (Section 8.2).

- Forests and agricultural lands had considerable declines in land cover alongside increases is developed land (Section 8.2)

- Impaired or declines in bioclassification ratings for benthos and/or fish communities in the Beaver Creek (Section 8.7.3), Nicks Creek (Section 8.7.3.1), "Lower" Little River (Section 8.7.3.2), Crane Creek (Section 8.7.3.3), Flat Creek (Section 8.7.3.5), Tank Creek (Section 8.7.4), Jumping Run Creek (Section 8.7.4), Anderson Creek (Section 8.7.4.1), Kenneth Creek (Section 8.7.5.2), Neills Creek (Section 8.7.5.3), Blounts Creek (Section 8.7.7), Cross Creek (Section 8.7.7.1), an unnamed tributary to Locks Creek (Section 8.7.7.2), and Little Cross Creek (Section 8.7.7.3) (Section 8.4).

- Several watershed actions plans are established for Neills Creek, Buckhorn Creek, and Daniels Creek-Cape Fear River subwatersheds in the Upper Cape Fear River subbasin (Section 8.6).

- Nutrient enrichment in Utley Creek drains into the White Oak Creek arm of Harris Reservoir which had a eutrophic status in 2021. The outlet of Harris Lake into Buckhorn Creek has recorded total Kjeldahl nitrogen concentrations that have nearly doubled between 2001 and 2020 most likely because of biological productivity in Harris Lake (Section 8.7.1.3).

- The landfill for coal combustion residuals structure near Gulf Creek ceased receiving waste on July 11, 2019. A permit for closure of the project was issued on April 7, 2021, requiring the permittee to maintain closure-care of the land parcel for 30 years, at the discretion of Division of Waste Management (Section 8.7.1.4).

- The highest total nitrogen concentrations (>1 mg/L) are typically found in the mainstem Cape Fear River (Sections 8.8.1.7 and 8.8.1.8) while the tributaries Lick Creek, Buckhorn Creek, Avents Creek, Upper Little River, Little River, and Rockfish Creek (Sections 8.7.1.9 and 8.7.5.5) that feed into the mainstem Cape Fear River typically have lower total nitrogen concentrations (<1 mg/L).

- Total phosphorus concentrations in the mainstem Cape Fear River exceed the concentrations considered normal for healthy piedmont streams (0.05 mg/L). Most annual mean values recorded at stations along the mainstem Cape Fear River typically approach or exceed 0.1 mg/L (Sections 8.8.1.9, 8.7.5.5, and 8.7.1.9).

- The central portion of the Cape Fear River Basin has been recognized as nutrient over-enriched (Section 8.8.1.10).
- Lick Creek (Section 8.7.1.7), Kenneth Creek (Section 8.7.5.2), and Neills Creek (Section 8.7.5.3) are on the 2022 impaired waters list for exceeding the turbidity water quality standard.
- Lick Creek (Section 8.7.1.9), Kenneth Creek, Neills Creek and Buies Creek (Section 8.7.5.5), as well as Rockfish Creek (Section 8.7.6.2), and Cape Fear River (Section 8.8.1.4) recorded annual fecal coliform bacteria exceedance rates are at and above 20%.
- The Division is currently conducting a localized investigation to determine the source of elevated ammonia signal in an unnamed tributary to Cross Creek (Section 8.7.7.1).
- Bonnie Doone Lake [AU#: 18-27-4-(1)b], Mintz Pond [AU#: 18-27-4-(1)d], and Glenville Lake [AU#: 18-27-4-(1.5)] recorded eutrophic conditions in 2013 (Section 8.7.7.4).
- Cape Fear River [AU# 18-(4.5); WS-IV] at station CPFBDL1 near the water supply intake behind Buckhorn Dam had elevated instream concentration of 1,4-dioxane, above the EPA health-based drinking water concentration representing a 1-in-a-million (1 $x10^{-6}$) cancer risk level for 1,4-dioxane of 0.35 µg/L (EPA IRIS, 2013). The 1,4-dioxane concentration ranged between <1 and 1.8 µg/L with three of the six samples below the PQL of 1 µg/L (Section 8.8.1.11).
- The Cape Fear River [AU# 18-(16.3); WS-IV] station B8 at Harnett County intake (23 of 67 samples (34.3%)); Cape Fear River [AU# 18-(16.7); WS-IV] station B6370000 at US-401 in Lillington (15 of 43 samples (34.9%)); and the Cape Fear River [AU#18-(25.5);WS-IV] at station B7480000 located at the Hofer WTP intake in Fayetteville (17 of 66 samples (24.8%)) had elevated instream concentration of 1,4-dioxane, above the EPA health-based drinking water concentration representing a 1-in-a-million (1 $x10^{-6}$) cancer risk level for 1,4-dioxane of 0.35 µg/L (EPA IRIS, 2013) (Section 8.8.1.11).

Figure 8-1: General Map of Monitoring Stations and DWR Permitted Facilities in the Upper Cape Fear River Subbasin

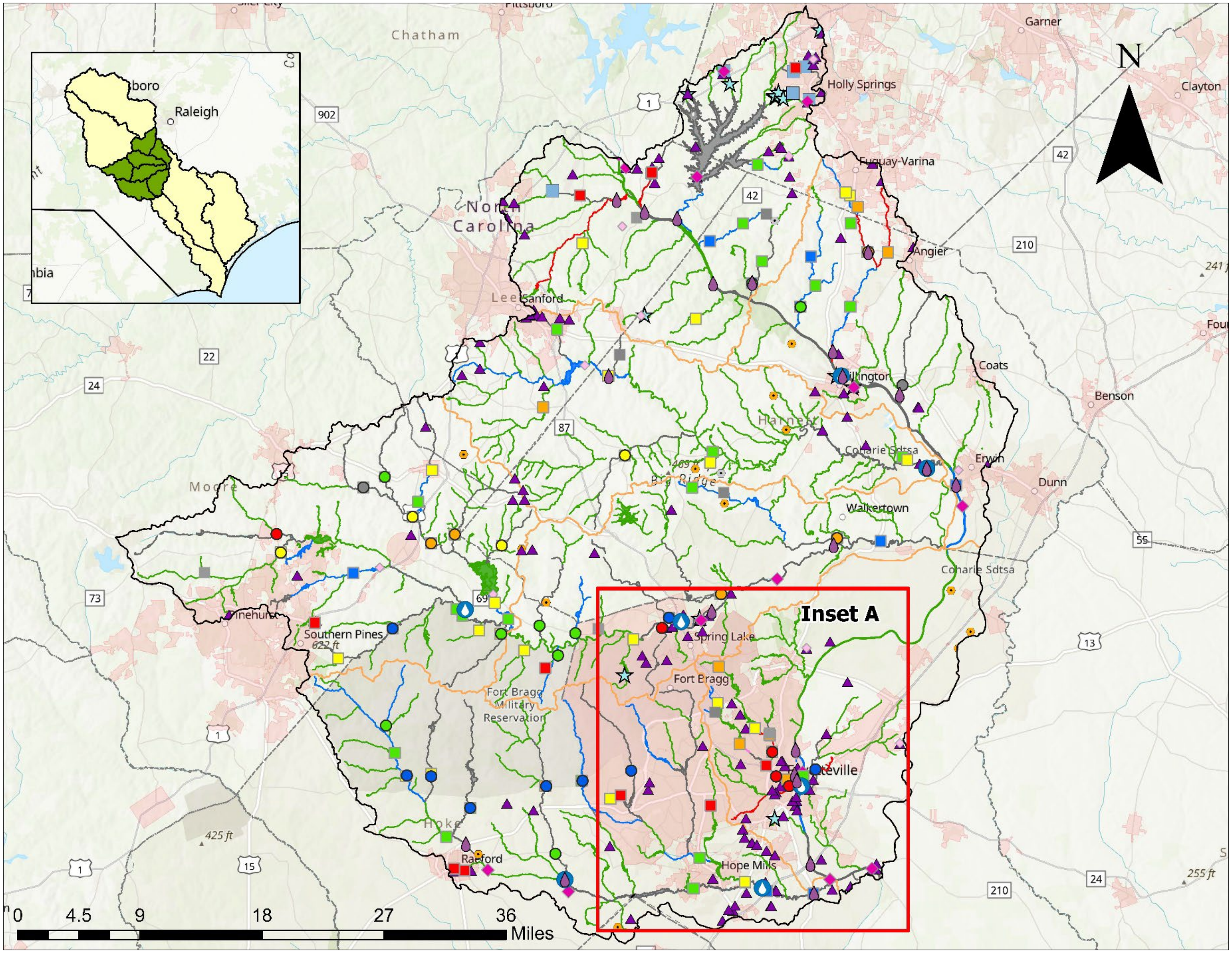


Figure 8-2: General Map Legend for Upper Cape Fear River Subbasin

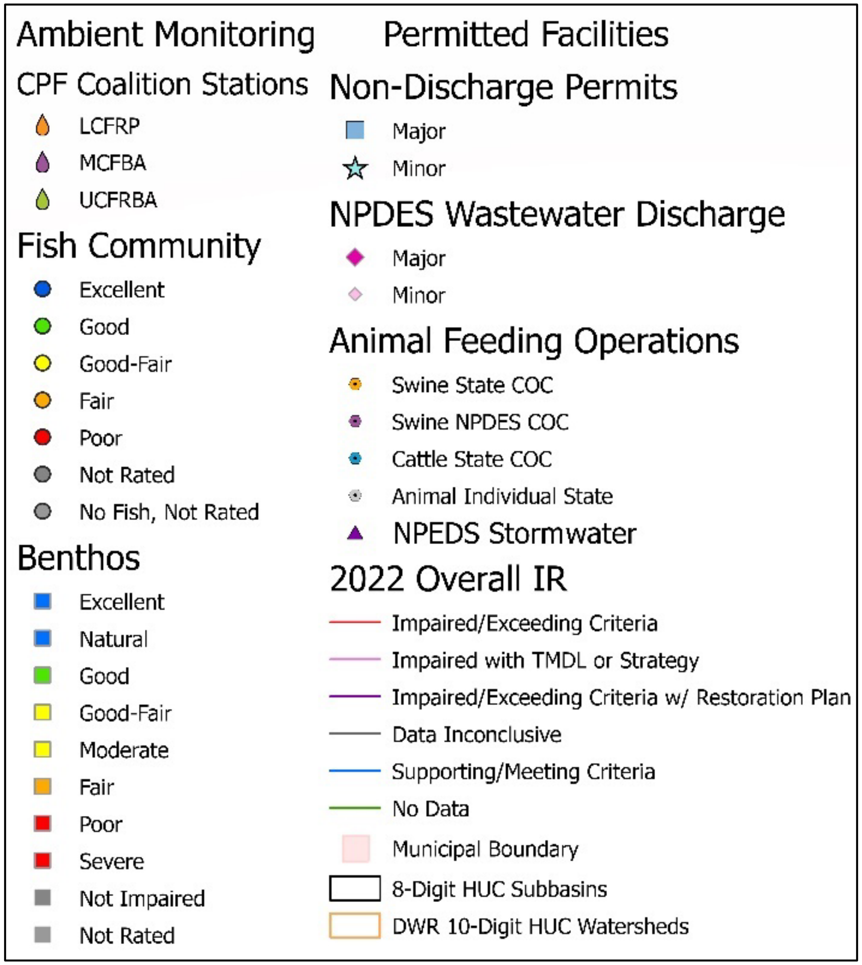
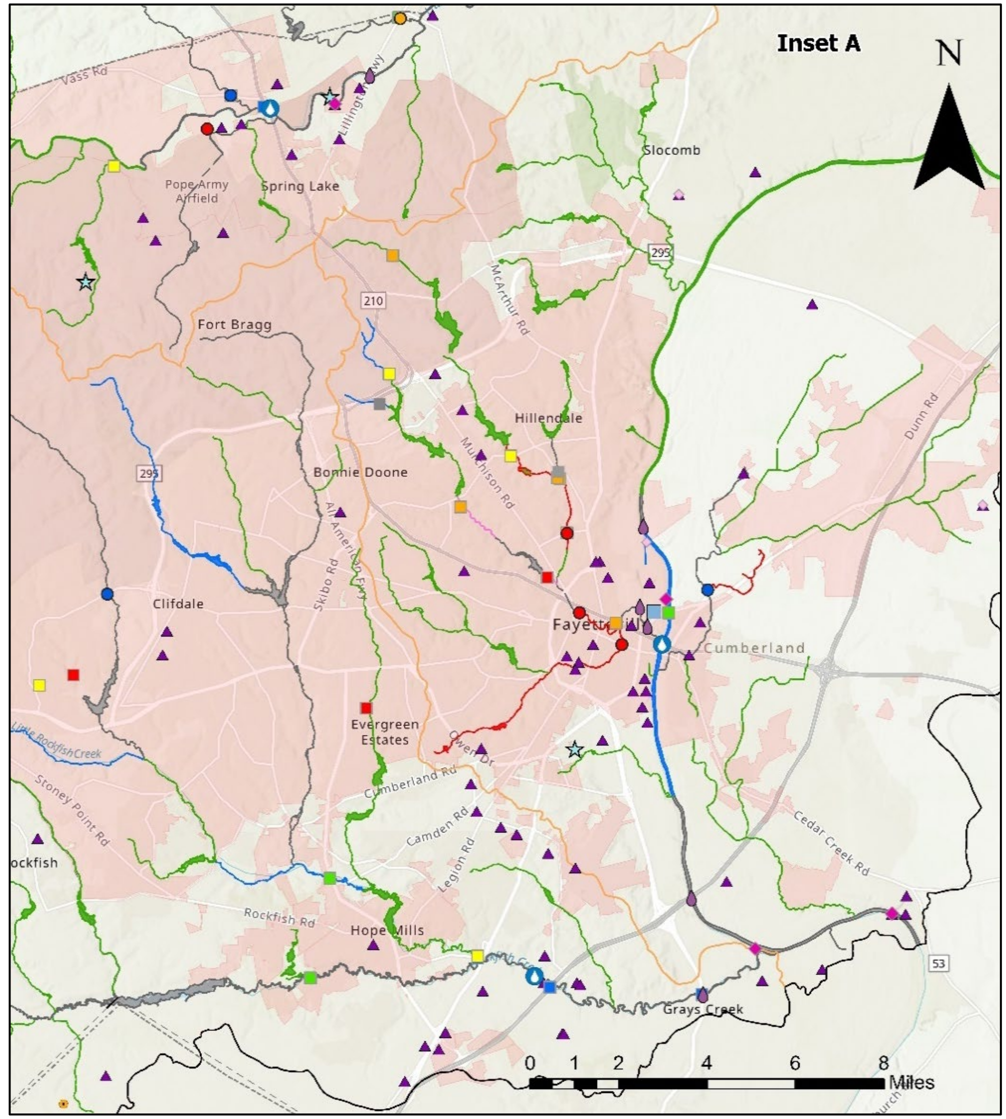


Figure 8-3: General Map of Monitoring Stations and Permitted Facilities in the Upper Cape Fear River Subbasin-Inset A



Impairments to impounded waters (FW acres) were solely due to chlorophyll *a* exceedances in the Cape Fear River behind Buckhorn Dam. The large percentage of data inconclusive assessment results for water bodies is in part due to an inadequate number of samples. Additional sampling would have allowed a determination of whether waters were meeting or exceeding criteria replications. See Chapter 2 for more information on the integrated report or the Chapter 2 Appendix for a full list of individual 2022 IR impairments.

Table 8-1: Upper Cape Fear River Subbasin 2022 Integrated Report Summary

Assessment Unit[1]	Map Color	FW Miles[2]	FW Acres[2]	SW Acres[2]
Total	All Colors Combined	1,367.7	5,867.7	0.0
Total Monitored	Combined Blue, Gray, Red, and Pink	558.3	4,320.8	0.0
Not Monitored	Green	809.4	1,546.9	0.0
Meeting Criteria (Category 1)	Blue	158.1	0.0	0.0
Data Inconclusive (Category 3)	Gray	360.0	4,198.9	0.0
Exceeding Criteria 303(D) (Category 5)	Red	37.0	121.9	0.0
Exceeding Criteria with TMDL (Category 4)	Pink	3.2	0.0	0.0
Exceeding Criteria (Combined Category 4 and 5)	Combined Red and Pink	40.2	121.9	0.0
% Exceeding of Monitored Exceeding (Combined Category 4 and 5)	Combined Red and Pink / Total	7.2%	0.0%	0.0%

1 All waterbodies in North Carolina are impaired for Fish Tissue Mercury and were not included Category 4, 5, and 5r impairments on this table.
2 FW – Freshwater, SW – Saltwater.

Table 8-2: Upper Cape Fear River Subbasin 2022 Impairments by Parameter (Category 4 and 5)

PARAMETER (Category 4 and 5 Combined)[1,2,3]	FW Miles	FW Acres
Benthos (Nar, AL, FW)	14.4	0.0
Chlorophyll a (40 µg/l, AL, NC)	0.0	121.9
Copper Dissolved Chronic (Calculated, AL, FW)	1.9	0.0
Dissolved Oxygen (4 mg/l, AL, FW)	12.2	0.0
Fish Community (Nar, AL, FW)	15.8	0.0
Mercury (0.012 µg/l, FC, FW)	1.9	0.0
pH (6 su, AL, FW)	1.9	0.0
Turbidity (50 NTU, AL, FW miles)	15.8	0.0

[1]Waterbody Uses: AL – Aquatic Life, FC – Fish Consumption, REC – Recreation.
[2]Waterbody Type: FW – Freshwater, NC - All North Carolina waters.
[3]Other: GM – Geometric Mean, Nar – Narrative, su – standard units.

Of the 1,367.7 FW miles in the Upper Cape Fear River subbasin, 41% have a supplemental designation as water supply (WS) (*Table 8-3*). Ninety-eight (98) percent of the FW acres in the Upper Cape Fear River subbasin have a WS classification. The large percentage of WS classifications in the Upper Cape Fear River subbasin is indicative of the reliance on water bodies for consumption, industrial processing, and power generation. Typically, WS-I waters are associated with watersheds with little to no development, and the amount of development generally increases up to WS-V. WS-I and WS–II are synonymous with the High Quality Waters (HQW) designation. There are no WS-I or WS–II classifications in the Upper Cape Fear River subbasin; however, WS-III waters may also have a supplemental HQW classification, and they do occur in the Upper Cape Fear River subbasin. Most of the WS-V acres in the Upper Cape Fear River subbasin are for Harris reservoir. Approximately 8% of the FW miles, over 100 miles, are classified for primary contact, Class B, including sections of Rockfish Creek and several of its tributaries and the headwaters of Upper Little River. There are also two wetland sites classified as Unique in the Upper Cape Fear River subbasin within Weymouth Woods State Park in Moore County. See Chapter 2 for more information on surface water classifications.

Table 8-3: Upper Cape Fear River Subbasin Surface Water Classifications

Classification*	Freshwater Miles	Freshwater Acres
C	1,367.7	5,867.8
B	104.5	387.2
WS-III	280.3	1,337.3
WS-IV	269.3	176.6
WS-V	15.4	4,237.0
WS TOTAL	565.0	5,750.9
CA	6.5	25.7
HQW	87.1	261.9

*Waterbody Classification C - Aquatic life propagation and secondary recreation, B - Primary contact recreation, WS - Water Supply, CA - Water Supply Watershed Critical Area, HQW - High Quality Waters

In 2019, the Division of Water Resources began an intensive monitoring study to gather additional information to support dissolved oxygen and nutrient modeling efforts. Both the Upper and Middle Cape Fear River Basin Monitoring Coalitions supported this study by increasing monitoring frequency and parameters at select stations as well as increasing monitoring frequency of several effluent constituents for select dischargers. EPA Region IV's modeling team is collaborating with the Division's modeling staff to develop both watershed and receiving water models for the areas of interest. These models are needed to support permitting in the basin, inform the development of management strategies for impaired waters, provide information on conditions associated with algal bloom frequency and duration, and provide information on the sources of nutrients and BOD-loading to the lower Cape Fear River. More information regarding this topic can be found in Chapter 2 and more information on the study plan is provided here.

8.2 Population and Land Use

Based on the 2020 Census data, the population in the Upper Cape Fear River subbasin is estimated to be 577,652 (*Table 8-4*). The largest municipalities in the Upper Cape Fear River subbasin are Fayetteville (208,501), Apex (58,780), Holly Springs (41,239), Fuquay-Varina (34,152), Sanford (30,261), Hope Mills (17,808), Southern Pines (14,347), and Spring Lake (11,660) (NC OSBM 2021). Except for Fayetteville and Hope Mills, these other municipalities are only partially within the Upper Cape Fear River subbasin.

The Fort Liberty Military Reservation was identified as a census designated place (CDP) for the 2000 census, with a resident population of 29,183, making it the second largest community entirely within the Upper Cape Fear River subbasin. Fort Liberty has nearly the same number of people that work on the base but live in surrounding communities. In 2008, Session Law 2008-74 granted Fayetteville and Spring Lake the right to annex Fort Liberty within Cumberland County. Fayetteville annexed 85% in the southern half and Spring Lake annexed the northern remainder. Fort Liberty was not a designated place for the 2010 census due to the annexations, and its population was added to the respective municipality (Wikipedia 2022). The annexation bumped Fayetteville up to the fifth-largest municipality in the state, and the base subsequently connected to Fayetteville's municipal water supply.

Fayetteville and Hope Mills are the largest municipalities completely within the Upper Cape Fear River subbasin. Fayetteville is the only municipality with a population greater than 100,000 in the Upper Cape Fear River subbasin and had a population increase of 3.9% from 2010 to 2020. In 2018, the U.S. Office of Management and Budget announced that the Fayetteville Metropolitan Statistical Area (MSA) would be expanded from Cumberland and Hoke counties to include Harnett County (U.S. OMB. 2018). This boosted Fayetteville's MSA population by nearly 30% to 526,719 (Cision PR Newswire 2020). Hope Mills has a population less than 20,000 and had an increase of 17.3% from 2010 to 2020. The greatest increases in population in the Upper Cape Fear River subbasin have occurred in southern Wake County, partially within the watersheds of Harris Lake (HUC10: 0303000401) and Buies Creek (HUC10: 0303000405), in the cities of Apex (55.4%), Holly Springs (66.7%), and Fuquay-Varina (89.1%) (U.S. Census Bureau 2022a).

The Rockfish Creek subbasin (HUC10: 0303000406) is the most populous of the seven subbasins, had the greatest increase in population from 2010 to 2020, and has the greatest population density at 703 persons/mi^2 (*Table 8-4*). The subbasin includes population growth in Hope Mills, southern Fayetteville and on and around the southern half of Ft. Liberty. Buckhorn Creek-CFR (HUC10: 0303000401) has a rural nature and, with the presence of Harris Lake, is the least populous of the seven subbasins and has the lowest population density (166 persons/mi^2). However, it had the third highest population change from 2010 to 2020 due to growth in southwestern Wake County. With planned high-tech manufacturing to be developed in the area near the community of Moncure, this subbasin is expected to see continued high-growth rates, changes in land use and impacts to water quality.

The Triangle Innovation Point (TIP), formerly known as the Moncure Megasite, is a 2,150-acre land parcel located in Chatham County, midway between Jordan and Harris lakes, with the goal of attracting original equipment manufacturing (OEM) (Chatham County Economic Development Corporation 2022). VinFast has purchased a parcel at this location to manufacture electric cars and batteries. The TIP is partially located within the Gulf Creek watershed (030000401). In anticipation of the dramatic change in land use in and around the TIP, Chatham County has undertaken a land-use planning effort to manage the impacts associated with growth (Recode Chatham 2023).

Table 8-4: Estimated Population Within the Watershed Boundary Scale (HUC 10)[1]

HUC 10 Name	HUC 10	Land Area (mi^2)	Population 2010	Population 2020	Population Density 2020 (pop/mi^2)	2010 – 2020 Pop. Change
Buckhorn Creek - Cape Fear River	**0303000401**	231	26,500	38,433	166	+11,933
Upper Little River	**0303000402**	220	37,485	43,024	196	+5,539
Headwaters Little River	**0303000403**	262	39,881	49,808	190	+9,927
Outlet Little River	**0303000404**	220	54,853	67,342	306	+12,489
Buies Creek – Cape Fear River	**0303000405**	167	45,575	54,266	325	+8,691
Rockfish Creek	**0303000406**	309	203,821	217,271	703	+13,450
Cross Creek – Cape Fear River	**0303000407**	222	102,414	107,508	484	+5,094
Upper Cape Fear Subbasin Total		**1,631**	**510,529**	**577,652**	**354**	**+67,123**

[1]Table data is from NC One Map US Census Block Data for 2010 and Esri Living Atlas for 2020 USA Census Redistricting Blocks processed for Cape Fear River Basin HUC10s.

The Upper Cape Fear River subbasin contains census boundaries for the Coharie and Lumbee tribes. A state designated tribal statistical area (SDTSA) is identified and delineated for state recognized tribes that are not federally recognized and do not have an American Indian reservation or off-reservation trust land (U.S. Census Bureau 2022b). An SDTSA has a concentration of people that identify with the tribe and have organized activities. The Lumbee SDTSA, which extends into the Lumber Basin, is reported with a population of 526,506 (U.S. Census Bureau 2021a). The Coharie SDTSA, which has seven parcels entirely within the Upper Cape Fear River subbasin, is reported with a population of 64,187 (U.S. Census Bureau 2021b).

The changes in land cover within the Upper Cape Fear River subbasin from 2001 to 2019 are summarized in *Table 8-5*. A comparison of 2019 land cover at the HUC10 watershed scale is also summarized in *Table 8-6*. *Figure 8-4* shows the spatial distribution of 2019 land cover in the Upper Cape Fear River subbasin. Land cover provides a perspective to view the water quality in this subbasin, given that the ratio of developed, agricultural, forest, and grass/shrub-covered lands influences the water quality within a watershed.

In 2019, land cover within the Upper Cape Fear River subbasin was predominantly forest land, with 42% coverage. The developed classification had 18% coverage. Agricultural comprised 14.7%, and 12.9% was classified as wetlands. Only 1.6 % was open water. Agricultural land cover had the greatest loss in the period from 2001 to 2019 at 5.27%, or 13 mi^2 while forest lost 3.65%, or 26 mi^2. The only increase is associated with development at 17.63%, or 44 mi^2. During this period, the developed classification has surpassed agriculture as the second-most land use in square miles. The largest area of development in the Upper Cape Fear River subbasin is the Hope Mills-Fayetteville-Ft. Liberty-Spring Lake corridor. Other areas of mostly suburban sprawl are along the perimeter of the Upper Cape Fear River subbasin and adjacent to Southern Pines, Sanford, Holly Springs, and Fuquay-Varina.

Table 8-5: Land Cover of the Upper Cape Fear River Subbasin (HUC8)

Land Cover[1]	2001	2011	2019	% Change 2001-2019	Mi^2 Change 2001-2019	Total Mi^2 2019
Agriculture	15.54%	14.91%	14.72%	**-5.27%**	**-13.34**	**239.94**
Barren Land[2]	1.24%	1.21%	1.18%	**-4.34%**	**-0.87**	**19.27**
Developed	15.44%	17.47%	18.16%	**17.63%**	**44.37**	**295.97**
Forest	43.72%	42.54%	42.12%	**-3.65%**	**-26.00**	**686.62**
Grassland/Shrub	9.57%	9.43%	9.34%	**-2.37%**	**-3.70**	**152.21**
Open Water	1.67%	1.67%	1.59%	**-4.89%**	**-1.33**	**25.92**
Wetlands	12.83%	12.77%	12.89%	**0.42%**	**0.88**	**210.04**
Total Mi^2						**1,629.96**

[1]Data were downloaded from the Multi-Resolution Land Characteristics NLCD website and processed for each Cape Fear River Basin HUC8 in 2022.

[2] Barren Land is a catch-all category for tilled land, new development, and cutover and bare rock areas.

Forest is the predominant land cover in the seven watersheds of the Upper Cape Fear River subbasin with the Buckhorn Creek Cape Fear River watershed (HUC10: 0303000401) having the greatest percentage while Cross Creek Cape Fear River watershed (HUC10: 0303000407) exhibited the least (*Table 8-6*). Buckhorn Creek Cape Fear River watershed had the greatest percentage of open water due to Harris Reservoir but also had the least amount of wetlands classification. Cross Creek Cape Fear River watershed had the greatest percentage of wetlands due in part to pocosin swamps east of I-95. Buckhorn Creek Cape Fear River watershed also had the least percentage of developed lands while Rockfish Creek watershed (HUC10: 0303000406) exhibited the greatest due to the west Fayetteville-Raeford corridor. Rockfish Creek watershed also exhibited the greatest amount of barren land, which is training areas within southern Ft. Liberty. Buies Creek Cape Fear River watershed (HUC10: 0303000405) had the greatest percentage of agricultural lands while Outlet Little River (HUC10: 0303000404) exhibited the least amount.

Table 8-6: Land Cover in the HUC10 Watersheds of the Upper Cape Fear River Subbasin.

Watershed	Land Area (mi^2)	Agriculture	Barren Land	Developed	Forest	Grassland/ Shrub	Open Water	Wetlands
Buckhorn Creek-Cape Fear River	231	10.8%	0.3%	9.6%	62.5%	9.3%	3.8%	3.8%
Upper Little River	220	21.6%	0.8%	12.5%	41.3%	9.5%	1.6%	12.6%
Headwaters Little River	262	11.3%	1.3%	14.8%	49.3%	10.7%	1.3%	11.3%
Outlet Little River	220	9.3%	1.8%	15.4%	45.5%	12.1%	1.0%	14.9%

Watershed	Land Area (mi²)	Agriculture	Barren Land	Developed	Forest	Grassland/ Shrub	Open Water	Wetlands
Buies Creek-Cape Fear River	167	29.5%	0.1%	16.0%	34.7%	7.7%	1.8%	10.3%
Rockfish Creek	309	7.9%	2.9%	29.5%	35.0%	9.8%	0.5%	14.5%
Cross Creek-Cape Fear River	222	19.8%	0.2%	25.2%	25.5%	5.5%	1.6%	22.2%

[1]Data were downloaded from the Multi-Resolution Land Characteristics NLCD website and processed for each Cape Fear River Basin HUC8 in 2022.
[2] Barren Land is a catch-all category for tilled land, new development, and cutover and bare rock areas.

Forestry (silviculture) activities are a nonpoint source of pollution when poorly implemented or improperly managed forestry practices impact water quality and stream habitat. Properly planned and executed forest management practices, however, facilitate the sustainable harvest of forest products while also protecting water quality. The North Carolina Forest Service (NCFS) is delegated the authority to monitor forestry operations in the state for compliance with the "Forest Practice Guidelines (FPGs) Related to Water Quality." The FPGs are a set of results-based guidelines meant to protect water quality and are mandatory, statewide requirements defined by North Carolina Administrative Code (NCAC) (02 NCAC 60C .0100-.0209). Best management practices (BMPs), such as temporary bridges (e.g., bridgemats), are used to ensure that the forest operators and landowners remain in compliance with the FPGs. The NCFS conducts site surveys across the state to assess the implementation of FPGs on timber harvests. The Forest Development Program (FDP), an afforestation or reforestation stand improvement cost-sharing program offered to private landowners, is also administered by NCFS. In addition, NCFS provides several types of management plans, such as a stewardship or pre-harvest plan, to private landowners (NCFS, 2022). The upper three subbasins in the Cape Fear River Basin—the Haw, Deep and the Upper Cape Fear River subbasin--have the highest forest cover percentage and have had the largest loss of forest cover since 2001 as compared to the lower three subbasins (See Chapter 1, Section 1.2.2). More information about FPGs, timber harvest inspections, FDPs, and management plans in the Cape Fear River Basin is available in chapters 1 and 4.

The total numbers, total acreage, and subbasin percentages for timber harvest inspections, forest management plans, and afforestation/reforestation in the Upper Cape Fear River subbasin from May 1, 2005 to October 31, 2021 are shown in *Table 8-7* and *Figure 8-5*. The distribution of forest management plans across the subbasin is also displayed in *Figure 8-6*. NCFS has been more active in the Upper Cape Fear River subbasin than any other subbasin in the Cape Fear basin. In the Upper Cape Fear River subbasin watershed, during this 16-year period, 9.12% of the subbasin was inspected for timber harvests; forest management plans were produced for 15.83% of the subbasin; and afforestation/reforestation management approaches were implemented in 3.43% of the subbasin (NCFS, 2022). See Chapter 1 for the basinwide distribution of timber harvest inspections and Chapter 4 for the basinwide density of forest management plans and afforestation/reforestation management.

Figure 8-4: Land Cover in the Upper Cape Fear River Subbasin

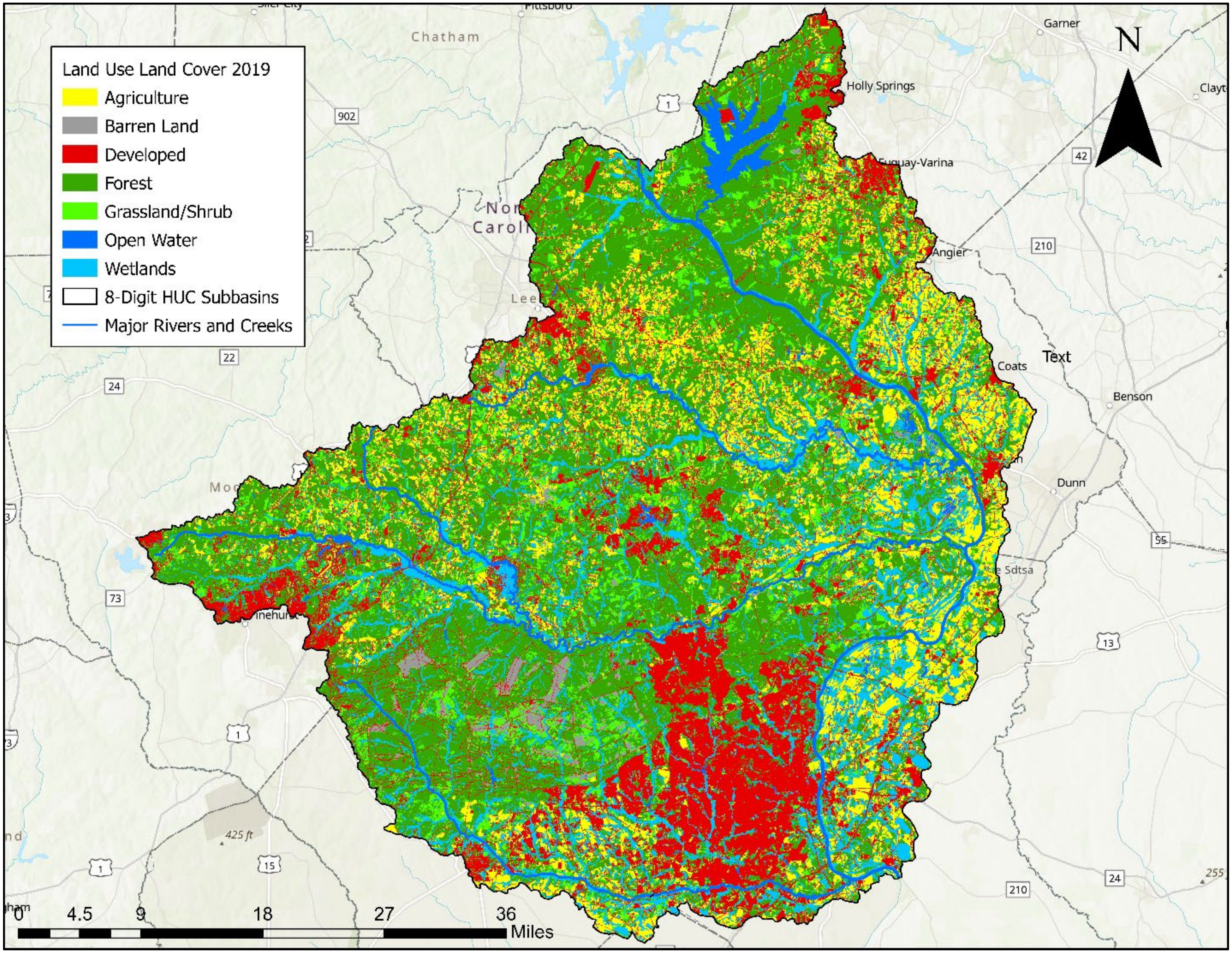


Table 8-7: Upper Cape Fear River Basin NCFS Management Approaches May 2005 to October 2021 (NCFS, 2022)

NCFS Management Approach	Number	Total Acres[1]	% of Subbasin
Harvest Inspections	1,868	95,112	9.12%
Forest Management Plans[2]	4,013	165,116	15.83%
Afforestation/ Reforestation	1,313	35,802	3.43%

[1]There are 1,043,179 total acres in the Upper Cape Fear River Basin
[2]Forest Management Plan types include Forest Management, Pre-Harvest, Practice, Regeneration, Rehabilitation, Replant, Stewardship and Urban plans.

Figure 8-5: Upper Cape Fear River Subbasin Percentage of Area (Acres) Assisted by NCFS Services (NCFS 2022)

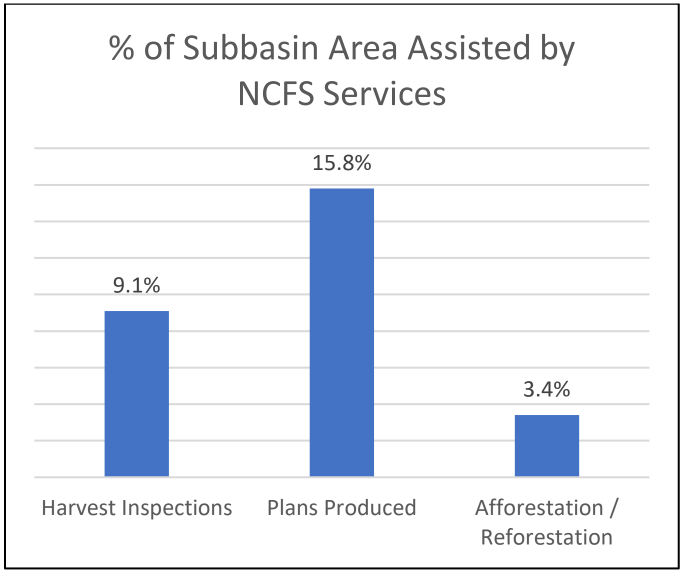
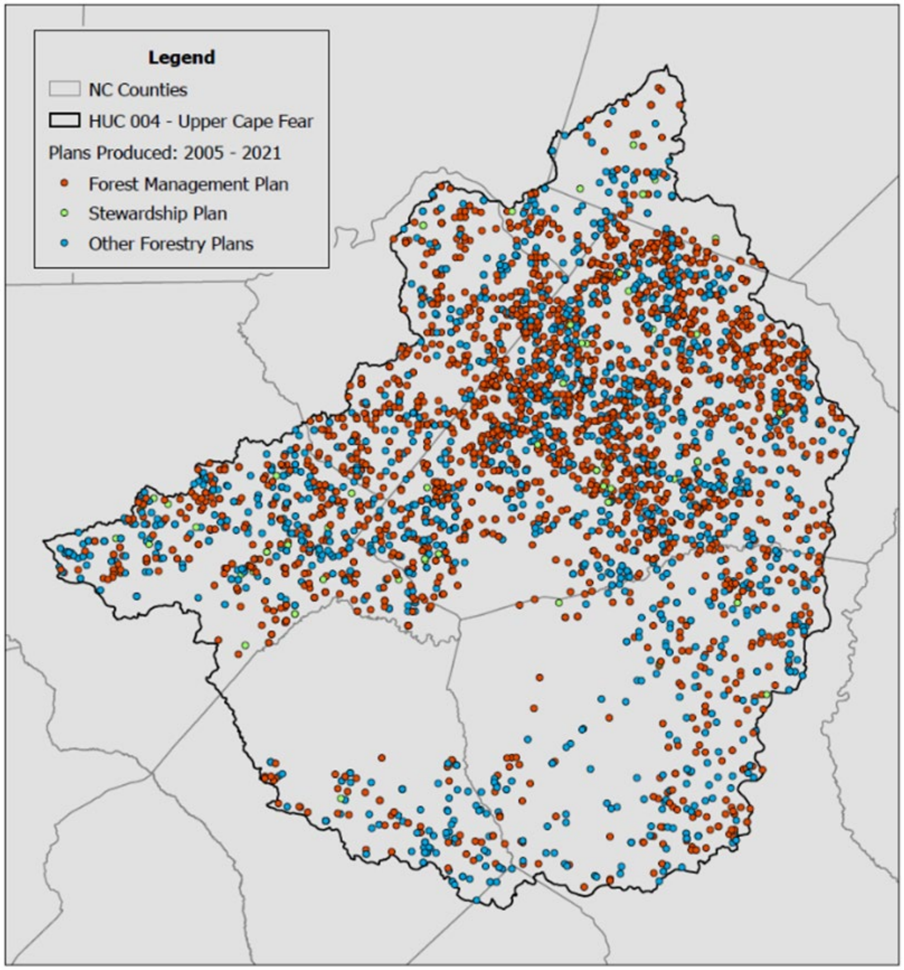


Figure 8-6: Upper Cape Fear River Distribution of plans provided by the NCFS within the 03030004 HUC (Upper Cape Fear) between May 2005 and October 2021 (NCFS, 2022).



The US Department of Agriculture (USDA) 2022 Census of Agriculture data indicate there are poultry operations in the Upper Cape Fear River subbasin counties in addition to permitted animal feeding operations (AFOs), which are described in the next section. DWR has minimal information on the location of poultry operations or the location of where manure is transported and applied. Counties chosen for the census data evaluation of poultry operations within the Upper Cape Fear River subbasin (Cumberland, Harnett, and Lee) have >50% land area within the Upper Cape Fear River subbasin, except for Hoke County, which was excluded as most of this county within the subbasin boundary is occupied by Fort Liberty (*Table 8-8*). Harnett County had higher poultry numbers than Cumberland and Lee counties for all years with 2.4 million for inventory and 14.2 million for production contracts in 2022. Harnett's poultry accounted for close to 56% of both the inventory and production contract poultry within the Upper Cape Fear River subbasin in 2022. There has been a significant decrease in poultry between 2007 and 2022 in the Upper Cape Fear River subbasin counties combined, with inventory decreasing 53% from 9.3 to 4.4 million and production contracts decreasing 49% from 47.9 to 24.4 million (*Table 8-8*). However, Lee County had an increase in both inventory and contract production during the same timeframe. Chapter 1, section 1.5.1 and the Chapter 1 Appendix have more information on the USDA Census data and Chapter 3, section 3.6 have basinwide animal operations permit maps and tables for comparison.

Table 8-8: USDA Census Data for Chicken/Poultry in Upper Cape Fear River Subbasin Counties

USDA Data	Cumberland	Harnett	Lee	Total[3]
2007				
Inventory[1]	1,141,086	6,924,614	1,265,939	9,331,639
Contract[2]	5,972,000	36,629,543	5,331,600	47,933,143
2012				
Inventory[1]	491,906	4,370,912	901,037	5,763,855
Contract[2]	2,123,702	24,727,216	3,922,000	30,772,918
2017				
Inventory[1]	471,057	4,248,960	1,526,533	6,246,550
Contract[2]	2,019,600	20,794,900	7,298,000	30,112,500
2022				
Inventory[1]	894,057	2,378,720	1,076,604	4,349,381
Contract[2]	4,259,600	14,167,340	5,988,000	24,414,940

[1]USDA Inventory numbers represent a point in time (End of December) when the census data were collected for chickens only.
[2]USDA Production Contract numbers are "totals for the portion of agriculture production raised and delivered under production contract" (USDA, 2017) for chickens only. Production Contract and Inventory are not additive. They each represent different data items.
[3]Counties included in this table had >50% land area within the Upper Cape Fear River Subbasin, however, Hoke County was excluded because the majority of the portion located in the Cape Fear River Basin is within Fort Liberty.

8.3 Permits

As of May 2022, there were 28 National Pollutant Discharge Elimination System (NPDES) wastewater, 30 non-discharge and land application, 130 NPDES stormwater, 407 state stormwater, and 15 animal feeding operation (AFO) permits issued in the Upper Cape Fear River subbasin (*Table 8-9*). A complete list of permits is in the Chapter 3 Appendix. *Figure 8-7* shows the location of the permitted facilities in the Upper

Cape Fear River subbasin. More information about the permitting programs is in Chapter 3, including a map of state stormwater facilities.

The Upper Cape Fear River subbasin accounts for nearly 25% (104.92 million gallons per day (MGD)) of the total permitted as-built discharge (425.47 MGD) in the Cape Fear River Basin. There are 13 major NPDES permits for municipal and industrial wastewater treatment plants (WWTPs) and 15 minor NPDES wastewater permits in the subbasin with a total permitted as-built flow of 104.92 MGD (*Table 8-9*). Facilities designated as major are permitted to discharge more than 1 MGD. Seven of the major facilities discharge directly to the Cape Fear River, including the two largest in the subbasin operated by the Fayetteville Public Works Commission, the Cross Creek WWTP (NC0023957) and Rockfish Creek WWTP (NC0050105), which have a combined permitted as-built flow of 46 MGD. Other waterbodies receiving discharge from major WWTPs include Little River, Brower Mill Pond, Buckhorn Creek (Harris Lake), Utley Creek, and Rockfish Creek. The Upper Cape Fear River subbasin also accounts for 8% of the total permitted field acreage (21,771 acres) for non-discharge and residual land application permits. Permitted fields are primarily used for land application of residual solids (see Chapter 3 and its Appendix).

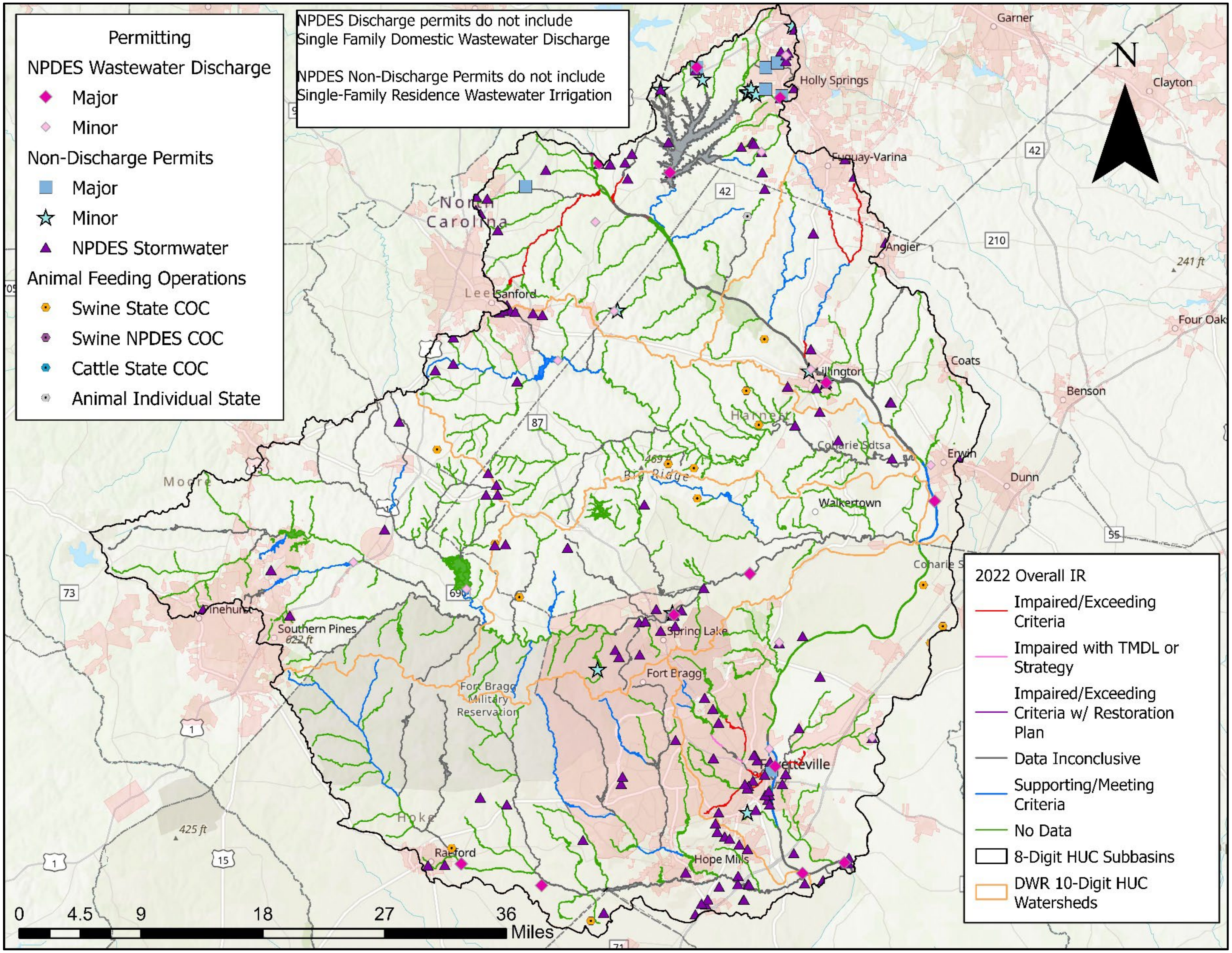
Table 8-9: Total Number of Permits Found in the Upper Cape Fear River Subbasin

Number of Permits[1]		**Permit Information[1]**	
NPDES Wastewater Discharge[2]			
Major	**Minor**	**Permitted As-Built (MGD)**	
13	15	104.92	
Non-Discharge and Land Application[3]			
Major	**Minor**	**Field Number**	**Field Acres**
8	22	101	1,845
Stormwater			
State	**NPDES**	**NPDES Outfalls**	
407	130	247	
Animal Feeding Operations			
Number of Permits		**Allowable Headcount**	**Allowable Weight (lb)**
15		70,917	10,480,889

[1]Active and expired permitted facilities and associated permit data were queried from the DWR Basinwide Information Management System (BIMS) in May 2022. All permits are associated with active facilities.
[2] Permitted NPDES discharge facility numbers are based on the number of facilities and as-built totals that discharge to the Cape Fear River Basin. Minor facilities include three single-family parcels.
[3]Some permitted fields are associated with facilities located outside of the Cape Fear River Basin.

Fewer AFOs are located in the Upper Cape Fear River subbasin compared to subbasins located in the lower part of the basin. Permitted AFO facilities include 13 swine state COCs (certificate of coverage) and two individual state permits. Overall basin maps and summary tables are available in Chapter 1, section 1.5.1, Chapter 1 appendix and permit maps and tables in Chapter 3, section 3.6.

Figure 8-7: NPDES Wastewater, NPDES Non-Discharge, NPDES Stormwater, and Animal Operations Permits in the Upper Cape Fear River Subbasin



Numerous NPDES and state stormwater facilities are concentrated near Fayetteville (see Chapter 3). Seven of the 32 NPDES MS4 (municipal separate stormwater sewer systems) stormwater permits in the Cape Fear River Basin are in the Upper Cape Fear River subbasin. NPDES MS4 permits are required for every owner/operator of facilities in areas that the US Census Bureau has designated as an Urbanized Area (see Chapter 3). MS4 stormwater permittees are Apex, Fort Liberty, Fayetteville, Fuquay-Varina, Holly Springs, Hope Mills, and Spring Lake.

8.4 Biological Health

Biological communities are highly sensitive to changes in water quality, as well as water quantity, and can reflect both long- and short-term environmental conditions. Benthos and fish community survey information is collected on species richness (i.e., diversity), abundance, and composition, as well as site-specific conditions, such as stream habitat, physical water quality parameters, stream width, and flow regime. Survey results, and the presence of pollution-tolerant and/or -intolerant benthos species, are used to calculate an IBI, or an Index of Biotic Integrity score. Fish community IBIs evaluate the effects of all classes of factors that influence the fish community (i.e., water quality, energy source, habitat quality, flow regime, and biotic interactions). Therefore, not all changes in the fish community are related to water quality. Fish community scores are a measure of the ecological health of the waterbody and may not directly correlate to water quality as benthic scores do. IBI scores are assigned a descriptive rating, or bioclassification: Excellent, Good, Good-Fair, Fair, Poor, Not Rated, or Not Impaired. An "EPT" Biotic Index (BI) can also be used to assign ratings by using pollution-sensitive species of mayflies (*Ephemeroptera*), stoneflies (*Plecoptera*), and caddisflies (*Trichoptera*). Benthic biocriteria, bioclassification assignment, and sampling methodology can vary with region and stream conditions. In the Upper Cape Fear River subbasin, four assessment methodologies were used: Full Scale, EPT, Qual4, and Qual5.

See the Benthic Standard Operating Procedures (SOP) or the Fish Community SOP available through the DWR Water Sciences Section (WSS) for more information on biological monitoring and bioclassification ratings. More information on basinwide biology sampling is also available in Chapter 2. The Biological Assessment Branch monitors each basin on a rotating 5-year cycle. Basin monitoring locations are often re-visited during each cycle. Additional locations, called special study sites, may be monitored once or multiple times and are assessed during the monitoring cycle year and/or between cycle years. The basin monitoring cycle years covered in this plan were completed in 2008, 2013 and 2018. Biological monitoring is occurring in 2023 as well but will not be included in this plan's update. The results of the previous monitoring cycle, completed in 2003, were evaluated as a point of comparison.

Figure 8-8, *Figure 8-9*, and *Figure 8-10* display all of the Upper Cape Fear River subbasin's current benthic and fish community site ratings. Most of the biology stations rated Fair or Poor are associated with urban areas: Fayetteville, Raeford, and rapidly developing Holly Springs. Several sites rated Excellent or Good are along Rockfish Creek and its tributaries in the lower part of the Upper Cape Fear River subbasin. A total of 72 benthic samples were collected between 2002 and 2008, counting both 5-year and special study samples. Twenty-seven samples were collected in 2009 through 2021. Chapter 2 Appendix lists the location, bioclassification, sampling methodology and year of the sampling events. Numerous sites sampled between 2003 and 2010 were not resampled between 2011 and 2019 due to reductions in staff.

Figure 8-8: Biological Community Monitoring Stations for Benthos and Fish in the Upper Cape Fear River Subbasin

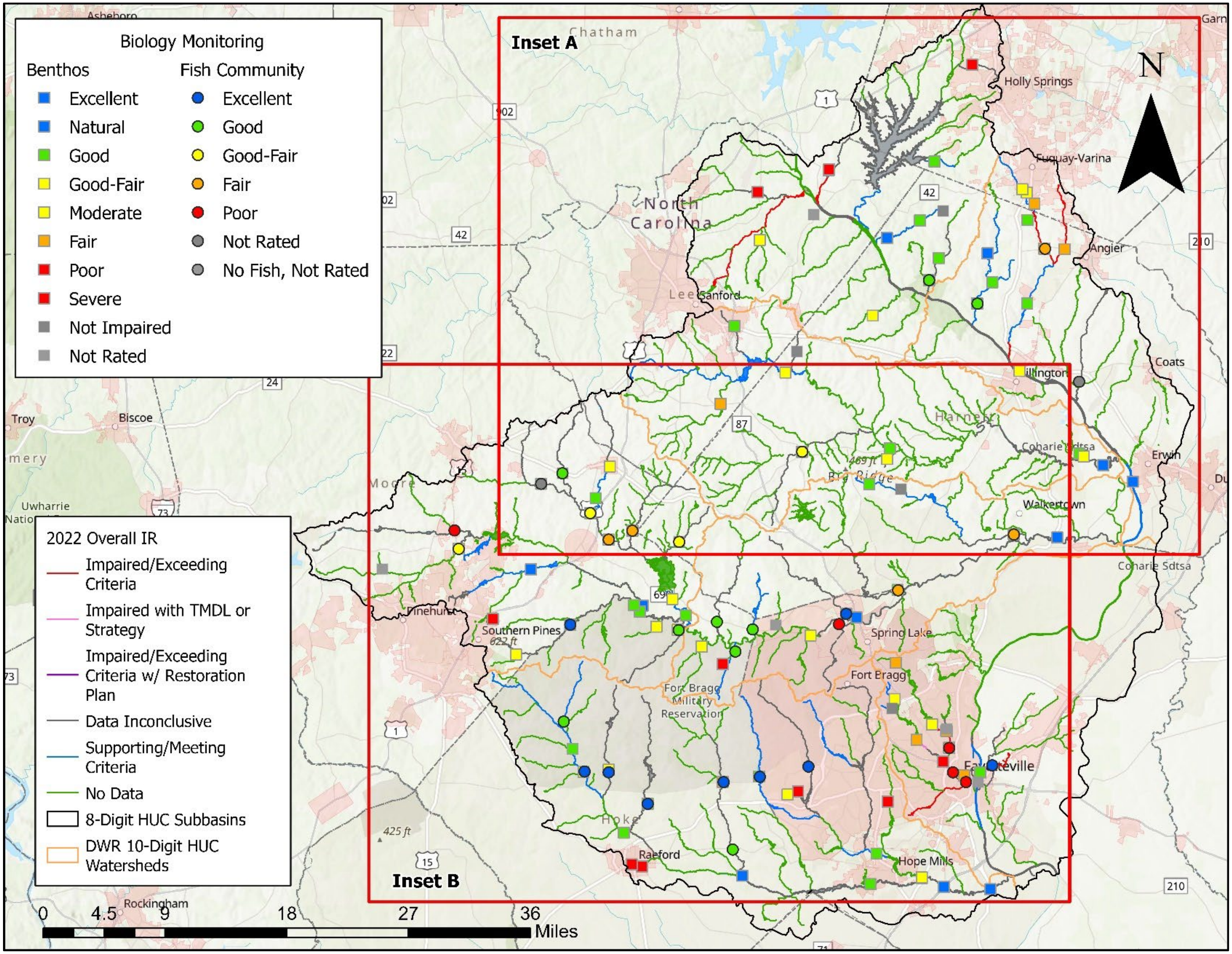


Figure 8-9: Biological Community Monitoring Stations for Benthos and Fish in the Upper Cape Fear River Subbasin - Inset A

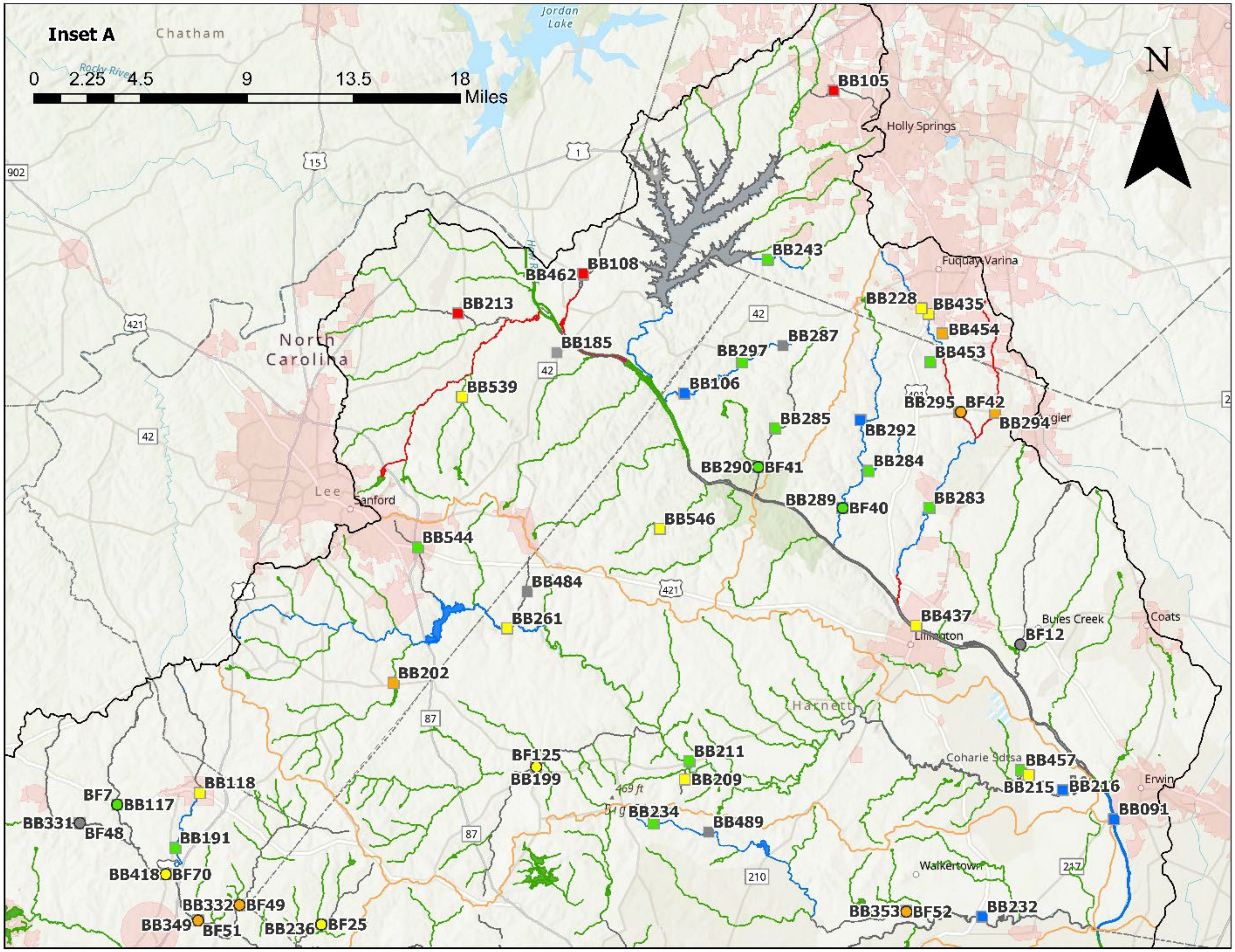
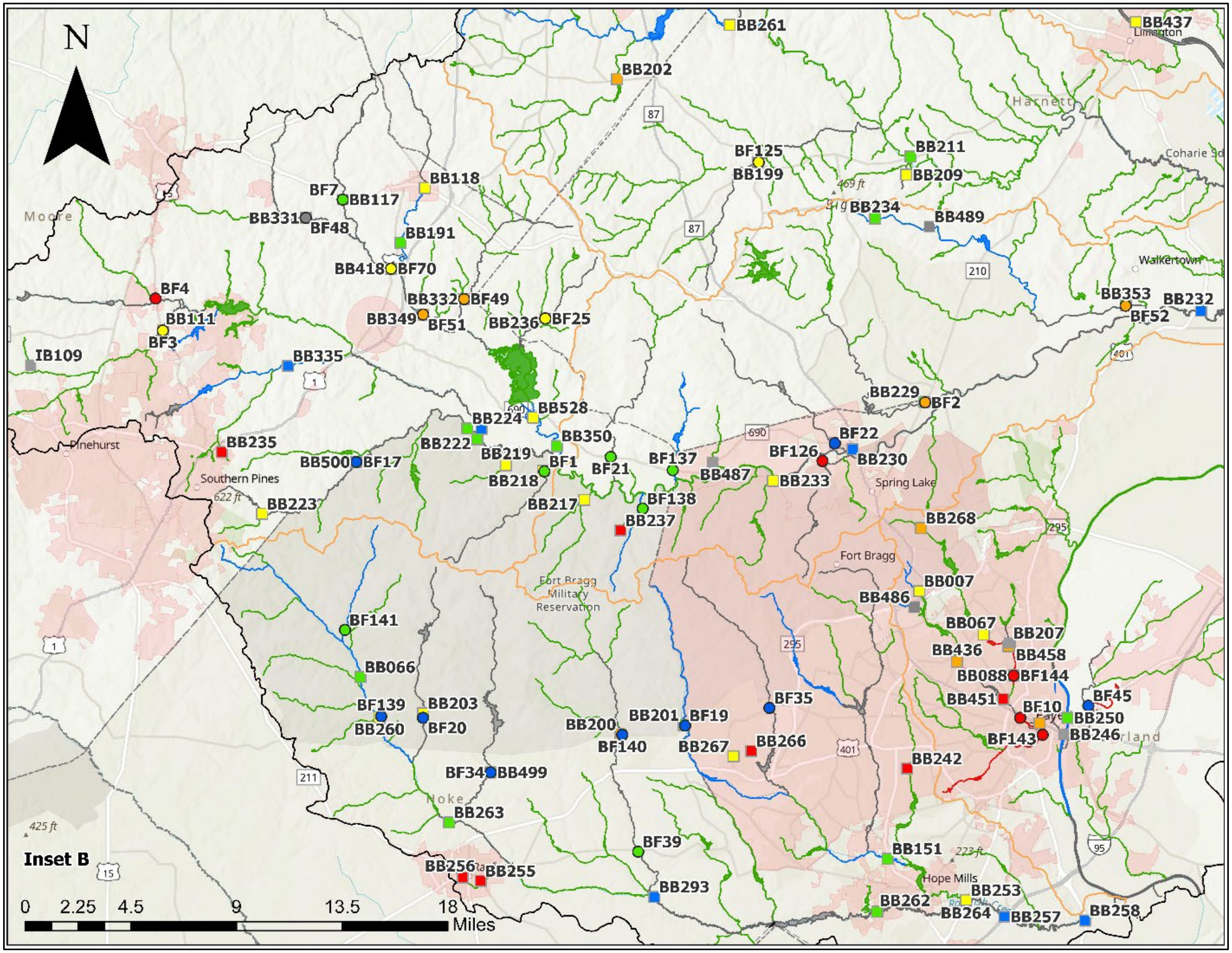


Figure 8-10: Biological Community Monitoring Stations for Benthos and Fish in the Upper Cape Fear River Subbasin - Inset B

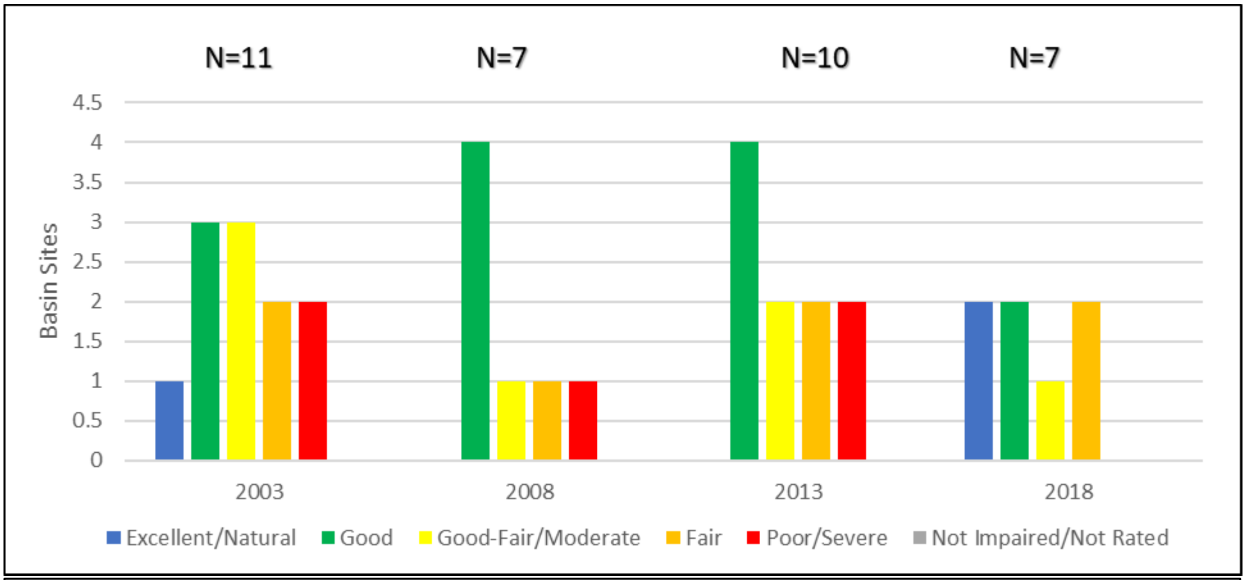


The most common reasons cited by field staff for bioclassification rating decline in this watershed included sedimentation and land disturbance. Fish and benthos basin sites that experienced bioclassification rating changes are discussed in detail below organized by HUC10 watersheds.

8.4.1 Benthic Macroinvertebrates

The Upper Cape Fear River subbasin benthos monitoring results for the four 5-year cycles are displayed in *Figure 8-11*. Basin site monitoring results for 2009 were also combined with 2008 as some stations were sampled (or resampled) in 2009 due to drought in 2008. Each of the seven HUC10 watersheds was sampled at least once between 2003 and 2018. Most of the HUC10s were also sampled in two different streams, except for Upper Little River (HUC10: 0303000402) and Outlet Little River (HUC10: 0303000404). Anderson, Cross, Rockfish, and Parkers creeks and Upper Little River were the streams that were sampled four times at the same station between 2003 and 2018. Neills, Little Rockfish, and Little Cross creeks were sampled three times during this period. Lower Little River and Nicks Creek were sampled twice while Hughes and Kenneth creeks were sampled once in 2003. All the stations that were sampled multiple times, except for one, remained consistently within the group of supporting or impaired ratings. Rockfish Creek dipped from Good in 2008 to Good-Fair in 2013 and up to Excellent in 2018. All benthos station results from 2002 to 2021 are available in the Chapter 2 Appendix.

Figure 8-11: Upper Cape Fear River Benthos Bioclassification Ratings 2003, 2008-2009, 2013, and 2018 for Basin Sites

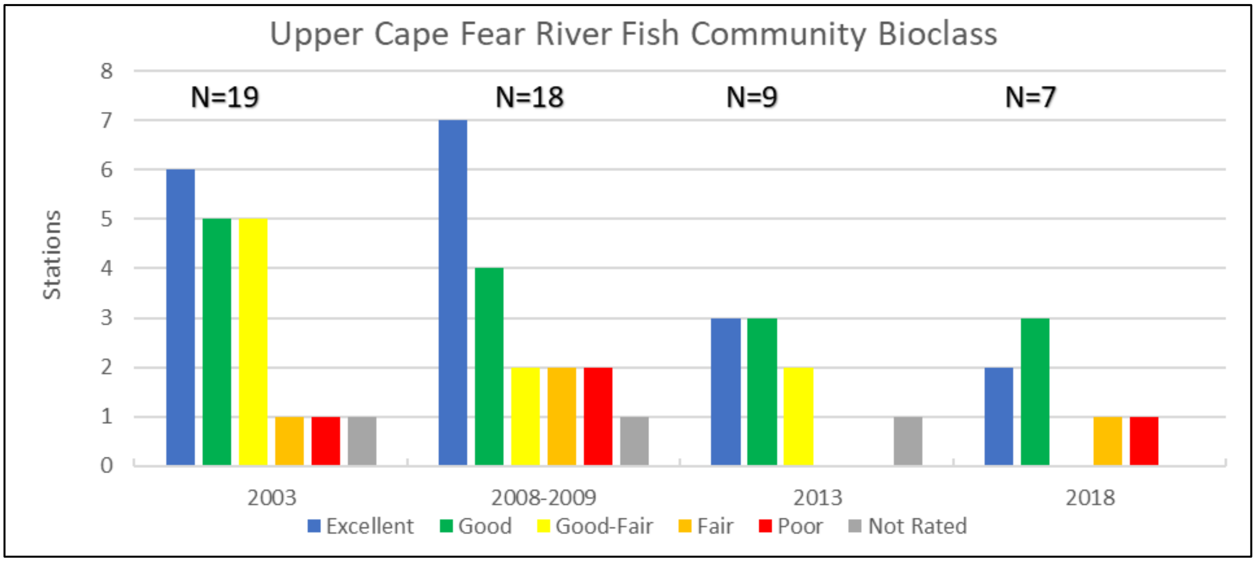


There is some variability in the basin monitoring sites chosen for monitoring cycle years 2003, 2008-2009, 2013, 2018. Graph data contains one station result per cycle year for 2003, 2013, 2018 and one station result for combined years 2008-2009. Where applicable, the most recent result for stations sampled >1 time per year(s) OR the most common result for stations sampled >2 times per year(s) was used.

8.4.2 Fish Communities

The Upper Cape Fear River subbasin fish community monitoring results for the four 5-year cycles and 2004 and 2009 are displayed in *Figure 8-12*. Monitoring results for 2003-2004 and 2008-2009 were combined in the graph as monitoring was not completed during regular cycle years. Less than half as many basin stations were monitored during the most recent two cycles (2013 and 2018) as compared with the previous two (2003 and 2008-2009). Additionally, there have been fewer sites rated Excellent and Good in recent years. All fish community station results from 2002 to 2021 are available in the Chapter 2 Appendix.

Figure 8-12: Upper Cape Fear River Fish Community Bioclassification Ratings 2003-2004, 2008-2009, 2013, and 2018



There is some variability in the basin monitoring sites chosen for monitoring cycle years 2003, 2008-2009, 2013, 2018. Graph data contains one station result per cycle year for 2013 and 2018 and one station result for combined years 2003-2004 and 2008-2009. Where applicable, the most recent result for stations sampled >1 time per year(s) OR the most common result for stations sampled >2 times per year(s) was used.

8.5 Ambient Water Quality

Monthly chemical and physical samples are taken by DWR through the Ambient Monitoring System (AMS) stations and coalitions of NPDES permit holders that are active in the Cape Fear River Basin. The Middle Cape Fear River Basin Association (MCFBA) collects ambient samples in the Upper Cape Fear River subbasin. Many of the ambient stations are associated with waterbody locations where potential pollution could occur from known land use activities in the subbasin. There are also portions of the subbasin where no water quality data are collected; therefore, water quality in those areas cannot be evaluated. Parameters collected depend on the waterbody classification, but typically include conductivity, dissolved oxygen, pH, temperature, turbidity, nutrients, and fecal coliform bacteria. Each classification has an associated set of standards the parameters must meet to be considered supporting the waterbody's designated uses. Stressors are either chemical parameters or physical conditions that at certain levels prevent waterbodies from meeting the standards for their designated use.

The method used to identify an impaired waterbody for the IR is typically based on 10% exceedance rate of a standard and 90% percent confidence for a set of data generally collected over five years. The IR methodology also addresses less common situations such as small datasets (<10 samples) as can happen with lake and reservoir sampling. See Chapter 2 for information on the IR methodology and the ambient monitoring programs, including the Random Ambient Monitoring System (RAMS). It is important to note that fecal coliform bacteria results not collected using a 5-in-30 methodology are used for screening purposes only.

Many of the water quality stations on the mainstem Cape Fear River are collected from a boat. At boat stations, the physical parameters are monitored using a calibrated *in situ* data probe/sonde that is lowered through the water column to record a reading at approximately 0.1 m (surface reading) and then at various depths. The data from the water column was averaged to get a daily average value that was used to determine the remaining summaries found throughout this chapter. The water quality standards generally apply to the readings collected at the surface and not the average water column readings. All other non-lake stations collect surface readings only so daily averaging was not necessary.

There are currently seven AMS and 20 MCFBA stations being monitored in the Upper Cape Fear River subbasin with three of the stations co-located for the AMS and MCFBA (B6370000, B6830000, and B7700000) (*Table 8-10* and *Figure 8-13*). A complete list of all ambient monitoring stations from 2000 to 2020 is available in the Chapter 2 Appendix. While the MCFBA primarily collect instream monitoring information in waterways with point source dischargers, they also maintain several voluntary instream monitoring stations in the Upper Cape Fear River subbasin not directly associated with a facility/discharger to understand the impacts of nonpoint sources in the Cape Fear River Basin. The MCFBA stations are sampled monthly in this subbasin. The Division recognizes the importance of this work and encourages continued monitoring of these stations.

An overall comparison of the Upper Cape Fear River HUC10 watershed scale ambient water quality results for samples collected in the basin from 2016 to 2020 is shown in *Table 8-11*. Mean results for pH, DO, conductivity, nutrients, turbidity, and fecal coliform were determined for stations that had a minimum of five-years and 40 average day records. *Table 8-11* also shows the HUC8 mean levels for these parameters from 2016 to 2020 in the Upper Cape Fear River subbasin, and for comparison purposes, the highest HUC8 and HUC10 mean levels basinwide for conductivity, nutrients, turbidity, TSS, and fecal coliform. An overall HUC8 scale comparison of the Cape Fear River Basin's six subbasins is available in Chapter 3. All of the HUC10 scale parameter means and the number of stations used in the analysis are available in the Chapter 2 Appendix. At the HUC8 scale, the Northeast Cape Fear subbasin (HUC8 03030007) had the highest mean five-year results for conductivity, fecal coliform bacteria, total phosphorus (TP), ammonia (NH3), total Kjeldahl nitrogen (TKN) minus ammonia while the Haw River subbasin (HUC8 03030002) had the highest mean five-year results for turbidity, TSS, total nitrogen (TN) and inorganic nitrogen, nitrate+nitrite (NOx). The highest basinwide HUC10 values included in the *Table 8-11* are described in-depth in their respective watershed chapters spanning chapters 6 through 11 of this report.

Table 8-10: Ambient Monitoring System and Coalition Stations in the Upper Cape Fear River Subbasin

Station ID	Station Location	Ecoregion LIII	Stream AU #	Stream Classification
B6130500	Lick Creek at SR 1500 near Corinth	Piedmont	18-4-(2)	WS-IV
B6160000	Cape Fear River at NC 42 near Corinth	Piedmont	18-(4.5)	WS-V
B6204000	Buckhorn Creek Beside SR 1921 near Corinth	Piedmont	18-7-(11)	C
B6215000	Cape Fear River at Captains Landing Subdivision near Cokesbury	Piedmont	18-(10.5)	WS-IV
B6230000	Avents Creek at SR 1418 near Cokesbury	Piedmont	18-13-(2)	WS-IV;HQW
B6252000	Neills Creek at US 401 near Lillington	Piedmont	18-16-(0.7)c2	WS-IV
B6320000	Kenneth Creek at SR 1441 Chalybeate Springs near Angier	Piedmont	18-16-1-(2)	WS-IV
B6370000	Cape Fear River at US 401 at Lillington	Southeastern Plains	18-(16.7)	WS-IV
B6485000	Buies Creek at Keith Hills Golf Course Maint Shop at Buies Creek	Southeastern Plains	18-18	WS-IV
B6750000	Carrs Creek at US 421 Bypass near Sanford	Southeastern Plains	18-20-7	C
B6820050	Upper Little River at SR 1222 near Broadway	Piedmont	18-20-(8)a	C
B6830000	Upper Little River at SR 2021 near Lillington	Southeastern Plains	18-20-(24.5)	WS-IV
B6840000	Cape Fear River at NC 217 at Erwin	Southeastern Plains	18-(20.7)a	WS-V
B7245000	Lower Little River at SR 2023 near Lobelia	Southeastern Plains	18-23-(10.7)	WS-III;HQW
B7280000	Lower Little River at SR 1451 at Manchester	Southeastern Plains	18-23-(24)	C
B7300000	Lower Little River at NC 210 near Spring Lake	Southeastern Plains	18-23-(24)	C
B7319100	Lower Little River at SR 1609 near Walkertown	Southeastern Plains	18-23-(24)	C
B7480000	Cape Fear River at Hoffer WTP Intake at Fayetteville	Southeastern Plains	18-(25.5)	C
B7500000	Cape Fear River at I-95 below Fayetteville	Southeastern Plains	18-(26)b	C

Station ID	Station Location	Ecoregion LIII	Stream AU #	Stream Classification
B7584900	Unnamed Tributary to Cross Creek at Cross Creek WRF at Fayetteville	Southeastern Plains	18-27-(3)cut2	C
B7590000	Cross Creek at US 301 Business and I-95 business at Fayetteville	Southeastern Plains	18-27-(3)c	C
B7600000	Cape Fear River at NC 24 at Fayetteville	Southeastern Plains	18-(26)a	C
B7615000	Locks Creek at SR 1006 Clinton Rd at Fayetteville	Southeastern Plains	18-28	C
B7616000	Unnamed Tributary to Locks Creek at US 301 near Fayetteville	Southeastern Plains	18-28ut3	C
B7679300	Rockfish Creek at US 401 Bypass near Raeford	Southeastern Plains	18-31-(12)	B
B7700000	Rockfish Creek at SR 1432 near Raeford	Southeastern Plains	18-31-(18)	B
B8224000	Rockfish Creek at SR 2350 near Cedar Creek	Southeastern Plains	18-31-(23)	C
B8230000	Rockfish Creek at NC 87 near Fayetteville	Southeastern Plains	18-31-(23)	C

Figure 8-13: Ambient Monitoring System and Coalition Stations in the Upper Cape Fear River Subbasin.

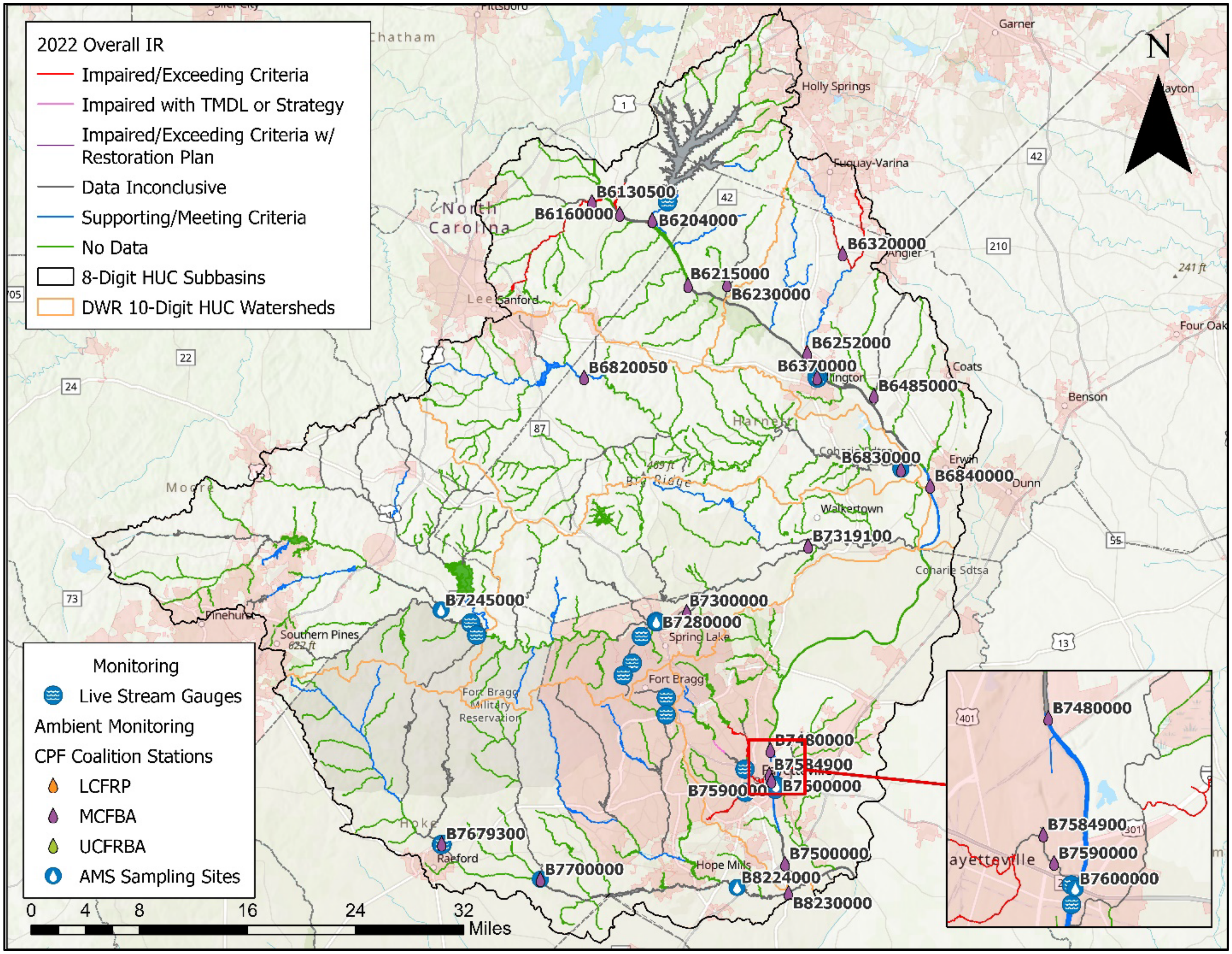


Table 8-11: Upper Cape Fear River Subbasin HUC10 Watershed Ambient Water Quality Means for 2016-2020

Watershed HUC 10	Watershed Name	Number of Stations^	pH	DO (mg/L)	Conductivity (µS/cm)	NH3 (mg/L)	TKN (mg/L)	NOx (mg/L)	TN (mg/L)	TP (mg/L)	Turbidity (NTU)	TSS (mg/L)	Fecal Coliform (CFU/100 mL)
Highest HUC 8 in Cape Fear River Basin		x̄			711	0.09	0.92	1.34	2.10	0.21	20.19	22.90	1,093
Highest HUC 10 in Cape Fear River Basin		x̄			1,413	0.27	1.44	2.62	3.48	0.38	26.63	26.64	2,478
03030004*	**HUC8 Upper CPF Watershed**	20	6.52	8.21	90	0.03	0.65	0.35	1.00	0.07	13.08	16.38	360
0303000401	Buckhorn Creek-Cape Fear River	3	7.02	7.75	138	0.05	0.84	0.35	1.19	0.09	16.80		401
0303000402	Upper Little	2	6.56	8.03	75	0.04	0.61	0.34	0.95	0.05	8.64	7.79	261
0303000403	Headwaters Little	1	6.54	8.47	40	0.02	0.44	0.15	0.58	0.02	3.78		124
0303000404	Outlet Little	3	6.10	8.85	48	0.03	0.52	0.24	0.77	0.06	7.01		262
0303000405	Buies Creek-Cape Fear River	3	6.99	8.25	125	0.04	0.72	0.48	1.195	0.08	20.57	18.78	480
0303000406	Rockfish Creek	4	5.55	8.40	44	0.02	0.49	0.22	0.71	0.04	8.26		280
0303000407	Cross Creek-Cape Fear River	4	6.86	8.03	107	0.04	0.71	0.49	1.20	0.08	17.73	21.78	506
Healthy Piedmont Stream[#]					12-90	0.05		0.30	0.80	0.05			
Minimally Impacted Streams[o]						<0.05	<0.5	<0.3	<0.8	<0.05			
EPA Nutrient Criteria - Piedmont[+]									0.70	0.038			
EPA Nutrient Criteria - Coastal Plain[+]									0.72	0.032			

^Ambient stations with a minimum of data collected for 5 years from 2016 to 2020 and 40 average day records were included in the analysis.
**#DWQ ESS- ISU Special Study. March 24, 2004, Rocky River Survey (Chatham County) Subbasin 03-06-12.
oDWQ ESS- ISU Special Study. March 14, 2005, Lower Cape Fear River/Estuary TMDL Study.
+USGS Circular #1350 – The Quality of Our Nation's Water – Nutrients in the Nation's Streams and Groundwater, 1992-2004. Dubrovsky et al., 2010.
Orange highlighted values represent the highest mean instream concentration or lowest DO concentration in comparison to the other HUC 10 watersheds.
Green highlighted row represents the overall HUC 8 watershed mean for each constituent for comparison purposes.

Emerging compounds (EC) are lesser known compounds that are increasingly being detected in soil, groundwater and surface water. They come from a wide range of sources, including industrial chemicals and their by-products, firefighting foams, pesticides, lawn and agricultural products, disinfection products, wood preservatives, home goods, as well as pharmaceutical and personal care products (PCPs) (EPA, 2024). In addition to industrial sources, these contaminants are often sent to landfills and wastewater treatment plants (WWTP) and subsequently discharged to surface waters. Many of these compounds do not readily biodegrade in the aquatic environment. Consequently, they often persist in water and are readily transported downstream because of a unique combination of physical and chemical properties that make them highly mobile and resistant to natural degradation.

In the last several years, emerging compounds have become the primary concern for the residents living in and receiving drinking water from the Cape Fear River Basin. Per- and polyfluoroalkyl substances (PFAS) and 1,4-dioxane are currently the primary contaminants of emerging concern in the Cape Fear River Basin due to their impact on human health in drinking water. The presence of these contaminants has been documented through sampling by university researchers, DEQ, the NC Collaboratory, public water and wastewater utility providers and other local and state entities.

After observing elevated concentrations of 1,4-dioxane reported as part of the EPA's Third Unregulated Contaminant Monitoring Rule (UCMR3, 2013-2015), DWR initiated a study of 1,4-dioxane in surface waters of the Cape Fear River Basin (October 2014) with the objective of identifying potential sources, understanding changes in concentrations, and documenting data that will help the state develop a regulatory strategy. During the study, elevated levels of 1,4-dioxane were identified mainly downstream of the Greensboro, Reidsville and Asheboro WWTPs. DWR continues to work with these facilities to decrease the concentration of 1,4-dioxane in their discharges and requires effluent monitoring to ensure compliance with the CWA. DWR has also added ambient instream monitoring for 1,4-dioxane concentrations in areas where potential contamination might occur. Available instream 1,4-dioxane data is reported throughout the subbasin chapters. A 1,4-dioxane specific chapter (Chapter 13) with detailed Cape Fear River Basin studies and DEQ actions addressing the contaminant is included as part of the basin plan.

Researchers from North Carolina State University (NCSU) detected elevated levels of PFAS (including GenX) in the Cape Fear River in 2013-2015. The next year, DEQ, along with DHHS, began investigating PFAS in the basin to identify the potential source of contamination. The source of GenX was traced to Chemours in Bladen County along the west bank of the Cape Fear River in the Lower Cape Fear River subbasin. Other PFAS compounds, some of which are no longer manufactured, are being found in surface and ground water throughout the basin. The sources of these compounds into the Cape Fear River system are from contaminated wastewater, groundwater and atmospheric deposition.

Due to the changing nature of the science and due to the extent and magnitude of PFAS contaminants found in the Cape Fear River Basin as well as what corrective actions to take, PFAS was not discussed in detail within the subbasin chapters of this plan. A PFAS specific chapter was completed after finalizing the water quality and quantity watershed portions of the plan. The most up to date information on the extent of PFAS contamination within the Cape Fear River Basin, completed studies, and what actions have been taken by DEQ and EPA are summarized in the PFAS chapter (Chapter 12). DEQ is actively working to identify sources of PFAS and working to reduce the loading to the Cape Fear River system.

In response to the rising interest in the public health effects associated with per- and polyfluoroalkyl substances (PFAS), the Intensive Survey Branch (ISB) conducted a special study in 2023 alongside their Ambient Lakes Monitoring Program (AMLP) to characterize the presence and concentrations of PFAS compounds in public drinking water supply reservoirs of the Cape Fear River Basin. For five months between May and September 2023, ISB tested surface water samples for 47 different PFAS at Ambient Lakes Monitoring stations nearest to the surface water intake of 15 public water supply (PWS) reservoirs in the Cape Fear River Basin, two of which are in the Upper Cape Fear River subbasin.

A total of 21 different PFAS compounds were found above the detectable laboratory practical quantitation limit (PQL) during the 2023 lakes monitoring study. At least one PFAS analyte was detected above the PQL in each reservoir during each sampling event. It is important to note that all analytical data reflect levels of target analytes detected in untreated surface waters, as opposed to finished drinking water. The results of this study are reported in detail in the PFAS Chapter of this plan (Chapter 12, Section 12.4.1.6).

The results demonstrated the widespread distribution of detectable PFAS in drinking water reservoirs in the Cape Fear River Basin. Additional long-term monitoring would be needed to evaluate the persistence of these compounds. The majority of the PWS facilities are taking part in the EPA Fifth Unregulated Contaminant Monitoring Rule (UCMR5) study, which requires PWS facilities to participate in monitoring for 29 different PFAS compounds in their finished drinking water. The results are reported to the State and EPA. The UCMR5 is discussed in detail section 12.4.2.4 of Chapter 12.

As science advances, laboratories are beginning to detect these compounds and researchers are discovering new details about their impacts. The science and research about emerging contaminants are quickly expanding, so DEQ has created a list of resources to help residents learn more. The latest information and updates can be found on the NC DEQ Emerging Compounds webpage.

8.6 Upper Cape Fear River Watershed Restoration Plans

The first step to watershed restoration is to develop a watershed plan. A watershed plan is a strategy and a work plan for achieving water resource goals that provides assessment and management information in a watershed. The Upper Cape Fear River subbasin has two EPA-defined nine-element watershed plans that have been developed to address impaired waterbodies (*Table 8-12*). More information about watershed planning and nine-element plans is available in Chapter 4.

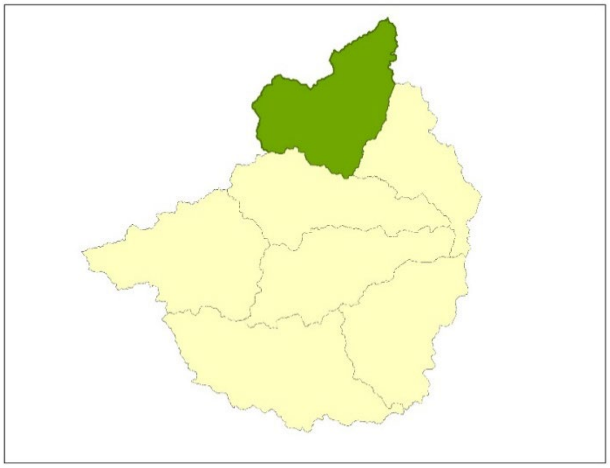
Table 8-12: Upper Cape Fear River Subbasin Watershed Plans

HUC8	HUC12	Watershed Plan	Plan Year	Plan Developer(s)
03030004	030300040501 030300040103 030300040105	Harris-Kenneth Creek 9-Element Plan (including Buckhorn, Parkers and Neills creeks)	2015	Triangle J Council of Governments
03030004	030300040704	Cross Creek Watershed	2018	Triangle J Council of Governments

8.7 Water Quality on the Watershed Scale (HUC 10)

To determine the source of pollutants in a watershed, it is useful to evaluate them on a smaller scale. Smaller-scale evaluations can also help identify where monitoring and restoration is needed or being conducted. North Carolina assigns numbers to surface waterbodies. For water quality assessment purposes, these numbers are referred to as assessment unit numbers (AU#). A letter attached to the end of the AU# indicates that the assessment unit has been segmented, or broken into smaller pieces, to target the water quality assessment and the data associated with it. AU#s that have water quality data associated with them are discussed here on a watershed (HUC10) scale. Not all stream segments are monitored by DWR. DWR does, however, value qualitative information from stakeholders throughout the basin to understand what is impacting water quality in a particular area. Information provided by stakeholders is incorporated into each watershed along with recommendations to protect and improve water resources in the watershed.

8.7.1 Buckhorn Creek – Cape Fear River (0303000401)



The Buckhorn Creek-Cape Fear River watershed covers 231 mi^2 in area and had a 2020 population of 38,433. This watershed is mostly forested (62.5%) primarily around Harris Lake and the adjoining tributaries of the Cape Fear River, followed by agricultural land (10.8%) which is dispersed across the watershed. Developed land (9.6%) is also in this watershed primarily around the areas of Holly Springs, Fuquay-Varina, Apex, and Sanford. Grassland/shrub (9.3%), barren land (0.3%), and open water and wetland (3.8% each) complete the landscape (*Table 8-6*, NLCD 2019).

There are four major (>1 MGD) NPDES discharge permits in the subbasin. Two permits are for Duke Energy power generation facilities: NC0003433 is to allow treated discharge from ash pits and groundwater remediation into the Cape Fear River at the retired Cape Fear Steam Electric Power Plant; and NC0039586 is to discharge the industrial, stormwater and domestic wastewater from the Shearon Harris Nuclear Power Facility into Harris Reservoir. NC0088846 is the Western Wake Reuse Facility's 18 MGD discharge to the Cape Fear River below Buckhorn Dam. NC0063096 is for Holly Springs' Water Reclamation Facility's 8 MGD discharge into Utley Creek, upstream of Harris Reservoir.

There are four minor (<1 MGD) NPDES permits in the Harris Reservoir drainage area for individual, community, and processing discharges. South of the Cape Fear River in this watershed there are three minor permitted discharges for the Sanford Water Treatment Plant (WTP), the Broadway WWTP, and a residential parcel.

The total permitted as-built discharge in this watershed for four major and four minor NPDES dischargers is 24.24 MGD. There are two single-family permits in the watershed. There are 23 NPDES stormwater and 12 state stormwater discharge permits in the watershed. Other permits include one Individual AFO permit for 2,400 head with an allowable weight of 324,000 pounds and permits for 133 acres of non-discharge wastewater, reclaimed water, and residual solids land application. Several of the wastewater irrigation fields are also associated with single family permits. A list of permitted facilities is in the Chapter 3 Appendix.

Overall, there are several water quality concerns in this watershed including nutrients (nitrogen and phosphorus), chlorophyll *a*, turbidity, dissolved oxygen, noxious aquatic plants, eutrophication, and stressed fish and benthic communities. Several of these concerns have resulted in waterways in this watershed being listed on the 303(d)-impaired waters list. The sources of these water quality concerns are the result of both point and nonpoint sources of pollution from upstream and nearby land use activities in the Cape Fear River Basin as the Buckhorn Creek-Cape Fear River watershed is where the Haw River and Deep River merge together to form the Cape Fear River. I*improvements needed in this watershed include implementing and maintaining BMPs for stormwater, nutrients, and sediment alongside improvements to waste management and localized investigations of stressed fish and benthos* *communities.* A portion of this subbasin overlays the Triassic geological basin. The streams in the Triassic typically exhibit low base flows and substrates not suitable for colonization. The use of benthos for water quality assessment has not been established for NC Triassic streams and as a result sampling stations in these streams are lacking, or existing data are deemed as Not Rated according to the current standard operating procedures.

8.7.1.1 Cape Fear River

The Cape Fear River [AU#: 18-(5.5)a] from NC Hwy 42 to Buckhorn Dam and is designated as Impaired for chlorophyll *a* in the 2022 IR. The construction of Buckhorn Dam was completed in 1905 to provide storage for a powerhouse located downstream on Buckhorn Creek, which began generation in 1908 (Naylor 1963; Young 1983). The purpose of the Buckhorn project was to supply the City of Fayetteville with electricity by the Cape Fear Power Company. Carolina Power and Light (CP&L) would later acquire the project, which would morph into Progress Energy, and eventually be acquired by Duke Energy. Although Buckhorn Dam remains, the remnants of the powerhouse and headrace were removed in 2010. The dam then provided cooling water for CP&L's Cape Fear Steam Station and water supply for the Town of Sanford. With the retirement of the steam station, the future of the storage may be to supplement Harris Reservoir should the Shearon Harris Nuclear Plant expand and to supply water to the TIP, adjacent to the Haw River. The impounded waters behind Buckhorn Dam stretch upstream to the Lockville Hydropower Project powerhouse on the Deep River and to Jordan Dam on the Haw River. A 2007 bathymetric survey of the impaired reach indicated that the maximum depth was 28 ft, and the average depth was 11.5 ft (DWR, unpublished data).

8.7.1.2 Buckhorn Creek

Buckhorn Creek [AU#: 18-7-(11)] is a tributary of the Cape Fear River with its confluence downstream of Buckhorn Dam. Buckhorn Creek's headwaters [AU#: 18-7-1 and -2] drain into the impounded backwaters of Harris Reservoir in the eastern arm of the impoundment, in addition to Jim Branch [AU#: 8-7-4] and Cary Branch [AU#: 8-7-5]. The DWR nomenclature for the Harris impoundment is Buckhorn Creek (Harris Lake) [AU#: 18-7-3]; however, Buckhorn Creek is not the largest drainage area in the Harris watershed. The cove formed by White Oak and Utley creeks contributes a larger drainage to Harris Lake.

Suburban sprawl near the towns of Apex and Holly Springs, in the eastern headwaters of the drainage, has converted land use to developed in the watersheds of Buckhorn, White Oak and Utley creeks and Big, Little and Norris branches. Land-use planning in the watershed is largely within Holly Springs' municipal boundary or extra-territorial jurisdiction (ETJ) (Town of Holly Springs 2022). Holly Springs' land-use plan is generally bounded by US 1 to the west, south of Triangle Expressway to the north, the Wake-Chatham-Harnett county boundaries to the south and SR1101 to the east. Apex's jurisdiction is south and north of the Triangle Expressway to the north and between US 1 and old US 1 to the west (Town of Apex 2023). The lower Buckhorn Creek watershed in Chatham County is outside of any municipal land-use planning area, and the area is predominately forested.

Buckhorn Creek is impounded to form the Shearon Harris Reservoir (WS-V), which is owned by Duke Energy. The dam was constructed in 1983 and provides cooling water for the Shearon Harris Nuclear Power Plant, as well as public recreation. The other significant tributaries of the reservoir include White Oak Creek, Little White Oak Creek, Thomas Creek, and Tom Jack Creek. The Tom Jack Creek watershed also has two dams that are used to create impoundments to direct water to the cooling-water canals that supply the nuclear station. Harris Reservoir was determined to have a eutrophic status as recently as 2018, which is consistent with previous ratings in 2013, 2008 and 2003 (Duke Energy Progress 2022). The noxious aquatic plant hydrilla, *Hydrilla verticillata*, was first discovered in the reservoir in 1988 (NCWRC 2023b). With the multiple stockings of sterile triploid grass carp *(Ctenophayrngodon idella*) into Harris Reservoir beginning in 2018, it appears that hydrilla is being managed.

Duke Energy informed the Nuclear Regulatory Commission (NRC) in 2008 of a planned expansion at the facility that would include two new reactors. The NRC initiated the environmental review process that included field studies for both the Cape Fear River below Buckhorn Dam to determine the impacts of pumping water from the Cape Fear River behind Buckhorn Dam into Harris Reservoir, and a study in Buckhorn Creek below Harris Dam to determine a flow requirement release from the dam. In 2013, Duke Energy informed the NRC that it was putting the expansion on hold (Duke Energy May 2, 2013 letter). With the expansion on hold, the downstream flow requirement to Buckhorn Creek from Harris Dam is also on hold.

Duke Energy is a large landowner within the subbasin, owning more than 24,000 acres both upstream and downstream of the Harris Dam in Wake and Chatham counties and in Lee County (Chatham County GIS 2023; Lee County GIS 2023; Wake County GIS 2023). Much of Duke's property is managed by others as game lands and parks. The NCWRC's 11,550-acre Harris Game Land encompasses a large area around the reservoir in Chatham, Harnett, and Wake counties. The Chatham Game Land is 2,670 acres and is downstream of the Harris dam, along Buckhorn Creek, its tributaries, and a segment of the riparian zone along the north side of the Cape Fear River. Wake County's Harris Lake County Park is 680 acres and located on the peninsula between White Oak and Little White Oak creeks. The DEQ Stewardship Program maintains a 22-acre conservation easement along privately owned riparian buffer in the upper Thomas Creek watershed between US 1 and Old US Hwy 1.

BB105	
Year	**Bioclassification**
2003*	Poor
BB243	
2003*	Good
*Special Study	

There are two benthos monitoring stations (BB105, BB243) in the Harris Reservoir drainage area. BB105 is on Little Branch [AU#: 18-7-6-1-1] and in 2003 it received a Poor rating. The segment was rated as Data Inconclusive in the 2022 IR. BB243 is on Buckhorn Creek [AU#: 18-7-(2)] and in 2003 received a Good rating. The segment was rated as Meeting Criteria in the 2022 IR. Downstream from these benthos stations, there is one ambient water quality monitoring station on Buckhorn Creek (B6204000, "Buckhorn Creek beside SR 1921 Buckhorn Rd near Corinth," which is a MCFBA coalition site. The impounded reach on Buckhorn Creek (Harris Lake) [AU#: 18-7-(3)] (WS-V) is listed in the 2022 IR as "Data Inconclusive" for 10 chemical/physical parameters. The surface water quality monitoring results from B2040000 are discussed alongside other stations near the end of the section on the Buckhorn Creek – Cape Fear River watershed.

8.7.1.3 Utley Creek / Buckhorn Creek (Harris Lake)

Utley Creek [AU#: 18-7-5.5], from the source near the Town of Holly Springs' Cultural Center, flows under the Highway 55 Bypass and by the Town of Holly Springs' 6 MGD Utley Creek Water Reclamation Facility (WRF) (with an 8.0 MGD expansion tier; NPDES Permit No. NC0063096). Utley Creek continues to flow westerly by a large industrial park, new housing developments, through two small impoundments--Thomas Mill Pond and Green Tree Reservoir--and wetlands before reaching its confluence with White Oak Creek, just above the White Oak Creek arm of Harris Lake. Utley Creek is currently well buffered but is an urbanizing watershed that is receiving much stormwater drainage from all the new development. Utley Creek is just one of many urbanizing subwatersheds draining to Harris Lake, which is classified as a Water Supply-V (WS-V) watershed. Wake County's southern landfill is within the Little Branch watershed, a tributary of Utley Creek, west of Hwy 55.

The use support rating for Utley Creek is listed as No Data (2022IR) due to the lack of ambient monitoring data available from a certified monitoring program. The stream is, however, monitored by the Town of Holly Springs as part of its NPDES permit requirement. This information is critical to DWR's understanding of the current conditions in this creek from the 8 MGD wastewater discharge and the impacts from development. Utley Creek is a small headwater stream with an average flow of only 0.82 cfs and a summer 7Q10 of 0.11 cfs. The instream waste concentration is 99% effluent at low flows.

Holly Springs - Utley Creek Discharge History

Utley Creek has a long history of eutrophication issues, dating back to at least 1996. Holly Springs maintains a discharge near the headwaters. This is one of the few discharges in the state where DWR's original position was that the discharge would need to be moved out of Utley Creek altogether. The following provides a summary of the history since 1996.

In July 1996, a fish kill and a severe algae bloom in Utley Creek prompted DWR (then-DWQ) staff to investigate and assess the cause. Staff documented an extensive algae bloom in both the Thomas Mill Pond and Green Tree Reservoir impoundments. During this site visit, the chlorophyll-*a* value in Thomas Mill Pond was 550 ug/L. Dissolved oxygen was 16.3 mg/L (193% saturation), and pH was 10.3 s.u.

Staff from DWQ visited the site again in July 1997 and documented another algae bloom in both Thomas Mill Pond and Green Tree Reservoir. DWQ sent a letter to Holly Springs in September 1997 reviewing short- and long-term options, noting limited opportunities for the town to expand its discharge into Utley Creek due to the creek's limited ability to assimilate oxygen-consuming wastes and existing eutrophic conditions downstream.

From May to August 2000, DWQ conducted a study to document and assess the causes of nutrient enrichment in Utley Creek. The study consisted of six site visits from May 5 to August 31, 2000. The nutrient load in Utley Creek was determined to originate from the Holly Springs Utley Creek WRF. Under normal summer low-flow conditions, the facility effluent provided approximately 91% of the total stream flow for Utley Creek. On average (based on grab samples), during the six sampling events, the WRF discharged 65 pounds per day (lb/d) of total nitrogen, 26 lb/d of total phosphorus, and 0.8 lb/d of ammonia. The WRF was determined to be the main nutrient source in Utley Creek.

In January 2001, DWQ provided a letter to Holly Springs noting that a regional approach to managing wastewater due to unprecedented growth in Wake County was necessary and staff would not be reviewing an Environmental Assessment (EA) submitted by Holly Springs for expansion to 4.88 MGD.

In March 2004, DWQ sent another letter to Holly Springs describing results of recent studies showing continued problems in Thomas Mill Pond, downstream of the discharge, and stated "continued discharge to Utley Creek - any discharge - is not a long-term solution."

In February 2007, Holly Springs notified DWQ in a letter providing "…confirmation from the Town of Holly Springs that we will relocate the treated effluent discharge from the Utley Creek Wastewater Treatment Plant to the Cape Fear River (via the Western Wake Regional Project)."

In the same month and in response to that letter from Holly Springs, a Finding of No Significant Impact (FONSI) was issued for expansion of Utley Creek WRF "for use when Western Wake Regional Water Reclamation Facility eventually accepts its treated effluent." It should be noted that the Authorization to Construct the WRF contained the condition that the treated effluent must be removed from Utley Creek. However, in September 2010, Holly Springs pulled out of the Western Wake Partnership and prepared an EA for a discharge into the White Oak Arm of Harris Lake. The EA included the preferred alternative to keep the discharge at the existing location in Utley Creek. The Division responded by reiterating that the goal was to remove the discharge from Utley Creek.

The primary reason for concern was the presence of Thomas Mill Pond and Green Tree Reservoir between the existing discharge and the White Oak Arm of Harris Lake. Duke Energy controls operations of all three of these reservoirs. Holly Springs contended that Green Tree Reservoir was not actually being used as a reservoir and was, in fact, free flowing. In May 2011, DWR notified Holly Springs that it would consider a discharge into Utley Creek between Thomas Mill Pond and Green Tree Reservoir if the town could procure a letter from Duke about plans to use the reservoir in the future. In lieu of the letter, Holly Springs requested speculative limits to move the discharge below both in June 2011. In September 2011, a FONSI was issued for a discharge into Utley Creek below Green Tree Reservoir. Holly Springs received the modified NPDES permit in April 2012 to include expansion flows of 6.0 and 8.0 MGD at the new outfall 002.

In March 2014, Holly Springs requested to modify its EA to keep the discharge at the current location citing breaches in the Thomas Mill Pond dam, Duke Energy had abandoned expansion plans, and to save on the approximately $13.1 million cost to move the discharge. DWR agreed to consider the request under two conditions: provide a letter from Duke regarding future operation plans and additional monitoring to include dye testing to support a nutrient response model that would include the Thomas Mill pond and Green Tree Reservoir. The monitoring results and model were provided to DWR in September 2014.

In November 2014, DWR issued speculative limits for the current location. However, Holly Springs was never able to procure a letter from Duke about future operation plans. Holly Springs provided a modified draft EA to DWR for review. DWR commented that staying in the current location represents several areas of uncertainty, permit reopener language would need to be added and there would need to be instream monitoring requirements at specific locations.

In April 2015, DWR modified the permit to stay at the current location with expansion flows of 6.0 and 8.0 MGD with special reopener language and instream monitoring requirements. As far as DWR is aware, there have been no documented stream restoration projects or other watershed efforts to potentially provide additional assimilative capacity in Utley Creek. The area continues to grow, and stormwater influences have become a concern for both Utley Creek and Harris Lake itself.

The previous basin plans have documented water quality concerns and made the following recommendations:

- 2000 Cape Fear River Basin Plan - Utley Creek is currently not rated. Water quality in Utley Creek is marginal with the current discharge and low impact land uses. Increased flow from the WWTP, as well as the expected stormwater flow, has the potential to not only increase nutrient loading but also increase sedimentation and streambank erosion. Land use planning in the watershed that considers water quality concerns is needed prior to large-scale development projects to minimize runoff effects. Because of water quality concerns in Utley Creek and the expected urbanization of the Harris Lake watershed, the Division recommended that Holly Springs explore other means of sewage disposal including connection to existing facilities in the area.
- 2005 Cape Fear River Basin Plan - Utley Creek from source to Harris Lake (4.6 miles) was Not Rated in the 2000 plan, and no data were collected to assign a use support rating during this assessment period. Earlier studies indicated the Holly Springs WWTP was a significant contributor of nutrients to the creek that could cause algal blooms and subsequent fish kills downstream. Because of the water quality problems noted above, the 2000 basin plan recommended that Holly Springs pursue other alternatives to a discharge into Utley Creek. It was also recommended that land use planning be used to prevent further increases in nutrient loading from the developing watershed. DWR (then DWQ) continued to recommend that Holly Springs find another wastewater disposal alternative.

Current instream water quality data is available as a result of the Holly Springs Utley Creek WRF permit requirement for downstream stations at Thomas Mill Pond (D2) and below the Green Tree Reservoir dam (D3). Since December 2015, the town has submitted its instream monitoring data directly into BIMS (Basinwide Information Management System) with its monthly DMRs (Daily Monitoring Reports). The data presented below was pulled from BIMS in March 2023. These data are not used for use support purposes; however, it allows for an overall understanding of the conditions in Utley Creek since 2016. The instream conditions appear to have improved in Utley Creek since the historical assessments in 1996 and 1997 (algal blooms and fish kills). The improved conditions are likely the results of wastewater treatment plant upgrades (improved treatment capabilities) and a breach of the Thomas Mill Pond dam, allowing for less ponding and limiting algal growth from occurring.

Holly Springs Wastewater Treatment Plant Effluent Data

While the total effluent flow is increasing, the total nitrogen and total phosphorus effluent concentrations have declined significantly over the last 10 to 15 years (*Figure 8-14*). Since 2019, the total nitrogen and total phosphorus effluent concentrations have been below 5.0 mg/L and 0.30 mg/L, respectively. The total nitrogen effluent concentrations in 2022 increased over the 2020 and 2021 concentrations, which resulted in an increase in the instream total nitrogen concentrations as well (*Figure 8-15*).

Holly Springs Instream Water Quality Data

Both instream total nitrogen and total phosphorus concentrations declined as a result of the improved treatment at the WRF with a large drop seen in 2019 (*Figure 8-15* and *Figure 8-16*). The total nitrogen instream concentrations appeared to increase somewhat in 2022 with about half of the samples at or above 2.0 mg/L and the yearly mean concentration at 1.75 mg/L where in 2019 the yearly mean was 1.0 mg/L. The total phosphorus remained relatively low in 2022 with only three records above 0.20 mg/L. The chlorophyll *a* concentrations were much lower than those reported in 1996 and 1997. The concentrations were below the 40 µg/L standard but were elevated in 2022, along with the nitrogen and turbidity concentrations (*Figure 8-17* and *Figure 8-18*). All three parameter concentrations increased at D3, which is downstream of Green Tree Reservoir. Higher chlorophyll-*a* concentrations could be occurring in the impounded area.

The increase in turbidity concentrations over the last five years is likely the result of increasing development in the Utley Creek watershed. Station D3 had a significant jump in turbidity in 2022 with 25% of the samples at or above the standard of 50 NTUs with a yearly average concentration of 39.4 NTUs and a maximum reading of 136 NTUs. The average turbidity concentration at station D2 in 2022 was only 6.4 NTUs. Station D3 is about 0.9 miles downstream from D2. There are several large development projects draining to Utley Creek between these two stations. *Holly Springs should make regular inspections of the BMPs to ensure compliance with sediment and erosion control measures during the ongoing development in the watersheds draining to Harris Lake.*

Conductivity is often used to identify a potential pollutant source in a watershed. The difference between the upstream and downstream conductivity readings in Utley Creek is extreme (*Figure 8-19*). The average upstream reading between 2016 and 2019 was 85.6 µmhom/cm in comparison to stations D2 and D3 at 644 and 616 µmhom/cm (at 25°C), respectively. A reading between 12 and 90 µmhom/cm is considered indicative of a pristine piedmont stream. There is no evidence that high conductivity is harmful, but it is an indicator that there is a wastewater source. Conductivity tends to be higher when there are Significant Industrial Users (SIUs) that discharge to a treatment plant. Holly Springs operates a pretreatment program, and as of March 2023, there are two active SIUs (Southern Wake Landfill and Seqirus) and two draft permits in the works (Amgen Inc. and Fujifilm Diosynth Biotechnologies).

The Town of Holly Springs is one of the fastest growing towns in NC. According to Holly Springs' 2021 Local Water Supply Plan on file with DWR, the 2021 population was 45,058 and the 2030 population is projected to be 60,126. The town is starting to assess the need to expand their WRF beyond its current 6 and 8 MGD permitted flows. There are many challenges with adding additional waste load to Utley Creek and Harris Lake. These include:

- Utley Creek is a very low-flow system with several impoundments;
- Utley Creek likely has limited assimilative capacity;
- Utley Creek drains to a water supply lake that is becoming more eutrophic each year and will receive increased nonpoint source runoff contributions from the expansive development that is occurring in the watershed; therefore, modeling of Harris Lake and the watershed will be needed. There is little to no data available in the watershed tributaries of Harris Lake. Modeling will need to include special studies of Harris Lake itself and the watershed to understand the sources and impacts on Harris Lake.

Figure 8-14: Town of Holly Springs Utley Creek Water Reclamation Facility Discharge Effluent Flow (A), Total Nitrogen (B) and Total Phosphorus (C) Concentrations between 2005-2022. Inset Graph in (C) is Detailed View of TP Concentrations From 2018 to 2023.

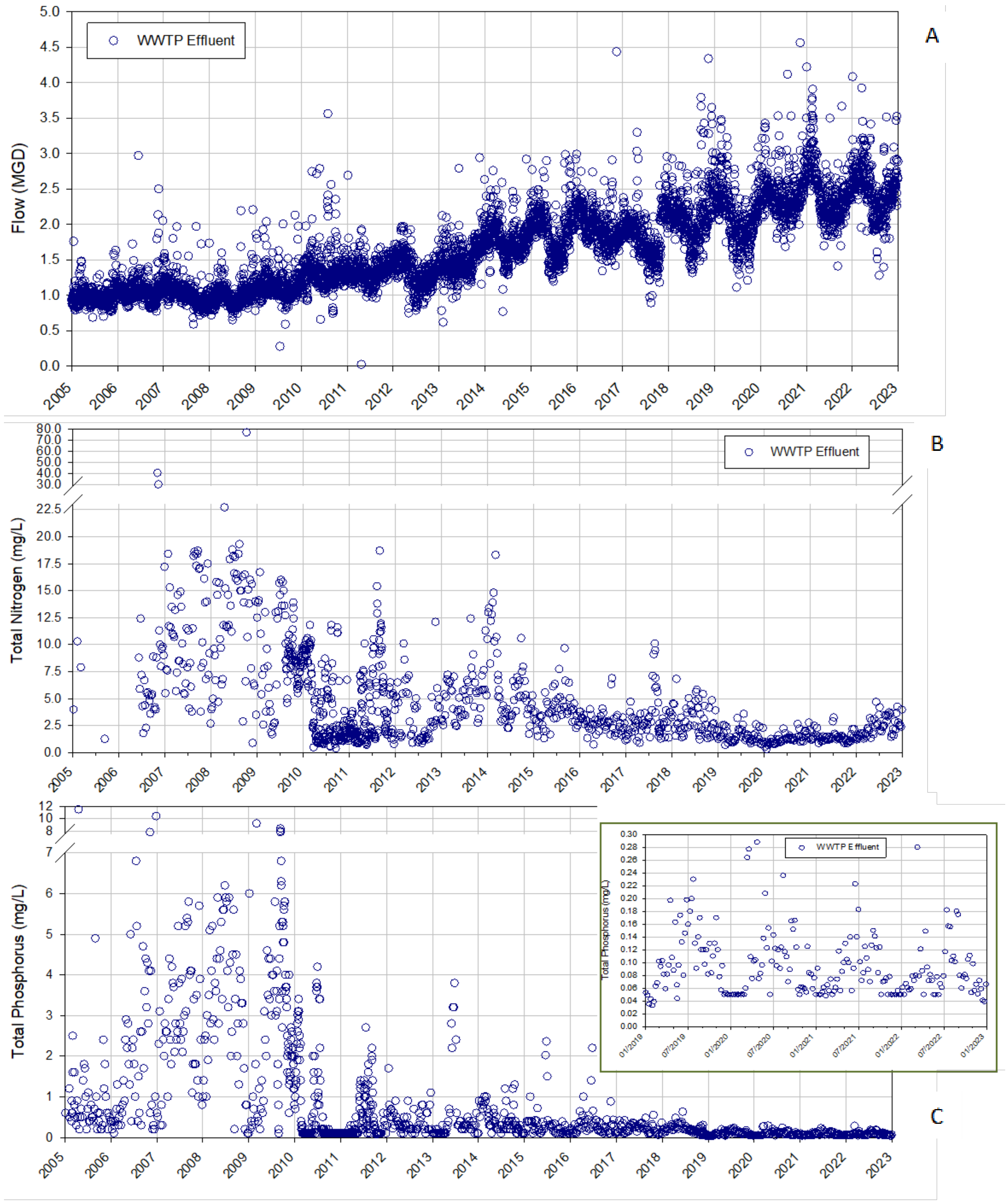


Figure 8-15: Utley Creek Instream Total Nitrogen Concentration with Corresponding Effluent Concentrations.

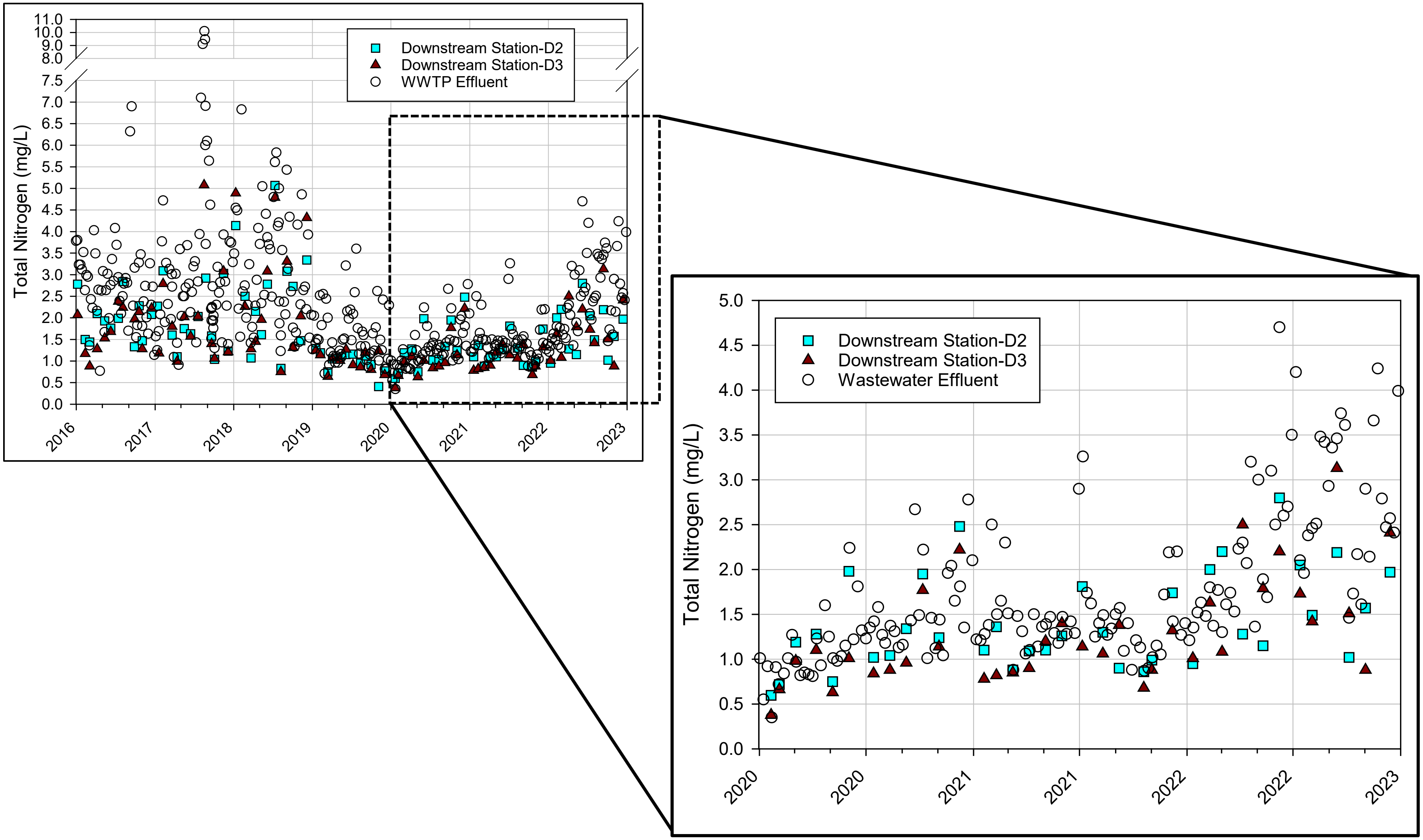
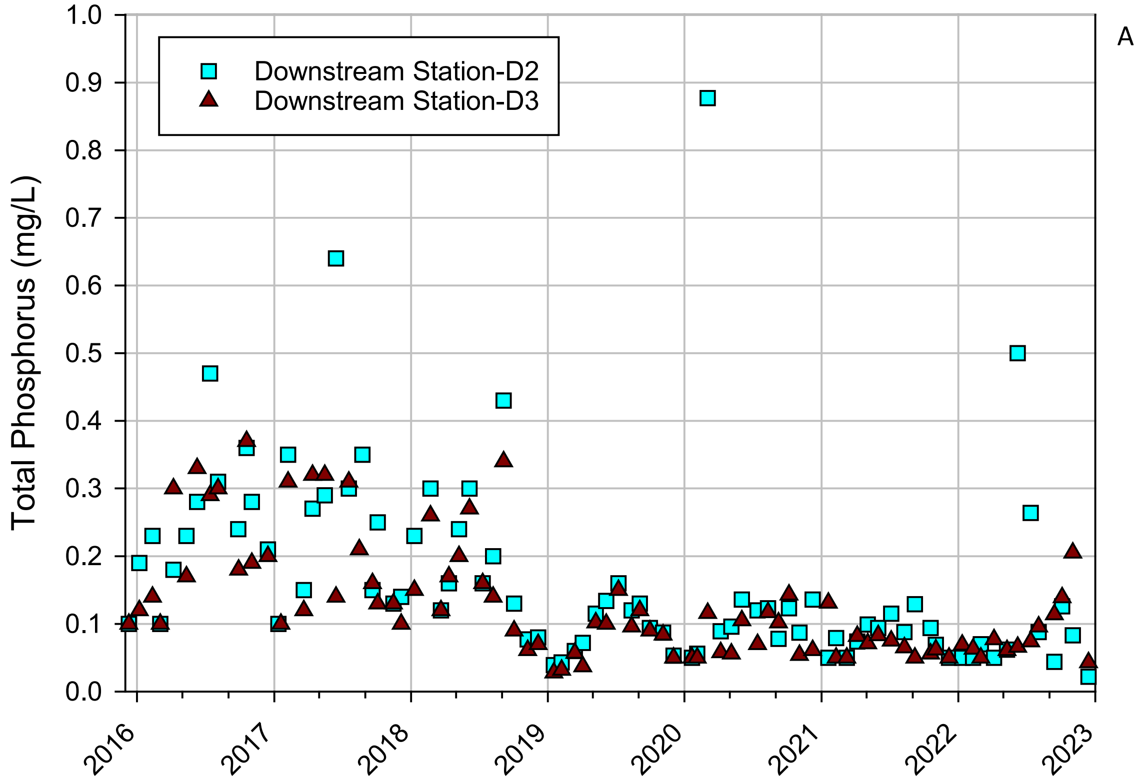


Figure 8-16: Utley Creek Instream Total Phosphorus (A) and Orthophosphate (B) Concentrations.



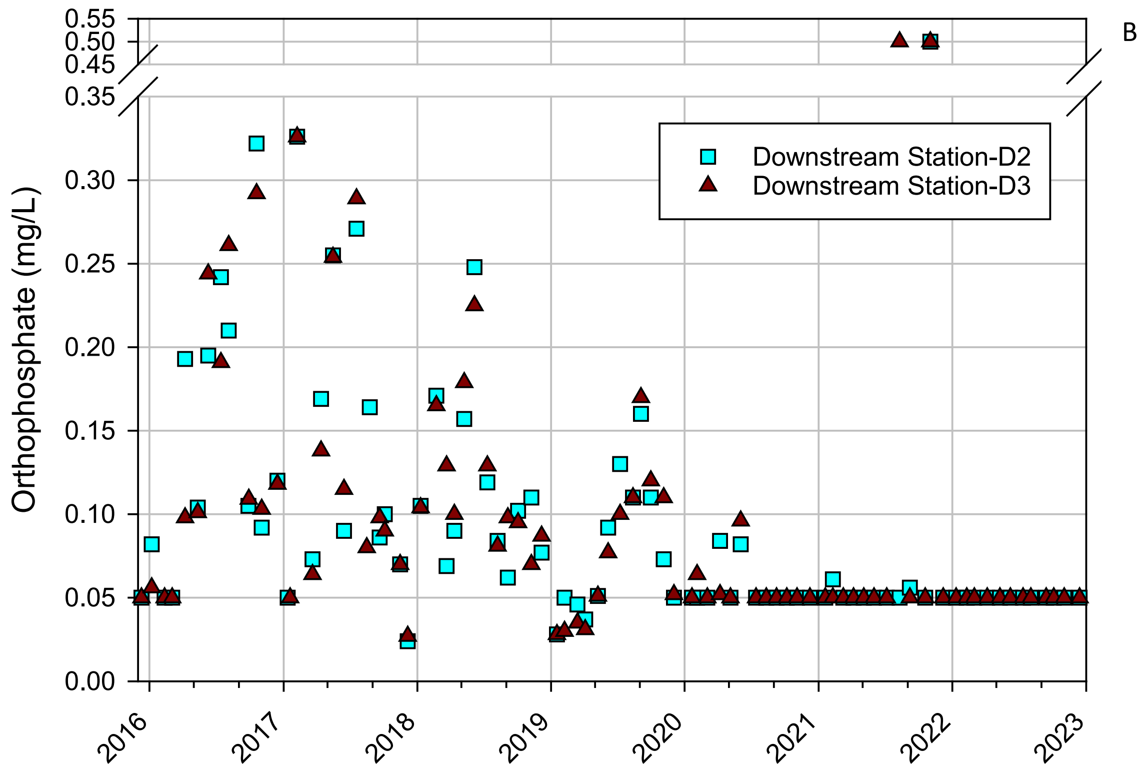


Figure 8-17: Utley Creek Instream Chlorophyll a Concentration Downstream of the Wastewater Treatment Plant Effluent Discharge.

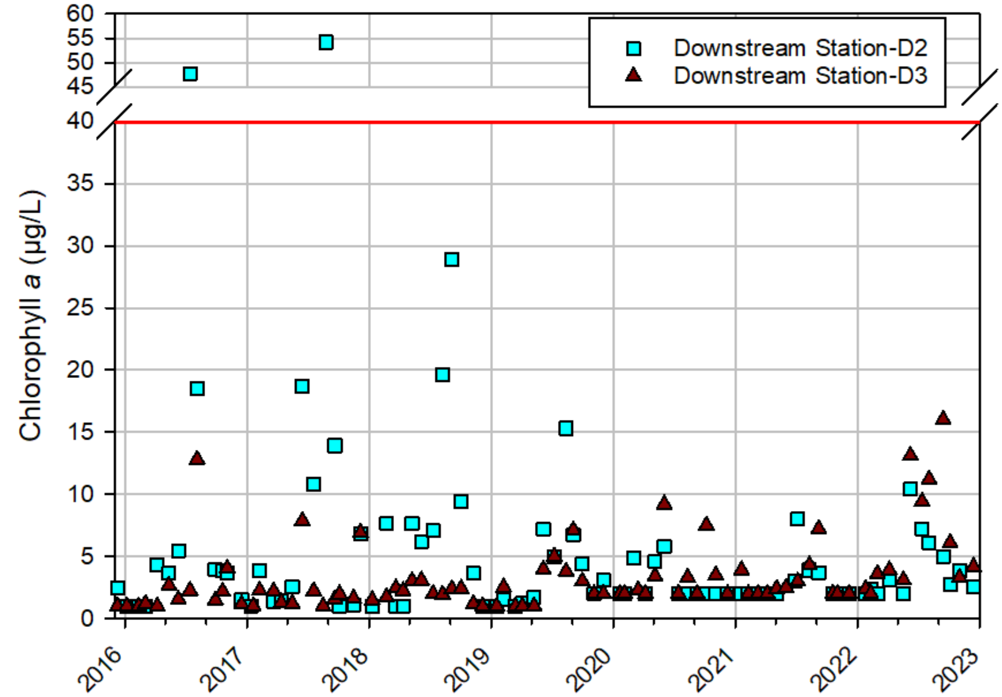


Figure 8-18: Utley Creek Instream Turbidity Concentrations Downstream of the Wastewater Treatment Plant Effluent Discharge.

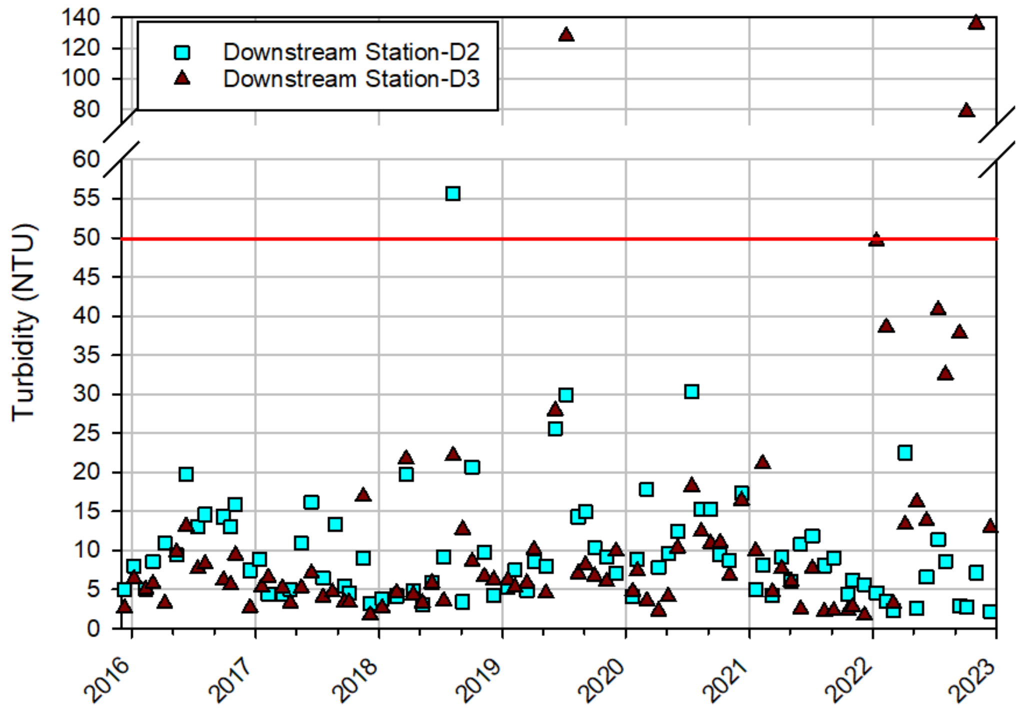
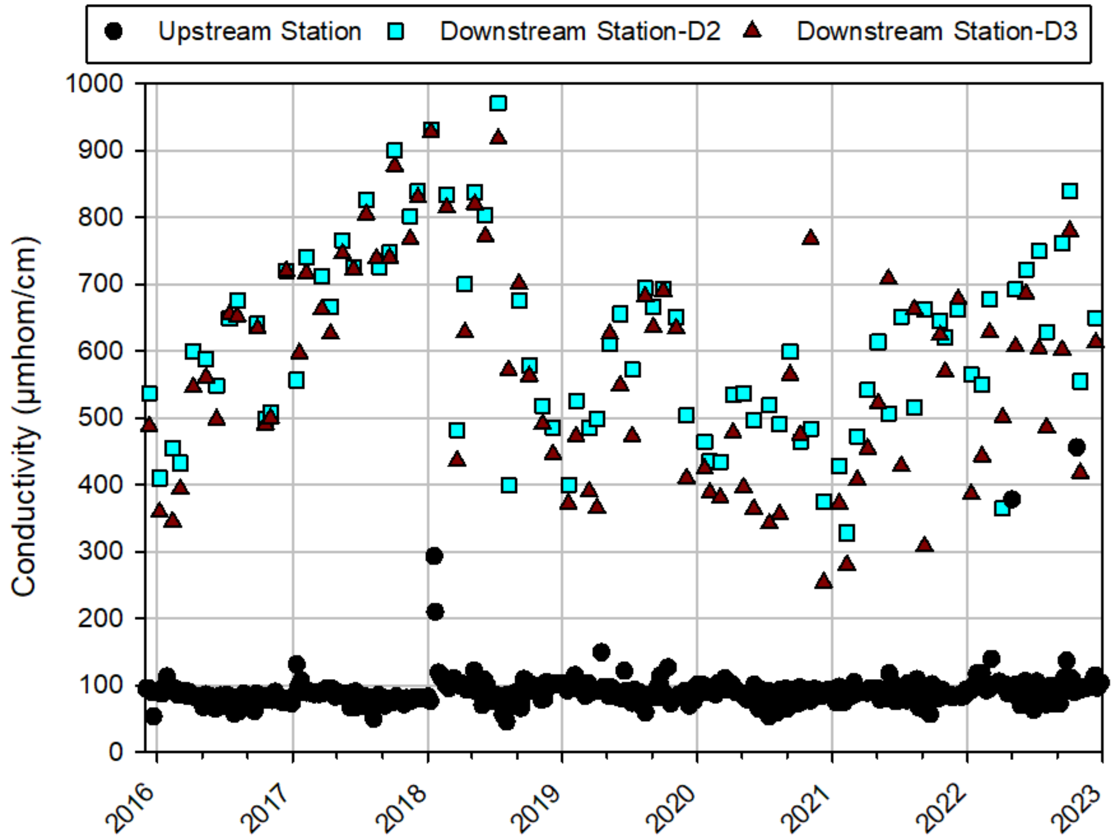


Figure 8-19: Utley Creek Instream Conductivity Upstream and Downstream of the Wastewater Treatment Plant Effluent Discharge.



- Utley Creek is within the Upper Cape Fear River Subbasin where there is currently a hold on the load permitting strategy due to possible nutrient over-enrichment.
- There may be instream nutrient criteria developed for this section of the Cape Fear River Basin. This could result in new instream criteria that the wastewater effluent would have to meet. There is also a chance that there could be a need to reduce the overall nitrogen and phosphorus load to the system as well. (See Chapter 2, Section 2.13 Nutrient Criteria Development Plan)

The Division continues to encourage Holly Springs to consider wastewater regionalization opportunities and to remove their discharge from Utley Creek. The town is also required to work with DWR to ensure their pretreatment program is sufficient to protect against accepting waste with potential emerging contaminants (EC). EC are a growing concern throughout the state and country. Working with new and existing SIU to ensure treatment or avoidance at the source is critical for a strong pretreatment program.

The Utley Creek watershed is experiencing a lot of development pressures, including more nonpoint source stormwater runoff, increased domestic and industrial wastewater as well as experiencing weather extremes, which can affect runoff and baseflow volumes. *Continued instream monitoring of Utley Creek* *is necessary. Instream monitoring should include year-round monitoring for the parameters included in the permitting strategy monitoring table* (Chapter 3, Table 3-8).

Utley Creek drains into the White Oak Creek arm of Harris Lake. Based on the 2022 IR, Harris Lake from the backwaters of Harris Lake to the Harris Lake Dam is not rated due to insufficient number of ambient water quality samples collected in 2013 and 2018. There were four samples collected during each year monitored. A total of three stations were assessed four times between May and August 2018 (*Table 8-13*).

The data collected by DWR indicated that the NC Trophic Status Index ranged between eutrophic and hypereutrophic with elevated levels of chlorophyll *a* throughout the summer (*Table 8-13* and *Figure 8-20*). The trophic status has continued to increase since the initial assessment in 1987. All three stations assessed exceeded the chlorophyll *a* standard in August 2018 (*Table 8-13*). The pH also exceeded the standard of 9.0 at the two upstream stations. The pH remained below the standard at the dam even though the chlorophyll *a* concentration was 72 µg/L on 8/28/2018. The pH exceeded the standard twice, or 50% of the time, at station CPF126A4, which is located at the point between the White Oak Arm and the Little White Oak Arm of Harris Lake. An algal growth potential analysis was done in July 2018 from water collected at the dam station (CPF126A6); the lake was identified as nitrogen limited (DWR-ISB 2018 Lakes Report).

Conditions in Harris Lake are changing and will continue to be impacted from the development occurring at an accelerated pace in the watershed. *There is a need to implement BMPs to limit stormwater volume, nutrients, and sediments from reaching the streams draining to Harris Lake.*

Table 8-13: Harris Lake ISB 2018 Water Quality Data. (Bolded numbers at or above the WQ standard)

Station CPF-	Date Sampled	Chl *a* (µg/L)	pH (s.u.)	DO (mg/L)	DO % Sat	Temp (°C)	Secchi (m)	TN (mg/L)	TP (mg/L)
126A2 Buckhorn Creek Arm	5/1/2018	17	7.4	10.1	111.5	20.6	1.3	0.82	0.07
	6/11/2018	32	8.4	7.3	95.2	28.1	0.7	0.94	0.08
	7/16/2018	31	8	8.3	109	29.1	0.7	1.01	0.08
	8/28/2018	**120**	**9.9**	13.3	175	29.6	0.6	1.31	0.14
126A4 Main channel of lake at Confluence of White Oak and Little White Oak Cr. arms	5/1/2018	15	7.3	10.3	112.5	19.9	0.8	0.84	0.07
	6/11/2018	33	**9.1**	9.9	131.4	29.4	1.1	1.01	0.07
	7/16/2018	**40**	8.8	9	117.8	29	0.5	1.13	0.09
	8/28/2018	**52**	**9.7**	13.2	171.4	29.2	1	0.99	0.1
126A6 Main channel of lake near dam	5/1/2018	18	7.3	9.9	110.9	21.2	1.3	0.78	0.07
	6/11/2018	26	8.8	9.7	128.1	29.2	0.8	1.01	0.08
	7/16/2018	34	7.6	7.1	91.7	28.4	0.8	1.02	0.09
	8/28/2018	**72**	7.6	5.3	68	28	0.8	1.01	0.12
WOC1 Upper portion of White Oak Cr. Arm	NA	NA	NA	NA	NA	NA	NA	NA	NA

Duke Energy Progress is required to monitor Harris Lake as a condition of its NPDES discharge permit (NC0039586) and provide a report yearly to DWR (NCDEQ-DWR 2021). This information is not for use-support purposes but allows for a better understanding of how conditions in the lake are changing. DWR recommends that both Duke and Holly Springs develop and have approved Quality Assurance Project Plans (QAPPs) so that their water quality data can be submitted to DWR and a determination be made whether the waters each monitors are meeting classification standards.

In 2021, Duke Energy Progress reported that Harris Reservoir continued to typify a biologically productive reservoir in the southeastern United States. Nutrient concentrations have been a concern in Harris Reservoir since phosphorus and nitrogen concentrations increased rapidly in the late 1980s and early 1990s and since 2000. Lake-wide phosphorus concentrations have been trending upwards since 2000 but showed a decrease in 2021, similar to nitrogen. Similar to the nutrient trends, chlorophyll-*a* concentrations in 2021 were similar to 2020 and lower than 2019. The North Carolina Trophic State Index, which is a measure of reservoir productivity, indicated that Harris Reservoir was eutrophic in 2021 (*Figure 8-21*). The changes in the trophic status reported by Duke over time showed similar increasing trend to that reported by DWR (*Figure 8-20* and *Figure 8-21*).

The watersheds that flow into Harris Reservoir have undergone land-use changes from 1992 to 2011. A general trend of decreasing forested land and increasing amounts of developed land and impervious surfaces are present in four of the six major watersheds (USGS 2019). Impairment of the watershed's functional ecosystem processes, environmental services, and biotic communities can occur as the percentage of impervious surfaces and development increases in the watershed. This can potentially lead to biological stressors in the reservoir, more frequent algal blooms, increased total suspended solids and turbidity, and greater areas of low dissolved oxygen. While Duke is still using the 2011 NLCD data, it is recommended that they use the 2019 NLCD dataset for their next annual report. A significant amount of development has occurred in the Harris Lake watershed since 2019, so even the most recent land cover available will underestimate the changes and the increased imperviousness of the watershed.

Similar to 2019 and 2020, there was a general trend in 2021 of water quality and chemistry analytes, such as turbidity, total solids, total suspended solids, and total dissolved solids, being higher in the upstream portions of the reservoir compared to other areas. Calcium, chloride, magnesium, sodium, sulfate, alkalinity, hardness, and specific conductivity showed a similar trend. Although most of the copper and zinc concentrations were below the detection limit, large spikes in these metals were observed in the upstream part of the reservoir. Duke concluded that most of the water quality parameters assessed were highest in the White Oak Creek Arm, above New Hill Holleman Road, where much of White Oak Creek, Big Branch, Little Branch, and Utley Creek drain a highly urbanizing area of Holly Springs.

Consistent with DWR data, Duke also reported the highest chlorophyll *a* concentration in the Buckhorn Creek Arm of the lake. This arm also drains large parts of Holly Springs and Wake County that are developing very quickly. *<u>BMPs and monitoring for sediment and erosion control compliance are necessary to reduce stormwater impacts to the watershed's streams and Harris Lake.</u>*

Figure 8-20: DWR/ISB Harris Lake Trophic Data (1987-1993 are summer lake averages and 2001-2018 are monthly lake averages).

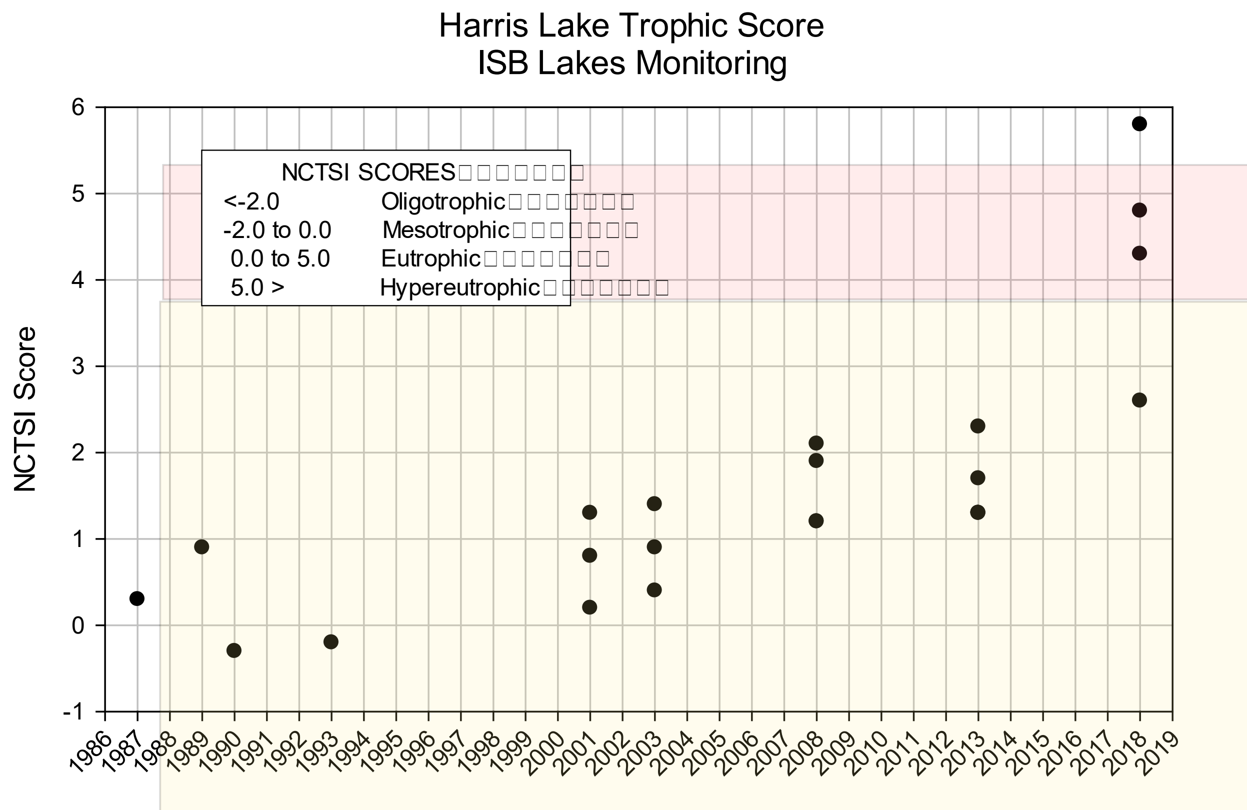
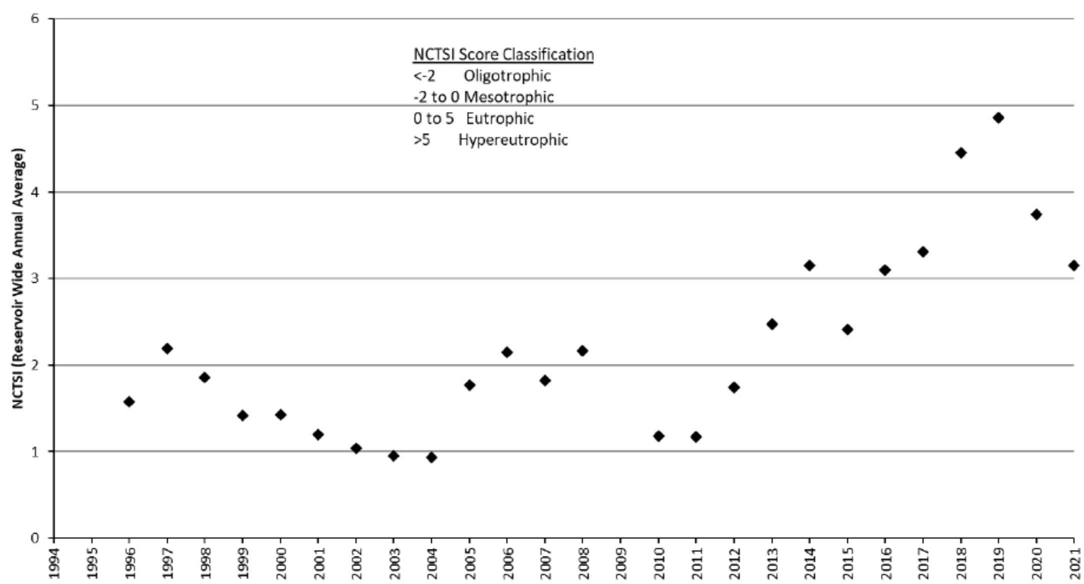


Figure 8-21: Duke Energy Progress NC Trophic State Index Annual Average for Harris Lake.



8.7.1.4 Gulf Creek

The Gulf Creek watershed land use is predominantly forested--short-rotation pine plots--with some grassland/shrub and agriculture. The east side of the watershed and upper headwaters are almost all forested. The west side has an equal mix of forest, agriculture and barren lands associated with brick manufacturing. The percentage of forested lands and impacts to water quality are dependent upon the timing and extent of timber harvesting, the quality of BMPs implemented and the time required to revegetate.

Brickhaven No. 2 Mine is located near the community of Brickhaven and an unnamed tributary of Gulf Creek. Owned by General Shale Brick Inc. (formerly Cherokee Sanford Group LLC), the tract was purchased in 2014 by Green Meadows LLC--a subsidiary of Charah Solutions, which is soon to be acquired by SER Capital Partners. The original parcel of land was subdivided into "A" and "B.” Green Meadows purchased "A,” and General Shale Brick retained ownership of "B.”

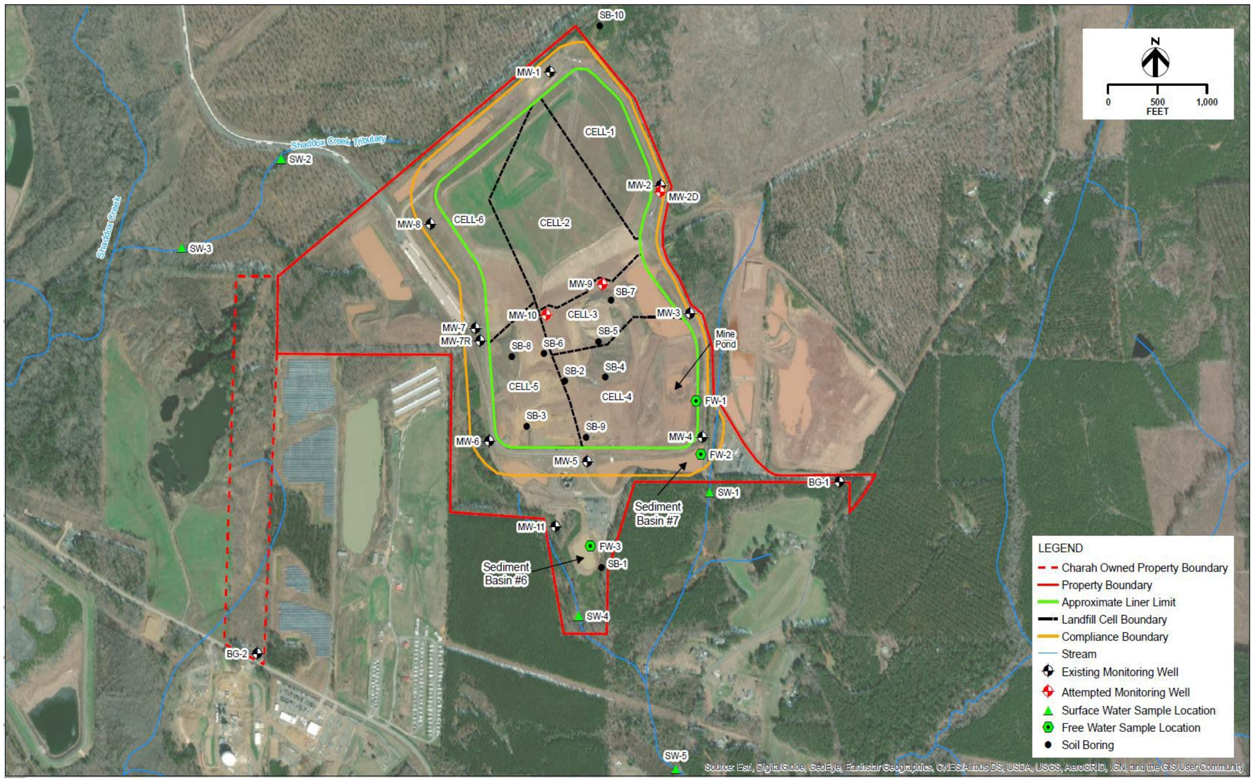
The site was repurposed as a landfill for coal combustion residuals (CCR). The project began with six cells delineated for CCR fill (*Figure 8-22*). As the reclamation and monitoring efforts progressed, the site was subject to the NC Coal Ash Management Act (CAMA) of 2014 (NCGS 130A-309.200 et seq.), the NC Mining Act of 1971 and EPA’s CCR rules under the authority of the Resource Conservation and Recovery Act, and the Clean Water Act. Oversight of the project has been within DEQ’s divisions of Water Resources; Energy, Mineral and Land Resources; and Waste Management. The placement of CCR began on October 23, 2015. The site was the recipient of CCR from Duke’s Riverbend (Gaston County) and Sutton (New Hanover County) coal-fired stations. The CCP material included fly ash, bottom ash, boiler slag, and/or flue gas desulfurization materials.

A settlement agreement in 2020 between non-government organizations (NGOs), NCDEQ and the mine owner established, in part, that deposition of CCR into the mine would cease (EnvironmentaLee et al. v. NCDEQ 2020). The number of cells containing fill was reduced from six to three cells, i.e., Nos. 1, 2 and 6. An additional condition of the settlement was that the owner of the Colon clay mine, adjacent to Roberts Creek in the Lick Creek watershed, would not develop the mine into a CCR deposition site.

This structure ceased receiving waste on July 11, 2019. The approximate amount of CCR placed in the structure prior to closure was 5,384,537 yd^3, or 7,237,665 tons. A permit for closure of the project was issued by DWM to Green Meadows, LLC and Charah Inc. on April 7, 2021 (NCDEQ-DWM 2021). The permittee must maintain closure-care of the land parcel for 30 years, at the discretion of DWM. Additionally, the permit, in part, requires the owner to agree that groundwater and surface waters at the facility are subject to the respective water quality standards; to maintain the integrity and effectiveness of the cap system; to maintain sediment and erosion controls according to statute; to maintain monitoring sites; to semi-annually sampling, at least, of groundwater and surface water sites; to test leachate; and to submit monitoring reports to DWM within 120 days of sampling. The permit does not prevent the use of the property post-closure but is subject to approval by DWM.

Gulf Creek has three designated AU numbers: the lower 0.3-mile reach at the Cape Fear River [AU#: 18-5-(2)] (WS-IV)(CA)--designated a critical area due to its proximity to the Town of Sanford’s public water supply intake, and the remainder of the upper reach [AU#: 18-5-(1)a and b](WS-IV). The remainder of the watershed has a classification of WS-IV for being within five miles of the intake. The lower segment of Gulf Creek, near its confluence with the Cape Fear River, is bisected by the canal that extends from Duke's dismantled Cape Fear Steam Station to the Buckhorn Dam, which received discharges from the power station.

Figure 8-22: Aerial Photograph of Brickhaven CCR Reclamation Project (HDR 2020).



There are four monitoring stations in the Gulf Creek watershed. Two fish community assessment monitoring sites on Gulf Creek (BF88, BF89), one benthic site (BB462), and one benthic site on the unnamed tributary that drains the Brickhaven reclamation site (BB108). The fish community sites returned impairment ratings for the lower most segments, [AU#: 18-5-(1)b] and [AU#: 18-5-(2)] and are listed on the 2022 303-d list for exceeding criteria; the upper segment [AU#: 18-5-(1)a] is Not Rated. The upper station has shown impairment since 1998 and the lower segment since 2000. The one benthic site on Gulf Creek, above the confluence with the unnamed tributary, returned a Fair rating in 1993. The benthic site on the unnamed tributary returned a Poor rating in 1993. Gulf Creek is Not Rated for benthos due to overlaying the Triassic Basin.

8.7.1.6 Parkers Creek

BB287	
Year	Bioclassification
2003*	Not Impaired
BB297	
2003	Excellent
2008	Good
2013	Good
2018	Good
*Special Study	

The Parkers Creek [AU#: 18-9](C;HQW) watershed is predominately forested closer to the Cape Fear River, but it becomes predominately a patchwork of forest and agricultural cover near the community of Duncan and more suburban sprawl closer to the Town of Fuquay-Varina. There are two benthos sampling stations in Parkers Creek (BB287 and BB297). At a drainage area of 0.8mi^2, BB287 reported a Not Impaired bioclassification in 2003. BB297, at a drainage area (DA) of 3.9mi^2, has been sampled since 1993, and it initially reported an Excellent rating but has trended toward a Good rating as recently as 2018. Parkers Creek received a Meeting Criteria in the 2022 IR. There are two benthos macroinvertebrate community monitoring stations on Parkers Creek [AU#: 18-9] which is a Class C and HQW tributary of the Cape Fear River. The upstream station BB287 was last sampled in 2003 as part of a special study and the downstream station BB297 has been sampled regularly as part of the basin sampling effort. Parkers Creek at station BB297 has consistently received a bioclassification score of Good. In 2018, this site once again received a bioclassification score of Good. While the bioclassification score has been stable over the years, and EPT BI (which is a based on the pollution tolerance of each taxon and their abundance) has improved, the total number of EPT taxa (mayflies, stoneflies, and caddisflies) has been on a decreasing trend. Historic samples with higher EPT richness were often conducted in the spring. If spring samples are excluded, the 2018 sample is close to average. Additionally, the lower number of taxa detected in 2018 may have been due in part to recent high flows prior to the sampling date.

8.7.1.7 Avents Creek / Mill Creek

BB285	
Year	Bioclassification
2000	Good
BB290	
2003*	Excellent
2006*	Excellent
2007*	Excellent
2013*	Excellent
BF41	
2003	Good-Fair
2009	Good
2013	Good-Fair
2018	Good
*Special Study	

Avents Creek [AU#: 18-13-(1)](C;HQW) and -(2)(WS-IV)] lies within Raven Rock State Park from its confluence with the Cape Fear River to just upstream of its confluence with Mill Creek [AU#: 18-13-3] (WS-IV;HQW). A section of Mill Creek's south bank forms a boundary for the state park. The lower reach of Avents Creek is mostly forested but becomes progressively more of a patchwork of forests, agricultural and suburban sprawl from the middle to the upper reach near the community of Duncan, close to Fuquay-Varina. The Triangle Land Conservancy (TLC) owns a 4,855-acre land parcel on Avents Creek south of SR 1418 (River Rd).

There are two benthos sampling stations on Avents Creek (BB290, BB285). There is one fish community sampling station on Avents Creek (BF41). The fish community station, BF41, south of SR 1418 (River Rd), has consistently indicated Excellent ratings between 2003 and 2013, as has the benthos station (BB290) at the same location and same time period. The upper benthos station on Avents Creek (BB285) at SR 1403 (Cokesbury Rd) produced a Good rating in 2000. There is one coalition monitoring station (B6230000) on Avents Creek that is sampled by MCFBA. The segment of Avents Creek (18-13-(2); "From a point 1.3 miles upstream of Harnett County SR 1418 to Cape Fear River") is listed in the 2022 IR as "Data Inconclusive" for fecal coliform. Surface water quality monitoring in Avents Creek is discussed alongside other water quality monitoring results in the Buckhorn Creek – Cape Fear watershed later in Section 8.7.1.9.

8.7.1.8 Lick Creek

The majority of the Lick Creek [AU#: 18-4-(2)] (WS-IV) watershed is forested with a mix of agricultural and grassland/shrub. The lower watershed has a patchwork of timber stands in various ages. The upper headwaters of the watershed have concentrated development associated with the City of Sanford. More than 1,300 acres between Lick Creek and Hwy 42 are within the NCWRC's Lee Game Land. There is a conservation easement riparian buffer on 53 acres along Lick Creek and Wallace Branch at their confluence. Lick Creek is on the 2022 303(d) list for exceeding the turbidity and dissolved oxygen water quality standards.

The Lick Creek watershed has two benthos stations on tributaries: BB213 on Hughes Creek [AU#: 18-4-7] and BB539 on Little Lick Creek [AU#: 18-4-5]. BB213 produced a Poor rating in 2003 and is listed as "Data Inconclusive" in the 2022 IR. Although BB539 produced a Good-Fair rating in 2016, the watershed is listed as "No Data" in the 2022 IR. The Lick Creek watershed has one sampling station (B6130500) on Lick Creek: an ambient station maintained by MCFBA. The 10.3-mile reach of Lick Creek "From dam at Olhams Lake to Cape Fear River" is on the 2022 303(d) list for exceeding both DO criteria, beginning in 2006, and turbidity, beginning in 2022. Monitoring notes on station (B6130500) indicate that the waterway is a stagnant and muddy stream that is heavily influenced by rainfall events. Surface water quality monitoring in Lick Creek is discussed alongside other water quality monitoring results in the Buckhorn Creek – Cape Fear watershed later in Section 8.7.1.9.

8.7.1.9 Cedar Creek

The Cedar Creek [AU#: 18-11-(1) and 18-11-(2)] watershed is predominately forested in the lower reach, closest to the Cape Fear River, where it forms the western boundary of Raven Rock State Park. The upper region of the watershed becomes a patchwork of predominately agricultural with some forests. There is also some suburban sprawl along the US 421 corridor, east of the Town of Broadway. There is a conservation easement of riparian buffer on 21 acres in the upper Cedar Creek watershed. Cedar Creek has a single benthos monitoring station (BB546) in the lower segment of the creek, AU# 18-11-(2). The station was sampled in 2021 as part of the random ambient monitoring system (RAMS). The sampling provided a Good-Fair rating.

BB546	
Year	**Bioclassification**
2021	Good-Fair

8.7.1.10 Cape Fear River, Deep River, Haw River, and tributaries in the Buckhorn Creek Watershed

The surface water quality data collected between 2001 and 2020, from the Haw River downstream from Jordan Lake (B4050000 and B4080000), the Deep River (B6040300), the mainstem Cape Fear River (B6160000 and B6215000), and several adjoining tributaries, including Lick Creek (B6130500), Buckhorn Creek (B6204000), and Avents Creek (B6230000), are provided below. The parameters presented in the following descriptions and graphics include fecal coliform bacteria, turbidity, dissolved oxygen, nitrate+nitrite, total Kjeldahl nitrogen, total nitrogen, and total phosphorus using 5-year average values. These parameters are paired with 5-year average discharge values from the USGS gage at Lillington (USGS# 02102500) along the Cape Fear River. Alongside the mainstem Cape Fear River discussion in this chapter, see Chapter 2 in Section 2.5.8 for more details regarding algal blooms, nutrients, and chlorophyll *a* in the mainstem Cape Fear River and Buckhorn Dam.

Overall, fecal coliform bacteria values in the Haw River (B4050000 and B4080000) were typically lower than the water quality standard of 400 colonies/100 mL and often lower than values recorded in the Deep River (B6040300) (*Figure 8-23*). The Deep River fecal coliform bacteria values typically hover around the water quality standard value of 400 colonies/100 mL. These two rivers combine to form the mainstem Cape Fear River midway between Jordan Dam and Hwy 42. The Cape Fear River then receives additional streamflow from Lick Creek (B6130500), Gulf Creek, and several additional tributaries before the first surface water quality monitoring station on the Cape Fear River (B6160000). During most of the 5-year intervals, Lick Creek's average fecal coliform bacteria values were above the 400 colonies/100 mL water quality standard with most years having similar concentrations as the Deep River. Together the Deep River, Lick Creek, and unmonitored tributaries appear to contribute to the elevated fecal coliform bacteria values recorded in the mainstem Cape Fear River at station B6160000 with annual exceedance rates that exceed 20% of the samples collected in a year (*Figure 8-24*). The next downstream station (B6215000) along the Cape Fear River also recorded fecal coliform bacteria values that approach and marginally exceed the fecal coliform bacteria water quality standard based on 5-year average values (*Figure 8-23*). During the 2016-2020 time frame most years exceeded the water quality standard at least 20% of the time (*Figure 8-24*). Reduction in fecal coliform bacteria levels in the Cape Fear River could be attributed to the contributing streamflow from Buckhorn Creek which has relatively low fecal coliform bacteria levels (B6204000) (*Figure 8-23*). Before leaving the Buckhorn Creek-Cape Fear River watershed, Avents Creek contributes streamflow to the Cape Fear River. Based on data collected at the surface water quality monitoring station in Avents Creek (B6230000), fecal coliform bacteria levels can be elevated above the 400 colonies/100 mL water quality standard as seen in the 2006-2010 and the 2016-2020 time frames (*Figure 8-23*). The exceedance rate can also exceed 40% during certain periods (*Figure 8-24*). While these results are reported here as exceeding the water quality standard and 5-year mean values, it is important to note that the water quality standard for fecal coliform bacteria is based on a 5-in-30 sampling methodology. The results presented here are best viewed as screening values to identify areas of potential concerns as the samples are analyzed outside of hold time and are not collected at a frequency consistent with a 5-in-30 sampling methodology. Also note that the mainstem Cape Fear River is not a Class B waterway and therefore the best intended use is not for primary recreational purposes (See Chapter 2 for additional information on Class B waterways).

Figure 8-23: Five-year Mean Fecal Coliform Bacteria Values in the Haw River (B4050000 and B4080000), Deep River (B6040300), Lick Creek (B6130500), Mainstem Cape Fear (B6160000 and B6215000), Buckhorn Creek (B6204000), and Avents Creek (B6230000).

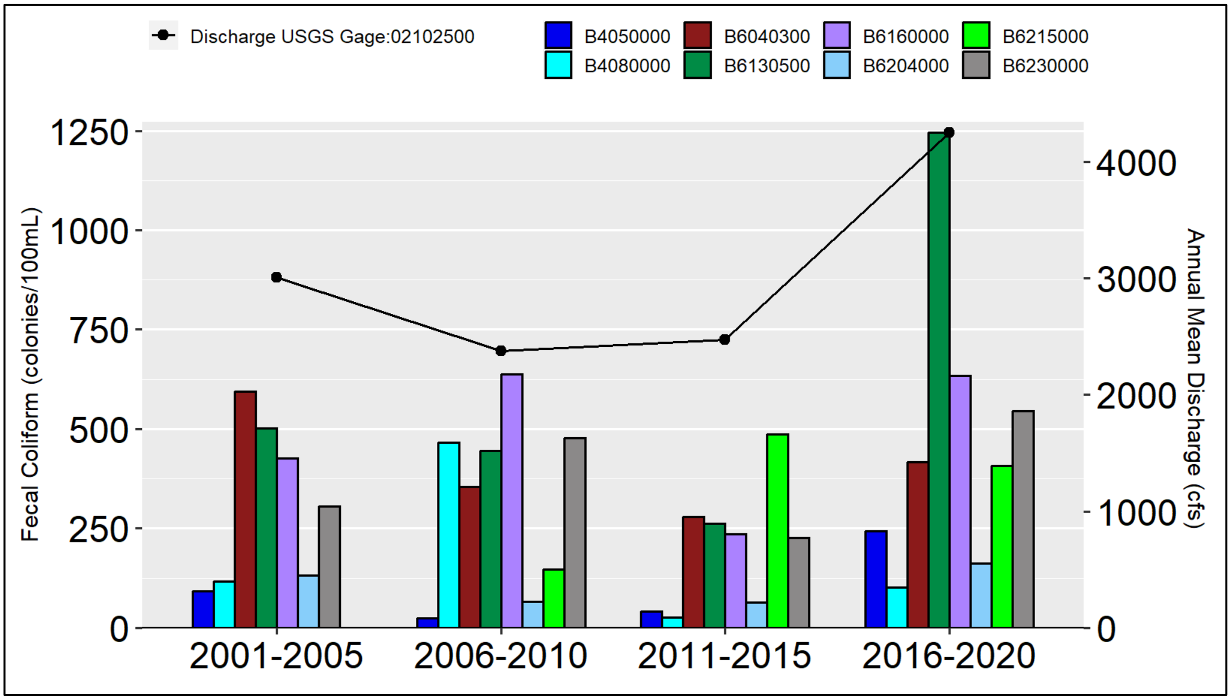
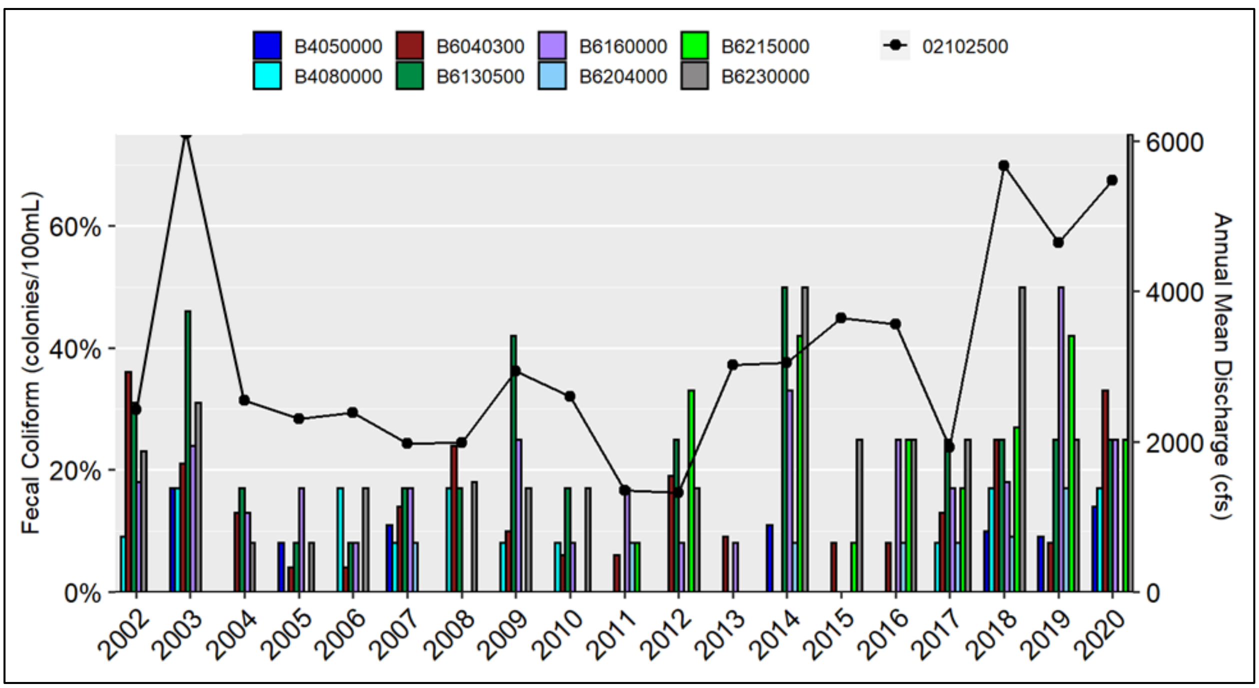
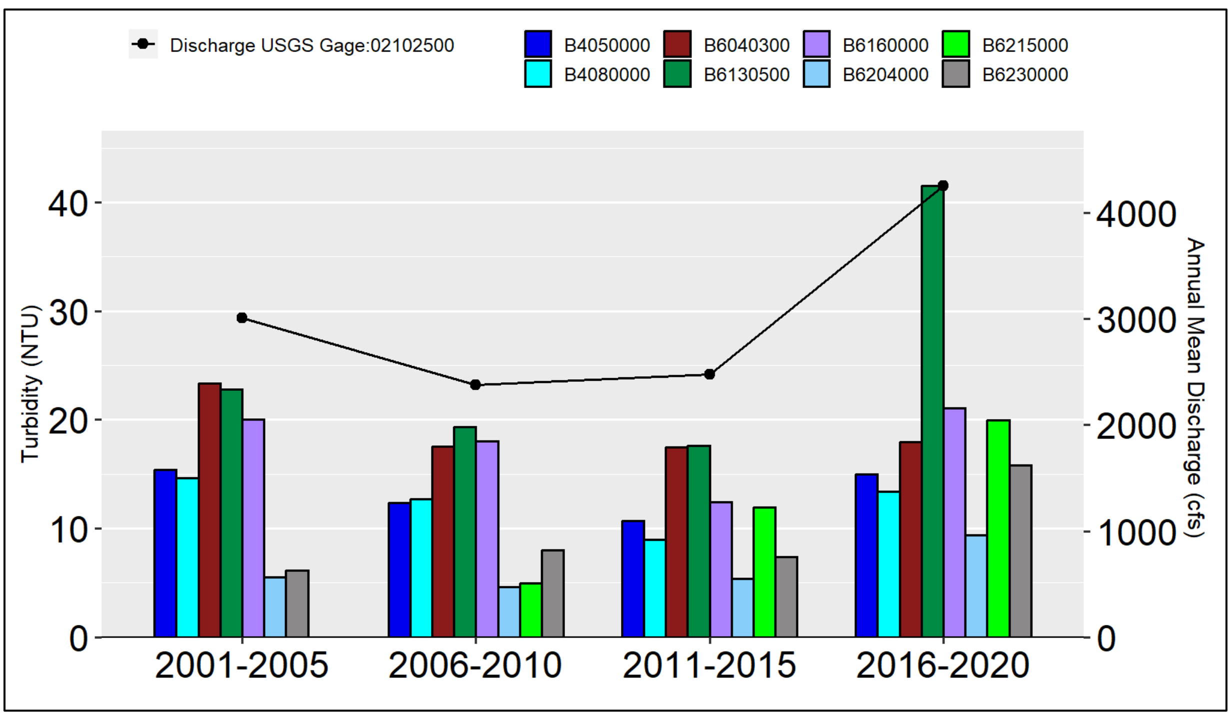


Figure 8-24: Annual Exceedance Rates for Fecal Coliform Bacteria Values in the Haw River (B4050000 and B4080000), Deep River (B6040300), Lick Creek (B6130500), Mainstem Cape Fear (B6160000 and B6215000), Buckhorn Creek (B6204000), and Avents Creek (B6230000) Based on a Water Quality Standard of 400 colonies/100 mL.



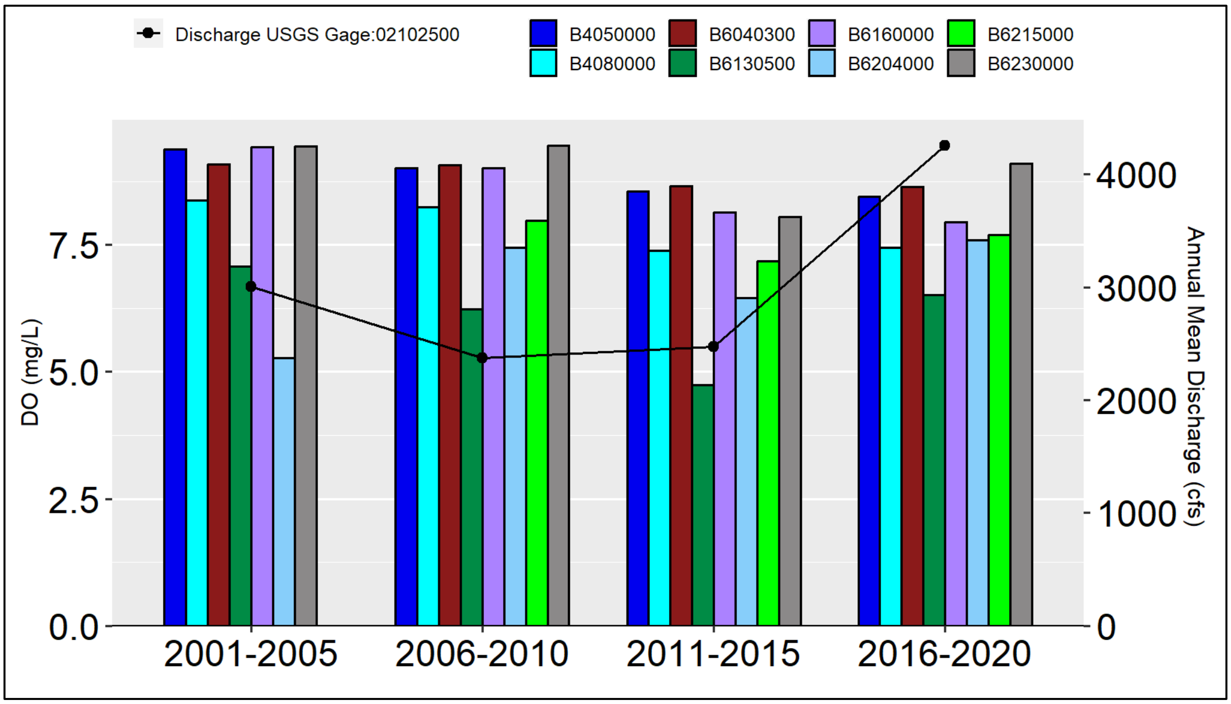
Turbidity concentrations in all the monitored waterways in the Buckhorn Creek–Cape Fear River watershed were relatively low compared to the water quality standard of 50 NTU. The exception to this is the surface water quality station on Lick Creek (B6130500) which recorded a 5-year average which approached this value between 2016-2020 (*Figure 8-25*). As noted previously Lick Creek [AU#: 18-4-(2)] is on the 2022 impaired waters list for exceeding the turbidity water quality standard. These elevated turbidity levels could be the result of nonpoint source pollution from increasing development in the area draining to the water quality monitoring station, forestry activities in the watershed, and/or runoff from agricultural lands stimulated by rainfall. Consistent with nonpoint source pollution impacts, most of the elevated turbidity levels recorded in Lick Creek coincide with elevated fecal coliform levels during the most recent five years on record (2016-2020) and varying levels of precipitation recorded at nearby precipitation monitoring stations. In addition to Lick Creek, as previously noted there has been considerable development in the areas draining to Harris Lake. As land use activities continue, *regular inspections of the BMPs to ensure compliance with sediment and erosion control measures in the watersheds and implementation of stormwater, forestry, and agricultural BMPs is needed to limit stormwater volume and sediments from reaching the streams draining to Lick Creek, Harris Lake, and ultimately the Cape Fear River.*

Figure 8-25: Five-year Mean Turbidity Values in the Haw River (B4050000 and B4080000), Deep River (B6040300), Lick Creek (B6130500), Mainstem Cape Fear (B6160000 and B6215000), Buckhorn Creek (B6204000), and Avents Creek (B6230000).



Overall, dissolved oxygen levels along the Cape Fear River were typically above the 5 mg/L water quality standard. Notably, Lick Creek (B6130500) and Buckhorn Creek (B6204000) had 5-year increments when the dissolved oxygen level fell below or approached the 5 mg/L water quality standard. Lick Creek has the lowest dissolved oxygen levels of all the monitored waterways in the Buckhorn Creek – Cape Fear watershed (*Figure 8-26*). Lick Creek [AU# 18-4-(2)] is on the 2022 impaired waters list for exceeding the 4 mg/L water quality standard. The sampling for dissolved oxygen on Lick Creek is quarterly and notably the lowest dissolved oxygen readings tend to occur during the summer (July) and fall (October) indicating lower flow conditions may influence the dissolved oxygen levels in Lick Creek. The low dissolved oxygen levels during the month of July have been recorded since at least 1998 with a value of 3.2 mg/L on 7/15/1998. _A natural conditions assessment might be warranted to determine whether these low dissolved oxygen levels are the result of natural conditions or anthropogenic influences._

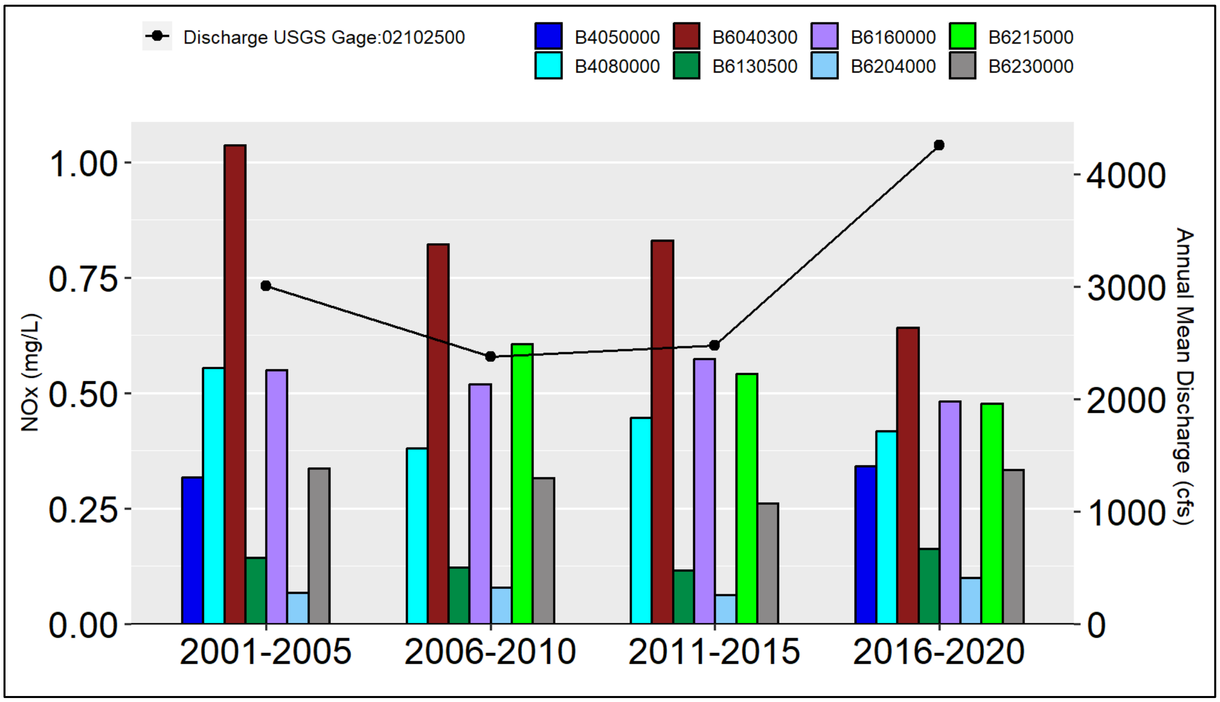
Figure 8-26: Five-year Mean Dissolved Oxygen Values in the Haw River (B4050000 and B4080000), Deep River (B6040300), Lick Creek (B6130500), Mainstem Cape Fear (B6160000 and B6215000), Buckhorn Creek (B6204000), and Avents Creek (B6230000).



Nitrate+nitrite concentrations in the Deep River (B6040300) were typically the highest of the monitored waterways in the Buckhorn Creek–Cape Fear watershed. See Chapter 7 for a more detailed discussion on the Deep River. While the Deep River has maintained the highest nitrate+nitrite concentrations, the 5-year average has progressively decreased from typical values of approximately 1 mg/L between 2001-2005 to values of approximately 0.64 mg/L collected between 2016-2020 (*Figure 8-27*). While stations along the Haw River (B4050000 and B4080000) and Cape Fear River (B6160000 and B6215000) record lower overall concentrations compared to the Deep River, the 5-year mean values continuously hovered around 0.5 mg/L, which is higher than the concentrations considered normal for healthy piedmont streams (<0.3 mg/L) (*Figure 8-27*). See Chapter 6 for a more detailed discussion on the Haw River. The adjoining tributaries, Lick Creek (B6130500), Buckhorn Creek (B6204000), and Avents Creek (B6230000) have nitrate+nitrite concentrations considered typical for healthy piedmont streams (*Figure 8-27*). Notably, of the three tributaries monitored in this watershed, Buckhorn Creek receives streamflow from

Harris Lake which as previously noted is a eutrophic lake that receives discharge from the Town of Holly Springs WWTP. Harris Lake processes the nitrate+nitrite concentrations while the water travels through the lake and overtime declining conditions have been observed. Along Buckhorn Creek there are no permitted facilities impacting the water quality therefore the concentrations observed in Buckhorn Creek are the result of impacts and processing through Harris Lake. One additional note regarding the nutrient levels observed in Buckhorn Creek is that there is no permitted minimum release therefore streamflow fluctuates which can result in higher or lower streamflow in Buckhorn Creek.

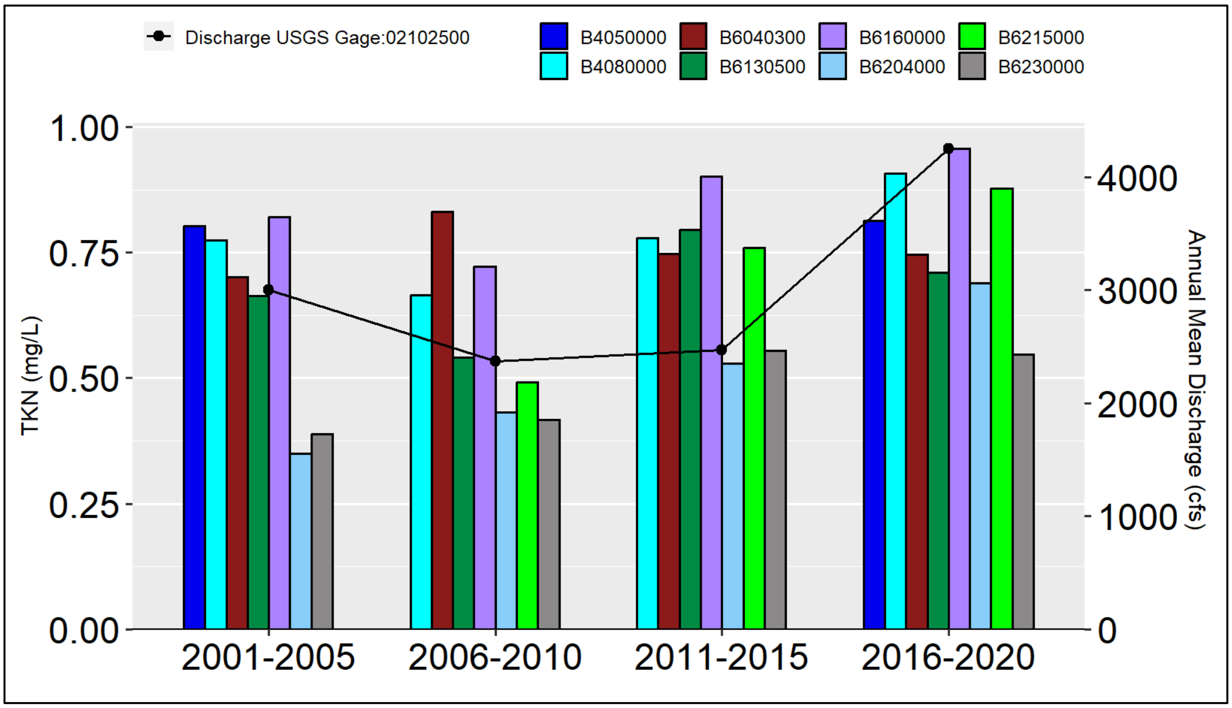
Figure 8-27: Five-year Mean Nitrate+Nitrite Values in the Haw River (B4050000 and B4080000), Deep River (B6040300), Lick Creek (B6130500), Mainstem Cape Fear (B6160000 and B6215000), Buckhorn Creek (B6204000), and Avents Creek (B6230000).



The total Kjeldahl nitrogen concentrations recorded in the Haw River (B4050000 and B4080000) are often higher than the concentrations coming from the Deep River (B6040300); except during the 2006-2010 period (*Figure 8-28*). The combination of these two major waterways coming together and additional contributions from Lick Creek appear to drive the sustained total Kjeldahl nitrogen concentrations along the upper section of the Cape Fear River (B6160000). The total Kjeldahl nitrogen concentrations in the mainstem Cape Fear River typically decrease as the waterway is monitored from upstream (B6160000) to downstream (B6215000), however, the 5-year averages have generally increased over time since 2001 (*Figure 8-28*). Higher total Kjeldahl nitrogen concentrations were recorded at the station behind Buckhorn Creek (B6160000) and the 2016–2020 time frame was the highest 5-year average since 2001. The adjoining tributaries of the mainstem Cape Fear River in the Buckhorn Creek-Cape Fear River watershed often have the lowest 5-year average concentrations. One notably concern is the increasing 5-year averages recorded at the station in the Buckhorn Creek (B6204000) which have nearly doubled between 2001 and 2020 most likely as a result of biological productivity in Harris Lake (*Figure 8-28*). The mainstem Cape Fear River (B6204000) downstream from the Buckhorn Creek confluence has increasing total

Kjeldahl nitrogen concentrations (*Figure 8-28*). Similar to total Kjeldahl nitrogen, the ammonia concentrations from the Haw River (B4050000 and B4080000) are often higher than the concentrations coming from the Deep River (B6040300) and sustained throughout the mainstem Cape Fear River through to station B6215000 (*Figure 8-29*). The ammonia concentrations recorded in the Haw River and behind Buckhorn Dam (B6160000) are occasionally higher than concentrations considered normal for healthy piedmont streams ($\leq$ 0.05 mg/L).

Figure 8-28: Five-year Mean Total Kjeldahl Nitrogen Values in the Haw River (B4050000 and B4080000), Deep River (B6040300), Lick Creek (B6130500), Mainstem Cape Fear (B6160000 and B6215000), Buckhorn Creek (B6204000), and Avents Creek (B6230000).



Total nitrogen concentrations follow a similar profile as the nitrate+nitrite concentrations with the Deep River (B6040300) often having the highest total nitrogen concentrations. Interestingly, the total Kjeldahl nitrogen concentrations recorded in the mainstem Cape Fear River (B6160000 and B6215000) are elevated relative to the contributing rivers including Lick Creek (B6130500), Buckhorn Creek (B6204000), and Avents Creek (B6230000) (*Figure 8-28*). This could be a result of conversion of inorganic nitrogen to organic forms of nitrogen through biological growth. This has resulted in the total nitrogen signature for the mainstem Cape Fear reaching comparable levels with the Deep River even though the predominant form of nitrogen is different between these two waterways (*Figure 8-28*).

Figure 8-29: Five-year Mean Ammonia Values in the Haw River (B4050000 and B4080000), Deep River (B6040300), Lick Creek (B6130500), Mainstem Cape Fear (B6160000 and B6215000), Buckhorn Creek (B6204000), and Avents Creek (B6230000).

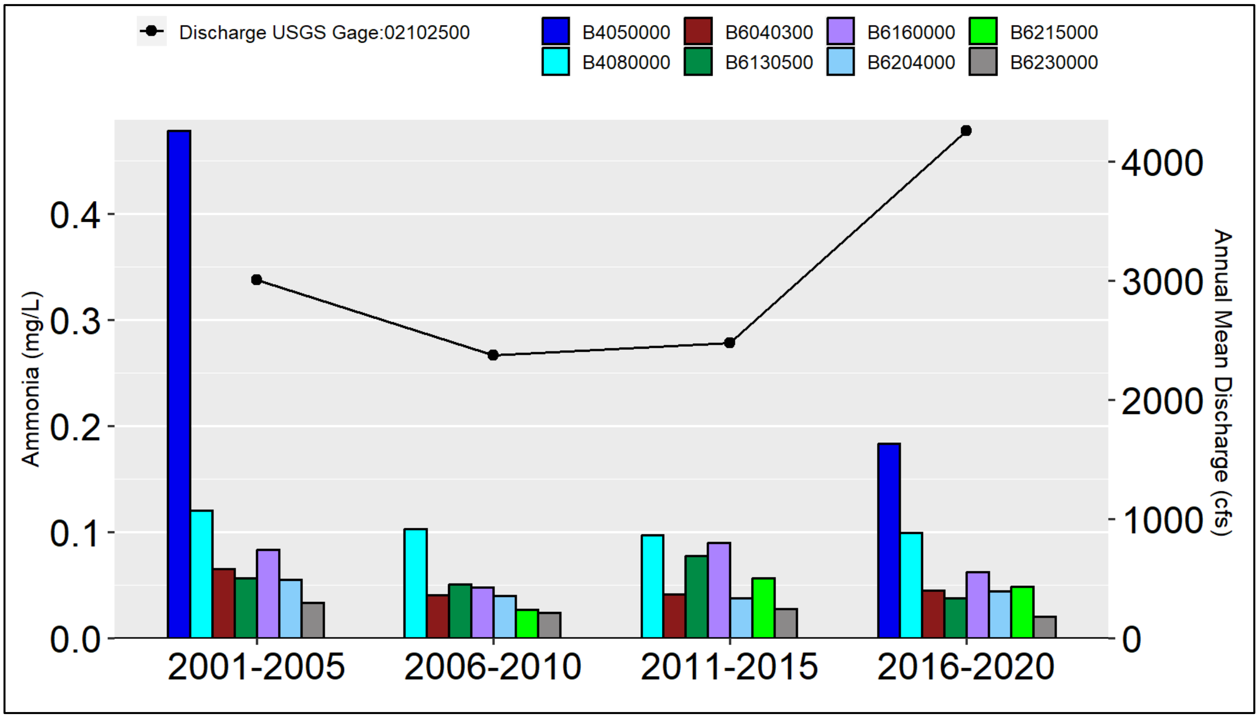
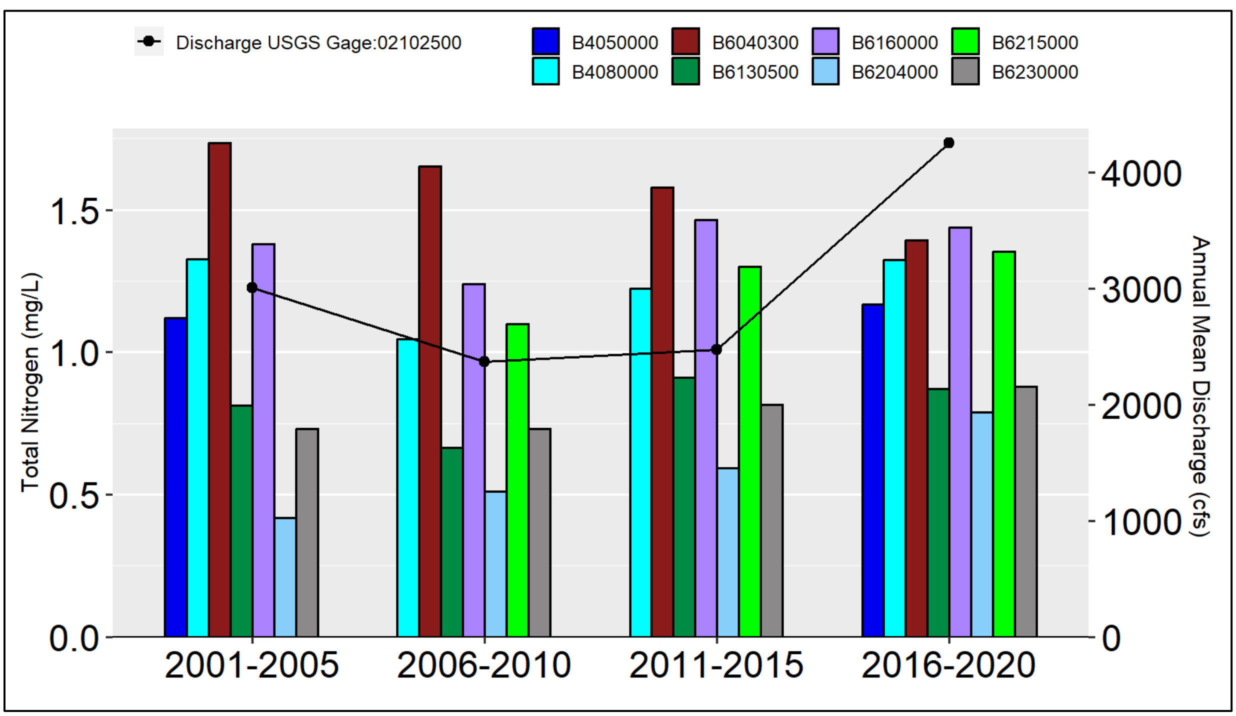
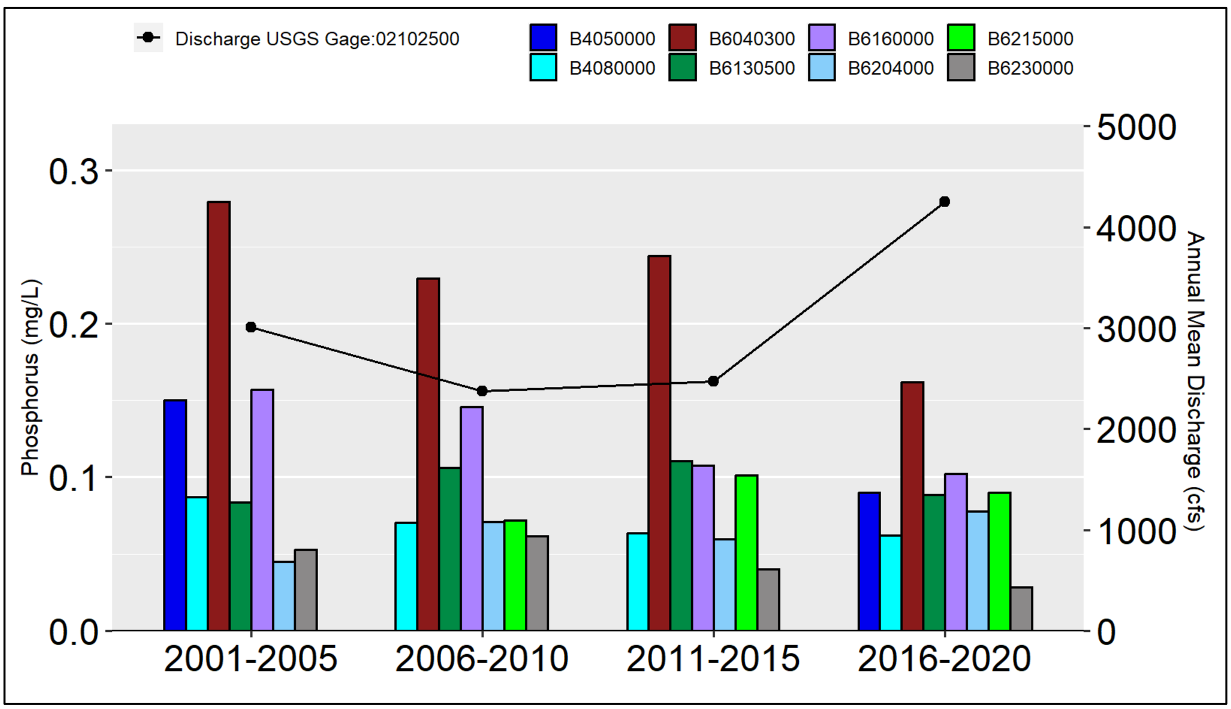


Figure 8-30: Five-year Mean Total Nitrogen Values in the Haw River (B4050000 and B4080000), Deep River (B6040300), Lick Creek (B6130500), Mainstem Cape Fear (B6160000 and B6215000), Buckhorn Creek (B6204000), and Avents Creek (B6230000).

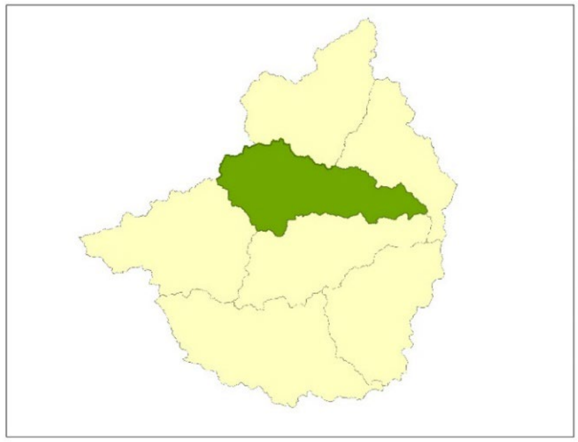


The total phosphorus concentrations are elevated above concentrations considered normal for healthy piedmont streams (≤ 0.05 mg/L) in the Deep River (B6040300), Lick Creek (B6130500), and the mainstem Cape Fear (B6160000 and B6215000). While it is unclear why the total phosphorus concentrations in Lick Creek are elevated; however, nonpoint sources of pollution including agriculture, land application fields, and sediment-bound or legacy phosphorus are most likely contributing as Lick Creek since this waterway does not have any point source dischargers. Notably, the concentrations recorded in the Haw River (B4050000 and B4080000), Buckhorn Creek (B6204000), and Avents Creek (B6230000) typically hover around the concentrations considered normal for healthy piedmont streams. Buckhorn Creek and Avents Creek typically record the lowest 5-year mean values for waterways in the Buckhorn Creek – Cape Fear watershed (*Figure 8-31*). The relatively low total phosphorus concentrations recorded in Buckhorn Creek are mostly likely an indication that Harris Lake is processing the total phosphorus loads delivered to the lake ultimately converting it into biological growth as mentioned previously. See Chapter 6 for a more detailed discussion on the Haw River.

Figure 8-31: Five-year Mean Total Phosphorus Values in the Haw River (B4050000 and B4080000), Deep River (B6040300), Lick Creek (B6130500), Mainstem Cape Fear (B6160000 and B6215000), Buckhorn Creek (B6204000), and Avents Creek (B6230000).



8.7.2 Upper Little River Watershed (0303000402)



Upper Little River is the sole drainage in this watershed and has a DA of 220 mi^2. The lower segment of the river [AU#: 18-20-(24.5)] is within the Protected Area for Dunn's water supply intake and classified WS-IV. The first 1,300 feet of the lower segment from the Cape Fear River is within the Critical Area for Dunn's water supply intake. The middle segment of the river [AU#: 18-20-(8)] is classified as C. The upper segment [AU#: 18-20-(1)] is classified as B. The eastern half of the watershed does not have high-density urban areas but is a patchwork of forested and agricultural fields. Overall forested land comprises 41.3% of this watershed. The more densely developed areas are in the western half of the watershed. Developed land is approximately 12.5% of the watershed. Along the southern boundary near Ft. Liberty there are a number of high-density residential developments in the Barbecue Creek drainage. In the northwest area of southern Sanford there is strip mall development, upstream of Lake Trace. However, agricultural fields and forested areas still predominate. Agricultural lands are 21.6% of the land cover in this watershed. Wetlands (12.6%), grassland and shrub (9.5%), barren land (0.8%), and open water (1.6%) are the remaining land covers in this watershed.

As of May 2022, there is just one minor NPDES wastewater discharge facility permitted for 0.68 MGD; five AFOs (one Animal Individual State and four Swine Certificates of Coverage) permitted for 28,776 head with 4.26 million pounds live weight; 12 acres of residual solids land-application and non-discharge reclaimed water fields; 16 NPDES and 26 state stormwater facilities. There is also one single-family NPDES permit in this watershed. See Chapter 3 Appendix for a list of permits.

As reported in the 2022 IR there are no impaired waterways in this watershed; however, mildly stressed biological communities (fish and benthos) in Little Rocky Run Creek [AU#: 18-20-16-1] and Barbecue [AU#: 18-20-13] creeks, low pH in the Upper Little River [AU#: 18-20-(24.5)], and Mirex—a persistent organochlorine pesticide and flame retardant--in Carrs Creek [AU#: 18-20-7] were parameters categorized as Data Inconclusive. The typical reason for such a category is the number of samples not greater than nine during the 5-year sampling window.

BB209	
Year	**Bioclassification**
2005*	Good-Fair
BB484	
2007*	Not Impaired
BF125	
2008	Good-Fair
BB544	
2017*	Good
*Special Study	

Benthic macroinvertebrate community sampling has occurred in several waterways in the Upper Little River watershed; however, resampling has not occurred for many of them. The benthic macroinvertebrate community on Little Rocky Run Creek [AU#: 18-20-16-1] at station BB209 was last sampled in 2005 at the SR 1128 bridge crossing with a DA of 0.3 mi^2 and received a Good-Fair rating. An unnamed tributary of the Upper Little River [AU#: 18-20-(8)aut5] was last sampled in 2007 at station BB484 near SR 1279 with a DA of 0.9 mi^2 and was deemed Not Impaired. In 2008, the fish community in Barbecue Creek [AU#: 18-20-13] was sampled at station BF125 near SR 1285 with a DA of 30.9 mi^2 and received a Good-Fair rating.

The Carrs Creek [AU#: 18-20-7] benthic community was sampled once in 2017 at station BB544 near the US 421 bridge crossing with a DA of 1.2 mi^2 and received a Good rating.

8.7.2.1 Upper Little River

As mentioned previously, the Upper Little River [AU#: 18-20-(1), 18-20-(8)a, 18-20-(8)b, and 18-20-(24.5)] has several classifications for the best intended uses of the Upper Little River. The upper reaches from the source to the dam at Lake Trace is a Class B waterway. This is followed by a Class C waterway from dam at Lake Trace to a point 0.6 mile downstream of Juniper Branch. The last stretch of the Upper Little River is Class WS-VI from a point 0.6 mile downstream of Juniper Branch to Cape Fear River.

The benthic macroinvertebrate community monitoring on the Upper Little River [AU#: 18-20-(8)b] at station (BB261) is the only station that has been resampled over time in the Upper Little River watershed. This station has been resampled eight times between 1988 and 2018. It has received a Good-Fair rating each time; except for 2013 when the EPT method was used and recorded a Poor bioclassification. This suggests that conditions at this location are stable. The present survey was conducted later in the year than any previous samples and differences in faunal composition may be the result of seasonal turnover. However, the general trend for this location is slightly negative with species richness declining and EPTBI (a measure or pollution tolerance) increasing.

BB261	
Year	**Bioclassification**
2003	Good-Fair
2008	Good-Fair
2013[1]	Poor
2015	Good-Fair
2018	Good-Fair
[1]EPT method used instead of typical Full Scale method	

The Upper Little River has several adjoining tributaries, including Juniper Creek, Barbecue Creek, Carrs Creek, and Little Rocky Run Creek. The MCFBA monitors two water quality stations on the Upper Little River-- one near Broadway (B6820050) and one near Lillington (B6830000). These two surface water quality monitoring stations typically record low pH, turbidity, and fecal coliform bacteria levels as indicated by the annual median and mean values (*Figure 8-32*, *Figure 8-33,* and *Figure 8-34*). Notably in 2020, annual mean fecal coliform bacteria levels exceeded the 400 colonies/100 mL water quality standard and turbidity was slightly elevated.

The pH recorded along the entire length of the Upper Little River is lower than other waterways in the Cape Fear River Basin; except the Little River and Rockfish Creek which are discussed later in this chapter. The exact cause and source of these lower pH values is unclear; however, it has been noted that the low buffering capacity of sandy soils and the potential influence of conifer trees could impact flow-through pH in the Upper Little River although this is an active area of research. Other factors (acidic soils, sulfur-bearing minerals, human influence, or other) may have an influence on the lower pH of the Upper Little River. Currently there are no North Carolina Sandhills specific studies, or conflicting information, to definitively support these two phenomena, although they could exist. *A natural conditions assessment might be warranted to determine whether these low pH levels are the result of natural conditions or anthropogenic influences.*

Between 2008 and 2020, annual mean nutrient concentrations (phosphorus and total nitrogen) were elevated in the upstream monitoring station (B6820050) relative to the downstream monitoring station (B8630000) (*Figure 8-35* and *Figure 8-36*). Both total nitrogen and phosphorus values at the upstream monitoring station were typically greater than concentrations considered normal for healthy piedmont streams (TN 0.8 mg/L; TP 0.05 mg/L). These elevated nutrient concentrations could be the result of both point and nonpoint sources of pollution cumulatively impacting the Upper Little River. The watershed is composed of developed land and agricultural land, which both have the potential to contribute nutrients through nonpoint source pollution, in addition to the Carolina Trace WWTP, which has an as-built flow of 675,000 gpd discharging into the Upper Little River.

The annual mean nitrate+nitrite concentrations typically hover around the concentrations considered normal for health piedmont streams (0.3 mg/L) often with higher concentrations at the upstream station (B6820050) compared to the downstream station (B6830000) (*Figure 8-37*). Similarly, annual mean total Kjeldahl nitrogen concentrations were often higher at the upstream compared to the downstream (*Figure 8-38*). Ammonia concentrations at the upstream station (B6820050) were also higher than the downstream station (B6830000) with concentrations elevated above levels considered normal for healthy piedmont streams (0.05 mg/L) (*Figure 8-39*). In addition to the two regularly sampled surface water quality monitoring stations, there was one temporary monitoring station (B6750000) that was sampled for two years. This station recorded low nutrient (total nitrogen and phosphorus) concentrations and turbidity levels; however, Mirex was categorized as Data Inconclusive in the 2022 IR.

DWR conducted screening-level Mann-Kendall trend seasonal tests for ammonia and total phosphorus that both displayed a significant decline for station B6830000 calculated at 95% confidence from data collected from 2000-2019. Total Kjeldahl nitrogen, nitrate+nitrite, as well as specific conductance at station B6830000 displayed a significant increase during this same time frame.

Figure 8-32: Annual Median pH Values in the Upper Little River (B6820050 and B6830000).

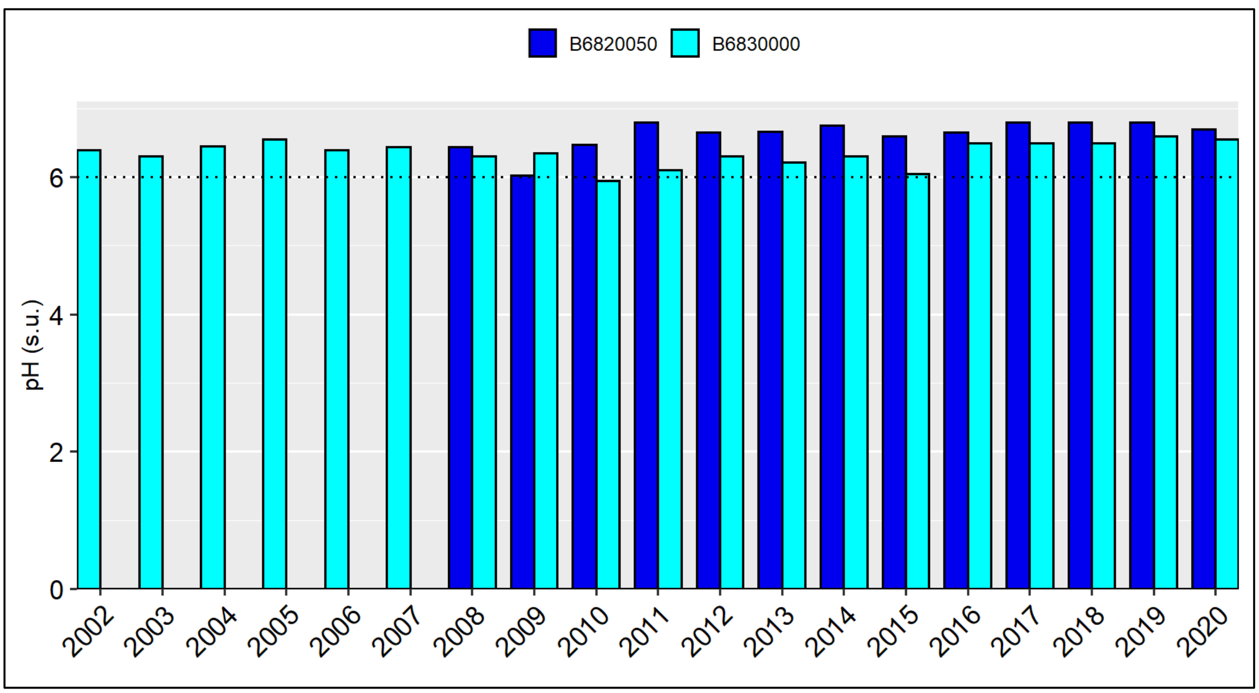


Figure 8-33: Annual Mean Turbidity Values in the Upper Little River (B6820050 and B6830000).

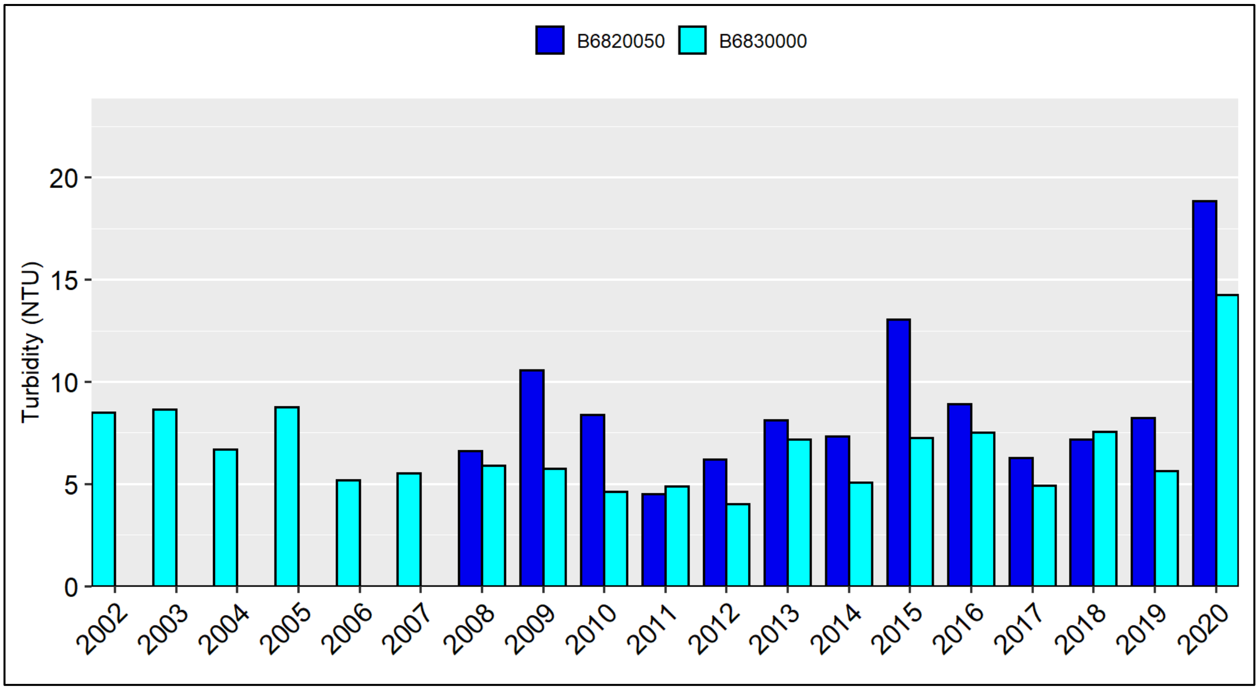


Figure 8-34: Annual Mean Fecal Coliform Bacteria Values in the Upper Little River (B6820050 and B6830000) with a Reference Line for the Water Quality Standard of 400 colonies/100 mL.

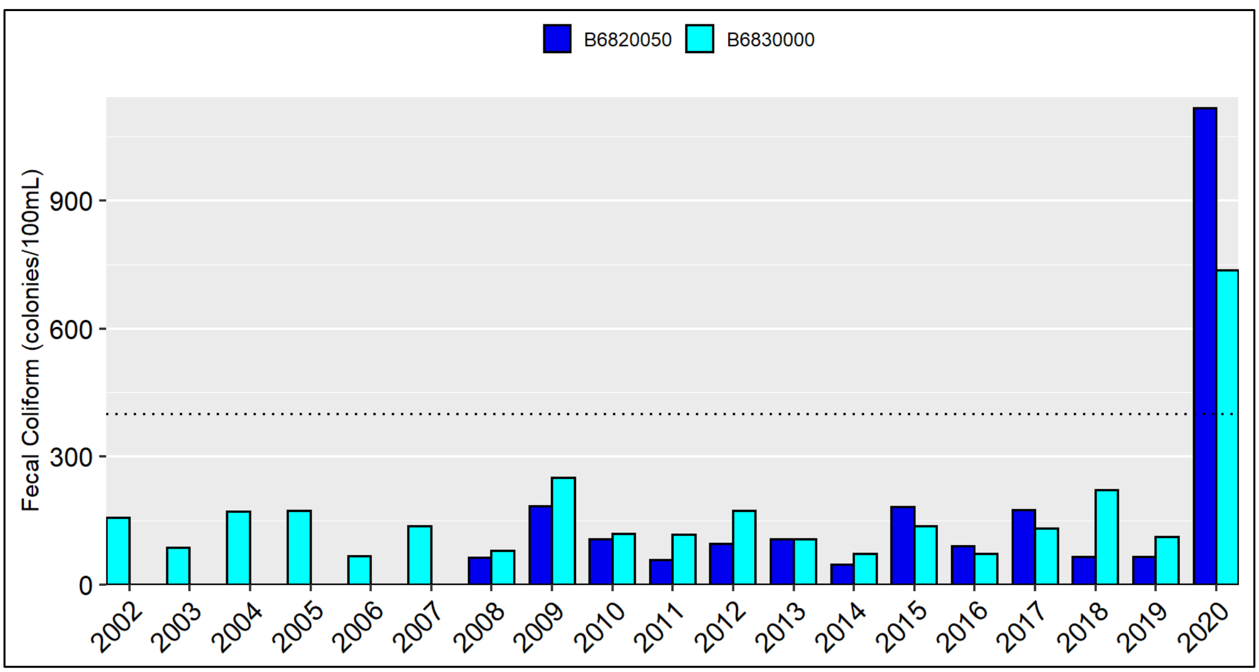


Figure 8-35: Annual Mean Total Phosphorus Values in the Upper Little River (B6820050 and B6830000).

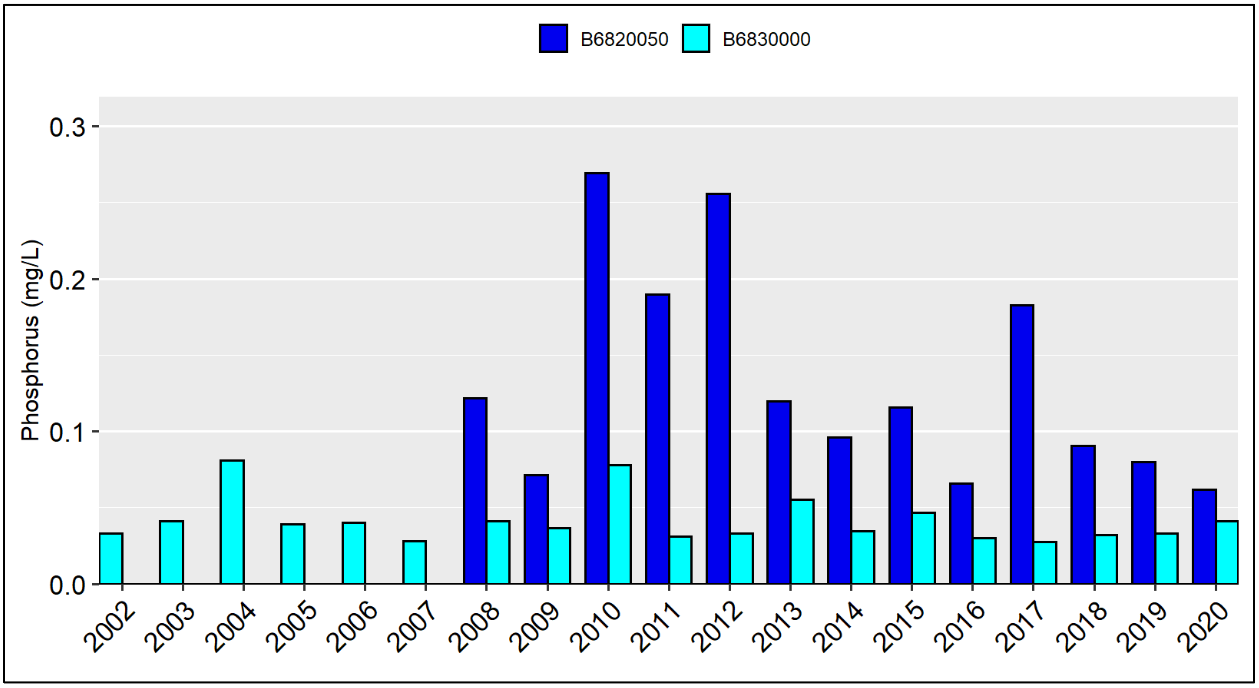


Figure 8-36: Annual Mean Total Nitrogen Values in the Upper Little River (B6820050 and B6830000).

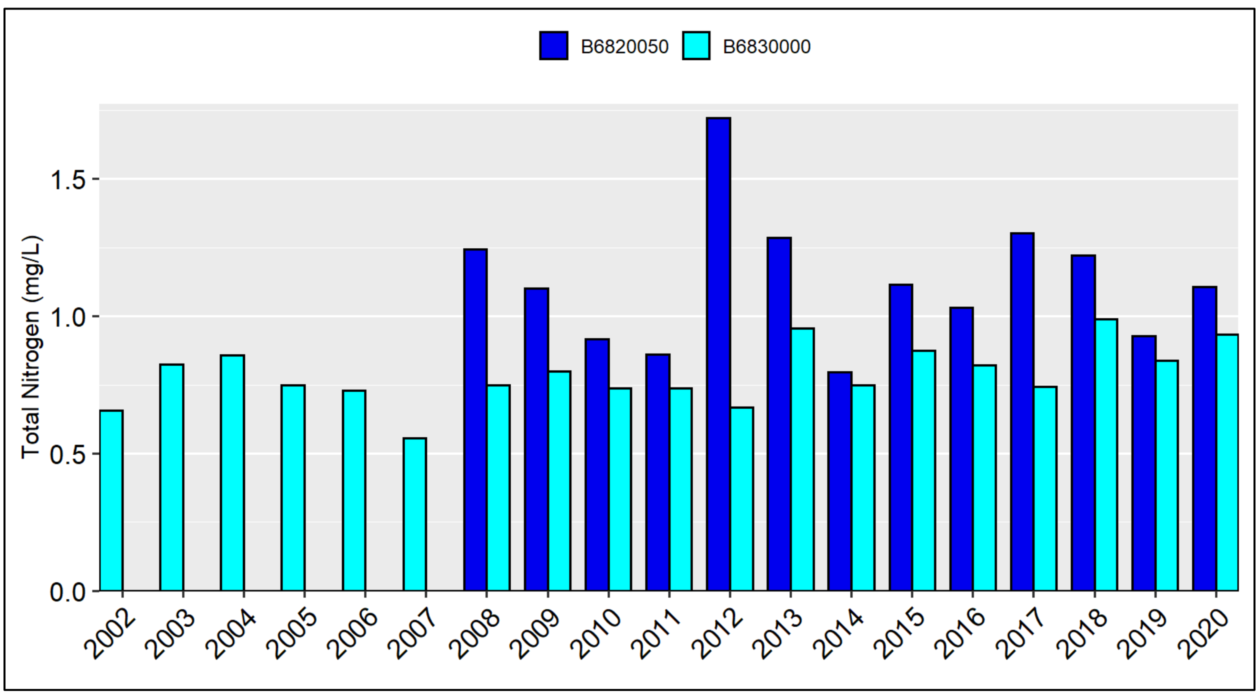


Figure 8-37: Annual Mean Nitrate+Nitrite Values in the Upper Little River (B6820050 and B6830000)

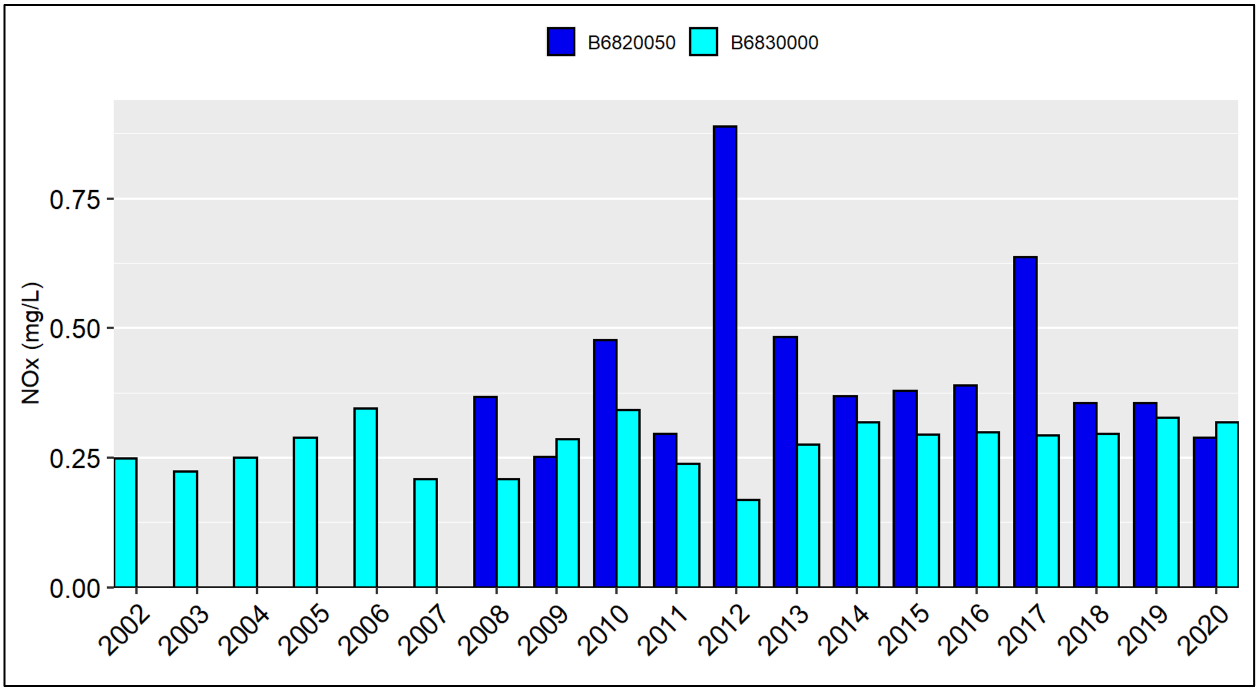


Figure 8-38: Annual Mean Total Kjeldahl Nitrogen Values in the Upper Little River (B6820050 and B6830000).

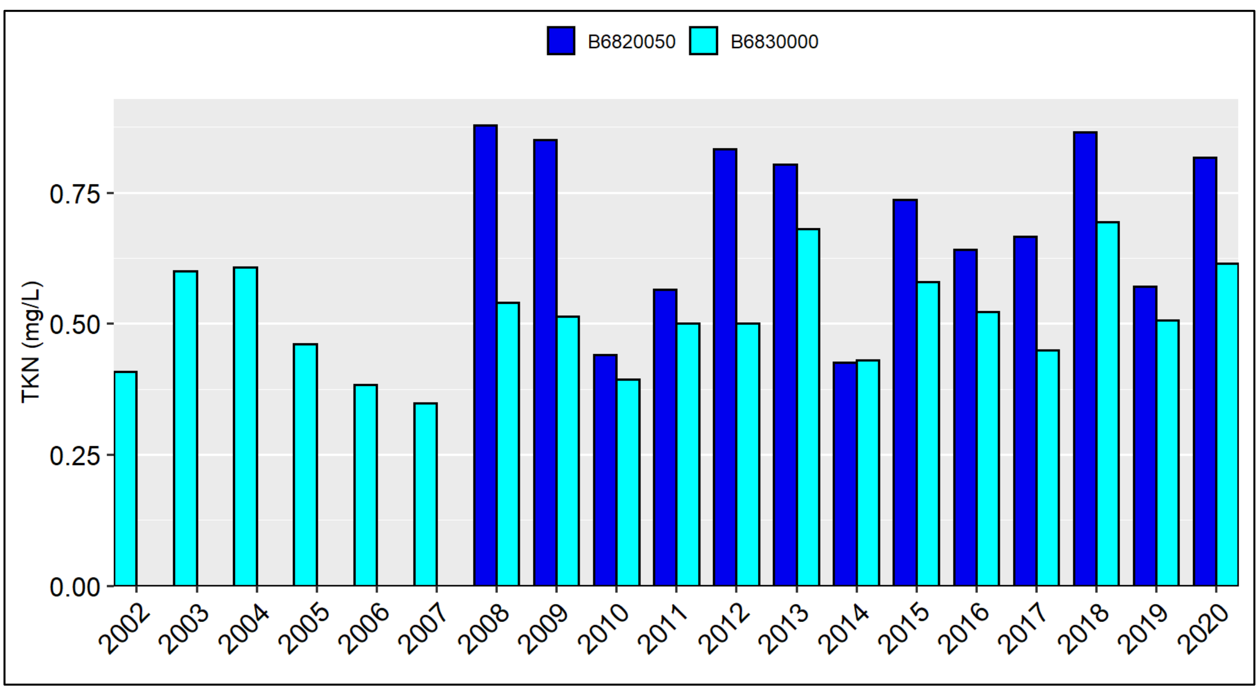
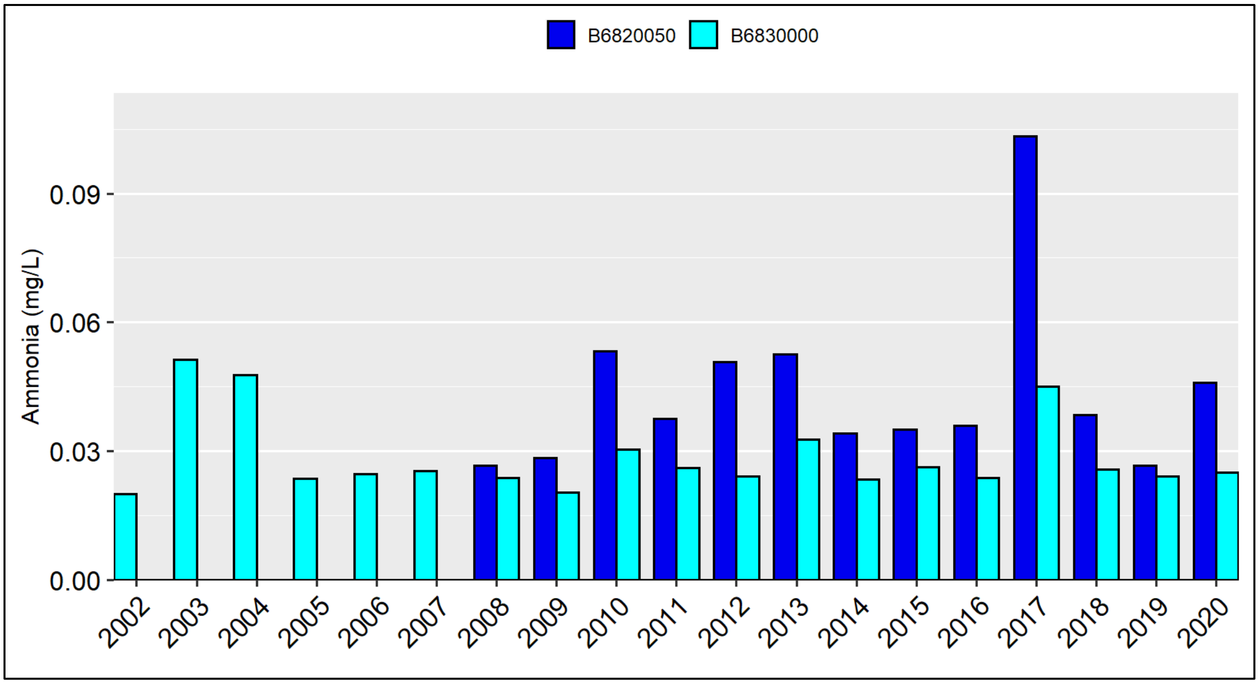
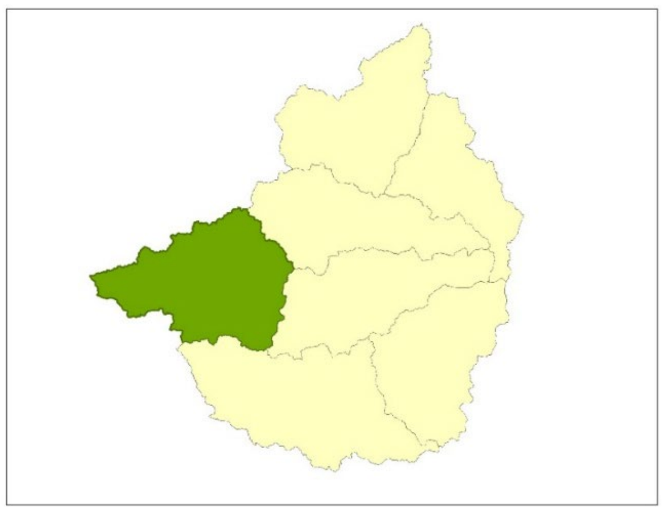


Figure 8-39: Annual Mean Ammonia Values in the Upper Little River (B6820050 and B6830000).



8.7.3 Headwaters Little River Watershed (0303000403)

The Headwaters Little River drainage area is 262 mi^2. The Headwaters Little River watershed is primarily composed of forest land (49.3%) along the headwaters of the Little River and tributaries. Developed land (14.8%) is also prevalent in this watershed primarily along the midstream and downstream tributaries. The remaining land covers are a mixture of wetlands (11.3%), agriculture (11.3%), grassland and grassland/shrub (10.7%), barren land (1.3%) and open water (1.3%). The watershed contains more than a dozen golf courses.



The land use in the eastern part of the watershed is primarily forested, including a northern section of Ft. Liberty, which includes portions of some of the large barren landing zones. Moving to the western portion of the watershed, a greater proportion of land use is agricultural to the north and more urban to the south, draining the northern portions of Southern Pines and Pinehurst. Rivers and streams in this watershed all classified as water supply (WS-III) and several of the waterways, including the Little River, Mill Creek, McDeeds Creek, and Thagards Lake, are classified as high quality waters (HQW). McDeeds Creek, and all its tributaries, are classified with the "@" symbol. The "@" symbol means that if the governing municipality has deemed that a development is covered under a “5/70 provision," where five percent of its jurisdiction in the watershed is outside of the water supply critical area is allowed new development up to 70% built-upon area, then the development is exempt from certain stormwater requirements (15A NCAC 02B .0311 (m)).

While this section discusses many of the rivers and streams including the Little River, Crane Creek, Mill Creek, and Nicks Creek that flow through the Headwaters Little River watershed, many tributary stations were sampled only once and have not been resampled recently due to staff limitations. This limits the interpretations of water quality in several waterways; however, their information is discussed with a recommendation to resample the stations as time and resources allow.

As of May 2022, there are just two minor NPDES wastewater discharge facilities permitted for 0.51 MGD; two swine AFOs permitted for 5,752 head count with 1.25 million pounds live weight; seven NPDES and 33 state stormwater facilities. See Chapter 3 Appendix for a list of permits.

This watershed contains a portion of the Sandhills physiographic region within the Atlantic Coastal Plain ecoregion. The downstream boundary of this watershed is the confluence of Crane Creek and Little River and has a drainage area of 262 mi^2. The watershed drains the downtown area of the Town of Southern Pines, as well as Vass, Cameron, West End, Seven Lakes, and Whispering Pines. The watershed also covers some of the northern areas of Ft. Liberty, including three of the barren landing zones. The Weymouth Woods Sandhills Nature Preserve is also in the watershed. This nature preserve is part of the state park program and is 915 acres in size.

A number of parcels in the watershed have “safe harbor agreements” with the USFWS. A safe harbor agreement (SHA), implemented as federal policy in 1999, allows the landowner to perform habitat management activities toward the enhancement, restoration or maintenance of endangered species without fear of land-use restrictions resulting from successful management practices. The landowner is allowed the use of their property, as well as the incidental take of targeted species. The SHA is most likely associated with long-leaf pines used by the red-cockaded woodpeckers for nest cavities. https://www.federalregister.gov/d/2022-04018/p-13

In 2021, the Walthour-Moss Foundation put 3,946 acres of longleaf pine forest northeast of Southern Pines in southern Moore County into conservation easement under the USFS’s Forest Legacy Program. There are two parcels with mitigation conservation easements along Little River between the James Creek and Griffin Lake confluences. There are two parcels with mitigation conservation easements, as well as SHA, along Little River between the Griffin Lake and Mill Creek confluences. There are two parcels, one owned by the Sandhills Area Land Trust (SALT), with mitigation conservation easements along Little River between the Mill Creek and Ponds Branch confluences. SALT also owns two parcels with conservation easements just upstream of Wads Creek that are on or adjacent to the Little River Golf Course. The Land Trust for Central NC owns a parcel with a conservation easement that encompasses the Little River just upstream of US 15-501.

There are no impaired waters in the Headwaters Little River watershed. There are several waterways are considered Data Inconclusive for fish community including James Creek [AU#: 18-23-13] (BF17), Flat Creek

[AU#: 18-23-15] (BF1), Cypress Creek [AU#: 18-23-16-10] (BF25), Herds Creek [AU#: 18-23-16-3] (BF7), and Beaver Creek [AU#: 18-23-16-8] (BF49). Many of these fish community stations were last sampled in either 2002 or 2008. These waterways received a rating of Good-Fair or better rating, except Beaver Creek, which had a fish community that rated as Fair in 2008.

The benthic macroinvertebrate community data in James Creek (BB500), Cypress Creek (BB236), Herds Creek (BB117), Beaver Creek (BB332), Little Cane Creek (BB118 and BB191), and Muddy Creek (BB502) were last collected in either 2002, 2003 or 2008. These waterways all received ratings of Good, Good-Fair, Not Impaired or Excellent. Only Little Cane Creek [AU#: 18-23-16-4a] was assessed as Data Inconclusive for benthic macroinvertebrates. It is unclear whether these waterways have improved or declined since resampling has not occurred. Notably Nicks Creek's benthic macroinvertebrate community, discussed later in this section, has declined over time. As time and resources allow, *the Division of Water Resources should evaluate the waterways in the Headwaters Little River watershed to determine where resampling could occur with emphasis on resampling the fish community in Beaver Creek since it last rated as Fair and the benthic macroinvertebrate community in Nicks Creek since it has declined overtime*.

BF17		BB500	
Year	**Bioclassification**	**Year**	**Bioclassification**
2003	Good	-	-
2008	Excellent	2008*	Excellent
BF25		**BB236**	
2002	Good-Fair	2002*	Not Impaired
BF7		**BB117**	
2002	Good	2002*	Not Impaired
BF49		**BB332**	
2002	Good-Fair	2002*	Good-Fair
2008	Fair		
BB118		**BB191**	
2003*	Good-Fair	2003*	Good
BB502			
2008*		Excellent	
*Special Study			

8.7.3.1 Nicks Creek

Nicks Creek from the source to the Little River runs 12.23 miles [AU#: 18-23-3-(0.5); 18-23-3-(1.5); and 18-23-3-(3)]. This waterway is rated Data Inconclusive for fish community (BF3) after receiving a Good-Fair rating in 2003 [AU#: 18-23-3-(3)]. The benthic macroinvertebrate community station (IB109) in a headwater unnamed tributary to Nicks Creek was sampled in 2006 receiving a Not Rated rating. Downstream from this station on Nicks Creek, another benthic macroinvertebrate community monitoring station (BB111) was sampled five times between 1988 and 2013. The first three samples received a Good rating while the last two received Good-Fair ratings. The change in rating is primarily due to less EPT taxa bring present in the waterway with a shift from greater than 20 EPT taxa collected in 1988, 1993, and 1998 to 15 EPT taxa collected in 2003 and 2013. Based on aerial imagery between 1999 and 2005, the Nicks Creek Greenway was developed and runs parallel to Nicks Creek. This development may have impacted the benthic macroinvertebrate community directly downstream by changing the substrate. The substrate was significantly altered between the 1998 and 2003 sampling efforts. The substrate shifted from primarily a gravel, sand, and/or cobble substrate between 1988 and 1998 to a primarily sand and gravel substrate in 2003, followed by a primarily boulder and gravel substrate in 2013. While the transition from a predominantly sand substrate to a more

BF3	
Year	**Bioclassification**
2003	Good-Fair
IB109	
2006	Not Rated
BB111	
2003	Good-Fair
2013	Good-Fair

heterogeneous substrate between 2003 and 2013 is most likely the result of the installation of stream restoration projects, the benthic macroinvertebrate community has continued to report relatively low EPT taxa during sampling. *Continued efforts to reduce erosion, create pool and riffle stream habitat, and monitor the benthic macroinvertebrate community at station BB111 where highway 22 crosses Nicks Creek may help promote their recovery at this location.*

8.7.3.2 Little River (Lower Little River) and Thagards Lake

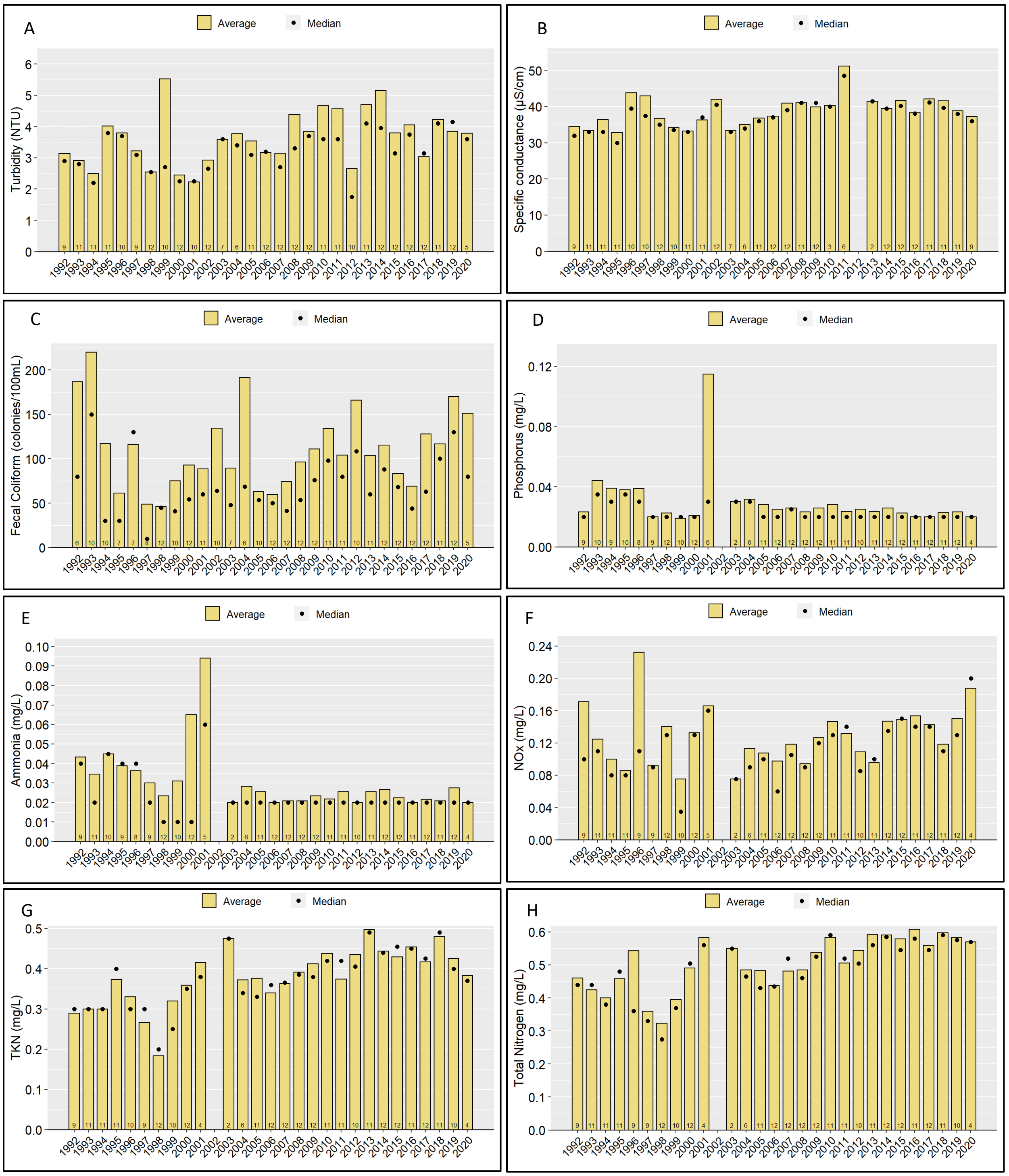
Little River from the source to the confluence with Crane Creek flows 32.17 miles [AU#: 18-23-(1), 18-23-(8), 18-23-(10.3), and 18-23-(10.7)]. This does not include the 203.8 ac that comprise Thagards Lake [AU#: 18-23-(5)]. This length of the Little River is classified as water supply (WS-III) and high quality waters (HQW), which protects drinking water and waters with excellent water quality. Thagards Lake has an additional stream classification for use as primary recreation (Class B). There is one surface water quality monitoring station (B7245000), one fish community monitoring station (BF004), and one benthic macroinvertebrate community monitoring station (BB352) sampled between 2002 and 2020 along the Little River. Notably, the surface water quality monitoring station is co-located with the benthic monitoring station located upstream of the confluence with James Creek on the Little River [AU#: 18-23-(10.7)]. The fish community monitoring station is in the headwater of the mainstem Little River [AU#: 18-23-(1)]. The Little River was rated “Data Inconclusive” for fish community and pH.

The fish community station (BF4) was last sampled in 2008, recording a Poor rating, which is a significant decline from the 2003 rating of Excellent. This significant change is most likely attributed to nonpoint source pollution, changes in stream habitat, or impacts from lower streamflow. There are no NPDES dischargers in the Little River drainage area upstream of this monitoring station. Downstream from this fish community monitoring station is the co-located water quality and benthic stations. In 2018, the benthic macroinvertebrate community received a bioclassification rating of Excellent. The station was sampled 10 times between 1988 and 2018 and received an Excellent rating each time except during periods of drought, affecting the stream in 2002-2003. In 2002, it received a Good-Fair rating and in 2003 and 2013, this station received a Good rating.

BF4	
Year	**Bioclassification**
2003	Excellent
2008	Poor
BB352	
2002*	Good-Fair
2003*	Good
2004*	Excellent
2008*	Excellent
2013	Good
2018	Excellent
*Special Study	

Overall, conditions at the one water quality monitoring station in the Little River (B7245000) have remained relatively clear with typically low turbidity (*Figure 8-40A*), specific conductance (*Figure 8-40B*), and fecal coliform bacteria levels (*Figure 8-40C*). Total phosphorus concentrations (*Figure 8-40D*) and ammonia (*Figure 8-40E*) have also remained low since 2002 compared to concentrations considered normal for healthy piedmont streams (0.05 mg/L). Total Kjeldahl nitrogen and nitrate+nitrite concentrations also remain below or typically hover around the concentrations considered normal for minimally impacted streams (TKN 0.5 mg/L; NOx 0.3 mg/L), having increased slightly over time since 2002. During 2016 to 2020-time frame, annual mean values for nitrate+nitrite were typically around 0.14 mg/L (*Figure 8-40F*), and total Kjeldahl nitrogen near 0.44 mg/L (*Figure 8-40G*). Together, these nitrogen compounds are contributing to the annual mean total nitrogen signature in this waterway, which was around 0.58 mg/L in the Little River (*Figure 8-40H*). DWR conducted screening-level Mann-Kendall trend seasonal tests for turbidity, fecal coliform, total Kjeldahl nitrogen, nitrate+nitrite, as well as, specific conductance, at station B7245000, resulting in a significant increase calculated at 95% confidence from data collected from 2000-2019.

Figure 8-40: Annual Mean Turbidity, Specific Conductance, Fecal Coliform Bacteria, Total Phosphorus, Ammonia, Nitrate+Nitrite (NOx), Total Kjeldahl Nitrogen (TKN), and Total Nitrogen in Little River at Station B7245000.



8.7.3.3 Crane Creek (Craine Creek) and Lake Surf

Crane Creek from the source to the Little River [AU#: 18-23-16a and 18-23-16b2] flows 22.62 miles; not including the 1067.56-acre Lake Surf [AU#: 18-23-16b1]. Similar to other waterways in the Headwaters Little River watershed, Crane Creek maintains the water supply classification (WS-III). Along this waterway there have been several fish and benthic macroinvertebrate community monitoring stations.

The Woodlake Country Club WWTP is the only permitted NPDES discharge facility located along Crane Creek [AU#: 18-23-16b2]. This facility has an as-built flow of 500,000 gallons per day. After a series of limit violations that proceeded to enforcement between 2010 and 2012, this facility has maintained a good compliance history with permitted limits.

In 2002 and 2003, four benthic macroinvertebrate community stations along the entire length of Crane Creek were sampled using the full-scale methodology. This sampling event recorded Good ratings for most stations (BB331, BB418, BB350) and a Good-Fair rating for station B349. The three stations that recorded a Good rating all had EPT scores above 20 while station BB349 only recorded 15 EPT taxa. Station BB349 also had the lowest total taxa (ST=60) compared to other stations sampled along Crane Creek (ST>=62). This could be attributed to the habitat at station BB349 as it had the highest percentage of sand substrate. These four stations have not been resampled since these sampling events. A new station (BB528) on Crane Creek [AU#: 18-23-16b], downstream from Lake Surf, was sampled in 2014, recording a rating of Good-Fair. This new station recorded the lowest EPT taxa (EPT=11) and total taxa (ST=43). This could be attributed to 80% of the substrate being composed of sand.

BB331	
Year	**Bioclassification**
2002*	Good
2003*	Good
BB349	
2002*	Good-Fair
BB350	
2002*	Good
BB418	
2002*	Good
BF48	
2002	Good-Fair
2008	Not Rated
BF51	
2002	Fair
BF70	
2002	Good-Fair
*Special Study	

Crane Creek [AU#: 18-23-16a] is Data Inconclusive for fish community. Three fish community stations (BF48, BF70, and BF51) are co-located with several of the previously mentioned benthic macroinvertebrate community monitoring stations. Notably, the fish community station BF51 is co-located with benthic station BB349 and recorded the only Fair rating of the three fish community stations. Station BF70 was also sampled in 2002, recording a Good-Fair rating, and the most upstream station BF48 recorded a Not Rated rating. *As time and resources allow the Division of Water Resources should evaluate the waterways in the Headwaters Little River watershed to determine where resampling could occur with emphasis on resampling the fish comm*unity in Crane Creek since it last rated as Fair.

8.7.3.4 Mill Creek (Old Town Reservoir, Warrior Lake, and Crystal Lake)

Mill Creek flows 12.18 miles near Southern Pines in the Sandhills [AU#: 18-23-11-(2) and 18-23-11-(5)]. This does not include the 58.08-acre Old Town Reservoir on Mill Creek [AU#: 18-23-11-(1)]. Mill Creek has many of the same stream classifications as other waterways in this watershed. These stream classifications include water supply (WS-III), high quality waters (HQW), and primary recreation (Class B), protecting drinking water and waters that have excellent water quality, as well as bodily contact during recreation. The upper AU of Mill Creek 18-23-11-(1), and the lower AU of Mill Creek, 18-23-11-(5), are both classified "WS-III;HQW:@." The middle AU of Mill Creek, 18-23-11-(2), is classified "WS-

III,B;HQW:@." Mill Creek, and all its tributaries, is classified with the "@" symbol. The "@" symbol means that if the governing municipality has deemed that a development is covered under a "5/70 provision," where five percent of its jurisdiction in the watershed is outside of the water supply critical area is allowed new development up to 70% built-upon area, then the development is exempt from certain stormwater requirements (15A NCAC 02B .0311 (m)).

Old Town Reservoir is an impoundment in the headwaters of Mill Creek. Built in 1925, this one-time water supply (discontinued in 1985) is currently open for public recreation. Maximum lake depth is 23 feet (seven meters). The lake's watershed is relatively undeveloped with the exception of a golf course.

There are two ambient lake monitoring program stations on Old Town Reservoir, CPF135B and CPF135D. Surface pH values for Old Town Reservoir ranged from 6.6 to 7.1 s.u. Secchi depths in 2018 ranged from 1.2 to 2.6 meters, indicating good water clarity. Concentrations of total phosphorus and ammonia were below DWR laboratory detection levels in 2018. Total Kjeldahl nitrogen ranged from 0.36 to 0.49 mg/L and nitrate+nitrite ranged from <0.02 to 0.02 mg/L. Chlorophyll-*a* values ranged from 8.4 to 24.0 ug/L. The tropic status for this waterway in 2018 was Mesotrophic. The Region 4, EPA Laboratory conducted an Algal Growth Potential Test on water samples collected on August 22, 2018, by DWR field staff. Results indicated that, at the time this lake was tested, the nitrogen and phosphorus were co-limited. Old Town Reservoir on Mill Creek is Data Inconclusive for hardness, pH, DO, nitrate+nitrite, water temperature, and chlorophyll *a* [AU#: 18-23-11-(1)]. Surface DO range from 8.0 to 10.1 mg/L. The higher DO values in May coincided with lower water temperatures in the lake.

Downstream from Old Town Reservoir there are two additional lakes: Warrior Lake and Crystal Lake. Between Warrior Lake and Crystal Lake there is one benthic macroinvertebrate community monitoring station (BB335) on Mill Creek at Camp Easter Road. The benthic macroinvertebrate community monitoring station was last sampled in 2000, receiving a rating of Excellent.

BB335	
Year	**Bioclassification**
1998	Excellent
2000	Excellent

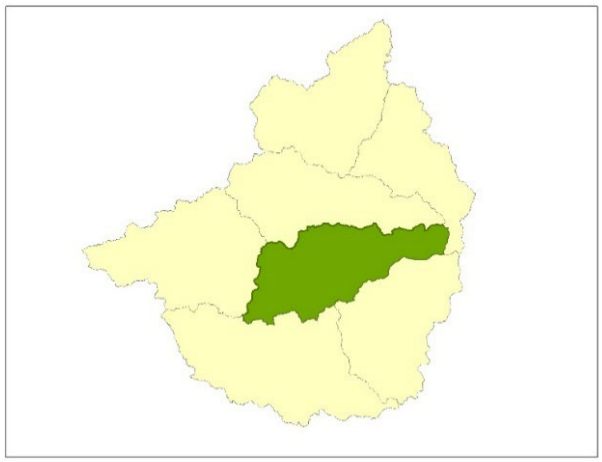
Mill Creek receives effluent from the Crystal WWTP (NC0057525) downstream of Crystal Lake. This NPDES permitted facility is 100% domestic with a permitted as built discharge of 12,000 gallons per day into Mill Creek and ultimately the Little River. This facility has a history of violations that proceeded to enforcement for permit limit violations between 2010 and 2020, including fecal coliform bacteria, pH, total suspended solids, and biological oxygen demand. The NPDES permitting process will be used to address any ongoing violations.

8.7.3.5 Flat Creek

BB331	
Year	**Bioclassification**
2008*	Excellent
2018*	Good-Fair
2019*	Good-Fair
2019*	Good-Fair
2019*	Good-Fair
BF1	
2003	Good
2008	Good
*Special Study	

Flat Creek from the source to Little River flows 6.24 miles [AU#: 18-23-15]. There are co-located fish and benthic macroinvertebrate community monitoring stations located in the downstream reach of this waterway. The fish and benthic macroinvertebrate communities both rated Excellent in 2008. Since 2008, only the benthic macroinvertebrate community has been continuously monitored with one sampling event in 2018 and three in 2019. During the sampling events post-2008, the benthic macroinvertebrate community has consistently rated Good-Fair. Water quality during the sampling events was relatively consistent. With the 2008 sampling, however, the substrate changed from a mixture of sand, gravel, and boulders to primarily sand and gravel substrate. The sand percentage changed from less than 30% in 2008 to more than 50% during the 2018 and 2019 sampling events. This substrate change coincided with a drop in EPT taxa from greater than 20 to less than or equal to 20; the lowest record being 15 EPT taxa collected in 2019. *Preventing erosion and transport of sediment into the Flat Creek substrate could help improve the benthic macroinvertebrate community in this waterway*.

8.7.4 Outlet Little River Watershed (0303000404)



The Little River at its confluence with the Cape Fear River has a drainage area of 482 mi^2. The Outlet Little River Watershed has a DA of 220 mi^2. The watershed drains the eastern half of the northern area of Ft. Liberty. The eastern half of the watershed is a patchwork of forested, grassland/shrub and agricultural lands. The center portion has more developed lands, such as the Town of Spring Lake, Pope Airfield, and high-density suburban communities accommodating Ft. Liberty, which extend to the northern base boundary. The western portion of the watershed is an equal mix of forest, grassland/shrub and agricultural lands. This portion also includes the barren lands of some of the Ft. Liberty drop zones. Across the Outlet Little River watershed, the predominant land cover is forested (45.5%), followed by developed land (15.4%), wetlands (14.9%), grassland and shrub (12.1%), agricultural land (9.3%), barren land (1.8%), and open water (1%) (*Table 8-6*, NLCD, 2019).

Begun in 2002, Sustainable Fort Liberty is a management system developed to allow the base to continue to train soldiers to the standards required to achieve assigned missions while promoting sustainable practices to protect local and regional ecosystems through both partnerships with various organizations and internal visions, goals and policies (Sustainable Fort Bragg 2003). The Army Compatible Use Buffer (ACUB) program is one such partnership effort to purchase easements or lands from willing partners surrounding the base to protect critical open areas while preventing encroachment that may conflict or hinder training activities (U.S. Army 2010). A land-use study was also produced in 2018 that examined the resources and development in the adjacent six counties to understand the state of compatible growth, to ensure the viability of the Longleaf Pine Ecosystem and to sustain Fort Liberty's mission (Benchmark Planning 2018). The collaboration developed 29 recommendations toward achieving their goals.

Sustainable Sandhills, a non-profit organization, was established through an initial partnership between Fort Liberty and NCDEQ to apply the philosophy of Sustainable Fort Liberty to the surrounding 9-county region. Fort Liberty is also an active partner in the North Carolina Sandhills Conservation Partnership (NCSCP), comprised of agencies, private landowners, and other area organizations with a shared vision of compatible development and habitat restoration and protection (NC Sandhills Conservation Partnership 2022). The NCSCP worked toward recovering the region's population of the endangered red-cockaded woodpecker, protecting over 16 miles of the Fort Liberty boundary, and conserving 18,000+ acres of longleaf pine forest.

Anderson Creek County Park is in southwestern Harnett County and consists of 1,014 acres surrounding North Prong Anderson Creek. Also, downstream of the county park is a conservation easement corridor of 167 acres along the North Prong and Youngs Pond on Farrar Dairy property. There is a Ft. Liberty mitigation wetland site along 78 acres of Jumping Run Creek upstream of SR 1117. The 1,400-acre Long Valley Farm parcel of Carver Creek State Park is located on Jumping Run Creek from upstream to downstream of the farm millpond on the north side of SR 1451.

In the watershed, as of May 2022, there were two major NPDES wastewater discharge facilities, Spring Lake WWTP (NC0030970) and South Harnett Regional WWTP (NC0030970), permitted for 16.5 MGD. Spring Lake WWTP has a permitted as-built of 1.5 MGD and South Harnett Regional WWTP has a permitted as-built of 15 MGD. Both facilities discharge to the Lower Little River. Between 2010 and 2020, both Spring Lake WWTP and South Harnett Regional WWTP did not receive any violations that proceeded to enforcement actions. See Chapter 3 Appendix for a list of permits. There are also two swine AFOs permitted for 17,082 head count with 2.9 million pounds allowable live weight, 403 acres of land application of residual solids, and 14 NPDES and 96 state stormwater facilities.

Overall water quality in the Little River is relatively clear with low turbidity with occasional instances of elevated fecal coliform bacteria possibly from nonpoint sources of pollution. Low pH was also found along the entire length of the Little River; however, it is unclear of the source of cause for this phenomenon. Nutrient (total nitrogen and phosphorus) concentrations have declined considerably since 2012; however, concentrations remain elevated above values considered normal for healthy piedmont streams prior to flowing into the Cape Fear River.

There are no impaired waters in the Outlet Little River watershed; however, several tributaries to Little River are considered "Data Inconclusive" for fish community including Buffalo Creek [AU#: 18-23-18], Muddy Creek [AU#: 18-23-26], Tank Creek [AU#: 18-23-27], and "larger" Jumping Run Creek [AU#: 18-23-29].

These fish community stations were last sampled in 2003 and/or 2008. Buffalo Creek (BF21) and Muddy Creek (BF22) were both sampled in 2008, recording ratings of Good and Excellent, respectively. The ratings for these two stations were either no change or improvement compared to the 2003 sampling events in these waterways. Tank Creek (BF126) and Jumping Run Creek (BF2) were only visited once, recording a rating of Poor and Fair, respectively suggesting signs of a stressed fish community. The co-located biological community station (BB229) in Jumping Run Creek was sampled in 2008, recording a rating of Good. In addition to the previously mentioned waterways, the fish community station in Hector Creek [AU#: 18-23-21] (BF137) and the "smaller" Jumping Run Creek [AU#: 18-23-20] (BF138) were sampled once in 2013 with both waterways getting ratings of Good. It is unclear whether many of these waterways have improved or declined recently since resampling has not occurred. *As time and resources allow localized investigations into the point and nonpoint sources contributing to the Poor and Fair ratings should be undertaken, and Tank Creek and "larger" Jumping Run Creek [AU#: 18-23-29] should be resampled to assess the status of the fish community.*

BF21	
Year	**Bioclassification**
2003	Good
2008	Good
BF22	
2003	Good-Fair
2008	Excellent
BF126	
2008	Poor
BF2	
2003	Fair
BB229	
2008*	Good
BF137	
2013	Good
BF138	
2013	Good
*Special Study	

8.7.4.1 Anderson Creek

North Prong Anderson Creek [AU#: 18-23-32-1] is a headwater tributary that joins with South Prong Anderson Creek [AU#: 18-23-32-2] to form Anderson Creek [AU#: 18-23-32]. The latest biological community sampling event on North Prong Anderson Creek was in 2006 with the most upstream station (BB234) rating Good and the downstream station (BB489) rating Not Impaired. Downstream from the North Prong Anderson Creek and South Prong Anderson Creek confluence on Anderson Creek there is one benthic macroinvertebrate community monitoring station (BB353) that is co-located with a fish community monitoring station (BF52) on Anderson Creek [AU#: 18-23-32]. The benthic macroinvertebrate community station (BB353) was sampled seven times between 1993 and 2018 and received a Good rating each time; except for the first sample in 1993 that received a Good-Fair rating. The fish community station (BF52) was last sampled in 2008, recording a rating of Fair, which is a decline from the 2003 rating of Good. Anderson Creek is not impaired for any parameters; however, the fish community rated as Data Inconclusive. *As time and resources allow localized investigations into the point and nonpoint sources contributing to the Fair ratings should be undertaken and Anderson Creek should be resampled to assess the status of the fish community.*

BB234	
Year	**Bioclassification**
2005*	Good
2006*	Good
BB489	
2006*	Not Impaired
BB353	
2003	Good
2008	Good
2013	Good
2018	Good
BF52	
2003	Good
2008	Fair
*Special Study	

8.7.4.2 Little River (Lower Little River)

The Little River from the confluence with Crane Creek ultimately drains into the Cape Fear. This section of the Little River flows 39.5 miles across three assessment units [AU#: 18-23-(15.5), 18-23-(23.5), and 18-23-(24)]. Sections of the Little River [AU#: 18-23-(15.5) and 18-23-(23.5)] are classified as a water supply (WS-III), which protects drinking water prior to the Fort Liberty water supply intakes. Additionally, sections of the Little River are also classified as a critical area (CA). There are four surface water quality monitoring stations (B7245000, B7280000, B7300000, and B7319100) in the Outlet Little River watershed sampled between 2002 and 2020 along the entire length of Little River. In 1998, two benthic macroinvertebrate community stations were monitored in Little River (BB230, BB232) both recording Excellent bioclassifications.

BB230	
Year	**Bioclassification**
1998	Excellent
BB232	
1998	Excellent

The lower section of the Little River was assessed to be Data Inconclusive for pH. While the IR assessment reports pH as Data Inconclusive, the pH recorded along the entire length of the Little River is lower than other waterways in the Cape Fear River Basin (*Figure 8-41*); except the Upper Little River and Rockfish Creek discussed in this chapter. The exact cause and source of these lower pH values is unclear; however, it has been noted that the low buffering capacity of sandy soils and the potential impact of conifer trees could exert an influence on flow-through pH in the Little River although this is an active area of research and other factors (acidic soils, sulfur-bearing minerals, human influence, or other) may have an influence on lower the pH of the Little River. Currently there are no North Carolina Sandhills specific studies, or conflicting information, to definitively support these two phenomena, although they could exist. *A natural conditions assessment might be warranted to determine whether these low pH levels are the result of natural conditions or anthropogenic influences.*

Notably between the most upstream surface water quality monitoring station (B7245000) and the next closest downstream station (B7280000) the annual median pH declines to values typically below the 6 s.u. water quality standard (*Figure 8-41*). When considering the point sources of pollution between these two stations, the NPDES facilities which discharge return flows typically maintained pH effluent values that are at or above 6 s.u.; except for a few values recorded in the effluent of Aqua North Carolina Inc - Woodlake Country Club WWTP (NC0061719) in July of 2007 and one value recorded in August of 2020. Downstream from station B7280000 the pH values typically increase to values hovering slightly above the 6 s.u. water quality standard at station B7300000 and B7319100; however, this may be influenced by return flows from the two major NPDES facilities discharging into the Little River (*Figure 8-41*).

Along the entire length of the Little River fecal coliform bacteria values are typically lower than the 400 colonies/100 mL water quality standard; however, several years have annual means greater than this value (*Figure 8-42*). Annual mean fecal coliform bacteria values recorded at several stations (B7280000, B7300000, and B7319100) were observed to exceed the 400 colonies/100 mL water quality standard in 20% or more of the samples collected in 2006, 2009, 2017, and 2020 (*Figure 8-43*). The reason for these elevated fecal coliform bacteria values is most likely associated with nonpoint sources as the two wastewater dischargers did not record fecal coliform bacteria limit violations during the 2010 to 2020 time frame, and there are no additional animal feeding operations. There are several land application fields for non-discharge land application between the upstream and downstream monitoring stations on the “lower” Little River. While these results are reported here as exceeding the water quality standard and annual mean values, it is important to note that the water quality standard for fecal coliform bacteria is based on a 5-in-30 sampling methodology. The results presented here are best viewed as screening values to identify areas of potential concerns as the samples are analyzed outside of hold time and are not collected at a frequency consistent with a 5-in-30 sampling methodology. Also note that the Little

River is not a Class B waterway and therefore the best intended use is not for primary recreational purposes (See Chapter 2 for additional information on Class B waterways). Annual mean turbidity values in the Little River were typically lower than their respective water quality standards (*Figure 8-44*).

Annual mean nutrient concentrations (total nitrogen and phosphorus) in the downstream sections of the Little River from station downstream of the confluence with Cain Creek (B7280000) to most downstream station (B7319100) on the Little River, were elevated above levels considered normal for healthy piedmont streams until approximately 2012 after which annual mean nutrient concentrations were reduced (*Figure 8-45* and *Figure 8-46*). While considerable declines were observed in nutrients along the Little River following 2012, the most downstream coalition monitoring station (B7319100) on the Little River continues to record total nitrogen and total phosphorus concentrations that are elevated above concentrations considered normal for health piedmont streams. Annual mean total nitrogen concentrations less than 0.8 mg/L and total phosphorus concentrations less than 0.05 mg/L are considered normal for healthy piedmont streams. Annual mean total Kjeldahl nitrogen concentrations (*Figure 8-47*) are typically higher than nitrate+nitrite concentrations (*Figure 8-48*), however, nitrate+nitrite concentrations are most likely elevated due point source return flows from NPDES dischargers while total Kjeldahl nitrogen is most likely from nonpoint sources. Combined, these different species of nitrogen contribute to the total nitrogen signature in the Little River, resulting in values that are typically at or exceed the concentrations considered normal for healthy piedmont streams.

The most likely reason for the declines in nutrient concentrations from stations B7280000, B7300000, and B7319100 was the removal of return flows from Fort Liberty's NPDES discharger (NC0003964) outfall in 2012 and relocation of their wastewater to the South Harnett Regional WWTP (NC0088366). The South Harnett Regional WWTP flow displays a considerable increase in return flows after this relocation (*Figure 8-49*). The South Harnett Regional WWTP is permitted for a flow of 15 MGD and Fort Liberty owns 10 MGD of this permitted flow.

As mentioned previously the elevated total nitrogen concentrations in the Little River are primarily composed of nitrate+nitrite concentrations which is consistent with potential influence from a point source discharger as the South Harnett Regional WWTP return flows are primarily comprised of nitrate+nitrite and lesser amounts of total Kjeldahl nitrogen (*Figure 8-50*). The total phosphorus concentrations in the South Harnett Regional WWTP did not change considerably after the relocation of the Fort Liberty outfall (*Figure 8-51*). As mentioned previously there was a considerable change in total phosphorus concentrations recorded in the Little River after this relocation primarily in stations B728000 and B7300000. The sustained elevated instream total phosphorus concentrations at the most downstream station in the Little River B7319100 suggesting this signal is from a combination of both point and nonpoint sources of pollution in the watershed. DWR's Basin Planning Branch supports moving nitrogen and phosphorus loads from the South Harnett Regional WWTP to the North Harnett Regional WWTP. *Developing a comprehensive understanding of the source(s) of elevated fecal coliform bacteria and nutrients (total nitrogen and phosphorus) is necessary to protect the Little River from further degradation and ultimately the Cape Fear River.*

Figure 8-41: Annual Median pH Values for the Little River (B7245000, B7280000, B7300000, and B7319100).

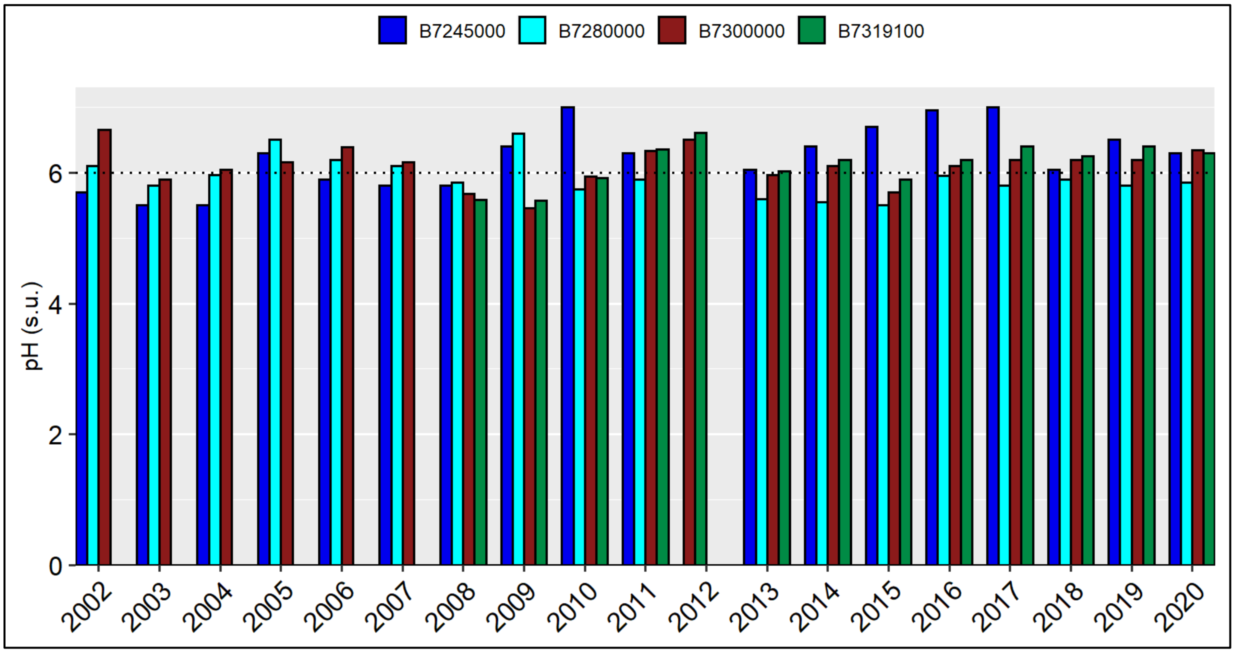


Figure 8-42: Annual Mean Fecal Coliform Bacteria Values for the Little River (B7245000, B7280000, B7300000, and B7319100) with Reference Line for the Water Quality Standard of 400 colonies/100 mL.

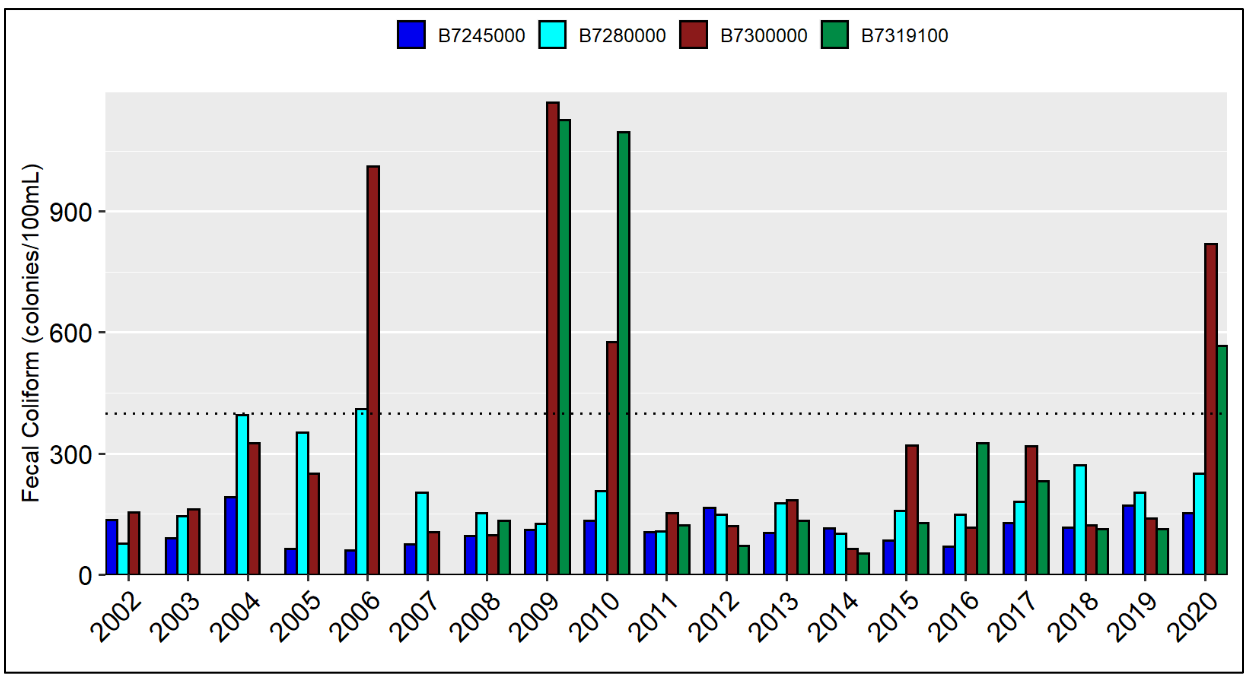


Figure 8-43: Annual Exceedance Rate for Fecal Coliform Bacteria Values for the Little River (B7245000, B7280000, B7300000, and B7319100) based on a Water Quality Standard of 400 colonies/100 mL.

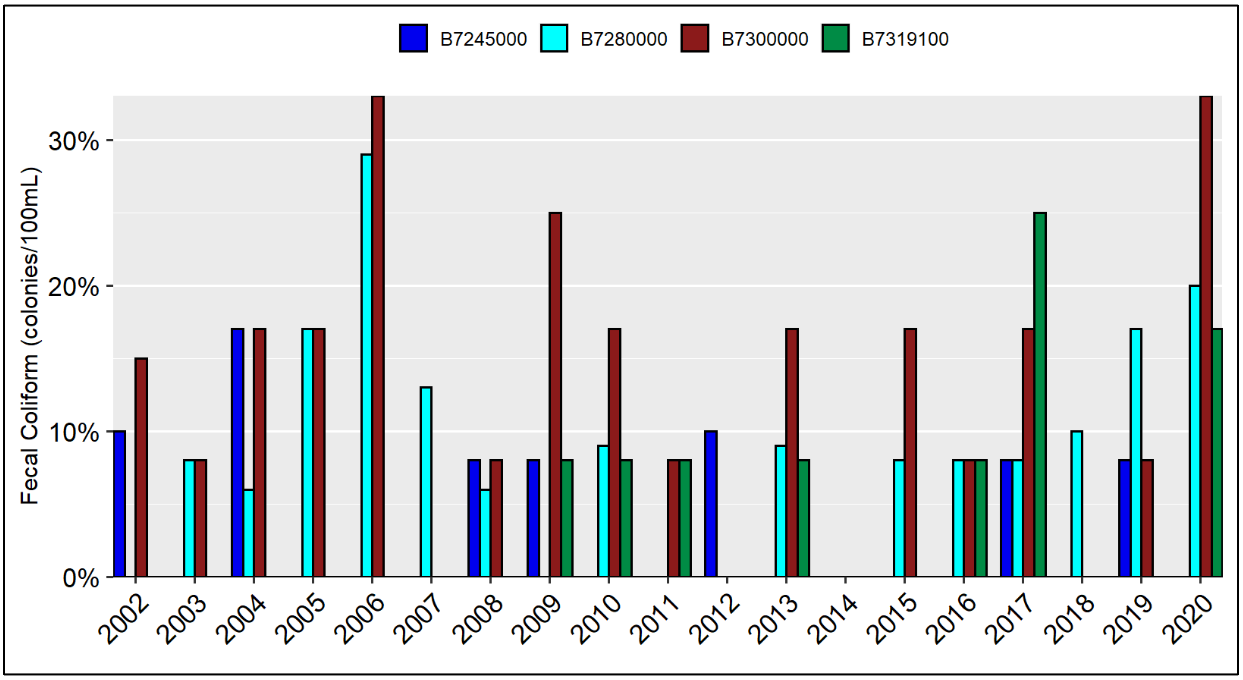


Figure 8-44: Annual Mean Turbidity Values for the Little River (B7245000, B7280000, B7300000, and B7319100).

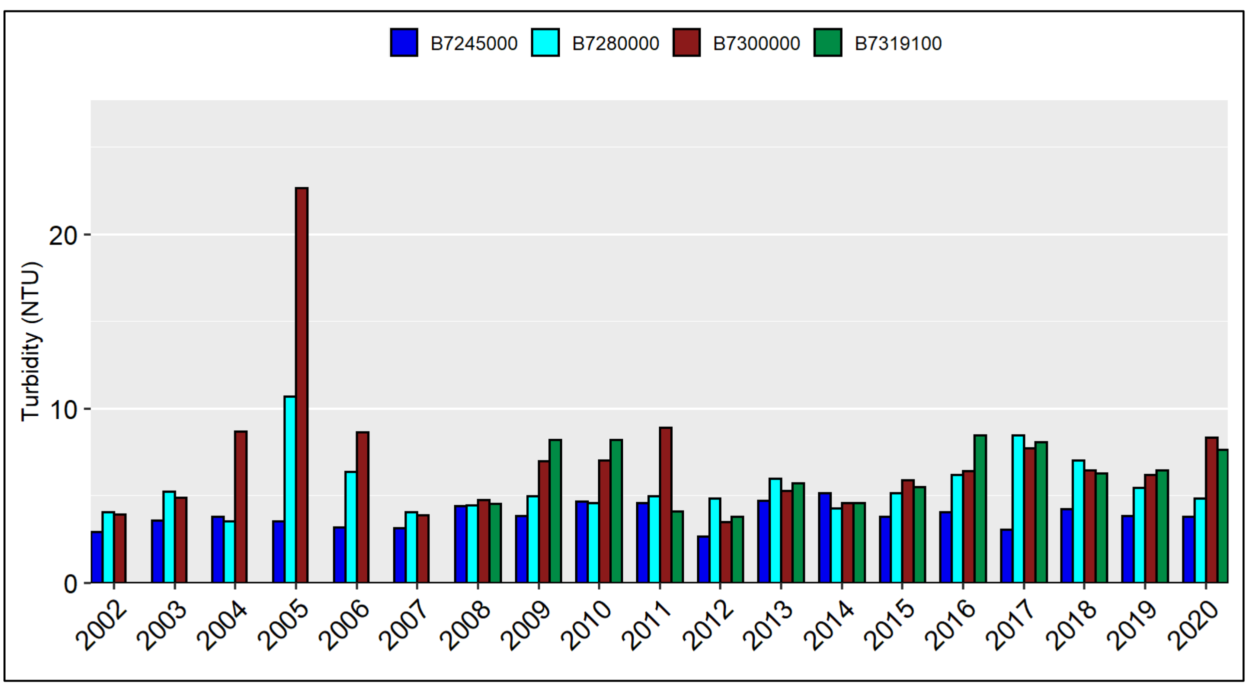


Figure 8-45: Annual Mean Total Nitrogen Values for the Little River (B7245000, B7280000, B7300000, and B7319100).

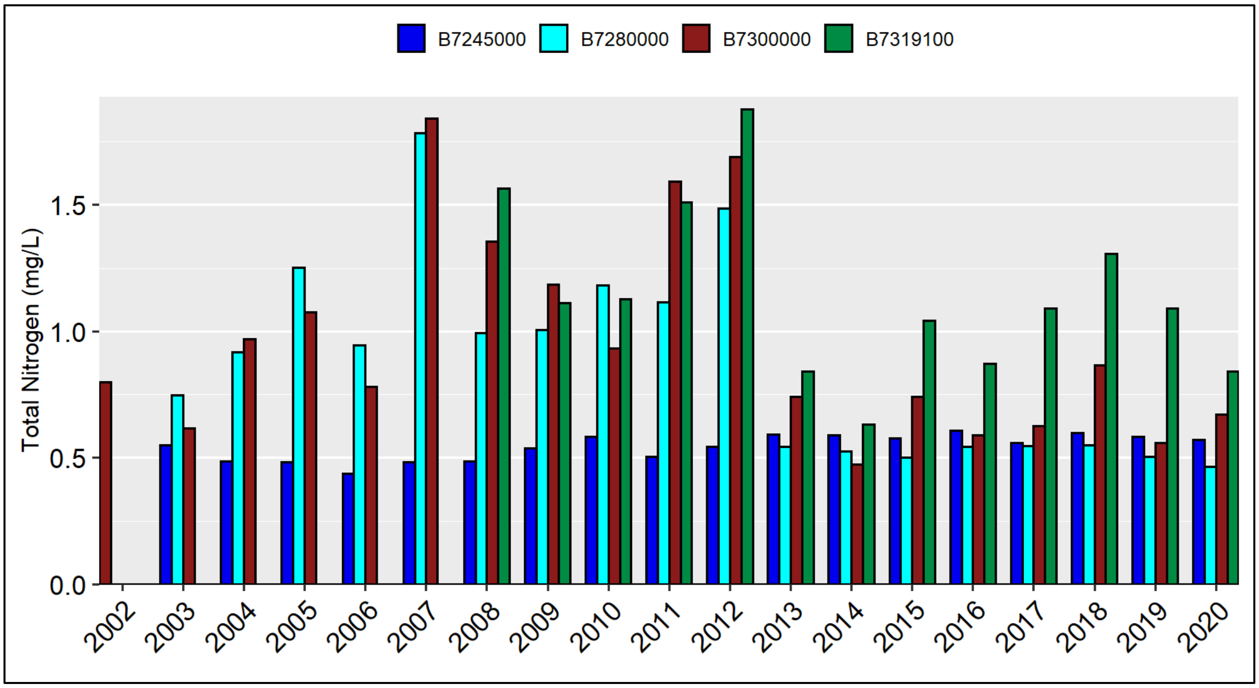


Figure 8-46: Annual Mean Total Phosphorus Values for the Little River (B7245000, B7280000, B7300000, and B7319100).

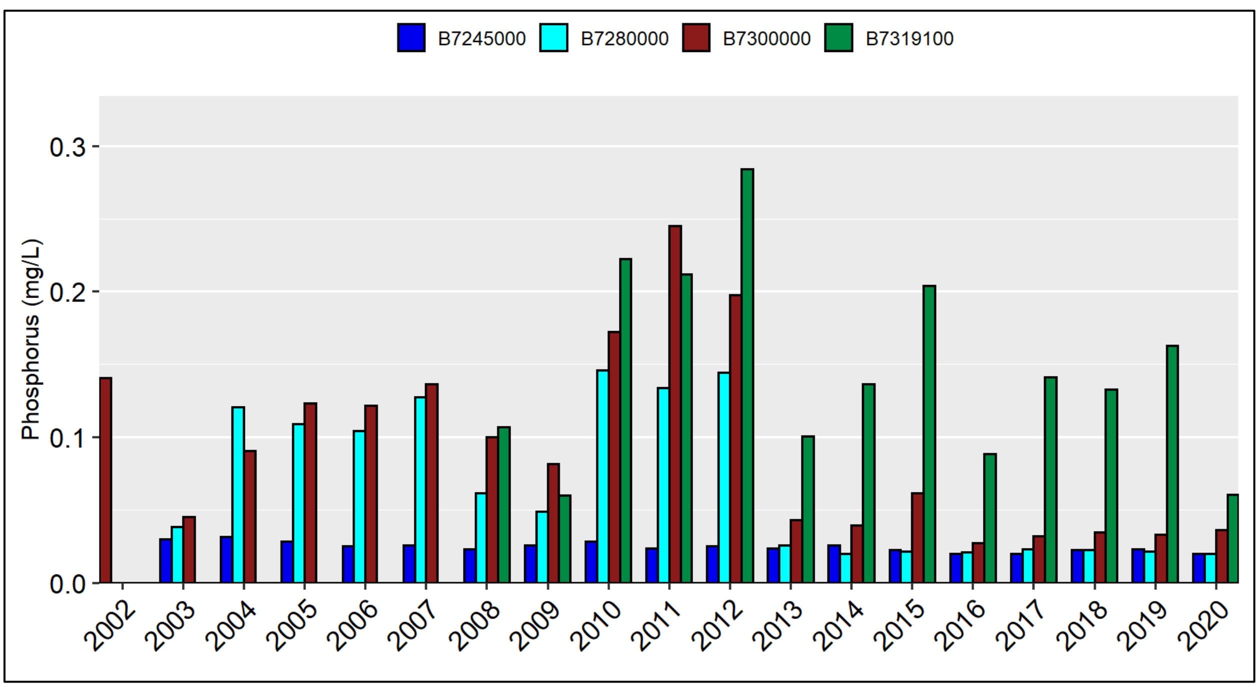


Figure 8-47: Annual Mean Total Kjeldahl Nitrogen Values for the Little River (B7245000, B7280000, B7300000, and B7319100).

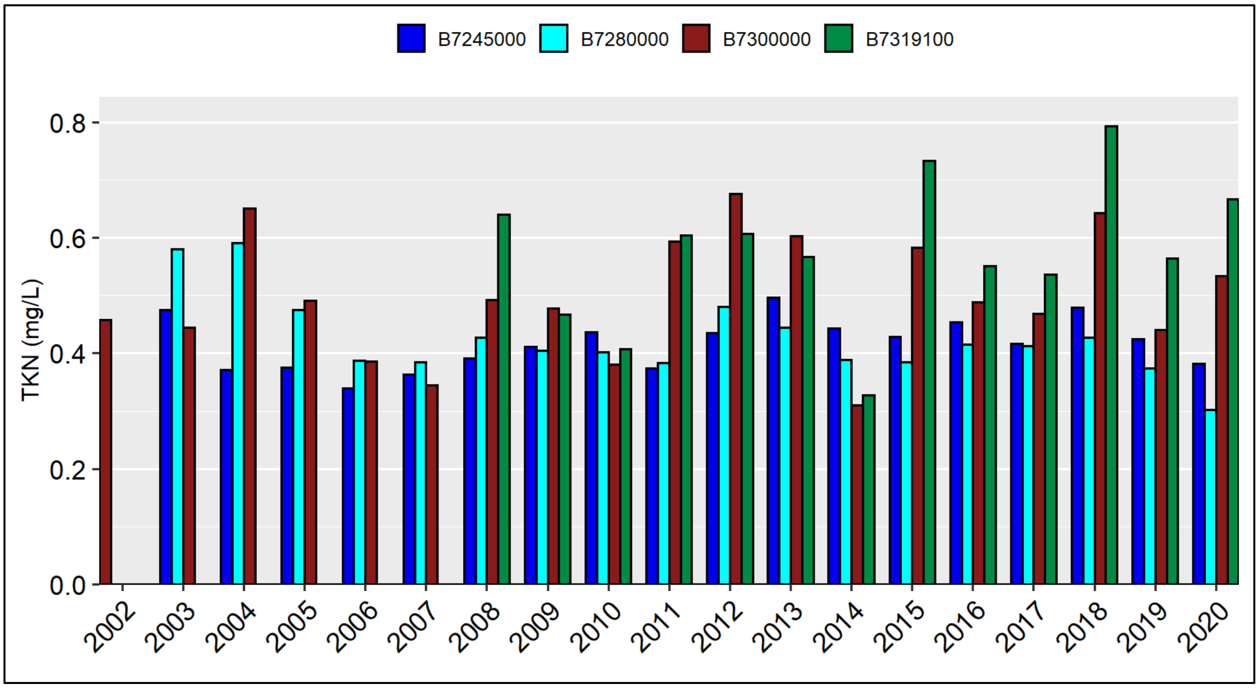


Figure 8-48: Annual Mean Nitrate+Nitrite (NOx) Values for the Little River (B7245000, B7280000, B7300000, and B7319100).

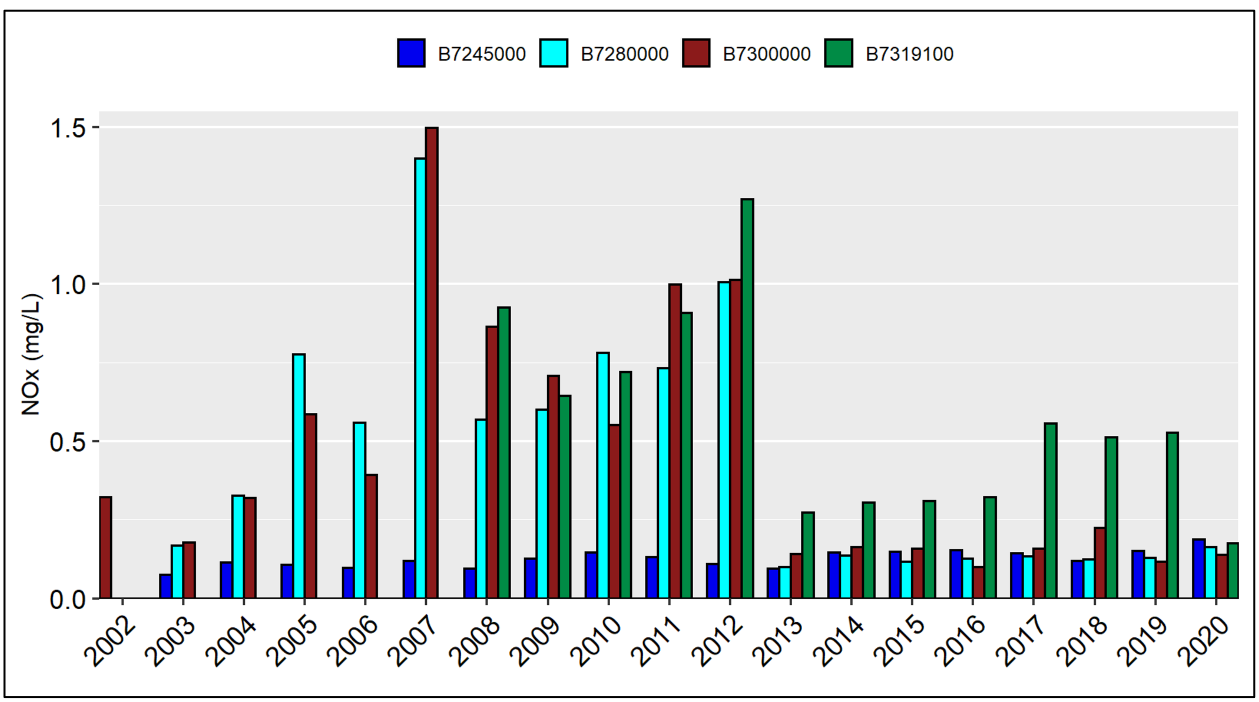


Figure 8-49: Flow from Outfall 001 at the South Harnett Regional WWTP.

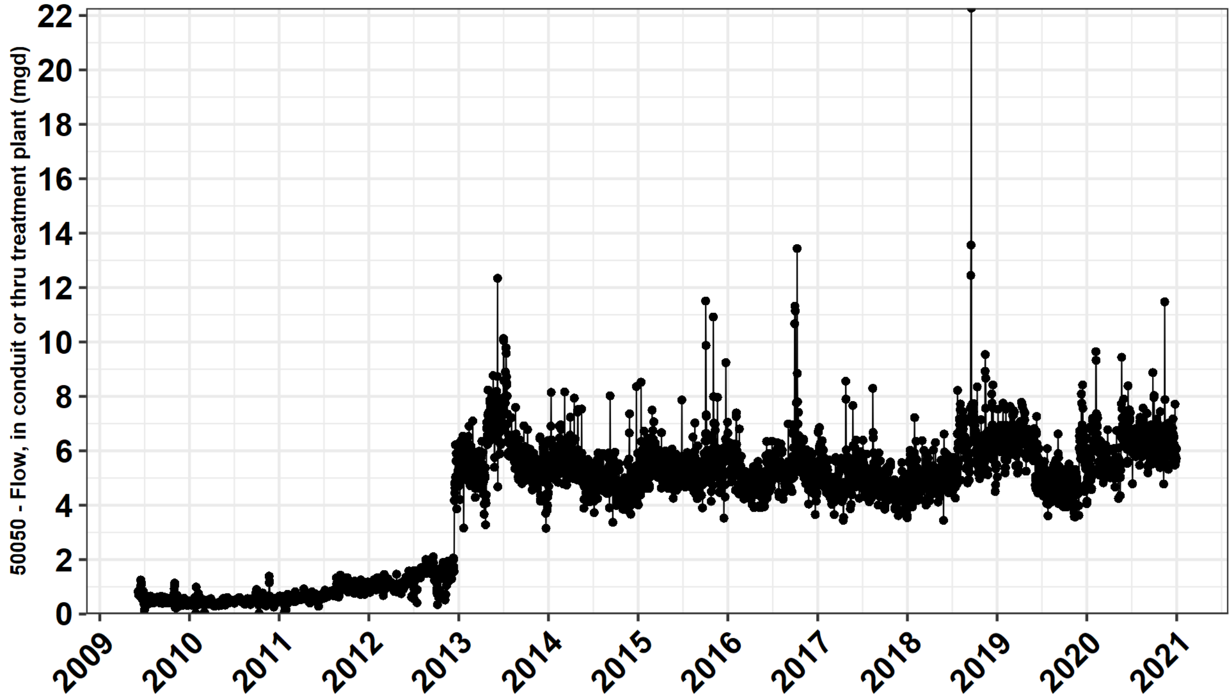


Figure 8-50: Total Nitrogen, Nitrate+Nitrite, Total Kjeldahl Nitrogen, and Ammonia Concentrations from Outfall 001 at the South Harnett Regional WWTP.

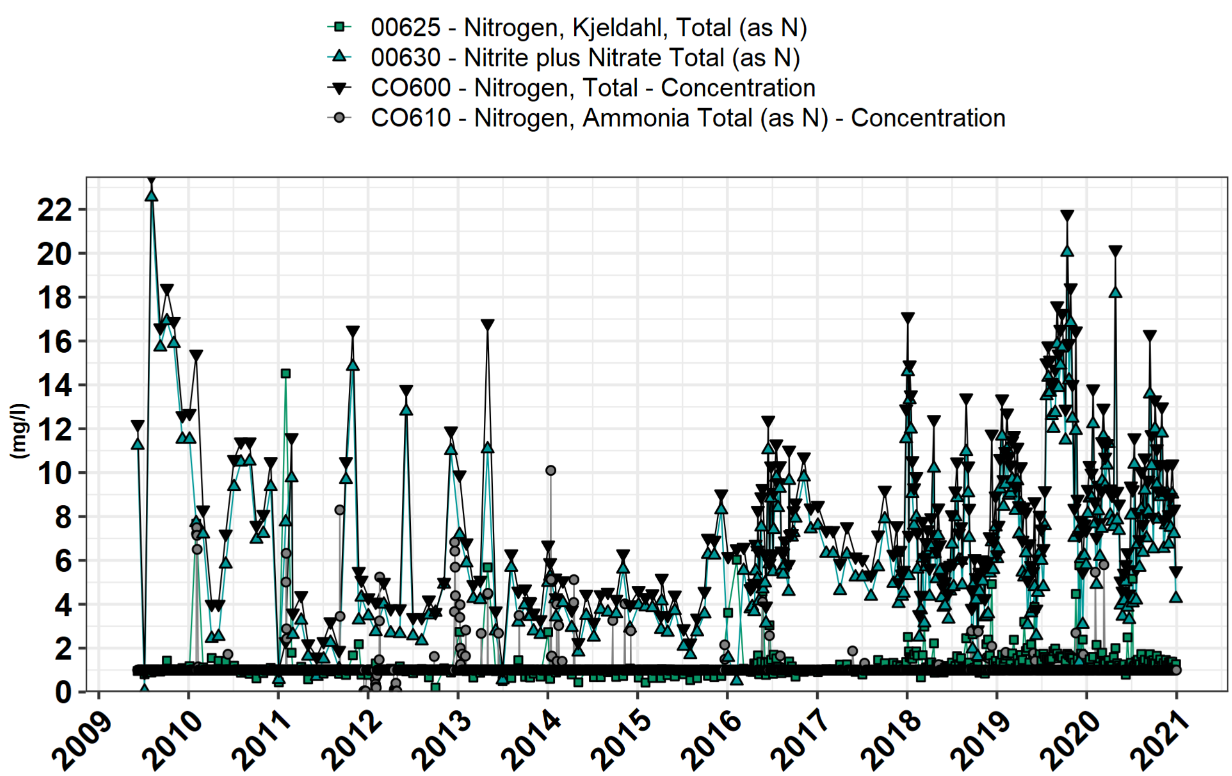
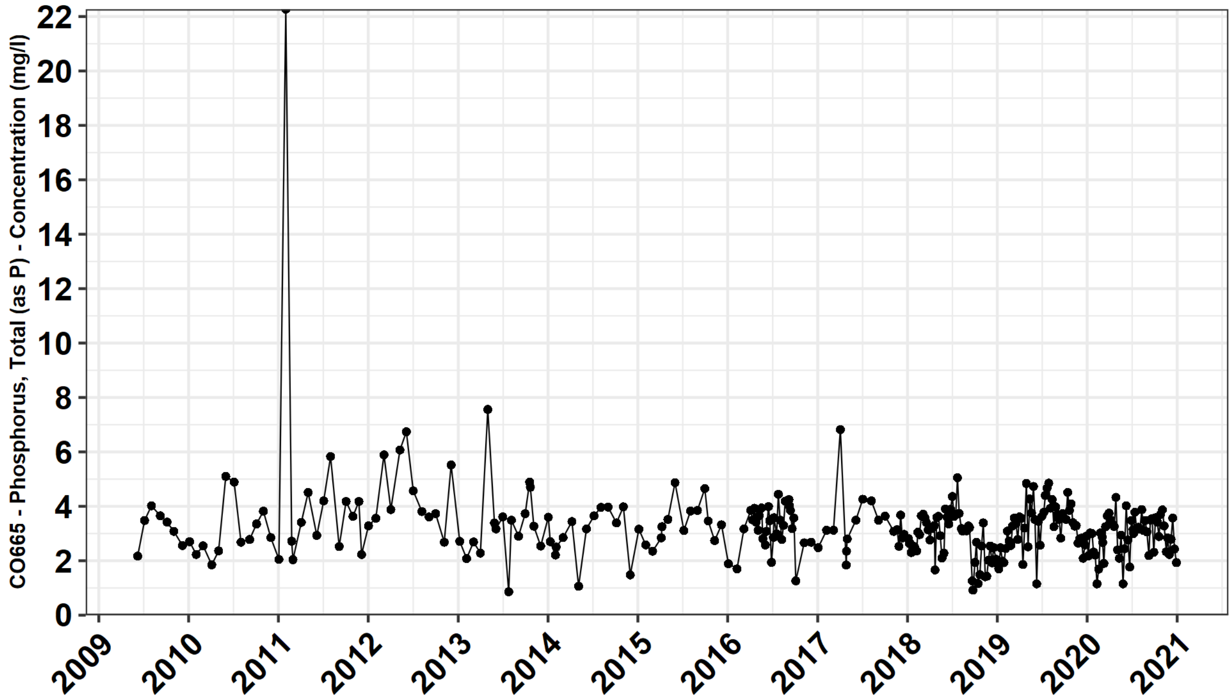
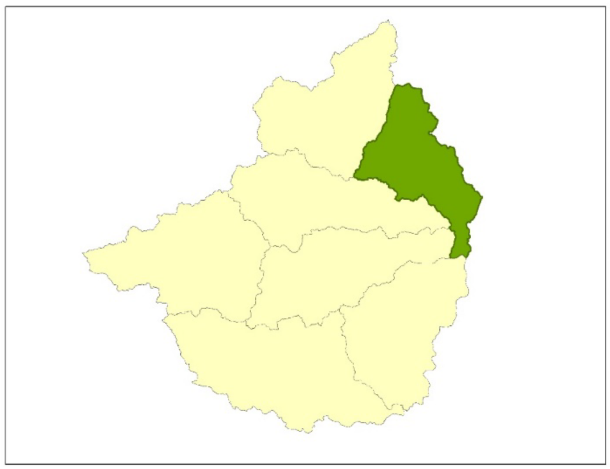


Figure 8-51: Total Phosphorus Concentrations from Outfall 001 at the South Harnett Regional WWTP.



8.7.5 Buies Creek – Cape Fear River Watershed (0303000405)



The Buies Creek watershed has a drainage area of 167 mi^2; the smallest HUC10 in the Upper Cape Fear River subbasin. The watershed has the greatest percentage of land in agricultural use (29.5%) of the seven watersheds in the Upper Cape Fear River subbasin. The majority of the subbasin's land use is forest (34.7%). The subbasin is ranked fifth of the seven subbasins for its increase in population during the 2010 decade, but it is third in terms of population density. The developed land is 16% of the land area, with the largest area of development in and around Fuquay-Varina. The remaining land cover is wetlands (10.3%), grassland and shrub (7.7%), open water (1.8%), and barren land (0.1%) (*Table 8-6*).

The northern-most boundary of the watershed is in Fuquay-Varina where the headwaters of Kenneth and Neills creeks are located. The boundary runs south through Kennebec, Angier, Coats and Erwin along the ridge paralleling the Black River. The upper boundary bisects Raven Rock State Park at the confluence of Avents Creek with the Cape Fear River. On the south side of the Cape Fear River, the watershed encompasses Fish Creek and Poorhouse Creek in Lillington before hugging the bank of the Cape Fear River.

The southern terminus of the watershed is at the Little River confluence on the Harnett-Cumberland county line.

As of May 2022, there were two major and two minor NPDES wastewater discharge facilities permitted for 11.25 MGD, one swine AFO permitted for 2,123 head count with 651,059 pounds live weight, 423 acres of land application of residual solids, and 10 NPDES and 37 state stormwater facilities. The major NPDES facilities are the North Harnett Regional WWTP (NC0021636), with a permitted as-built flow of 7.5 MGD, and Dunn WWTP (NC0043176) with a permitted as-built flow of 3.75 MGD. Both facilities discharge to the Cape Fear River mainstem. From 2010 to 2020, both facilities had at least one limit violation that proceeded to enforcement. The North Harnett Regional WWTP also had several limit violations for 5-day biological oxygen demand and ammonia in December of 2018. The NPDES permitting process will be used to address any ongoing violations. See Chapter 3 Appendix for a list of permits.

Overall, there are several water quality concerns in this watershed including nutrients (nitrogen and phosphorus), turbidity, as well as stressed fish and benthic macroinvertebrate communities. Several of these concerns have resulted in waterways in this watershed being listed on the 303(d)-impaired waters list. The sources of these water quality concerns are the result of both point and nonpoint sources of pollution from upstream and nearby land use activities in the Cape Fear River Basin as Buies Creek – Cape Fear River watershed is a continuation of the mainstem Cape Fear River draining from Buckhorn Creek – Cape Fear River watershed. Improvements to this watershed include implementing and maintaining BMPs for stormwater, nutrients and sediment alongside improvements to waste management and localized investigations of stressed fish and benthos.

8.7.5.1 Hector Creek

Hector Creek [AU#: 18-15-(0.7)](WS-IV;HQW) is in the Protected Area (PA) for the Town of Lillington's water supply intake. The creek's headwaters [AU#: 18-15-(0.4)](C;HQW) are in the southern portion of Wake County, near Fuquay-Varina's burgeoning suburban sprawl.

There are two fish community sampling sites on the mainstem of Hector Creek (BF94 and BF40). The upper site (BF94) was sampled in 1994 and received a Good rating. The lower site (BF40) was sampled once in 2018 and received a Good rating. There are three benthos sample sites in the Hector Creek watershed: two on the mainstem (BB289 and BB292) and one on the Coopers Branch [AU#18-15-1] tributary (BB284). BB292 was sampled once in 2003 and received an Excellent rating. BB289 received all Excellent ratings for four samples between 1988 and 2007. The Coopers Branch site was sampled once in 2003 and received a Good rating.

BF94	
Year	**Bioclassification**
1994	Good
BF40	
2018	Good
BB289	
2003*	Excellent
2006*	Excellent
2007*	Excellent
BB292	
2003*	Excellent
BB284	
2003*	Good
*Special Study	

8.7.5.2 Kenneth Creek

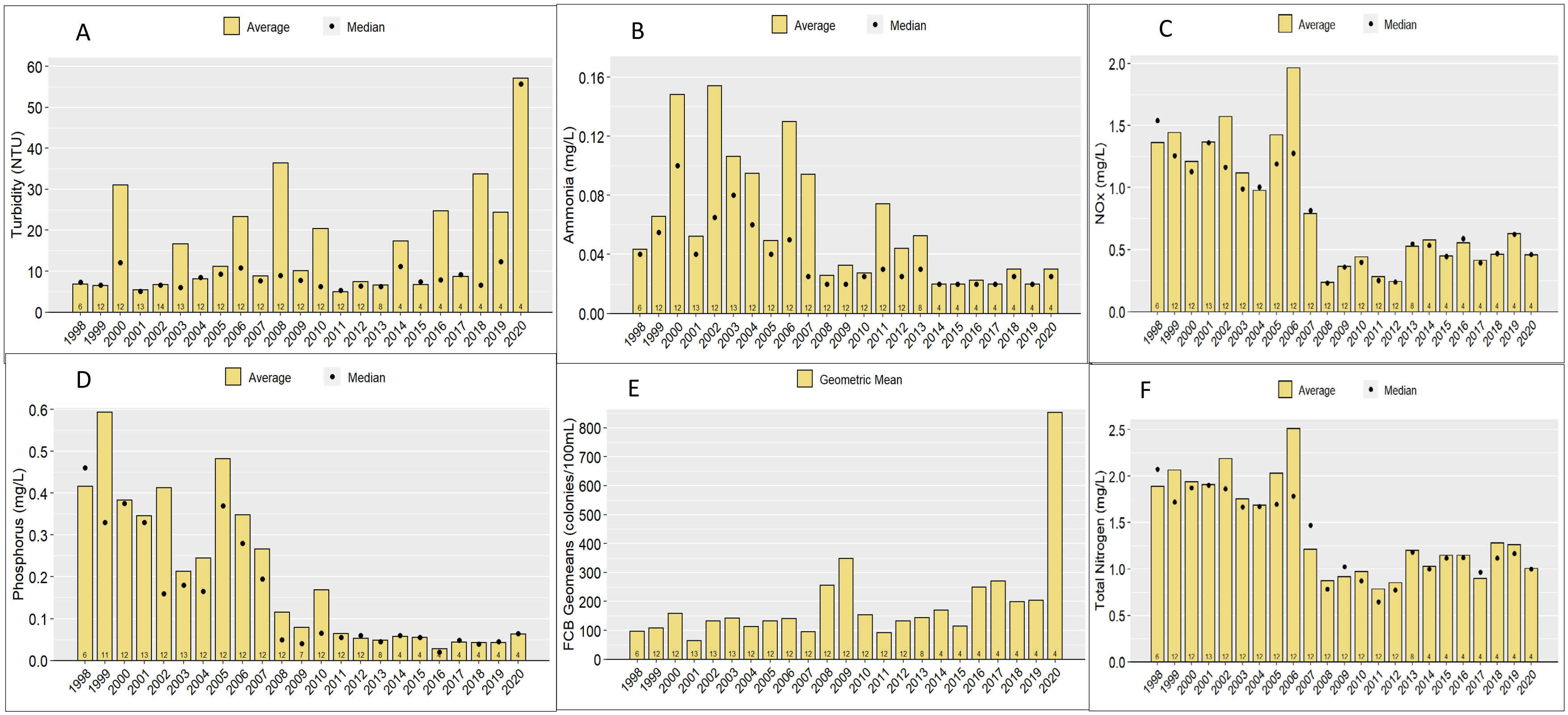
Kenneth Creek [AU#: 18-16-1-(1 and 2)] is the largest tributary of Neills Creek (discussed in the next section) with a DA of 16.6 mi^2. Kenneth Creek receives most of the urban runoff from Fuquay-Varina. The creek within Wake County, outside Lillington's PA, is classified as C. In Harnett County, within the PA, Kenneth Creek is classified as WS-IV.

There are three benthos monitoring stations on Kenneth Creek (BB228, BB435, BB295) and two on unnamed tributaries (BB454, BB453). In Wake County, the uppermost station on Kenneth Creek, BB228, at SR 1100, received a Good rating in 2003 and a Good-Fair in 2007. The station located at US 401, BB435, received a Good-Fair in 1998. The station (BB454) located on an unnamed tributary at SR 2772 received a Poor rating in 1990 and a Fair rating in 1998. In Harnett County, the Kenneth Creek station (BB295) at SR 1441 received either Poor or Fair ratings between 1993 and 2007, with the most recent being Fair. The unnamed tributary station (BB453) at SR 1447 received a Good rating in 1991. The sole fish community station in the watershed (BF42) is located on Kenneth Creek at SR 1441 and received a Fair rating in 2018.

BB228	
Year	**Bioclassification**
2003*	Good
2007*	Good-Fair
BB435	
1998	Good-Fair
BB295	
2003	Poor
2007*	Fair
BF42	
2003	Good
2009	Good-Fair
2013	Not Rated
2014	Good-Fair
2018	Fair
*Special Study	

The MCFBA maintains a water quality monitoring station on Kenneth Creek (B6320000) at SR 1441 near Angier. This segment of Kenneth Creek, [AU#: 18-16-1-(2)], from the county line to Neills Creek is on the 2022 303(d) list for exceeding criteria for benthos, fish community and turbidity. This segment is also listed on the 2022 IR as "Data Inconclusive" for fecal coliform. Fuquay-Varina retired the Kenneth Branch WWTP (NPDES 0028118) shortly after purchasing 2.6 MGD of wastewater capacity in the North Harnett WWTP, which discharges into the Cape Fear River (Fuquay-Varina IBT draft EIS 2022). The town has an option to purchase an additional 3.4 MGD in the future. The town also maintains two permitted discharges in the Neuse Basin. The cessation of the discharge into Kenneth Creek reduced water quality parameters, i.e., ammonia, nitrate+nitrite, total nitrogen, phosphorus, based on yearly averages, medians, and geometric means over the past decade (*Figure 8-52*). Surface water quality monitoring in Kenneth Creek is discussed alongside other water quality monitoring results in the Buies Creek – Cape Fear watershed later in Section 8.7.5.5.

Figure 8-52: Turbidity, Ammonia, Nitrate+Nitrite (NOx), Phosphorus, Fecal Coliform Bacteria (FCB), and Total Nitrogen in Kenneth Creek at Station B6320000.



8.7.5.3 Neills (Neals) Creek

The Neills Creek [AU#: 18-16-(0.7)] watershed is 38 mi^2 and drains the downtown areas of Fuquay-Varina and Angier. The watershed has multiple classifications based on location. Neills Creek in Wake County, outside of the PA for Lillington's public water supply intake, is classified as C. In Harnett County, in the PA, Neills Creek is WS-IV.

BB294	
Year	**Bioclassification**
2003	Fair
2007*	Good-Fair
2013	Fair
2018	Fair
BB283	
2003*	Fair
2007*	Good
*Special Study	

Neills Creek has multiple segments listed on the 2022 303(d) list for exceeding criteria. The following segments exceed criteria for benthos: "From source to a point 0.3 mile upstream of Wake-Harnett County Line" [AU#: 18-16-(0.3)]; "From a point 0.3 mile upstream of Wake-Harnett County Line to SR 1441" [AU#: 18-16-(0.7)a]; and "From SR 1441 to Kenneth Creek" [AU#: 18-16-(0.7)b]. There are two benthos monitoring stations on Neills Creek: one upstream of the Kenneth Creek confluence (BB294) and one downstream of the confluence (BB283). The upstream station at SR 1441 has been sampled six times between 1993 and 2018 and has trended downward from Good to Good-Fair to Fair. Comparisons of past data are hindered by seasonal differences. However, this stream was sampled in the summer of 2007 and rated similarly to the current bioclassification. This stream appears to be exhibiting negative trends for both EPT species richness and ETPBI (a measure of pollution tolerance). Habitat observations suggest this site is affected by excessive sedimentation. The proportion of coarse substrates such as boulder, cobble, and gravel have largely been replaced by fine sediment, which may be a limiting factor for some EPT taxa. The downstream station (BB283) at SR 1403 was sampled in 1988, 2003 and 2007 and has tended to improve from Good-Fair to Fair to Good. *Reducing sediment transport from the surrounding landscape to Neills Creek will improve water quality in the headwaters of Neills Creek and should be prioritized to improve the benthic macroinvertebrate community habitat.*

The segment of Neills Creek "From US 401 to the Cape Fear River" [AU#: 18-16-(0.7)c2] exceeds criteria for turbidity. The MCFBA maintains a monitoring station on Neills Creek (B6252000) at US 401. The Neills Creek segment [AU#: 18-16-(0.7)c2], "From US 401 to the Cape Fear River," is listed on the 2022IR as "Data Inconclusive" for fecal coliform. Surface water quality monitoring in Neills Creek is discussed alongside other water quality monitoring results in the Buies Creek – Cape Fear watershed later in Section 8.7.5.5.

8.7.5.4 Buies Creek

BF12	
Year	**Bioclassification**
2003	Not Rated

The Buies Creek watershed has a drainage area of 28 mi^2. It has two major tributaries: West Buies and East Buies creeks. The watershed, except for the upper headwaters, is within the Protected Area for the Town of Dunn's public water supply intake. The watershed is mostly a patchwork of agricultural, forested, and residential land use south of Angiers to the Cape Fear River with some concentrated development in the community of Buies Creek and Campbell University. The creek runs beside a golf course community near its confluence with the Cape Fear River. The MCFBA maintains a monitoring station adjacent to the golf course on Buies Creek downstream of the tributary confluences (B6485000). Buies Creek (AU#: 18-18; "From source to Cape Fear River") is listed in the 2022 IR as "Data Inconclusive" for fecal coliform. Surface water quality monitoring in Buies Creek is discussed alongside other water quality monitoring results in the Buies Creek – Cape Fear watershed later in Section 8.7.5.5. The sole biological monitoring station in the Buies Creek watershed is a fish community station (BF12) off of SR 1519. It was sampled in 2003 but is Not Rated. Buies Creek is also listed in the 2022 IR as "Data Inconclusive" for fish community.

8.7.5.5 Cape Fear River and adjoining tributaries in the Buies Creek Watershed

The surface water quality data collected between 2001 and 2020 from the mainstem Cape Fear River (B6215000, B6370000, and B6840000), and several adjoining tributaries--Kenneth Creek (B6320000), Neills Creek (B6252000), Buies Creek (B6485000), and the Upper Little River (B6830000)-- are provided in the following figures. The parameters presented on these graphs are fecal coliform bacteria, turbidity, nitrate+nitrite, total Kjeldahl nitrogen, total nitrogen, and total phosphorus, using 5-year average values and annual exceedance rates of the water quality standard. These parameters are paired with 5-year average discharge values from the USGS gage at Lillington (USGS# 02102500) along the Cape Fear River. The Cape Fear River station B6215000 is absent from the 2001 to 2005 period. In 2015-2016, the mainstem Cape Fear River station (B6370000) was resampled as part of the dissolved metals pilot study which did not result in a water quality impairment.

Overall, 5-year average fecal coliform bacteria along the mainstem Cape Fear River (B6215000, B6370000, and B6840000) fluctuates between exceeding the 400 colonies/100 mL water quality standard and falling below the water quality standard (*Figure 8-53*). The adjoining tributaries of Kenneth Creek (B6320000), Neills Creek (B6252000) and Buies Creek (B6485000) appear to be contributing to the elevated concentrations recorded in the mainstem Cape Fear River. Based on annual exceedance rates of the water quality standard the different sections of the mainstem Cape Fear River, adjoining tributaries (Kenneth Creek, Neills Creek, and Buies Creek) can reach exceedance rates at and above 20% (*Figure 8-54*). The Upper Little River often had the lowest 5-year mean fecal coliform bacteria values and lowest annual exceedance rates. While these results are reported here as exceeding the water quality standard and 5-year mean values, it is important to note that the water quality standard for fecal coliform bacteria is based on a 5-in-30 sampling methodology. The results presented here are best viewed as screening values to identify areas of potential concerns as the samples are analyzed outside of hold time and are not collected at a frequency consistent with a 5-in-30 sampling methodology. Also note that the mainstem Cape Fear River is not a Class B waterway and therefore the best intended use is not for primary recreational purposes (See Chapter 2 for additional information on Class B waterways).

Turbidity concentrations in all the monitored waterways in the Buies Creek – Cape Fear River watershed were relatively low compared to the water quality standard of 50 NTU for non-trout, freshwater streams. The exception to this is the surface water quality station on Kenneth Creek (B6320000) and Neills Creek (B6252000), which recorded a 5-year average that approached and exceeded 25 NTU between 2016-2020 (*Figure 8-55*). As noted previously, Kenneth Creek [AU#: 18-16-1-(2)] and Neills Creek [AU#: 18-16-(0.7)c2] are on the 2022 impaired waters list for exceeding the turbidity water quality standard. This increase in turbidity could be the result of increasing development upstream of the water quality monitoring station. Between 2001 and 2019, the developed land upstream of station B6320000 increased from 25% to 35% (approximately 1.54 mi^2) and impervious surface cover increased from 7.4% to 11% of the developed land cover. Similarly, between 2001 and 2019, the developed land upstream of station B6252000 increased from 17% to 24% (approximately 2.63 mi^2) and impervious surface cover increased from 4.4% to 6.8% of the developed land cover. *<u>As development continues, regular inspections of the BMPs to ensure compliance with sediment and erosion control measures during the ongoing development in the watersheds and implementation of stormwater BMPs are needed to limit stormwater volume and sediments from reaching the streams draining to Kenneth Creek and Neills Creek.</u>*

Nitrate+nitrite concentrations in the mainstem Cape Fear River were typically the highest of the monitored waterways in the Buies Creek – Cape Fear River watershed. The Cape Fear River has maintained typical values of approximately 0.5 mg/L between 2001-2020 at the three monitoring stations (*Figure 8-56*). Similarly, Kenneth Creek (B6320000) also records nitrate+nitrite concentrations that hover around 0.5 mg/L. Kenneth Creek flows, which flows into Neills Creek (B6252000), approaches 0.5 mg/L during the 2001-2005 and 2016-2020 periods but hovers around 0.3 mg/L during the 2006-2015 time frame. Adjoining tributaries, Buies Creek (B6485000) and the Upper Little River (B6840000), have nitrate+nitrite concentrations that typically hover around the concentration considered normal for healthy piedmont streams (0.3 mg/L).

Ammonia concentrations in the mainstem Cape Fear River and adjoining tributaries have recently fallen to levels considered normal for healthy piedmont streams during 2016 – 2020 (0.05 mg/L) (*Figure 8-57*). Previously, the mainstem Cape Fear River, Kenneth Creek, and Buies Creek all had 5-year mean values that approached or exceeded values considered normal for healthy piedmont streams. While ammonia concentrations have declined in many of these streams, the water quality monitoring stations along the upper section of the Cape Fear River (B6215000 and B6370000) still approach the 0.05 mg/L value considered normal for healthy piedmont streams.

Total Kjeldahl nitrogen is composed of ammonia and organic nitrogen. While ammonia contributes to these concentrations, in the mainstem Cape Fear River and adjoining tributaries in the Buies Creek – Cape Fear River watershed it appears to be a small fraction of the total Kjeldahl nitrogen signature. During most years, the mainstem Cape Fear River (B6215000, B6370000, and B6840000) typically has the highest total Kjeldahl nitrogen concentrations alongside Buies Creek (*Figure 8-58*). The lack of point sources and permitted facilities in Buies Creek suggests the total Kjeldahl nitrogen signature is primarily controlled by nonpoint sources. Kenneth Creek, Neills Creek, and the Upper Little River consistently recorded lower 5-year total Kjeldahl nitrogen mean values.

The total nitrogen concentrations recorded in the mainstem Cape Fear River tend to be elevated above 1.0 mg/L and often approach 1.25 mg/L (*Figure 8-59*). Notably, Kenneth Creek also recorded elevated total nitrogen levels that exceeded 1.0 mg/L; however, the primary form of nitrogen in that waterway is nitrate+nitrite during 2001-2010. After 2010, the nitrate+nitrite concentration decreased, and the primary form of nitrogen became total Kjeldahl nitrogen most likely because of retiring the Kenneth Branch WWTP (NPDES 0028118). Total nitrogen levels in tributaries of the Cape Fear River (Buies Creek, Neills Creek, and Upper Little River) tend to approach and marginally exceed 1.0 mg/L. All the monitored waterways in the Buies Creek – Cape Fear River watershed record total nitrogen concentrations that often approach or exceed concentrations considered normal for healthy piedmont streams (0.8 mg/L).

Total phosphorus concentrations in the mainstem Cape Fear River are elevated with values approaching or exceeding 0.1 mg/L (*Figure 8-60*). Tributaries of the mainstem Cape Fear River (Buies Creek, Neills

Creek, and Upper Little River) typically record lower concentrations than the mainstem Cape Fear River. Notably, Kenneth Creek, Neills Creek, and Buies Creek had total phosphorus concentrations that typically approached or exceeded 0.1 mg/L until after the year 2010, based on 5-year mean values. These total phosphorus concentrations are higher than values considered normal for healthy piedmont streams (0.05 mg/L).

Figure 8-53: Five-year Mean Fecal Coliform Bacteria Values in the Mainstem Cape Fear River (B6215000, B6370000, and B6840000), Kenneth Creek (B6320000), Neills Creek (B6252000), Buies Creek (B6485000), and the Upper Little River (B6830000).

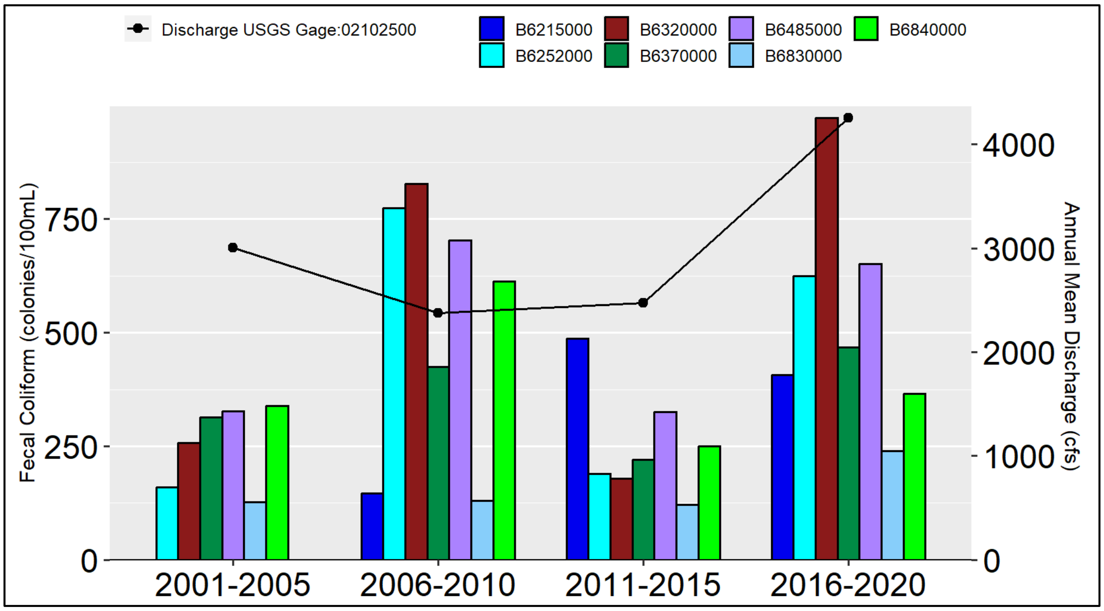


Figure 8-54: Annual Exceedance Rate for Fecal Coliform Bacteria Values in the Mainstem Cape Fear River (B6215000, B6370000, and B6840000), Kenneth Creek (B6320000), Neills Creek (B6252000), Buies Creek (B6485000), and the Upper Little River (B6830000) Based on a Water Quality Standard of 400 colonies/100 mL.

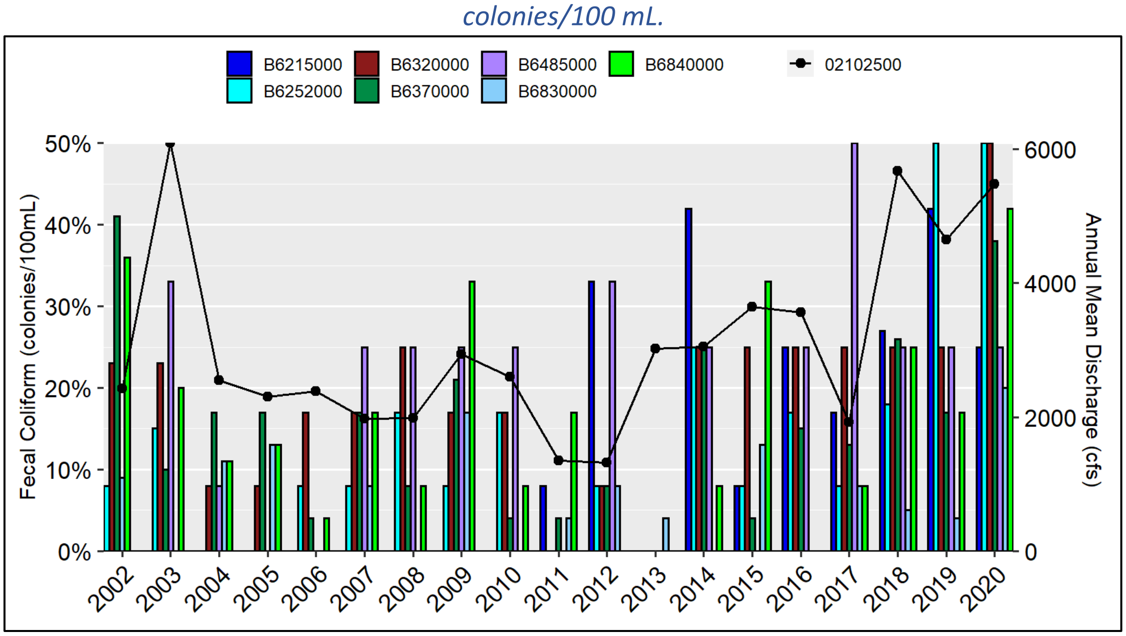


Figure 8-55: Five-year Mean Turbidity Values in the Mainstem Cape Fear River (B6215000, B6370000, and B6840000), Kenneth Creek (B6320000), Neills Creek (B6252000), Buies Creek (B6485000), and the Upper Little River (B6830000).

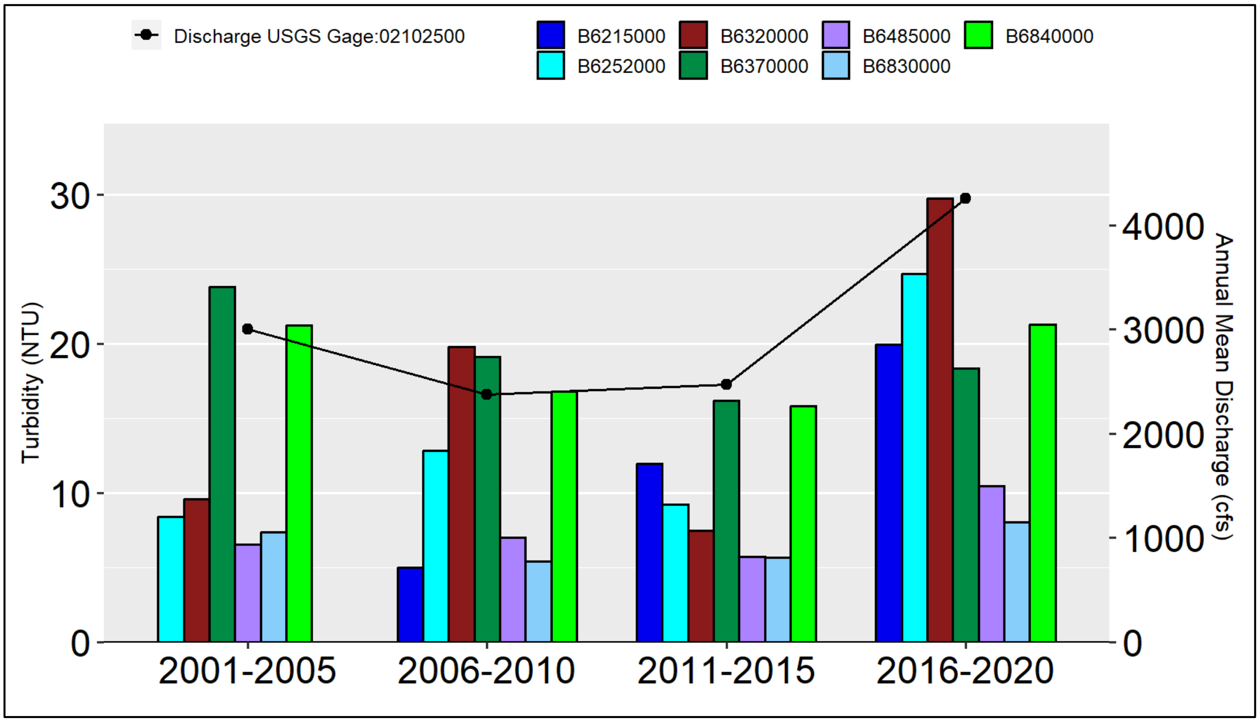


Figure 8-56: Five-year Mean Nitrate+Nitrite (NOx) Values in the Mainstem Cape Fear River (B6215000, B6370000, and B6840000), Kenneth Creek (B6320000), Neills Creek (B6252000), Buies Creek (B6485000), and the Upper Little River (B6830000).

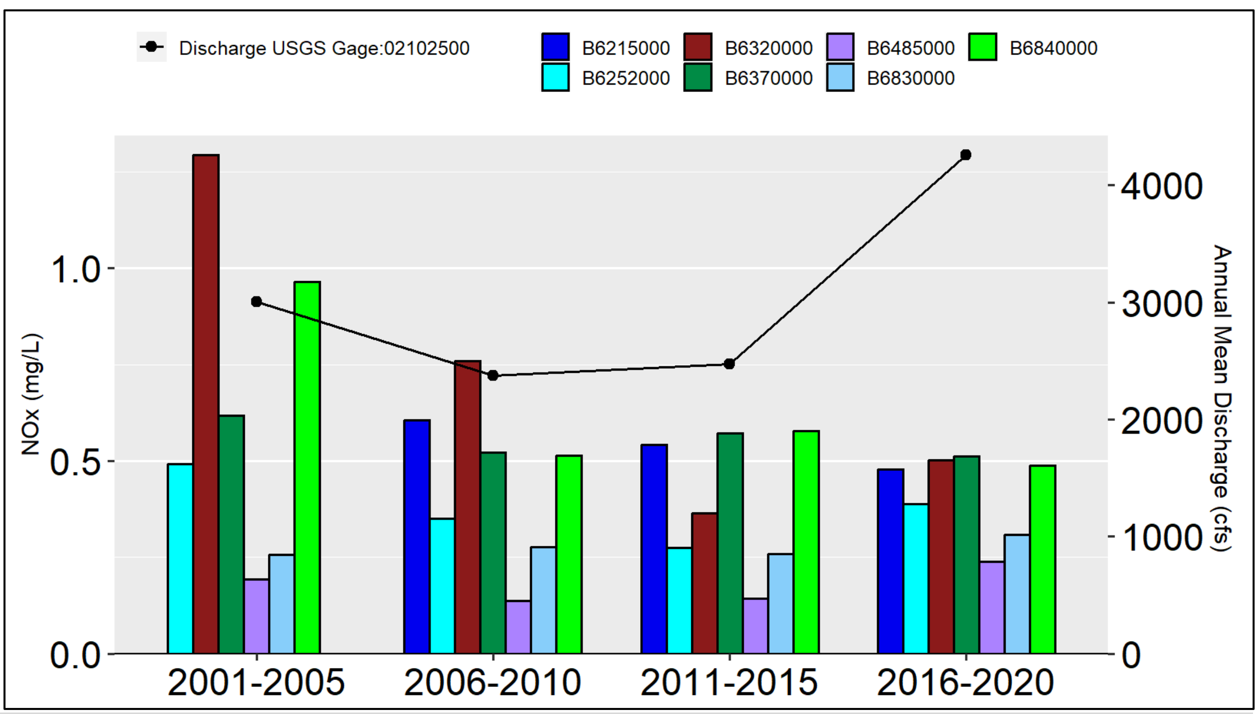


Figure 8-57: Five-year Mean Ammonia Values in the Mainstem Cape Fear River (B6215000, B6370000, and B6840000), Kenneth Creek (B6320000), Neills Creek (B6252000), Buies Creek (B6485000), and the Upper Little River (B6830000).

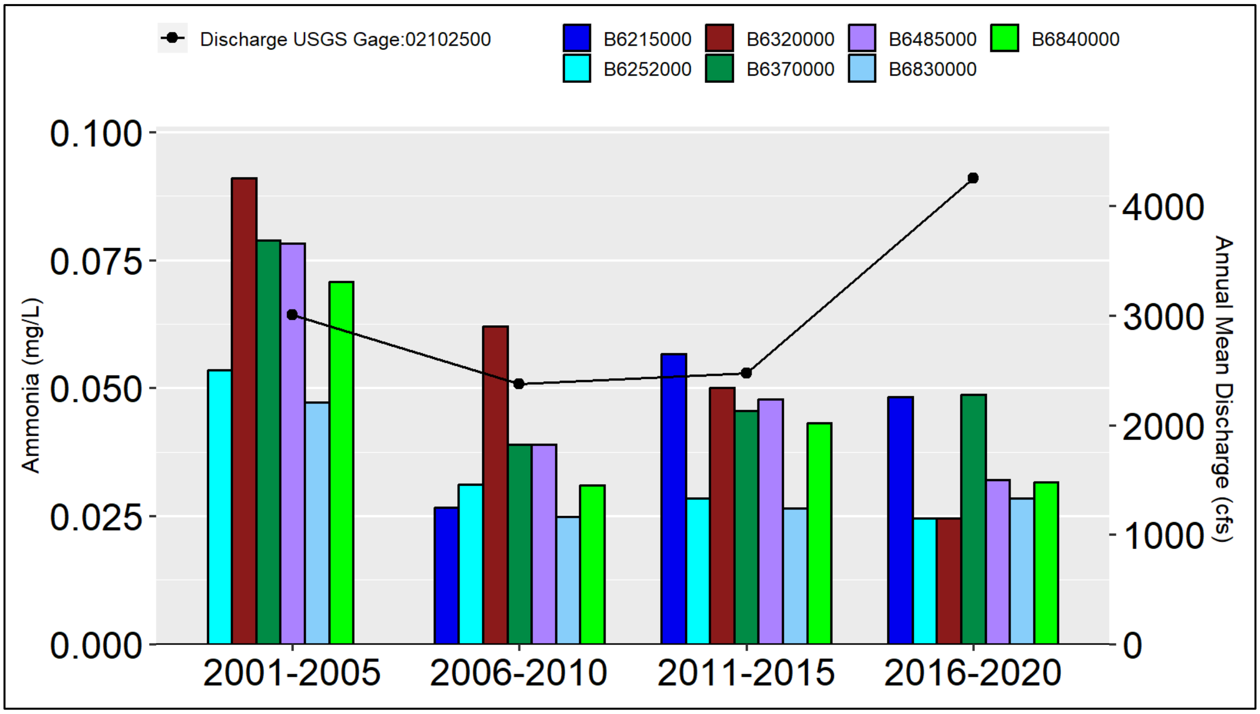


Figure 8-58: Five-year Mean Total Kjeldahl Nitrogen Values in the Mainstem Cape Fear River (B6215000, B6370000, and B6840000), Kenneth Creek (B6320000), Neills Creek (B6252000), Buies Creek (B6485000), and the Upper Little River (B6830000).

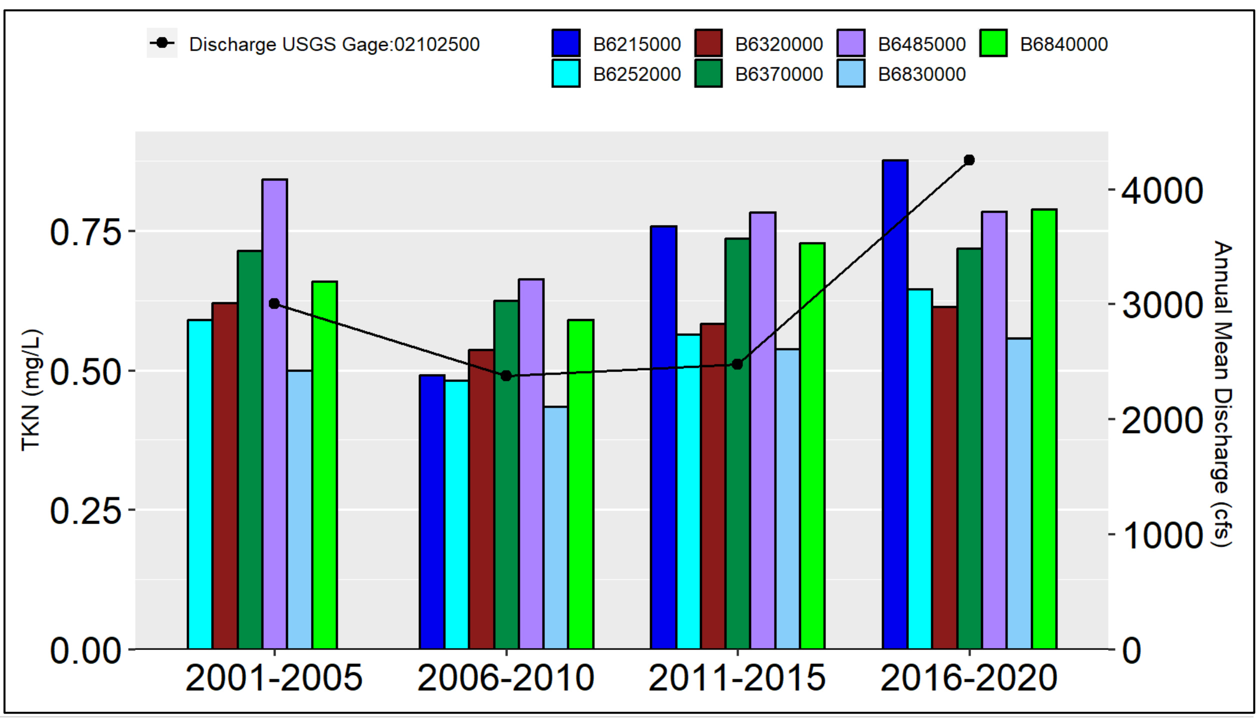


Figure 8-59: Five-year Mean Total Nitrogen Values in the Mainstem Cape Fear River (B6215000, B6370000, and B6840000), Kenneth Creek (B6320000), Neills Creek (B6252000), Buies Creek (B6485000), and the Upper Little River (B6830000).

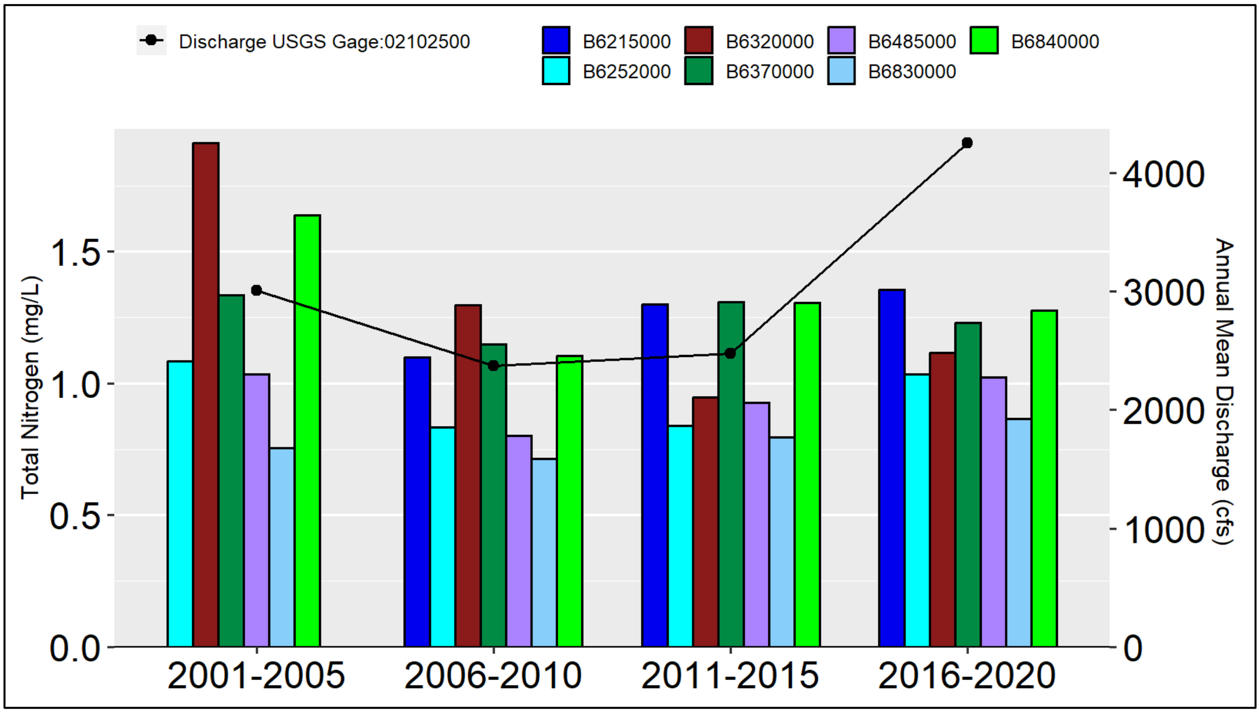
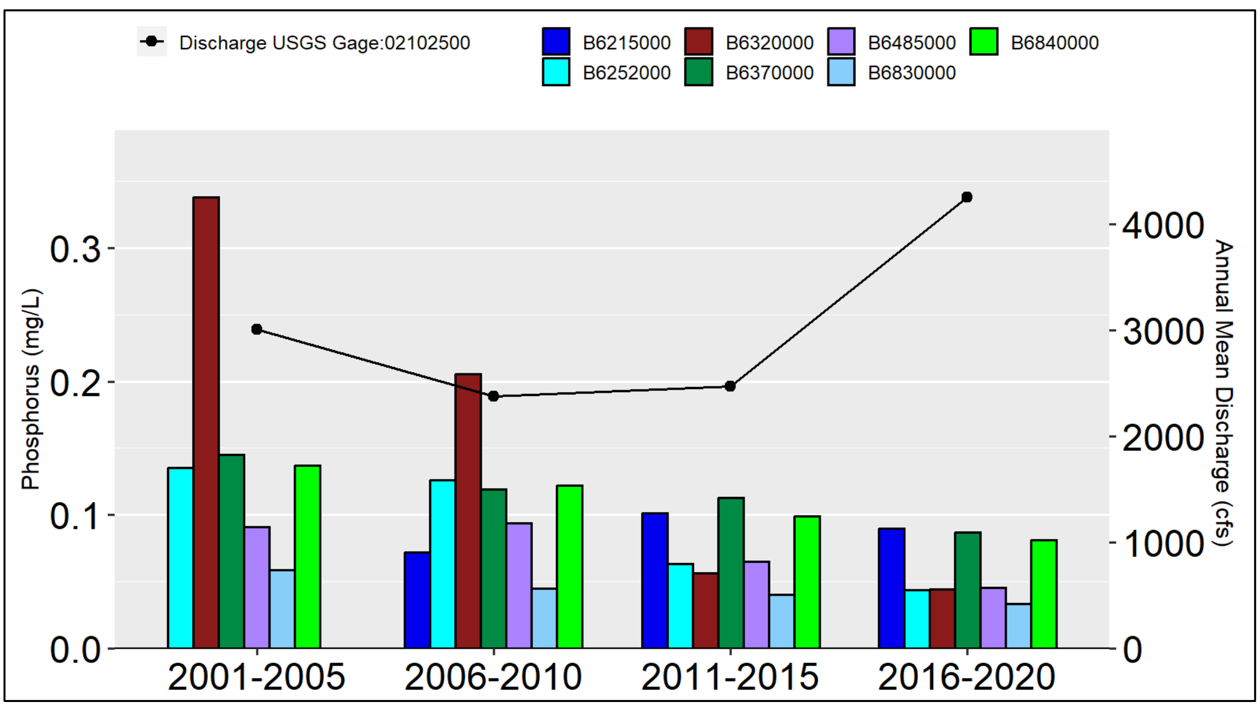
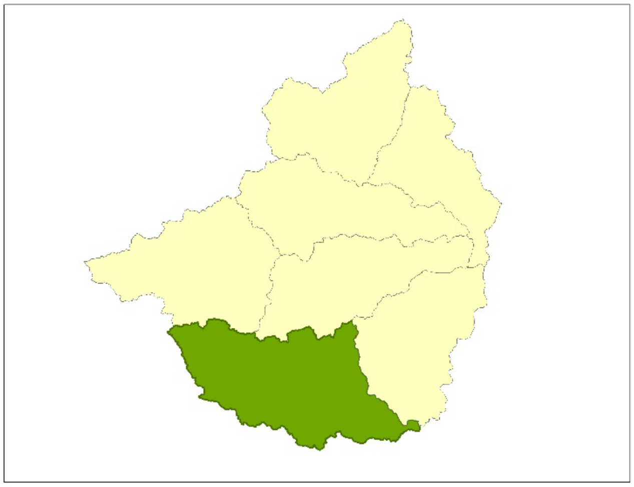


Figure 8-60: Five-year Mean Total Phosphorus Values in the Mainstem Cape Fear River (B6215000, B6370000, and B6840000), Kenneth Creek (B6320000), Neills Creek (B6252000), Buies Creek (B6485000), and the Upper Little River (B6830000).



8.7.6 Rockfish Creek Watershed (0303000406)



The Rockfish Creek watershed is 309 mi^2. The watershed drains the municipalities of Hope Mills, Raeford, and western Fayetteville. The watershed also drains the southern half of the Ft. Liberty military base with its built-upon areas and forested, grassland/shrub and barren areas. The southeastern area of the watershed, near the confluence with the Cape Fear River, is largely forested and agriculture. The area around Hope Mills and to the north is mostly dense residential development to accommodate Fayetteville and Ft. Liberty. The western half of the watershed that is not within Ft. Liberty is a patchwork of forest, agricultural, grassland/shrub and suburban and urban development, including the Town of Raeford. The Ft. Liberty lands are forest, shrub and barren lands used for military training.

As of May 2022, there were two major NPDES wastewater discharge facilities permitted for 4.5 MGD, two swine AFO permitted for 7,104 head with 213,120 pounds of allowable live weight, 157 ac of land application of residual solids, and 10 NPDES and 161 state stormwater facilities. The major NPDES facilities are the Hoke County WWTP (NC0089176), with a permitted as-built of 1.5 MGD and the Raeford WWTP (NC0026514), with a permitted as-built of 3.0 MGD. Both facilities discharge to Rockfish Creek. See Chapter 3 Appendix for a list of permits.

There is a 46-acre parcel in the DEQ Stewardship Program that is the remnants of a bay lake, east of Raeford near Scurlock School in the headwaters of Beaver Creek. Another remnant bay lake, Arabia Bay, near the Arabia community, sits on the ridge between Rockfish Creek and Little Marsh Swamp Creek and is a mitigation project to restore the natural hydrology.

The NCWRC 1,021-acre Nicholson Creek Game Land abuts Ft. Liberty and includes Upchurch Lake in the Nicholson Creek watershed. The NCWRC 2,690-acre Rockfish Creek Game Land also abuts Ft. Liberty and lies between Rockfish and Mill creeks. A parcel of the game land is known as Calloway Forest Preserve and is managed by The Nature Conservancy in consultation with the U.S. Fish and Wildlife Service to protect and enhance habitat for species endemic to the Carolina Sandhills. The Gordon Butler Nature Preserve is a 12.5-acre parcel owned and managed by the North Carolina Botanical Garden. It is located at the confluence of Buckhead and Little Rockfish creeks at the upper end of Hope Mills Lake.

The Rockfish Creek watershed is primarily composed of forest land (35.0%) along the headwaters of Rockfish Creek and tributaries. Developed land (29.5%) is also prevalent in this watershed, primarily along the midstream tributaries. The remaining land covers are a mixture of wetlands (14.5%), grassland and grassland/shrub (9.8%), agriculture (7.9%), barren land (2.9%) and open water (0.5%).

The mainstem river flowing through the Rockfish Creek watershed is Rockfish Creek. Some of the larger tributaries are Little Rockfish Creek, Puppy Creek, Bones Creek, Nicholson Creek, Piney Bottom Creek, and

Juniper Creek. As reported in the 2022 Integrated Report, there are no impaired waterways in this subbasin; however, stressed biological communities (fish and benthos), low pH, and elevated fecal coliform bacteria are identified as "Data Inconclusive" for several waterways.

8.7.6.1 Puppy Creek

Puppy Creek flows 10.51 miles across eastern Hoke County [AU#: 18-31-19]. This waterway received a Fair rating in 2003, indicating the benthos community at monitoring station (BB200) is possibly stressed due to point and/or nonpoint sources of pollution. While the benthos community showed signs of stress in Puppy Creek in 2003, the co-located fish community monitoring station (BF140) records Puppy Creek with high quality habitats, water quality parameters, and fish assemblage characteristics, and two consecutive Excellent ratings in 2013 and 2018.

BF200	
Year	**Bioclassification**
2003*	Fair
BF140	
2013	Excellent
2018	Excellent
BF39	
2003	Good
2008	Good-Fair
*Special Study	

8.7.6.2 Rockfish Creek

Surface water quality monitoring stations are positioned along the entire 47.59-mile length of Rockfish Creek in this watershed through regular sampling at four monitoring stations (B7679300, B7700000, B8224000, B8230000). The stations are arranged from upstream to downstream along the following assessment unite in the following order: [AU#: 18-31-(12), 18-31-(18), and 18-31-(23)]. The upstream surface water quality monitoring stations (B7679300 and B7700000) are located on primary recreation water (class B). The downstream surface water quality monitoring stations (B8230000 and B8224000) are located on secondary recreation waters (class C). These classifications aim to protect the multiple uses of Rockfish Creek.

Historically, the furthest upstream surface water quality monitoring station (B7679300) has recorded two years (2009 and 2010) with annual average fecal coliform bacteria values that exceeded the 400 colonies/100 mL water quality standard (*Figure 8-61*). This is most likely due to extreme events as less than 10% of the samples collected that year exceeded the 400 colonies/100 mL water quality standard (*Figure 8-62*). Notably, in 2003 and 2012 more than 20% of the samples collected exceeded the 400 colonies/100 mL water quality standard with an annual average of approximately 250 colonies/100 mL. The next downstream water quality station (B7700000) has considerably higher annual average fecal coliform bacteria values with most years exceeding the 400 colonies/100 mL water quality standard and the annual percentages of samples exceeding this water quality standard often approach or exceed 20% of the samples collected since 2002. There have been several 5-in-30 assessments completed at this station. The latest one was completed in October 2014. The geometric mean was 211.46 colonies/100 mL, which violated the water quality standard. Additionally, 20% of the samples were over 400 colonies/100 mL. Between the two upstream stations (B7679300 and B7700000) there exists a single animal feeding operation and the Raeford WWTP (NC0026514). Based on the compliance history between 2010 and 2020 for the Raeford WWTP, there have been no enforcement cases for fecal coliform bacteria in the effluent. The effluent contributes 8.67% of the instream waste concentration in Rockfish Creek.

Farther downstream along the mainstem Rockfish Creek, at station B8224000 fecal coliform bacteria levels decline based on annual average values (*Figure 8-61*). While the annual average values are often below the 400 colonies/100 mL water quality standard, during the 2016-2020 time frame approximately

1 out of 4 samples (27.5%) were recorded exceeding the 400 colonies/100 mL water quality standard; more than 50% of the samples in 2017 exceeding this water quality standard (*Figure 8-62*). Between stations B7700000 and B8224000 there exists a single animal feeding operation and the Hoke County WWTP (NC0089176). The county's facility has not had a history of compliance issues for fecal coliform bacteria in the effluent between 2010 and 2020. The facility discharges into Rockfish Creek upstream of B8224000 and contributes 2.9% of the instream waste concentration. The influence of elevated fecal coliform bacteria levels in the middle section of Rockfish Creek at stations B7700000 and B8224000 is observable in *Figure 8-61*, with most annual mean values for those stations elevated above the 400 colonies/100 mL water quality standard. The most downstream Rockfish Creek station (B8230000) indicates fecal coliform bacteria levels are sometimes lower than the 400 colonies/100 mL water quality standard before discharging to the Cape Fear River; however, several years (2003, 2004, 2008, 2011, and 2014) have annual average values in excess of 400 colonies/100 mL (*Figure 8-61*). Exceedance rates based on samples collected throughout the year also suggest several years approach or exceed the water quality standard 20% of the time since 2002 (*Figure 8-62*).

While these results are reported here as exceeding the water quality standard and annual mean values, it is important to note that the water quality standard for fecal coliform bacteria is based on a 5-in-30 sampling methodology. The results presented here are best viewed as screening values to identify areas of potential concerns as the samples are analyzed outside of hold time and are not collected at a frequency consistent with a 5-in-30 sampling methodology. Also note that portions of Rockfish Creek are Class B waterways and therefore the best intended use is primary recreational purposes (See Chapter 2 for additional information on Class B waterways). *Recommendations for Rockfish Creek include stream walks to identify straight pipes and failing septic systems. Alongside source identification, the fecal coliform bacteria data collected in 2014 using a 5-in-30 sampling methodology on assessment unit 18-31-(18) in the middle section of Rockfish Creek should be reviewed and the waterway should be considered for placement on the impaired waters list. If the data collected in 2014 is no longer valid, it may be necessary to collect additional samples through a 5-in-30 methodology and submit for this creek's consideration for placement on the impaired water list.*

Another concerning parameter in Rockfish Creek is pH. Most of the annual median values were below the 6 s.u. water quality standard (*Figure 8-63*). It should be noted that this waterway flows through the Sand Hills ecosystem and transitions to the Southeastern Floodplains and Low Terraces (as discussed previously). It was also determined in the 2018 Integrated Report that the pH of Rockfish Creek could potentially be due to natural conditions. The pH recorded along the entire length of the Rockfish Creek is lower than other waterways in the Cape Fear River Basin; except the Upper Little River and Little River, which were discussed previously in this chapter. The exact cause and source of these lower pH values is unclear; however, it has been noted that the low buffering capacity of sandy soils and the potential impact of conifer trees could exert an influence on flow-through pH in Rockfish Creek although this is an active area of research and other factors (acidic soils, sulfur-bearing minerals, human influence, or other) may have an influence on lower the pH of the Rockfish Creek. Currently, there are no North Carolina Sandhills specific studies, or conflicting information, to definitively support these two phenomena, although they could exist. The pH in Rockfish Creek appears to improve progressively as the drainage area increases and more streamflow is contributed. The lowest values observed were at the most upstream station B7679300, and higher values were observed prior to joining the mainstem Cape Fear River at station B8230000. *A natural conditions assessment might be warranted to determine whether these low pH levels are the result of natural conditions or anthropogenic influences*.

BB293	
Year	**Bioclassification**
2003	Good
2008	Good
2013	Good-Fair
2018	Excellent
BF139	
2013	Good
2018	Excellent
BF141	
2013	Excellent
2018	Good
BB203	
2003	Good-Fair
BF20	
2003	Excellent
2008	Excellent
BB499	
2008	Good
BF34	
2003	Excellent
2008	Excellent
BB201	
2003*	Good-Fair
2008*	Good
BF19	
2003	Excellent
2008	Excellent
2013	Excellent
BB151	
2003	Good
2008	Good
2013	Good
BF35	
2003	Good-Fair
2008	Excellent
*Special Study	

Nitrate+nitrite concentrations in Rockfish Creek are especially low in the headwaters as recorded at station B7679300, however values increase considerably at the next downstream station (B7700000) (*Figure 8-64*). Station B7700000 typically records the highest nitrate+nitrite concentration and values typically decline to typical values hover around the EPA nutrient criteria for coastal waters along the entire length of the waterway (*Figure 8-64*). Similarly, total Kjeldahl nitrogen concentrations are only elevated above 0.75 mg/L in 2004, 2007, 2008, and 2009 (*Figure 8-65*). The typical total nitrogen concentrations are reflective of the relatively low nitrate+nitrite and total Kjeldahl nitrogen concentrations in Rockfish Creek (*Figure 8-66*). While the nitrogen concentrations in Rockfish are typically low, the total phosphorus concentrations have historically been elevated above the EPA nutrient criteria for coastal waters; however, in recent years (2016 – 2020) the typical concentrations have declined considerably compared to historical values (*Figure 8-67*). Typical total phosphorus concentrations still hover slightly above and below 0.05 mg/L and are not quite below or at the EPA nutrient criteria for coastal waters (0.032 mg/L). Turbidity values were typically below the 50 NTU non-trout water quality standard; however, occasional extreme values have increased the average turbidity concentrations. The highest turbidity values were typically observed in the two farthest downstream stations, B8224000 and B823000, which had the highest mean values since 2002 (*Figure 8-68*).

DWR conducted screening-level seasonal Mann-Kendall trend seasonal and non-seasonal tests for total phosphorus and ammonia, which all displayed significant declining trends for station B7700000, B8224000, and B8230000 calculated at 95% confidence from data collected from 2000-2019. Turbidity at all three stations displayed significant increasing trends during this same time frame.

Rockfish Creek had several benthos monitoring stations along its entire length before discharging into the Cape Fear River. Although numerous monitoring stations have been established in the Rockfish Creek watershed, only station BB293 on Rockfish Creek has been sampled consistently since 2003. This station was sampled eight times between 1990 and 2018, receiving a Good-Fair in 1990 and 2013, five Good ratings from 1993 to 2008, and an Excellent in 2018. Despite the improvement in bioclassification, the long-term trend for this site is stable, exhibiting modest improvement. Biologists noted that Rockfish Creek clearly represents an exemplary and scenic Sandhills regional reference watershed, showing near optimal water quality parameters, habitat assessment scores, and fish community (BF139) condition in this latest biological survey. Several tributaries that drain to Rockfish Creek also recorded Good or Excellent ratings in either 2008, 2013, or 2018 including Piney Bottom Creek (BF141), Juniper Creek (BB203, BF20), Nicholson Creek (BB499, BF34), Little Rockfish Creek (BB201, BF19, BB151), Bones Creek (BF35).

Figure 8-61: Annual Mean Fecal Coliform Bacteria Levels in Rockfish Creek based on a Water Quality Standard of 400 colonies/100 mL.

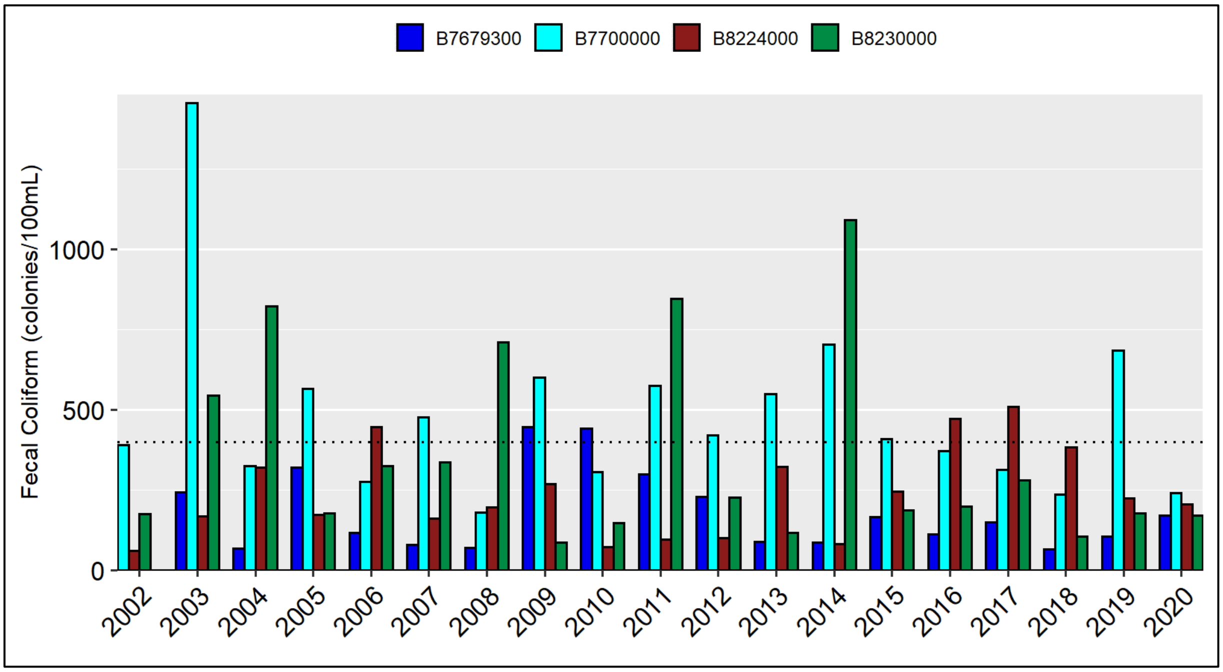


Figure 8-62: Annual Exceedance Rate for Fecal Coliform Bacteria Levels in Rockfish Creek based on a Water Quality Standard of 400 colonies/100 mL.

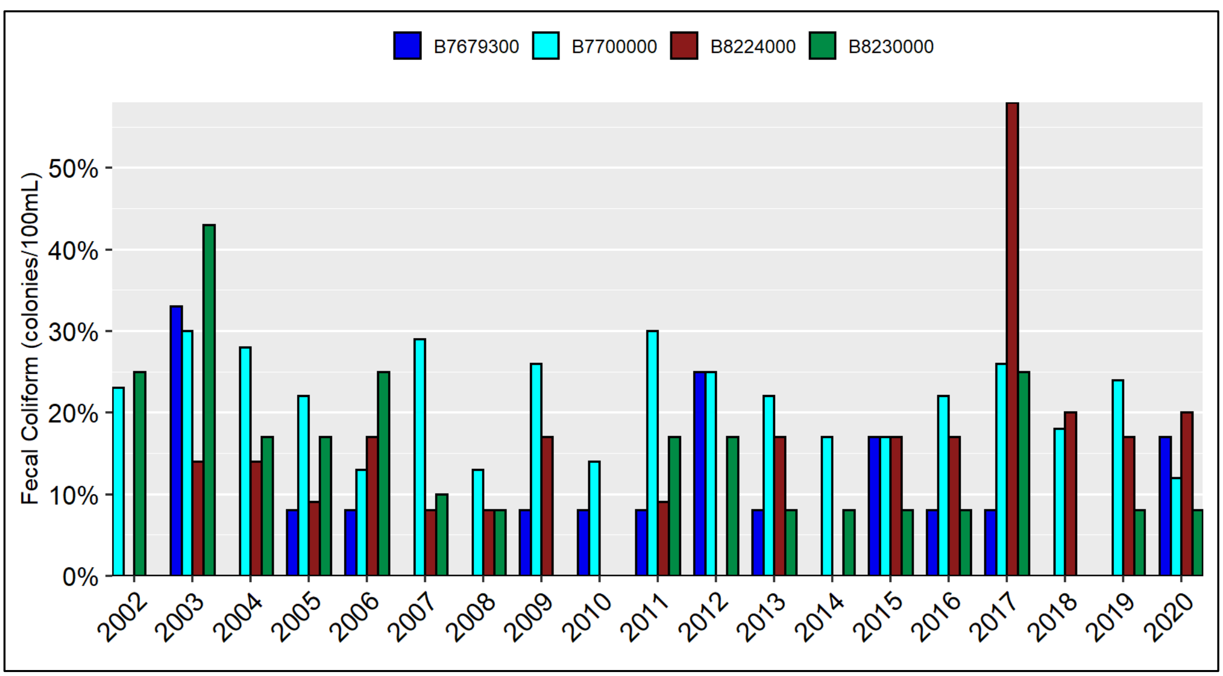


Figure 8-63: Annual Median pH Levels in Rockfish Creek (BB7679300, B7700000, B8224000, B8230000).

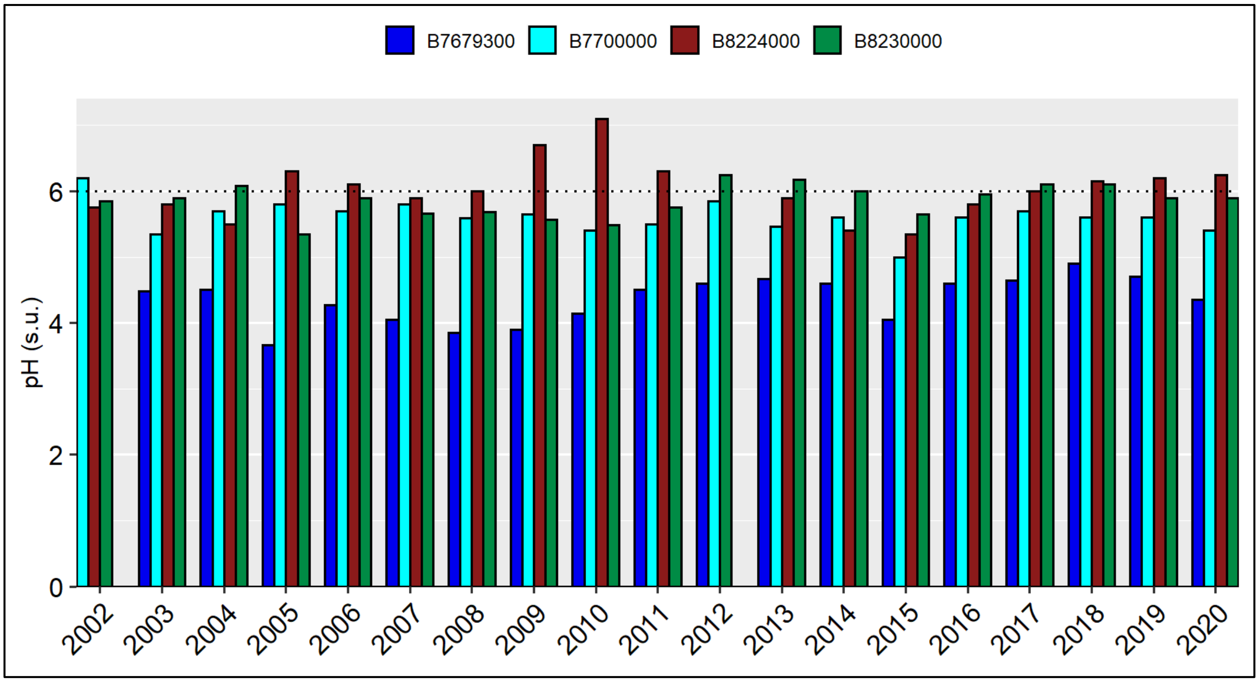


Figure 8-64: Annual Mean Nitrate+Nitrite (NOx) Concentrations in Rockfish Creek (BB7679300, B7700000, B8224000, B8230000).

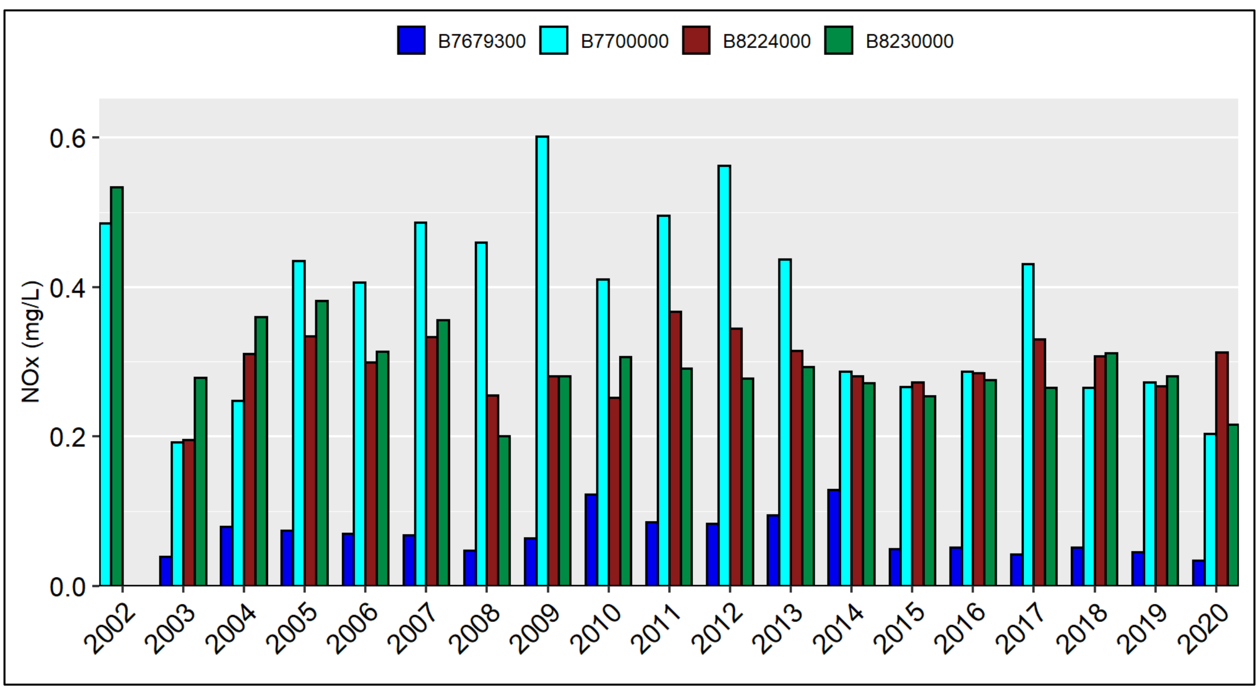


Figure 8-65: Annual Mean Total Kjeldahl Nitrogen (TKN) Concentrations in Rockfish Creek (BB7679300, B7700000, B8224000, B8230000).

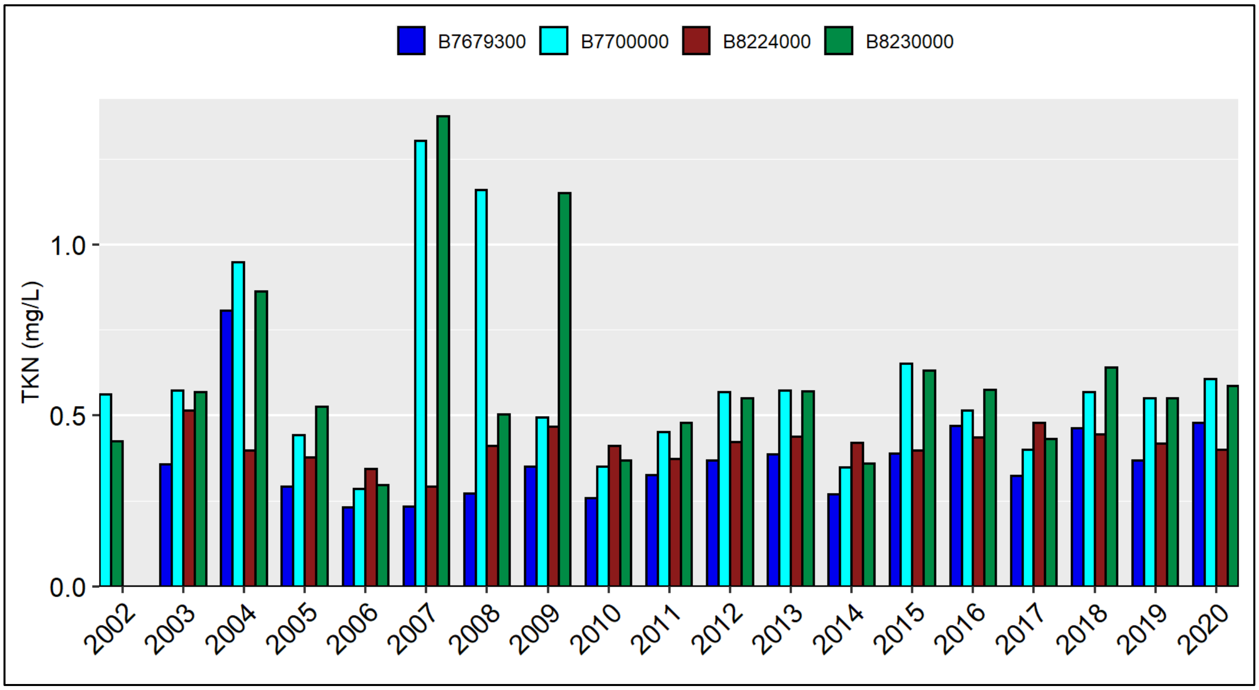


Figure 8-66: Annual Mean Total Nitrogen Concentrations in Rockfish Creek (BB7679300, B7700000, B8224000, B8230000).

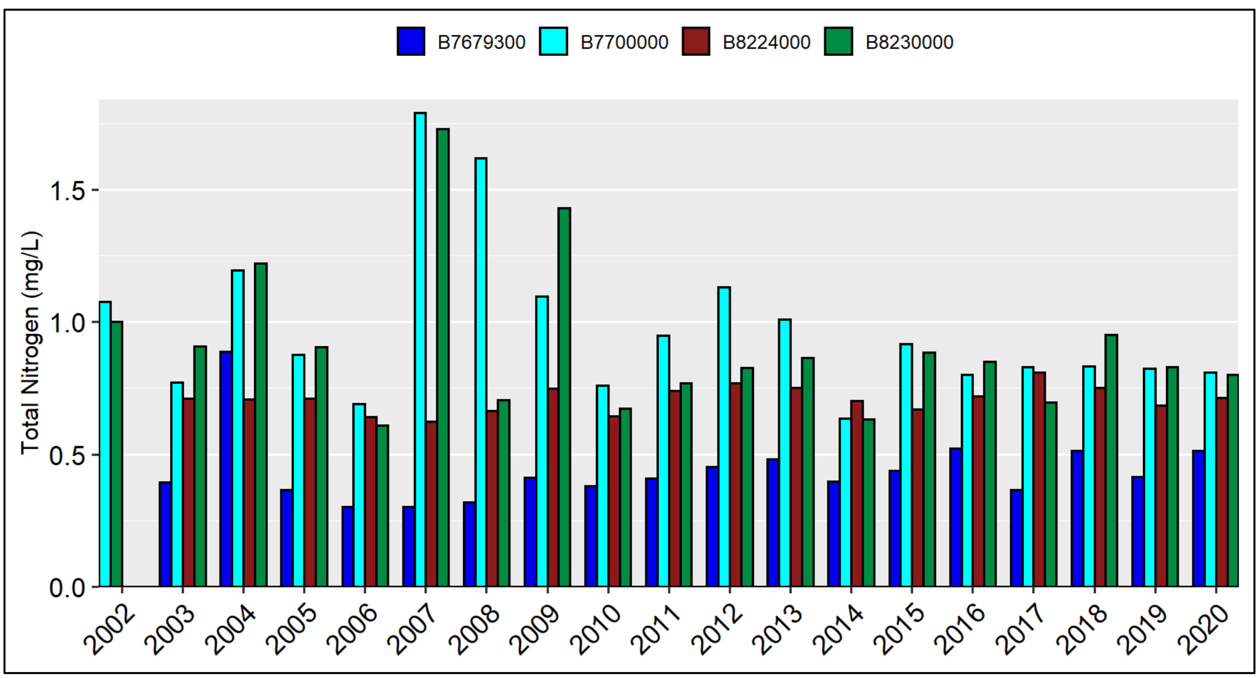


Figure 8-67: Annual Mean Total Phosphorus Concentrations in Rockfish Creek (BB7679300, B7700000, B8224000, B8230000).

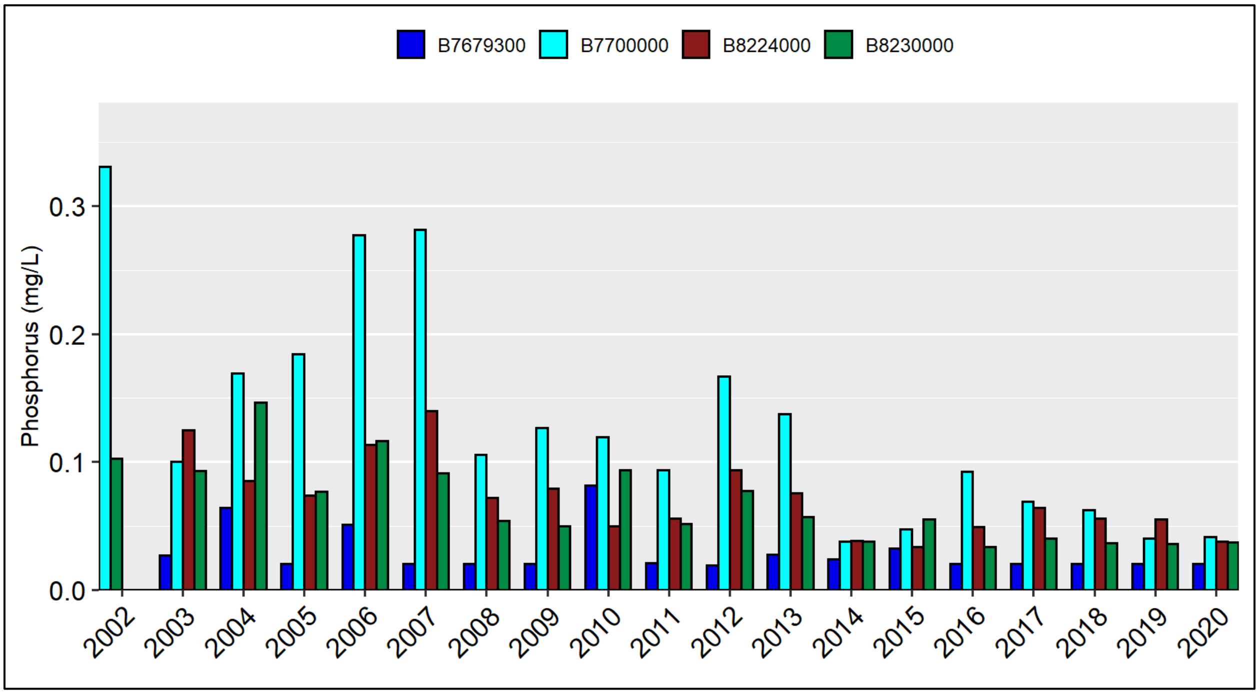
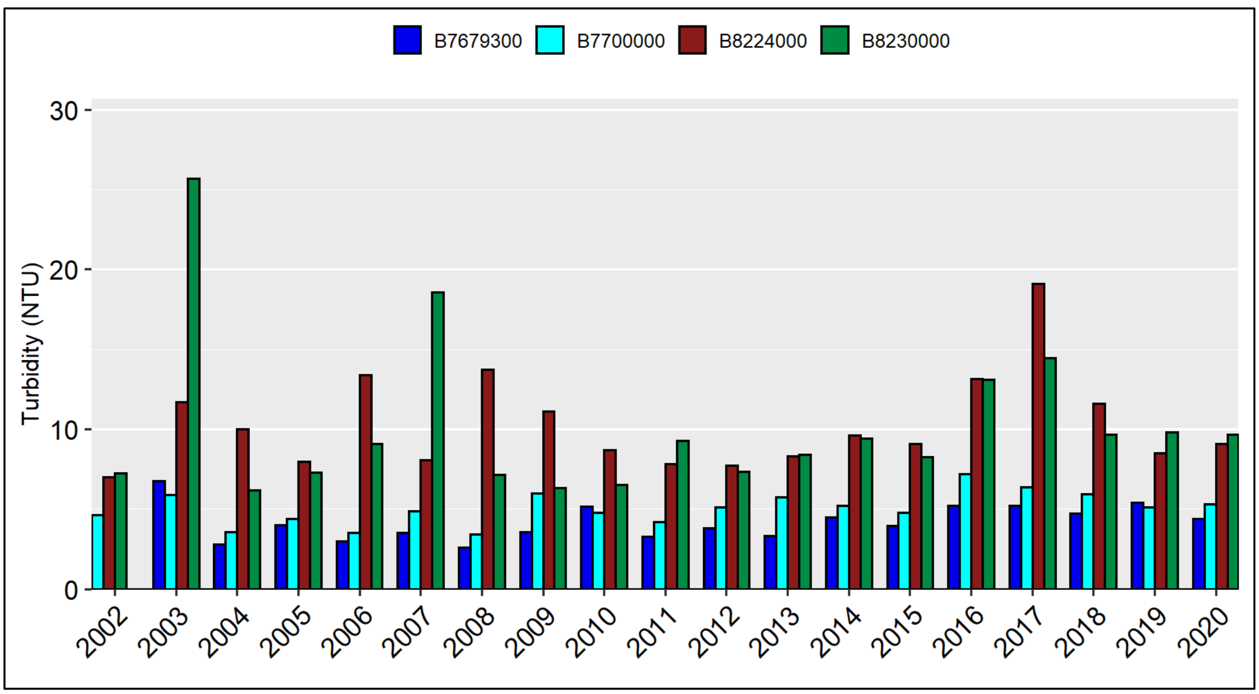
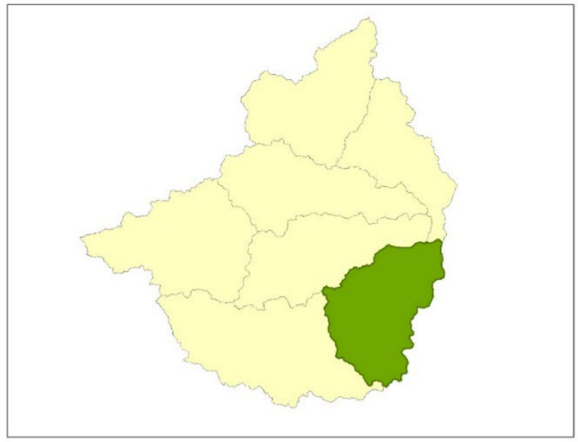


Figure 8-68: Annual Mean Turbidity in Rockfish Creek (BB7679300, B7700000, B8224000, B8230000).



8.7.7 Cross Creek – Cape Fear River Watershed (0303000407)



The Cross Creek-Cape Fear River watershed has a drainage area of 222 mi^2 and encompasses the tributaries of the Cape Fear River between the Little River confluence at the Harnett-Cumberland County boundary downstream to midway between the Locks and Cedar Creek confluences, excluding the Rockfish Creek watershed. The portion of the watershed west of the Cape Fear River is dominated by the City of Fayetteville. North of the I-295 Bypass, the watershed becomes more agricultural and forested lands. South of Fayetteville and I-95 this western portion also becomes increasingly more agricultural and forested lands. There is limited urban development on the east side of the Cape Fear River except for East Fayetteville. Most of the land use is agricultural and developed land used for concentrated suburban communities and industrial manufacturing. The I-95 corridor runs the length of the watershed east of the river with some strip development along the corridor. The Sandhills Access area of Carvers Creek State Park is in the watershed and is about 3,000 acres. The Carvers Creek parcel was added to the state park system in 2005 and lies in the Carvers Creek watershed. The City of Fayetteville's Arnette Park is a 100-acre mixed-use park adjacent to the Cape Fear River. Pearces Mill Creek lies on the north boundary of the park.

As of May 2022, there were three major and two minor NPDES wastewater discharge facilities permitted for 47.25 MGD, two swine AFOs permitted for 7,680 head count with 875,200 pounds live weight, 717 acres of land application of residual solids, and 33 NPDES and 42 state stormwater facilities. The major NPDES facilities are the Cedar Creek Site (NC0003719), an industrial WWTP owned by Dak Americas (NC0089176) with a permitted as-built flow of 1.25 MGD and two municipal WWTPs owned by the Fayetteville Public Works Commission, the Cross Creek WWTP (NC0023957) with a permitted as-built flow of 25 MGD and the Rockfish Creek WWTP (NC0050105) with a permitted as-built flow of 21 MGD. All facilities discharge to the Cape Fear River mainstem. See Chapter 3 Appendix for a list of permits.

BF143	
Year	**Bioclassification**
2014	Poor

There are several waterways that are on the impaired waters list and several that have also been delisted in this watershed. The impaired waterways include sections of Blounts Creek, Cross Creek, an unnamed tributary to Locks Creek, and Little Cross Creek; however, Little Cross Creek has a management plan in place to improve water quality. Another waterway discussed in this section but is not on the impaired waters list is an unnamed tributary to Cross Creek with elevated fecal coliform bacteria, turbidity, and nutrients (ammonia, nitrate+nitrite, and phosphorus). Blounts Creek [AU#: 18-27-5] is not discussed in detail in this chapter due to limited information; this waterway was only sampled once in 2014 receiving a Poor rating for its fish community (BF143). Another waterway in this watershed that is not discussed in detail is Gum Log Canal; it was sampled in 2003 and 2008, both recording an Excellent bioclassification rating. *As time and resources allow, the Division of Water Resources should evaluate the waterways in the Cross Creek watershed to determine where resampling could occur with* *emphasis on resampling the fish community in Blounts Creek since it was last rated as Poor, as well as the fish and benthic macroinvertebrate community in Cross Creek since both are rated as Fair or Poor.*

The mainstem Cape Fear River, which is included in this watershed, is discussed in a later section of this chapter. That section provides a full description of the chemical and physical parameters. There are no benthic macroinvertebrate community or fish community sampling stations along this section of the Cape Fear River in the Cross Creek watershed. A more localized watershed plan was developed by Triangle J Council of Governments, which includes more details on the Cross Creek watershed (*Table 8-12*). Additionally, many of the lakes (Bonnie Doone Lake, Mintz Pond, and Glenville Lake) have a eutrophic status. Eutrophic conditions describe a lake with high biological productivity and low water transparency. *Improvements to this watershed include reducing point and nonpoint source pollution to improve the eutrophic conditions in Bonnie Doone Lake, Mintz Pond, and Glenville Lake.*

8.7.7.1 Cross Creek

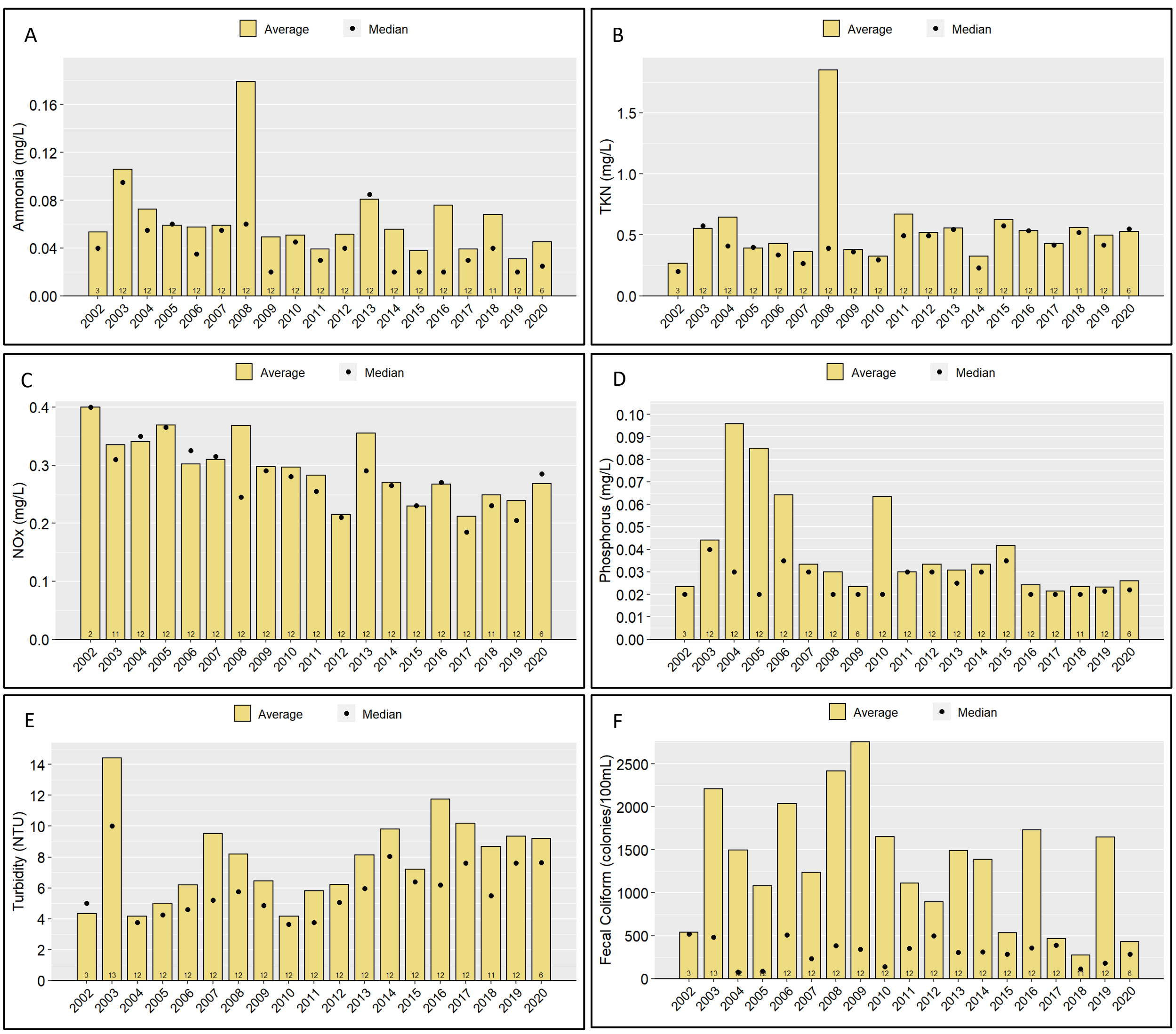
Several sections of Cross Creek remain on the impaired water list for exceeding aquatic life criteria. The most upstream reach of Cross Creek [AU#: 18-27-(1)c] flows 2.7 FW miles from Country Club Road to a point 0.5 mile upstream of the water supply intake at Murchison Road in Fayetteville. This waterway is classified as a water supply (WS-IV). The fish community at station BF144 in this section of Cross Creek has remained on the impaired waters list since 2016, recording a Fair bioclassification rating in 2014 and a Poor rating in 2018. In addition to the fish community monitoring, two benthic macroinvertebrate community stations were sampled in 2003. The upstream benthic macroinvertebrate community monitoring station (BB067) recorded a Good-Fair rating, and the downstream station (BB088) recorded a Fair rating. There are no ambient surface water quality monitoring stations along this stretch of Cross Creek. An unnamed tributary of Cross Creek at the publicly owned treatment works (POTW) [AU#: 18-27-(3)cut2] from source to Cross Creek was on the 2000 303(d) list but was delisted for dissolved oxygen in 2022 from Category 5 (exceeding criteria) to 3a (data inconclusive) due to new data. Another benthic macroinvertebrate community station (BB207) on an unnamed tributary to Cross Creek near Rosehill Road was sampled in 2003, but it was given a Not Rated.

BF144	
Year	**Bioclassification**
2014	Poor
2018	Fair
BB067	
2003*	Good-Fair
BB088	
2003	Fair
BB075	
2003	Good-Fair
2008	Fair
2013	Fair
2018	Fair
BB207	
2003*	Not Rated
BF10	
2003	Poor
*Special Study	

Farther downstream another section of Cross Creek [AU#: 18-27-(3)b], spanning 1.4 miles from Hillsboro Street to Blounts Creek, has remained on the impaired waters list for exceeding aquatic life criteria related to the benthic macroinvertebrate community. This section of Cross Creek is classified for secondary recreation (Class C). The benthic macroinvertebrate community station (BB075) was sampled five times between 1993 and 2018. The station was rated Fair each time except for a Good-Fair in 2003. The biologists noted Cross Creek has rarely received a bioclassification score better than Fair, which has resulted in this section of stream being included on the 303(d)-list since 2008. Cross Creek is deeply channelized, exhibits flashy hydrology, and its substrate consists of primary anthropogenic materials, such as concrete, brick, and asphalt. Additionally, there is a single fish community station (BF10) that was sampled in 2003 and recorded a rating of Poor; resampling has not occurred at this station.

Before Cross Creek discharges into the Cape Fear River there is a single ambient surface water quality monitoring station (B7590000). This station has shown the creek with levels of nutrients, i.e., ammonia, nitrate+nitrite, total Kjeldahl nitrogen, and total phosphorus, that are typically close to the concentrations considered normal for a healthy piedmont stream (*Figure 8-69A,B,C,D*). Turbidity levels are typically lower than the water quality standard (*Figure 8-69*). Notably, fecal coliform bacteria values measured at this monitoring station record instances when concentrations spike. This is evident by the large separation between the mean and median values based on water quality sampling (*Figure 8-69*).

Figure 8-69: Annual Mean and Median Ammonia, Total Kjeldahl Nitrogen (TKN), Nitrate+Nitrite (NOx), Total Phosphorus, Turbidity, Fecal Coliform in Cross Creek at Station B7590000.



The screening-level Mann-Kendall statistical test was run at station B7590000 for the 2010 to 2019 time period. A non-seasonal Mann-Kendall trend tests at 95% confidence for monitoring data collected from 2010 to 2019 for turbidity and total suspended solids showed a significant increase during this time frame. A screening-level Mann-Kendall seasonal statistical test for dissolved oxygen and total phosphorus showed a significant decrease for this period. Trends were insignificant for ammonia, fecal coliform bacteria, nitrate+nitrite, pH, specific conductivity, and total Kjeldahl nitrogen.

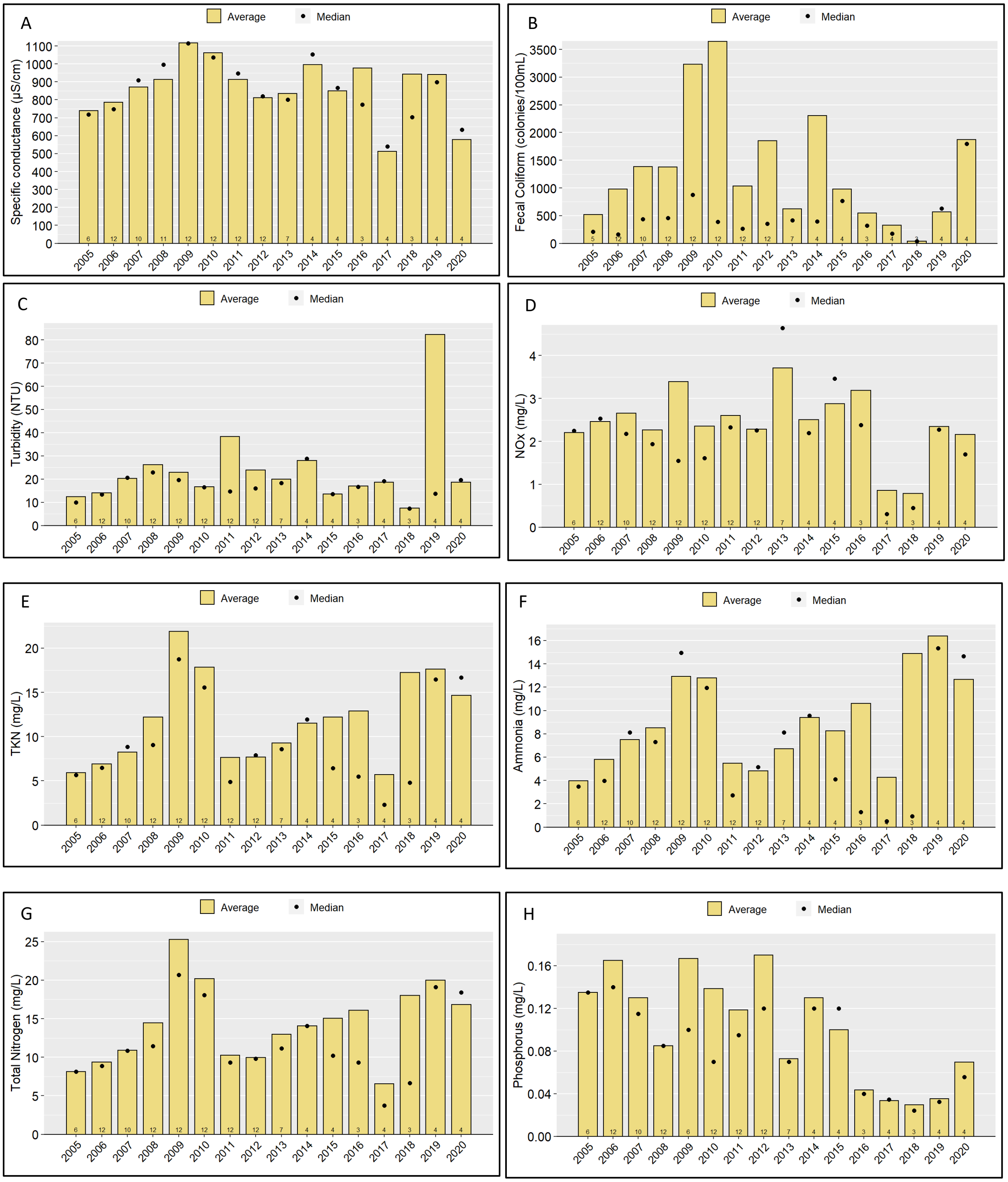
An unnamed tributary to Cross Creek has been monitored by MCFBA at water quality station (B7584900 at Lat: 35.05991; Long: -78.86468) since 2005 with concerning results presented below as mean and median values for several water quality parameters. The first notable parameter is specific conductance, which is a measure of ions in solution, is well above concentrations often seen in unimpacted waterways. The annual mean and median values are typically more than 500 us/cm (*Figure 8-70A*).

Another elevated water quality parameter is fecal coliform bacteria which has mean and median values that exceed 400 colonies/100 mL (*Figure 8-70B*); median values even approach and exceed 1,000 colonies/100 mL in 2020 (*Figure 8-70B*). While turbidity levels in this waterway are not typically in excess of the 50 NTU water quality standard for non-trout waters, the values are higher than most of the waterways described previously in the Upper Cape Fear subbasin (*Figure 8-70C*).

Alongside the previously mentioned concerning water quality readings, nitrate+nitrite concentrations in this waterway are elevated above concentrations considered normal for a healthy piedmont stream (0.3 mg/L) (*Figure 8-70D*). Total Kjeldahl nitrogen (ammonia + organic nitrogen) concentrations are also elevated in this waterway with ammonia concentrations primarily driving the elevated signal (*Figure 8-70E* and *Figure 8-70F*). The Fayetteville Regional Office is working with the Cumberland County Solid Waste landfill to ensure that their groundwater and stormwater is not contributing to the elevated nutrients and bacteria loading.

Together the nitrate+nitrite and total Kjeldahl nitrogen concentrations are resulting in total nitrogen concentrations well above concentrations considered normal for healthy piedmont streams (0.8 mg/L) (*Figure 8-70G*). In addition to elevated total nitrogen, total phosphorus concentrations have remained elevated in this tributary over much of the monitoring record; however, after 2016 these values have declined to hover around values considered normal for healthy piedmont streams (0.05 mg/L), except in 2020 when the average and median concentrations were slightly above this value (*Figure 8-70H*). Developing a comprehensive understanding of the source(s) of elevated fecal coliform bacteria, turbidity, and nutrients (total nitrogen and phosphorus) is necessary to protect this tributary from further degradation.

Figure 8-70: Annual Mean and Median Values for Specific Conductance, Fecal Coliform Bacteria, Turbidity, Nitrate+Nitrite (NOx), Total Kjeldahl Nitrogen (TKN), Ammonia, Total Nitrogen, and Phosphorus in an Unnamed Tributary to Cross Creek.



8.7.7.2 Locks Creek

BF45	
Year	**Bioclassification**
2003	Excellent
2008	Excellent

Locks Creek [AU#: 18-28] was sampled in 2019 and 2020 as part of the Random Ambient Monitoring Program. The overall water quality in the mainstem Locks Creek had marginally high nitrate+nitrite concentrations and low pH. Notably, an unnamed tributary to Locks Creek [AU#: 18-28ut3] from the source to Locks Creek was historically sampled as part of the 2007-2008 RAMS sampling effort and exceeded several water quality parameters. The unnamed tributary to Locks Creek station was resampled in 2015-2016 during the dissolved metals pilot study which resulted in that waterbody remaining impaired. The unnamed tributary to Locks Creek impairment parameters includes pH (since 2010), dissolved oxygen (since 2010), dissolved copper (since 2018), and mercury (since 2014). In addition to the recent water quality monitoring the fish community was sampled at station BF45 in 2003 and 2008 with both events recording an Excellent bioclassification rating.

8.7.7.3 Little Cross Creek

BB486	
Year	**Bioclassification**
2007*	Not Impaired
BB436	
2003*	Fair
BB451	
2003	Fair
2008	Poor
2013	Poor
*Special Study	

Little Cross Creek (Bonnie Doone Lake, Kornbow Lake, Mintz Pond) [18-27-4-(1)a] from source to Bonnie Doone Lake was on the 2000 303(d) list but was delisted for benthos in 2022 from Category 5 (exceeding criteria) to 1 (meeting criteria) because the wrong site was used for assessment in 2003. Two assessment units along Little Cross Creek are impaired with a TMDL or a strategy to improve water quality in place. These sections include the stream reach from Kornbow Lake to a point 0.5 miles upstream of the backwaters of Glenville Lake [AU#: 18-27-4-(1)e] and the reach from the dam at Glenville Lake to Cross Creek [AU#: 18-27-4-(2)].

The biological community on an unnamed tributary to Little Cross Creek was sampled at station (BB486) in 2007 and received a Not Impaired rating. This is the most upstream biological monitoring station sampled between 2002 and 2020. Two additional biological community stations were sampled along the entire stream reach of Little Cross Creek during this same period. One of these stations (BB436) is positioned just below Mintz Pond. This station was sampled once in 2003 and received a Fair rating. Farther downstream of Glenville Lake is the only recently sampled biological community monitoring station (BB451). This station was sampled four times between 1998 and 2013 and received ratings of Fair in 1998 and 2003 and Poor ratings in 2008 and 2013.

8.7.7.4 Bonnie Doone Lake, Kornbow Lake, Mintz Pond, and Glenville Lake

Bonnie Doone Lake, constructed in the early 1900s, is the first in a series of four lakes formed as impoundments on Little Cross Creek. The four lakes in upstream to downstream order are Bonnie Doone Lake [AU#: 18-27-4-(1)b], Kornbow Lake [AU#: 18-27-4-(1)c], Mintz Pond [AU#: 18-27-4-(1)d], and Glenville Lake [AU#: 18-27-4-(1.5)]. These waterbodies serve as a backup water supply for the City of Fayetteville. The public is restricted from accessing all four lakes. During the 2009 ambient lakes monitoring program sampling season, all four lakes were sampled. During the following sampling season in 2013, only three of the four lakes were sampled. The 2013 sampling season excluded sampling of Kornbow Lake. The results from these sampling events are documented in the Lake and Reservoir Assessments Cape Fear River Basin, 2009 and Lake and Reservoir Assessments Cape Fear River Basin, 2013 reports. Historically, these lakes have been noted to have low pH levels due to natural conditions and were listed as impaired for biological integrity in 1998 (Bonnie Doone Lake, Mintz Pond, Kornbow Lake) and 2000 (Glenville Lake). Currently, these waterbodies are meeting water quality standards. Notably, the 2013 sampling efforts in Bonnie Doone Lake, Mintz Pond, and Glenville Lake recorded eutrophic conditions based on the North Carolina Trophic Status Index. Eutrophic conditions describe a lake with high plant productivity and low water transparency. Kornbow Lake, last sampled in 2008, was determined to be mesotrophic. Mesotrophic conditions describe moderate biological productivity. Kornbow has been predominantly mesotrophic since it was first monitored by then-DWQ in 1993.

8.8 Upper Cape Fear River Mainstem Physical and Chemical Evaluation

Water quality was evaluated and compared along the entire Cape Fear River mainstem at 32 AMS, coalition, and co-located stations. The river was divided into five segments based on HUC8 and HUC10 boundary lines. Seven stations were evaluated in the Upper Cape Fear River subbasin, comprising the first segment. The lower four segments: Harrison and Turnbull Creeks, Hood Creek, Brunswick River Creek, and the estuary are in the Lower Cape Fear (LCF) River subbasin and described in Chapter 9.

Cape Fear River Mainstem Ambient Water Quality Evaluation

Cape Fear River Mainstem Segment	Number of Stations
Upper Cape River Fear	7
LCF - Harrison and Turnbull Creeks	8
LCF - Hood Creek	7
LCF - Brunswick River Creek	7
LCF - Estuary	3

Figure 8-71 and *Figure 8-72* provide spatial displays of the seven stations used in the evaluation of the Upper Cape Fear River segment. The sampling organization for each station is also identified as AMS, coalition, or co-located, and the location of the USGS gage at Lillington is also shown. *Figure 8-71* is overlaid on 2019 land cover, and *Figure 8-72* shows permitted facilities for NPDES stormwater, NPDES dischargers, and AFOs, and the location of non-discharge and fields for residual solids. Stations in the figures are color coded by hydrologic order and match the color coding on *Table 8-14* and *Figure 8-73*.

Graphs for the river segments were developed to show the yearly standard exceedance rates and means for parameters of interest collected between 2002 and 2020. It should be noted that the method used to identify an impaired waterbody for the IR is based on the exceedance rate of a standard and percent confidence (90%) for a set of data generally collected over a 5-year period and not based on individual yearly statistics as represented in the graphs in this chapter (see Chapter 2 for more information on the IR). The parameters of interest and statistics shown for each river segment set of graphs includes 5-year and yearly means, as well as exceedance rates for turbidity, fecal coliform, DO, and pH. Specific conductivity and nutrients do not have water quality standards, although reference values for nutrients are presented in *Table 8-11*. Yearly geomeans graphs were also developed for fecal coliform. The yearly average discharge, or streamflow, was overlaid on the Upper Cape Fear River water quality graphs using data from the USGS gage Cape Fear River at Lillington, NC (02102500) on the Cape Fear River. The yearly discharge values were computed by calculating the yearly mean value of the mean daily discharge values. These yearly discharge values are representative of the mean daily streamflow volume flowing through a particular area of a stream throughout the period of one year. *Table 8-14* lists stations by hydrologic order in each river segment with the sampling organization (AMS, MCFBA, and LCFRP), sample years by parameter, location descriptions, ecoregion, and stream classification.

Another series of graphics relate the water quality parameter concentrations to the distribution of flows into bins (*Figure 8-74*). The USGS gages and surface water quality stations were paired, i.e., co-located, when any two stations were not more than three miles away from each other and less than or equal to a 10% drainage area difference. The average daily discharge for the date of the surface water quality sample was used to calculate the water quality mean and median values for the three flow bins. The flow bins are based on the 25th and 75th percentiles (i.e., <=25th is low, >=75th is high, in between is medium) calculated using 30 years of discharge data collected between 1991 – 2020.

Table 8-14: Upper Cape Fear River Mainstem Water Quality Stations for Evaluation

Station Order	StationID	AMS	MCFBA	AU Description	AU#	Class
1	B6160000	2002-2006 - turbidity, FCB, physical field parameters, 2003-2006 - nutrients	2002-2020 - All	From a point 0.5 mile upstream of NC Hwy 42 to NC Hwy 42 (Sanford water supply intake)	18-(4.5)	WS-V
2	B6215000		2010-2020 - All	From a point 0.6 mile downstream of mouth of Daniels Creek to a point 0.2 mile downstream of Neills Creek	18-(10.5)	WS-IV
3	B6370000	2002-2020 - turbidity, FCB, nutrients, 2002-2011 and 2013-2020 - physical field parameters	2002-2020 - All	From Lillington water supply intake to Upper Little River	18-(16.7)	WS-IV
4	B6840000	2002-2006 - turbidity, FCB, physical field parameters, 2003-2006 - nutrients	2002-2020 - All	From Dunn water supply intake to Lower Little River	18-(20.7)a	WS-V
5	B7480000	2017 - physical field parameters	2002-2020 - All	From a point 0.5 mile upstream of City of Fayetteville water supply intake to City of Fayetteville water supply intake	18-(25.5)	C
6	B7600000	2002-2020 - turbidity, FCB, physical field parameters, 2002-2011 and 2013-2020 - nutrients		From City of Fayetteville water supply intake to Pearces Mill Creek	18-(26)a	C
7	B7500000		2002-2020 - All	From Pearces Mill Creek to Grays Creek	18-(26)b	C

Note - This table lists Ambient Monitoring System (AMS) and Coalition - Middle Cape Fear Basin Association (MCFBA) parameters collected each year at Cape Fear River mainstem stations. Physical field parameters include temperature, pH, and specific conductivity, and nutrients include ammonia, TKN, NOx, and TP. AMS and Coalition average day data were combined for the mainstem Upper Cape Fear River graphics. Only station parameter data with at least eight average day records in a year are included in the graphical images.

Figure 8-71: Upper Cape Fear River Mainstem Water Quality Stations for Evaluation with 2019 Land Cover

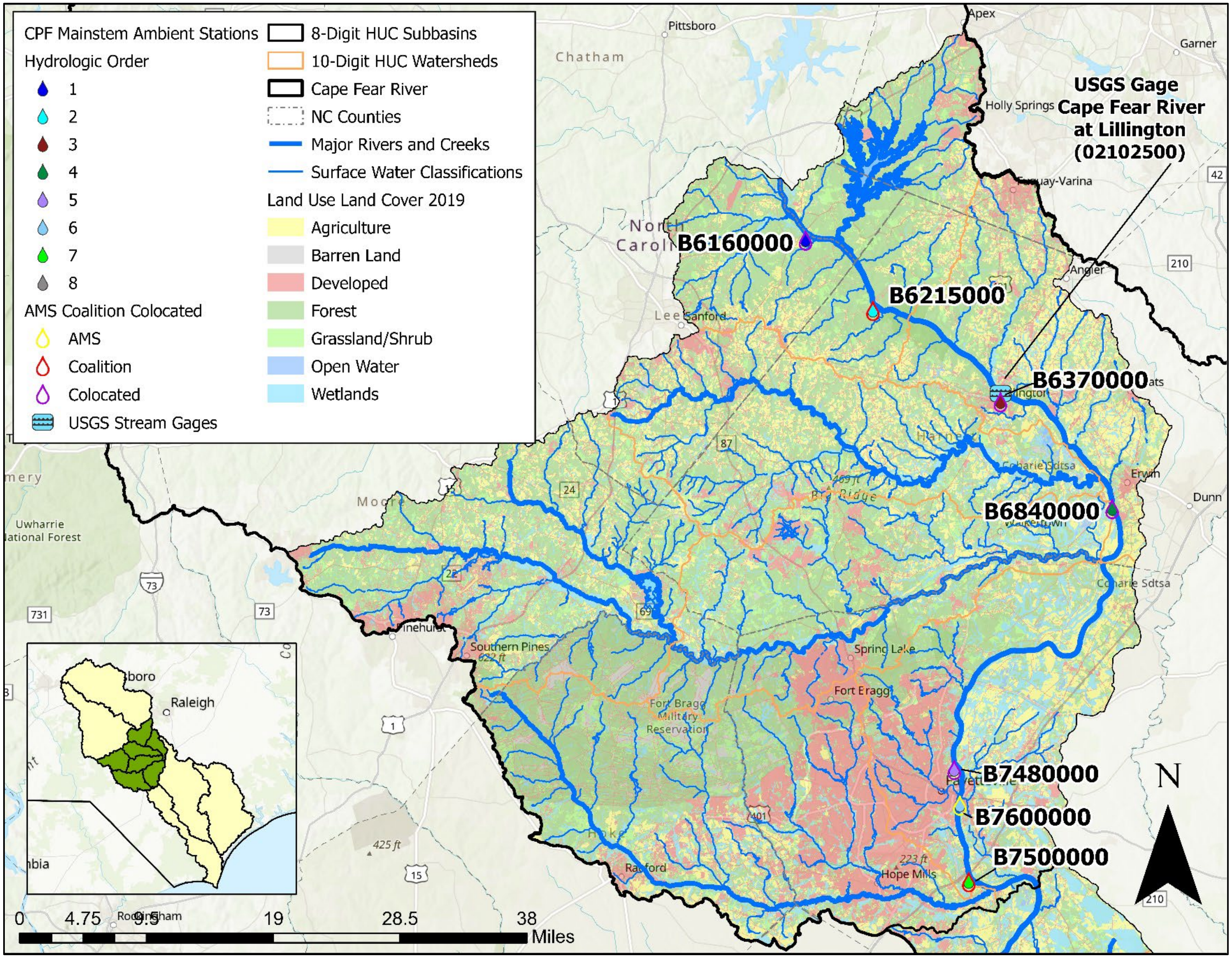
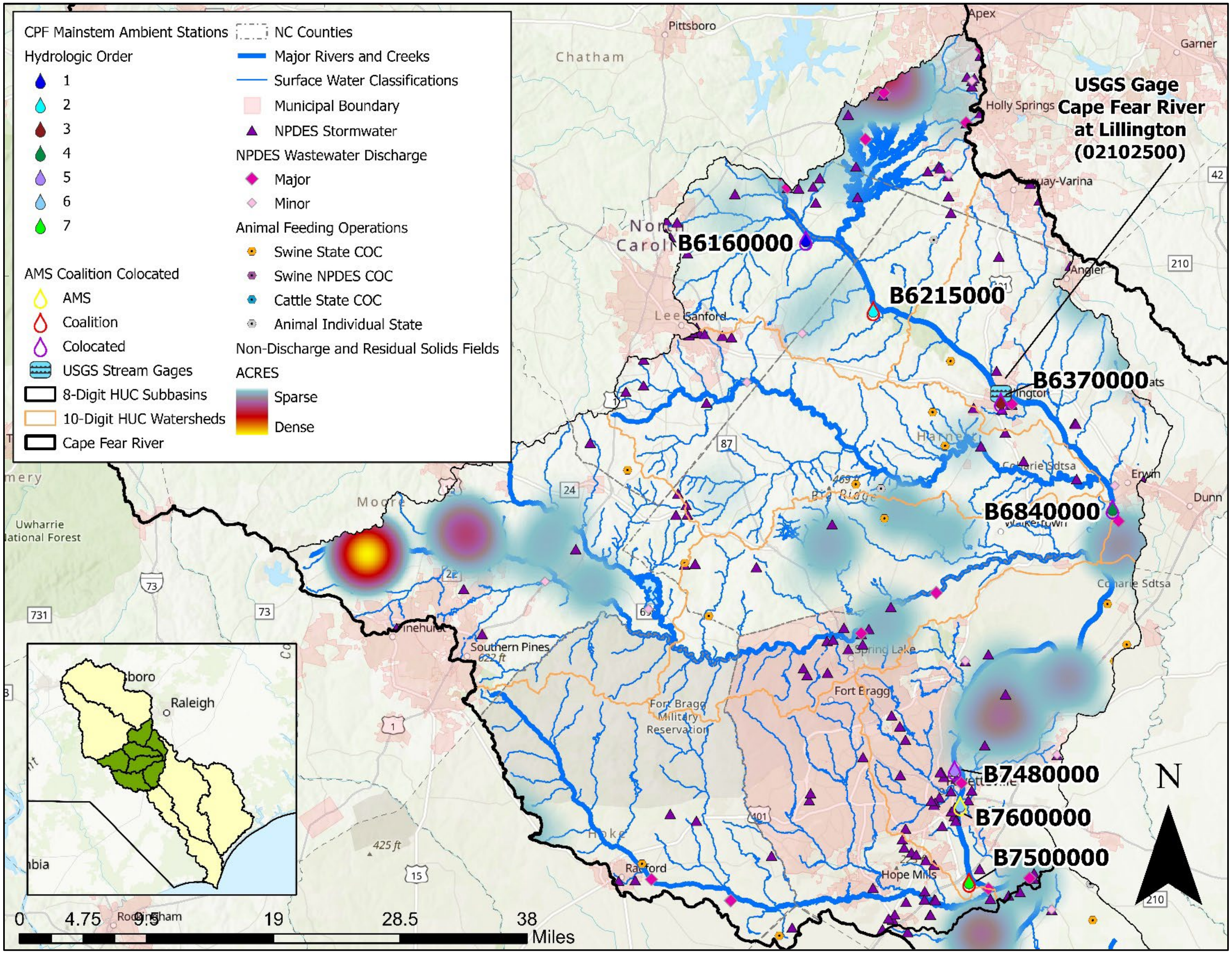
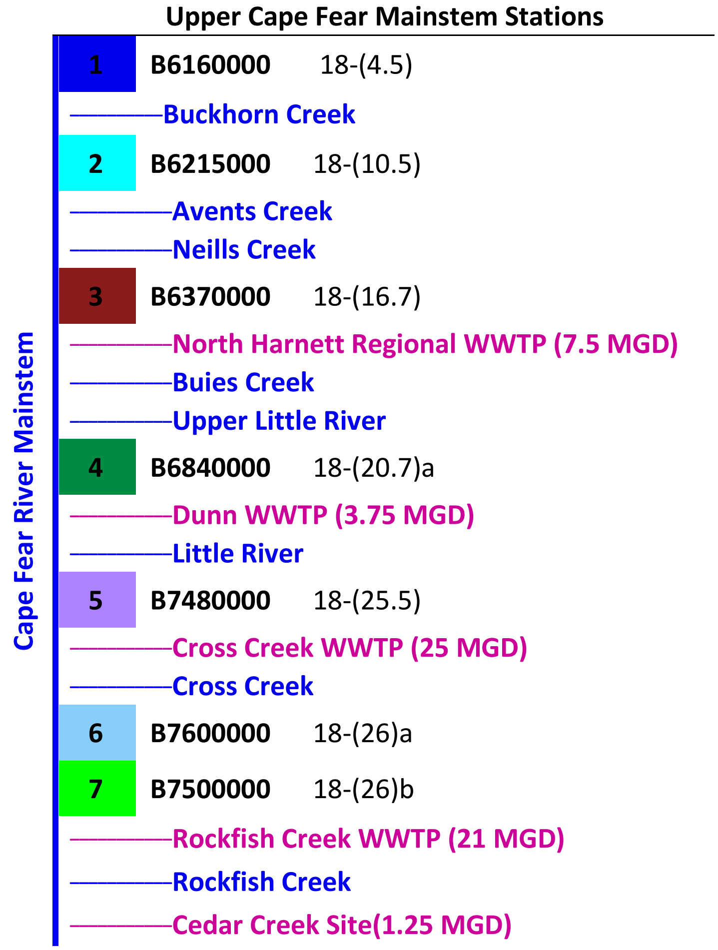


Figure 8-72: Upper Cape Fear River Mainstem Water Quality Stations for Evaluation with Permitted Facilities and Non-Discharge and Residual Solids Fields



The Upper Cape Fear River mainstem evaluation included seven (7) stations located along approximately 67 FW miles composed of 15 assessment units (*Figure 8-73*).

Figure 8-73: Schematic of the Position of Ambient Water Quality Monitoring Stations (black), Assessment Unit Numbers, NPDES Permitted Facilities (magenta), and Tributaries (blue).



Surface water quality stations B6160000 and B6215000 are in the Piedmont ecoregion while the remaining stations are in the Southeastern Plains ecoregion. The waterways monitored include streams classified for secondary recreation (C), water supply (WS-IV or WS-V), and several water supply waters that carry the critical area (CA) classification. *Figure 8-73* also shows the Cape Fear mainstem station locations relative to five (5) major NPDES point source discharge facilities and several tributaries, including: Buckhorn Creek, Avents Creek, Neills Creek, Buies Creek, Upper Little River, Little River, Cross Creek, and Rockfish Creek.

The Cape Fear River [AU#: 18-(5.5)a] from NC Hwy 42 to Buckhorn Dam and is designated as Impaired for chlorophyll *a* in the 2022 IR. The 2022 IR also found several parameters to be data inconclusive at these seven surface water quality monitoring stations across several assessment units. This includes elevated or insufficient data for chloride, turbidity, fecal coliform bacteria, sulfate, fluoride, and 1,4-dioxane, as well as, stressed benthic macroinvertebrate communities at AU# 18-(4.5); elevated fecal coliform bacteria at AU# 18-(10.5); elevated fecal coliform bacteria and elevated dissolved copper concentrations at AU# 18-(26)b. All other parameters assessed for these AUs, and others, for the 2022 IR were meeting criteria along these segments of the mainstem Cape Fear River in the Upper Cape Fear River subbasin.

As of May 2022, there were 28 NPDES wastewater, 30 non-discharge and land application, 130 NPDES stormwater, 407 state stormwater, and 15 animal feeding operation (AFO) permits issued in the Upper Cape Fear River subbasin (*Table 8-9*). A complete list of permits is in Chapter 3 Appendix. *Figure 8-7* shows the location of the permitted facilities in the Upper Cape Fear River subbasin. More information about the permitting programs is in Chapter 3, including a map of state stormwater facilities. Along this segment of the mainstem Cape Fear River there are a total of five major NPDES dischargers: North Harnett Regional

WWTP, Dunn WWTP, Cross Creek WWTP, Rockfish Creek WWTP, and DAK Americas, LLC-Cedar Creek Site, with a collective permitted as-built flow of 58.5 MGD.

The North Harnett Regional WWTP (NC0021636) is the first major permitted wastewater facility along the mainstem Cape Fear River. This facility has an as-built flow of 7.5 MGD and discharges into the mainstem Cape Fear River. From 2010 to 2020, the North Harnett Regional WWTP had several limit violations, which proceeded to enforcement cases for biological oxygen demand (5-day), ammonia, and flow, as well as a single enforcement case for fecal coliform bacteria. The City of Dunn WWTP (NC0043176) is the second major permitted wastewater facility along the mainstem Cape Fear River. This facility has an as-built flow of 3.7 MGD and discharges into the Cape Fear River. Between 2010 and 2020 this facility had several limit violations for flow that proceeded to enforcement cases. The Cross Creek WWTP and Rockfish Creek WWTP are the third and fourth major permitted wastewater dischargers, respectively, and between 2010 and 2020 neither of these facilities had limit violations that proceeded to enforcement cases. Finally, the DAK Americas, LLC-Cedar Creek Site (NC0003719) is the last major permitted discharger along the mainstem Cape Fear River in the Upper Cape Fear River subbasin. This facility has an as-built flow of 1.25 MGD and discharges into the Cape Fear River. Between 2010 and 2020 this facility had several limit violations for flow, biological oxygen demand (5-day), total suspended solids, and ammonia. The NPDES permitting process will be followed to address any ongoing violations at these facilities.

The North Harnett Regional WWTP was recently approved to expand from 7.5 MGD to 16.5 MGD and to transfer nitrogen and phosphorus load from their South Harnett Regional WWTP to the North Harnett Regional WWTP. The South Harnett Regional WWTP currently discharges to the Little River (Lower Little River [AU# 18-23-(24)]), a tributary to the Cape Fear River. The expansion and transfer would nearly double the wastewater volume and the nitrogen and phosphorus loading to the segment of the Cape Fear River [AU# 18-(16.7)] where the discharge for the North Harnett Regional WWTP is located. This segment of the Cape Fear River is listed on the 2022 IR as Data Inconclusive (Not Rated) due to elevated instream fecal coliform bacteria and 1,4-dioxane concentrations. Currently, the nearest monitoring station is approximately 10 miles downstream at B6840000 at NC 217 in Erwin, NC.

DWR’s Basin Planning Branch supports moving nitrogen and phosphorus loads from the South Harnett Regional WWTP to the North Harnett Regional WWTP. Because both discharges are upstream of Lock & Dam #3, the water quality impact behind the dam will likely not be significantly different from current conditions, but by removing the discharge from Little River, it may be more protective of the Little River (Lower Little River) watershed. The transfer, however, warrants more data collection in the mainstem Cape Fear River to monitor current and future nutrient loads.

The North Harnett Regional WWTP’s discharge is in a portion of the Cape Fear River that is designated as a Water Supply Watershed (WS-IV). The City of Dunn withdraws water approximately 8.25 miles downstream of the discharge point. It is critically important that DWR understand the water quality impacts upstream of this user. Because of its use as a water supply and the concerns over elevated fecal coliform bacteria and nutrients in the river, the Basin Planning Branch worked with the NPDES permitting branch to *recommend additional instream monitoring station* downstream at the Wildlife Road access point, which is approximately 1.5 miles downstream of the discharge.

The additional instream monitoring station was recommended because:

1. Wastewater volume will increase in that segment of the Cape Fear River,

2. Nutrient loading (adding 55,582 lb/yr. total nitrogen and 18,525 lb/yr. total phosphorus) will increase with the expansion, and

3. Understanding of nutrients throughout this system is needed to monitor impacts and document reductions, if needed, especially as the area continues to grow and new industrial facilities come online.

The impacts from this expanded discharge and load may not be seen for several years given the area is still growing in population and new industries. Having a station that can record the changes over time is helpful to DWR's permit writers, basin planners, watershed modelers, watershed management decision-makers, and ultimately, Harnett County. Data collected throughout the watershed, but especially below the discharge, allows for a better understanding of the direct impact the discharge may have on the river. An instream monitoring station 1.5 miles downstream will assist with this when compared to downstream monitoring stations located farther downstream. The NPDES discharge permit was finalized on July 27, 2023 with the downstream monitoring requirement included (NC0021636 2023 permit).

8.8.1.1 Turbidity

Turbidity levels in the mainstem Cape Fear River are typically below the water quality standard of 50 NTU with 5-year means typically varying between 10 NTU and 25 NTU (*Figure 8-75*). During times of elevated flows, the water clarity can decline due to sediment transport through stormwater and/or other nonpoint sources of pollution (i.e., forestry, development, and agriculture), generating higher turbidity levels as seen in annual average values for 2003, 2018, and 2020 at several stations along the Cape Fear River (*Figure 8-76*).

The farthest upstream station (B6160000) on the Cape Fear River, located downstream of the confluence of the Haw and Deep rivers, and the next downstream station (B6215000) typically had relatively few exceedances of the turbidity water quality standard (*Figure 8-77*). The stations positioned along the next downstream section of the Cape Fear River (B6370000 and B6840000) are more varied in the exceedance rates with at least 5 years displaying rates greater than 10%. As previously noted, Kenneth Creek, a tributary of Neills Creek, and Neills Creek are on the impaired waters list for turbidity and may be contributing to the elevated turbidity recorded at these two mainstem Cape Fear River stations. Sedimentation was also noted as a concern for the benthic macroinvertebrate community in Neills Creek. The farthest downstream stations, B7480000 and B7500000, recorded the highest exceedance rates, which were elevated above 20% twice during 2002 to 2020 (*Figure 8-77*). Notably, station B7600000, located between stations B7480000 and B7500000, did not record nearly as many exceedances of the water quality standard during this same time frame. This could be due to the quick nature of these elevated turbidity events. The association between stormwater and sediment transport can be seen in the average turbidity levels recorded at station B6370000 and the co-located USGS gage at Lillington (02102500) where average turbidity levels exceeded 40 NTU during higher flows (>=3,670 cfs) compared to approximately 7 NTU during lower flows (<= 641 cfs) (*Figure 8-74A*).

DWR conducted screening-level seasonal and non-seasonal Mann-Kendall trend tests at 95% confidence for monitoring data collected from 2000 to 2019 at the mainstem Cape Fear River stations. Ambient water quality station B6215000 did not have trends tests for 2000 to 2019, due to lack of data. Turbidity significantly decreased at stations B6160000 and B6840000 while trends were insignificant at all the remaining stations (B6370000, B7480000, B7600000, and B7500000). *Continuously improving stormwater management to reduce elevated turbidity pulse loading events from development, forestry, and/or agricultural activities across the upstream reaches and watershed of the Cape Fear River will help ameliorate the water clarity recorded downstream.*

8.8.1.2 pH

The general pattern in median pH values of the mainstem Cape Fear River is from typically higher values recorded in the upstream sections (B6160000 and B6215000), lower fluctuating values in the middle sections (B6370000, B6840000, and B7480000) and lowest values recorded in the downstream sections (B7600000 and B7500000) (*Figure 8-78*). The annual median pH values for the mainstem Cape Fear River typically hovers around 7 s.u. except for a few years (2002, 2007, and 2010) when the most upstream stations (B6160000 and B6215000) were elevated above this level (*Figure 8-79*). During most years, the station directly downstream from where the Cross Creek and Cape Fear River confluence (B7600000) had the lowest pH value along the Cape Fear River section in the Upper Cape Fear River watershed.

The decreasing pH values observed in the Cape Fear River from upstream to downstream in the Cape Fear River could be attributed to the influence from tributaries that had marginally lower pH values than the mainstem Cape Fear River. As described in the previous section the Upper Little River, Little River, and Rockfish Creek all have pH values that are lower than other waterways monitored in the Cape Fear River Basin. The exact cause and source of these lower pH values is unclear; however, it has been noted that the low buffering capacity of sandy soils and the potential influence of conifer trees could exert an influence on flow-through pH in the Upper Little River although this is an active area of research and other factors (acidic soils, sulfur-bearing minerals, human influence, or other) may have an influence on lower the pH of the Upper Little River. Currently there are no North Carolina Sandhills specific studies, or conflicting information, to definitively support these two phenomena, although they could exist.

Overall, exceedances of the pH water quality standard either above 9 s.u. or below 6 s.u. in the Cape Fear River have been limited to only two upstream stations (B6160000 and B6370000) with exceedances greater than 10% (*Figure 8-80*). Four samples were collected at upstream station B6160000 in 2000 that were above the 9 s.u. water quality standard. Three samples collected in 2010 at station B6370000 were below the 6 s.u. water quality standard. The higher pH values observed in the upper portion of the Cape Fear River are likely influenced by releases from Jordan Lake dam. This includes contributing nutrients, algal populations that feed possible blooms downstream. These algal growths stimulate a response in water quality elevating the pH above the 9 s.u. water quality standard behind Buckhorn dam. As mentioned previously the Cape Fear River [AU#: 18-(5.5)a] from NC Hwy 42 to Buckhorn Dam and is designated as Impaired for chlorophyll *a* in the 2022IR. More details regarding chlorophyll *a*, algal blooms, and streamflow around Buckhorn dam can be found in Section 2.5.8 of Chapter 2. The water quality data at station B6370000 and the co-located USGS gage (02102500) at Lillington indicate that typically higher pH values are recorded during higher flows ($\geq$ 3,670 cfs) while lower pH values are observed during lower flows ($\leq$ 641 cfs) (*Figure 8-74B*). Interestingly, the flow recorded at USGS gage 02102500 was relatively high with daily average streamflow values of 3,770 cfs or greater during the times when the few pH values were recorded to be lower than 6 s.u. at station B6370000.

8.8.1.3 Dissolved Oxygen

During the 2001 to 2010-time period, dissolved oxygen (DO) values generally declined from upstream to downstream (*Figure 8-81*). A considerable change in annual mean DO levels was recorded at the most upstream station (B6160000) between the 2011 and 2012-time period (*Figure 8-82*). During subsequent years, lower DO was observed in the upstream section of the Cape Fear River (B6160000 and B6215000), the highest values were recorded in the middle section (B6370000 and B6840000), and the downstream typically had the lowest DO levels (B7480000 and B760000) (*Figure 8-82*). The lower DO observed in the upstream section of the Cape Fear River could be due to two contributing factors. First, the decrease in dissolved oxygen levels at station B6160000 could be correlated with the extreme values recorded during algal blooms events behind Buckhorn dam. The frequency of elevated dissolved oxygen levels (>12 mg/L) decreased considerably around 2010 which is consistent with the decrease in annual average dissolved oxygen values (*Figure 8-82*). Second, unmonitored waterways with similar chemical profiles to Lick Creek could be contributing streamflow with low DO during lower flow periods. As previously noted, Lick Creek is on the impaired waters list for DO and contributes streamflow to the Cape Fear River upstream of stations B6160000 and B6215000. Another notable pattern is at the downstream station B7600000 which had several years (2014, 2015, 2018, and 2020) with the highest mean values in the Cape Fear River. This may be the result of sampling differences between the DWR ambient monitoring program and the monitoring coalition. A surface sample is collected at station B7600000 for DO while a depth profile method is used at stations B7480000 and B7500000.

There were few values recorded below the 4 mg/L water quality standard in the section of the mainstem Cape Fear River within the Upper Cape Fear River subbasin with only two stations (B6215000 in 2015 and B7600000 in 2009) that recorded values that fell below this standard during more than 10% of the samples (*Figure 8-83*). These exceedances coincided with the lower flow periods recorded at the USGS gage at Lillington (02102500). Dissolved oxygen levels at station B6370000 in the mainstem Cape Fear River typically recorded lower values with an average value of 7.47 mg/L during lower flows (≤ 641 cfs) and higher values with an average value of 9.51 mg/L during higher flows (≥ 3,670 cfs) (*Figure 8-74C*).

DWR conducted screening-level seasonal Mann-Kendall trend tests at 95% confidence for monitoring data collected from 2000 to 2019 at the mainstem Cape Fear River stations. Ambient water quality station B6215000 did not have trends tests for 2000 to 2019, due to lack of data. Dissolved oxygen significantly decreased at station B6160000, while the remaining stations (B6370000, B6840000, B7480000, B7600000, and B7500000) trends were insignificant.

8.8.1.4 Fecal Coliform Bacteria

During the 2006-2010 and 2011-2015 time frames, none of the stations along the mainstem Cape Fear River had exceedance rates at or above 20%; with the highest exceedance rate recorded at station B6215000 at 18.3% (*Table 8-15*). Interestingly, during the 2016-2020 time frame most of the upstream stations (B6130500, B6160000, B6215000, and B6370000) along the mainstem Cape Fear River exceeded the water quality standard at least 1 out of 5 times (>20%), the middle sections stations (B6840000 and B7480000) exceeded the water quality standard at least 1 out of 7 times (>15.5%), and the downstream stations in the Upper Cape Fear River subbasin exceeded the water quality standard approximately 1 out of 5 times (B7500000 and B7600000) (>19.0%) (*Table 8-15*). While these results are reported here as exceeding the water quality standard, it is important to note that the water quality standard for fecal coliform bacteria is based on a 5-in-30 sampling methodology. The results presented here are best viewed as screening values to identify areas of potential concerns as the samples are sometimes analyzed outside of hold time and are not collected at a frequency consistent with a 5-in-30 sampling methodology. Also note that the mainstem Cape Fear River is not a Class B waterway and therefore the best intended use is not for primary recreational purposes (See Chapter 2 for additional information on Class B waterways).

As described previously during the 2016–2020 time frame, several tributaries including Lick Creek, Avents Creek, Kenneth Creek, and Neills Creek draining to the mainstem Cape Fear River upstream of the monitoring station near Lillington (B6370000) had multiple years of elevated fecal coliform bacteria concentrations. These tributaries are most likely contributing to the greater than 20% exceedance rate recorded at stations along the mainstem Cape Fear River recorded between the 2016–2020 time frame (*Table 8-15*). Downstream from the station at Lillington (B6370000) fewer extreme values of fecal coliform bacteria are observed, until Cross Creek joins the mainstem Cape Fear River above station B7500000 (*Figure 8-84*). In general, fecal coliform bacteria values recorded at stations along the mainstem Cape Fear River are variable with all stations typically approaching the 400 colonies/100 mL water quality standard based on 5-year average values at various points in time over the past 20 years (*Figure 8-85*).

The sources of fecal coliform bacteria in these adjoining tributaries are most likely nonpoint sources of pollution. As noted previously most of the point source discharges return flow to the mainstem Cape Fear River and only a single enforcement case at North Harnett Regional WWTP was recorded between 2010-2020 between these facilities. Notably, the waterways with NPDES dischargers returning flow (i.e., Little River, Upper Little River, and Rockfish Creek) have exceedance rates of less than 10% during the 2016-2020 time frame.

The impacts from nonpoint sources of pollution are also discernible from the flow separated graphics as average fecal coliform bacteria levels are approximately 854 colonies/100 mL during high flows ($\geq$ 3,670 cfs) while average values are approximately 99 colonies/100 mL during lower flow periods ($\leq$ 641 cfs) (*Figure 8-74D*). Similarly, the annual mean and geometric mean values display a similar pattern with high flow years correlating with higher fecal coliform bacteria values (*Figure 8-86* and *Figure 8-87*). During those high flow years, the exceedance rate at downstream stations (B7480000 and B7500000) were greater than 30% (*Figure 8-84*). The occurrence of elevated fecal coliform bacteria in the waterways during higher flow periods is an indication that nonpoint sources of pollution are mobilizing these fecal coliform bacteria from the landscape into the waterways. Preventing these elevated fecal coliform bacteria levels from occurring would be protective of bodily contact in the mainstem Cape Fear River.

Table 8-15: Fecal Coliform Bacteria Exceedance Rates for Stations along the Mainstem Cape Fear River.

Station ID	(2006 – 2010)		(2011 – 2015)		(2016-2020)	
	Exceedance Rate	Number of Samples	Exceedance Rate	Number of Samples	Exceedance Rate	Number of Samples
B6160000	11.10%	72	13.30%	60	27.10%	59
B6215000	0.00%	6	18.30%	60	27.10%	59
B6370000	10.90%	119	8.60%	116	21.20%	118
B6840000	12.50%	72	11.70%	60	18.30%	60
B7480000	6.70%	60	11.70%	60	15.50%	58
B7500000	10.00%	60	11.70%	60	20.70%	58
B7600000	7.50%	53	8.60%	58	19.00%	58

8.8.1.5 Specific Conductance

The 5-year mean specific conductance in the mainstem stations along the Cape Fear River in the Upper Cape Fear River subbasin generally declines from upstream to downstream (*Figure 8-88*). This could be due to the influx of water with lower concentrations of ions in solution entering the Cape Fear River as the drainage area increases from upstream to downstream; although this does not indicate that all ions are decreasing equally or that certain ions are not increasing as observed from upstream to downstream (i.e. nitrate+nitrite as described later in this chapter). Changes in specific conductance are also observed as it corresponds to higher streamflow values. The years with exceptionally high streamflow display some of the lowest annual mean specific conductance values compared to years with lower flow rates (*Figure 8-89*). This can also be seen in *Figure 8-74E* as lower average values of 111 uS/cm were recorded during higher flows (≥ 3,670 cfs), while higher average specific conductance values of approximately 194 uS/cm recorded during lower flows (≤ 641 cfs). The most abrupt change in specific conductance values occurs between stations B6840000 and B7480000. This could be attributed to the additional streamflow from the Little River, Carvers Creek, and the surrounding landscape diluting concentration of ions in the mainstem Cape Fear River.

8.8.1.6 Total Kjeldahl Nitrogen and Ammonia

Total Kjeldahl nitrogen is the combination of organic nitrogen and ammonia. The general pattern of total Kjeldahl nitrogen along the Cape Fear River is from higher values upstream to lower values downstream as seen in the 5-year and annual mean values (*Figure 8-90* and *Figure 8-91*). Typically, the highest total Kjeldahl nitrogen concentrations are recorded downstream from the confluence of the Deep and Haw rivers and upstream of Buckhorn Dam (B6160000). As described previously, high total Kjeldahl nitrogen concentrations often stem from streamflow in the Haw River downstream from Jordan Lake and the Deep River, combined with contributions from Lick Creek and the Cape Fear River's capacity for increased biological growth behind Buckhorn dam.

Downstream from the Buckhorn Dam additional concerns were previously noted as there are increasing total Kjeldahl nitrogen concentrations from Harris Lake drainage into Buckhorn Creek driven by the conversion of inorganic nitrogen supplied by surrounding waterways to organic forms of nitrogen as it passes through Harris Lake and stimulates biological growth. Additionally, the increase in total Kjeldahl nitrogen in the Upper Little River since 2000, as well as nonpoint sources of total Kjeldahl nitrogen in Buies

Creek and the Little River are contributing to sustaining the total Kjeldahl nitrogen concentrations in the Cape Fear River through to station B7480000.

The lowest total Kjeldahl nitrogen concentrations are typically recorded near the station directly downstream from the Cross Creek confluence (B7600000). Notably, throughout the 2002 to 2020 time frame, the most downstream station in the Upper Cape Fear River subbasin (B7500000) has had several occurrences of elevated annual mean total Kjeldahl nitrogen concentrations that exceeded the annual average values recorded at several upstream stations. As there are only a few adjoining tributaries between station B7480000 and B7500000 the source causing the considerable increase in total Kjeldahl nitrogen is most likely from the adjoining tributaries and nearby land uses.

DWR conducted screening-level seasonal and non-seasonal Mann-Kendall trend tests at 95% confidence for monitoring data collected from 2000 to 2019 at the mainstem Cape Fear River stations. The total Kjeldahl nitrogen concentrations have significantly increased at stations B6160000, B62150000, B6370000, and B6840000 based on a seasonal trends test (*Table 8-16*). A non-seasonal trends test at stations B7480000 and B7600000 also showed a significant increase for total Kjeldahl nitrogen during this same time frame (*Table 8-16*). It is unclear what is driving these increases in total Kjeldahl nitrogen concentrations; however, these results suggest upstream sections have the capacity to produce biological growth increasing the total Kjeldahl nitrogen concentration, nonpoint sources could be contributing, and/or nitrogen is being mobilized and released from storage in concert with the elevated ammonia concentrations discussed in the next section. As noted previously, the most upstream watershed (Buckhorn Creek – Cape Fear River) has the highest 5-year average total Kjeldahl nitrogen and ammonia concentrations of all the watersheds in the Upper Cape Fear River subbasin based on data collected between 2016 and 2020.

Similar to total Kjeldahl nitrogen, ammonia concentrations generally decline from upstream to downstream based on 5-year and annual mean values (*Figure 8-92*). Annual mean ammonia concentrations at the most upstream stations (B6160000) are often higher than concentrations considered normal for healthy piedmont streams (0.05 mg/L) (*Figure 8-92* and *Figure 8-93*). As previously noted, this is most likely due to the elevated ammonia concentrations from the Haw River. DWR conducted screening-level seasonal and non-seasonal Mann-Kendall trend tests at 95% confidence for monitoring data collected from 2000 to 2019 at the mainstem Cape Fear River stations. Ammonia concentrations significantly decreased at downstream stations B6840000 and B7600000, and B7500000; while it was not significant at upstream stations B6160000, B6370000, and B7600000; and not tested at station B6215000 (*Table 8-16*).

Streamflow also exerts control on the total Kjeldahl nitrogen concentrations and ammonia concentrations (*Figure 8-74F, G*). *Figure 8-74G* displays that average total Kjeldahl nitrogen concentrations were typically lower with average values of 0.60 mg/L during lower flow conditions (≤641 cfs) while average values were higher (0.86 mg/L) during periods of higher flow (≥ 3,670 cfs). Similarly, average ammonia concentrations were lower with values of approximately 0.029 mg/L during periods of lower flow (≤ 641 cfs) while average values were higher with values of approximately 0.076 mg/L during periods of higher flow (≥ 3,670 cfs) (*Figure 8-74F*). This suggests that during higher flow events total Kjeldahl nitrogen concentrations become elevated through a combination of higher ammonia concentrations and likely nitrogen mobilized that is released from sediment storage.

8.8.1.7 Nitrate+nitrite (NOx)

Based on the 5-year mean values, the nitrate+nitrite (NOx) concentrations generally increase from upstream to downstream (*Figure 8-94*). This is possibly due to increased point and nonpoint sources of pollution input from the surrounding landscape as the drainage area increases. Based on annual mean nitrate+nitrite concentrations, values recorded in the mainstem Cape Fear are typically above concentrations considered normal for healthy piedmont streams (0.3 mg/L).

The lowest nitrate+nitrite concentrations are typically recorded along the first four stations in the main stem Cape Fear River (B6160000, B62150000, B6370000, and B6840000). While the upstream nitrate+nitrite concentrations are lower than downstream concentrations, the typical concentrations are still higher than values considered normal for healthy piedmont streams. As previously discussed, the sources of nitrate+nitrite in the upstream stations are most like a combination of the Deep and Haw rivers. The lower three stations on the mainstem Cape Fear River (B7480000, B7600000, and B7500000) consistently record the highest nitrate+nitrite concentrations. A considerable change in nitrate+nitrite concentrations have been observable in the annual mean values between stations B6840000 and B7600000 (*Figure 8-95*). As noted previously, nitrate+nitrite concentrations from the Little River could have contributed to the elevated concentrations recorded at station B7480000. Additionally, Cross Creek contributes flow to the mainstem Cape Fear River between stations B7480000 and B7600000. The Cross Creek – Cape Fear River watershed has the highest 5-year average nitrate+nitrite concentrations of all the watersheds in the Upper Cape Fear River subbasin based on data collected between 2016 and 2020 (*Table 8-11*). The cumulative impact of nitrate+nitrite concentrations from the Little River and Cross Creek could explain why the nitrate+nitrite concentrations in the mainstem Cape Fear River increase from upstream to downstream.

The screening-level seasonal Mann-Kendall trends test at one upstream station B6370000 indicated a significant decrease in nitrate+nitrite concentrations between the 2000 and 2019-time frame. The remaining stations (B6160000, B6840000, B7480000, B7600000, and B7500000) on the mainstem Cape Fear River in the Upper Cape Fear subbasin displayed insignificant trends during this same time frame (*Table 8-16*). Notably, during the 2010–2019 time frame, stations (B6160000, B6215000, B6370000, B7480000, B7600000, and B7500000) displayed a significant decrease in nitrate+nitrite concentrations (*Table 8-16*). This overall decrease is also suggested in the difference between 5-year average values for 2011-2015 and 2016-2020 (*Figure 8-94*).

The average nitrate+nitrite nitrogen concentrations recorded during the medium flow periods were highest with average values of approximately 0.58 mg/L. During higher flow periods ($\geq$ 3,670 cfs) the average nitrate+nitrite concentrations were similar to medium flow conditions with typical values of 0.57 mg/L. During the lower flow periods ($\leq$ 641 cfs) the average nitrate+nitrite concentrations were lowest with an average value of 0.50 mg/L. This indicates consistent contribution from both point and nonpoint sources of pollution are sustaining the elevated nitrate+nitrite concentrations within the mainstem Cape Fear River (*Figure 8-74H*).

8.8.1.8 Total Nitrogen

The combination of total Kjeldahl nitrogen and nitrate+nitrite form the total nitrogen signature in waterways. Together these different forms of nitrogen produce a general pattern of elevated total nitrogen levels at the most upstream stations and downstream stations with stations in the middle section of the waterway typically having lower concentrations (*Figure 8-96*). While the total nitrogen pattern is from higher to lower total nitrogen concentrations it is important to note that the two parameters that measure nitrogen, total Kjeldahl nitrogen and nitrate+nitrite, have differing patterns as discussed previously. Total Kjeldahl nitrogen decreases from upstream to downstream while nitrate+nitrite increases from upstream to downstream.

The statistics calculated throughout this chapter suggest that the highest total nitrogen concentrations (>1 mg/L) are typically found in the mainstem Cape Fear River while the tributaries (Upper Little, Little River, and Rockfish Creek) that feed into the mainstem Cape Fear River typically have lower total nitrogen concentrations (<1 mg/L). This indicates that any dilution in the total nitrogen signature from upstream tributaries with lower total nitrogen concentrations (<1 mg/L) is negated by downstream contributing point and nonpoint sources of pollution which increase the total nitrogen concentrations in Cape Fear River back above 1 mg/L prior existing the Upper Cape Fear River subbasin. Based on annual mean total nitrogen concentrations all stations record total nitrogen concentrations that exceed the values considered normal for healthy piedmont streams (0.8 mg/L) (*Figure 8-97*). Most years have an annual mean value that exceeds 1.0 mg/L.

Based on flow and water quality at station B6370000, total nitrogen concentrations were highest with average values of approximately 1.4 mg/L during the higher flow periods (≥ 3,670 cfs) (*Figure 8-74I*). Medium flow periods and lower flow periods (≤ 641 cfs) had lower average total nitrogen values (*Figure 8-74I*). In addition to having inverse patterns in the total Kjeldahl nitrogen and nitrate+nitrite concentrations from upstream to downstream, these two nitrogen measurements have inverse patterns with generally increasing total Kjeldahl nitrogen and generally decreasing nitrate+nitrite concentrations overtime (*Figure 8-98*).

8.8.1.9 Total Phosphorus

While all stations along the mainstem Cape Fear River have similar total phosphorus concentrations, the furthest upstream and downstream stations in the Upper Cape Fear River subbasin typically have the highest values with lower values observed at stations in the middle section of the Cape Fear River (*Figure 8-99*). As discussed previously the upstream stations (B6160000, B6370000, and B6840000) are most likely influenced by the elevated total phosphorus concentrations from the Deep River and Haw River, as well as nonpoint sources (agriculture, land application fields, and/or sediment-bound or legacy phosphorus) in Lick Creek. The downstream stations' (B7480000, B7600000, and B7500000) elevated total phosphorus are most likely influenced by the point and nonpoint sources in the Little River, as well as unmonitored tributaries of the mainstem Cape Fear River. Cross Creek and Rockfish Creek both have total phosphorus concentrations lower than the concentrations observed in the mainstem Cape Fear River. Total phosphorus concentrations in the mainstem Cape Fear River exceed the concentrations considered normal for healthy piedmont streams (0.05 mg/L). Most annual mean values recorded at stations along the mainstem Cape Fear River typically approach or exceed 0.1 mg/L (*Figure 8-100*). Notably, average total phosphorus concentrations were observed to be the highest with values of 0.15 mg/L during periods of higher flow (≥ 3,670 cfs) and lowest with values of 0.08 mg/L during periods of lower flow (≤ 641 cfs) (*Figure 8-74J*).

Screening-level non-seasonal Mann-Kendall trends tests for stations B6160000, B6215000, B6370000, B6840000 based on data collected between 2000 and 2019 indicate a significant decrease in total phosphorus concentrations (*Table 8-16*). Similarly, screening-level seasonal Mann-Kendall trends test at stations B7480000, B7600000, and B7500000 indicate a significant decrease in total phosphorus concentrations (*Table 8-16*). Station B6215000 was not tested (*Table 8-16*).

8.8.1.10 Chlorophyll *a*/Algal Blooms

The 2000 basin plan reported on the presence of algal blooms in the mainstem Cape Fear River and recognized that blooms were contributing to dissolved oxygen issues in the river and estuary (2000 plan data window was 9/1/1993-8/31/1998). In July 1998, the Middle Cape Fear River Basin Association began to monitor the central portion of the Cape Fear River Basin, which allowed for a better understanding of water quality conditions in the central portion of the Cape Fear River Basin.

The 2005 basin plan chlorophyll *a* data assessment (data window - 9/1/1998-8/31/2003) resulted in several portions of the mainstem Cape Fear River being added to the 2006 impaired waters list. After the completion of the 2005 basin plan, changes in sampling protocols, changes in use support methodology and issues with the coalition's chlorophyll *a* laboratory results, made interpreting changes in chlorophyll *a* and water quality conditions challenging.

Severe Harmful Algal Blooms (HABs) occurred between 2009 and 2012 along the Cape Fear River mainstem from the confluence with the Deep and Haw rivers downstream below Lock and Dam #1 near Wilmington. However, chlorophyll *a* standard violations (>40 µg/L) were only recorded above Buckhorn Dam even though the algal blooms were considered severe and extreme which resulted in NC DHHS releasing public health advisories about contact with HABs in the riverine system. This is an indicator that there is likely an issue with the sampling technique and/or that the state standard of 40 µg/L is not protective of these flowing riverine systems.

The segment of the Cape Fear River behind Buckhorn Dam [AU# 18-(5.5)a] was sampled in 2010 as part of a special study and was added to the Ambient Lakes Monitoring Program in 2013 and 2018. The three-year dataset showed that when the flow of the Cape Fear River drops below about 900 cfs at the Lillington USGS flow gage for an extended period of time, algae will likely bloom if the other environmental controlling factors are suitable (such as temperature and light). It is important to understand that the non-drought low flow target at Lillington is 600 cfs (± 50 cfs). The flow target at Lillington is met from flows out of the Deep River and releases from Jordan Lake by the USACOE. More detailed descriptions of chlorophyll *a* and algal blooms on the mainstem Cape Fear River are available in section 2.5.8 and 2.7 of chapter 2.

The central portion of the Cape Fear River Basin has been recognized as nutrient over-enriched. As such, DWR has a permitting strategy that requires a no net increase in watershed loading for nitrogen and phosphorus while additional processes are underway that will assist DWR in understanding how best to protect the quality of the Cape Fear River for all uses. These actions include watershed models of the central portion of the Cape Fear River Basin and work with the Nutrient Criteria Development Plan (NCDP) Scientific Advisory Council (SAC) to develop potential instream nutrient criteria or a response variable that protects the most sensitive uses of the resource. These actions could lead to the need for future reductions in nutrient loading to this system from all point and nonpoint watershed sources (more information is available in the permitting strategy section 3.2.4 of chapter 3 and the NCDP (2.14) and chlorophyll *a* (2.5.8 and 2.7) sections of chapter 2.

Figure 8-74: Average and Median Values for Water Quality Data Collected at Station B6370000 Between 2002 and 2020 Separated into Flow Bins Based on Discharge Percentiles using Data Collected Between 1991 and 2020 at USGS Gage 02102500.

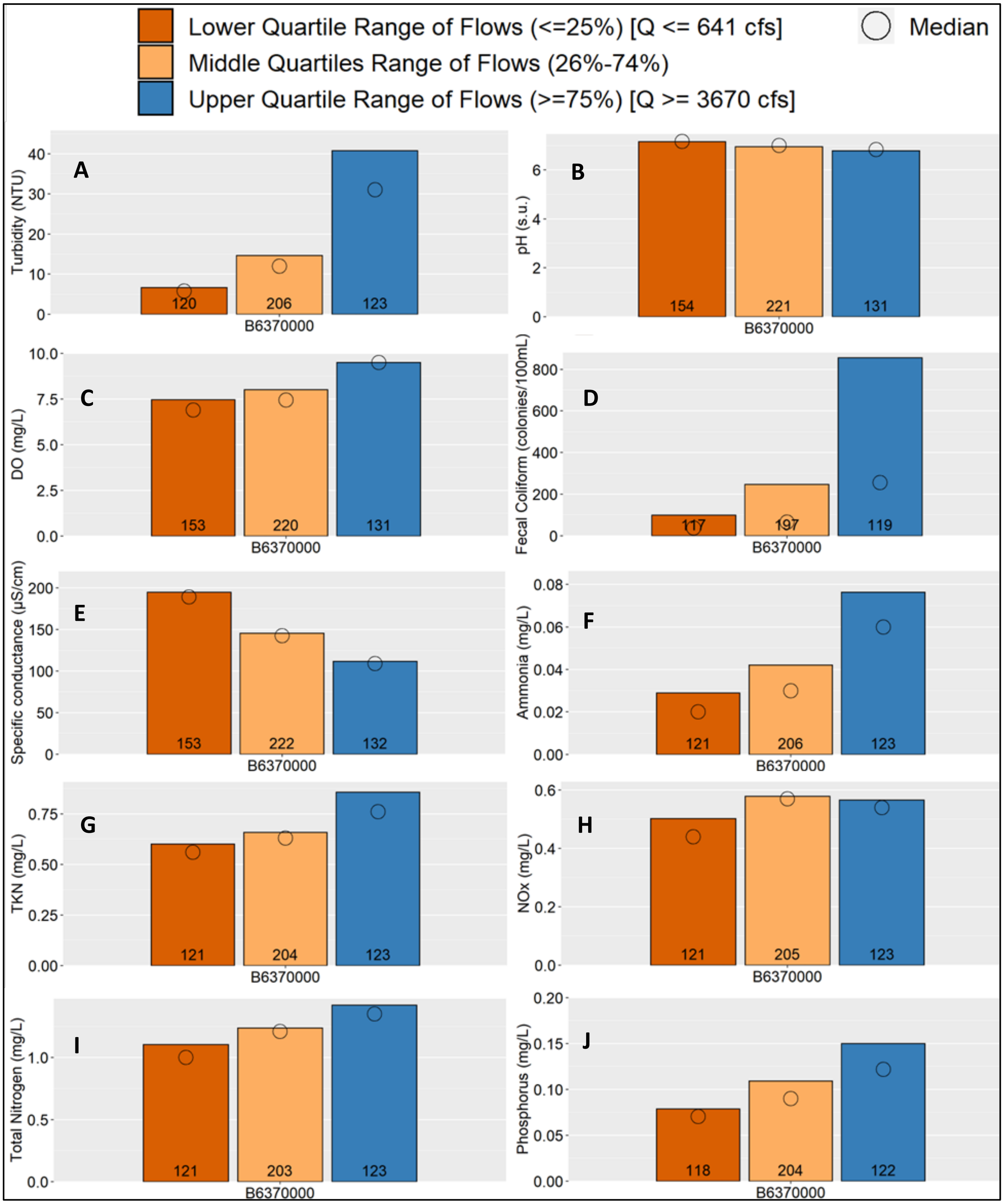


Figure 8-75: Upper Cape Fear Mainstem Stations Five-Year Mean for Turbidity.

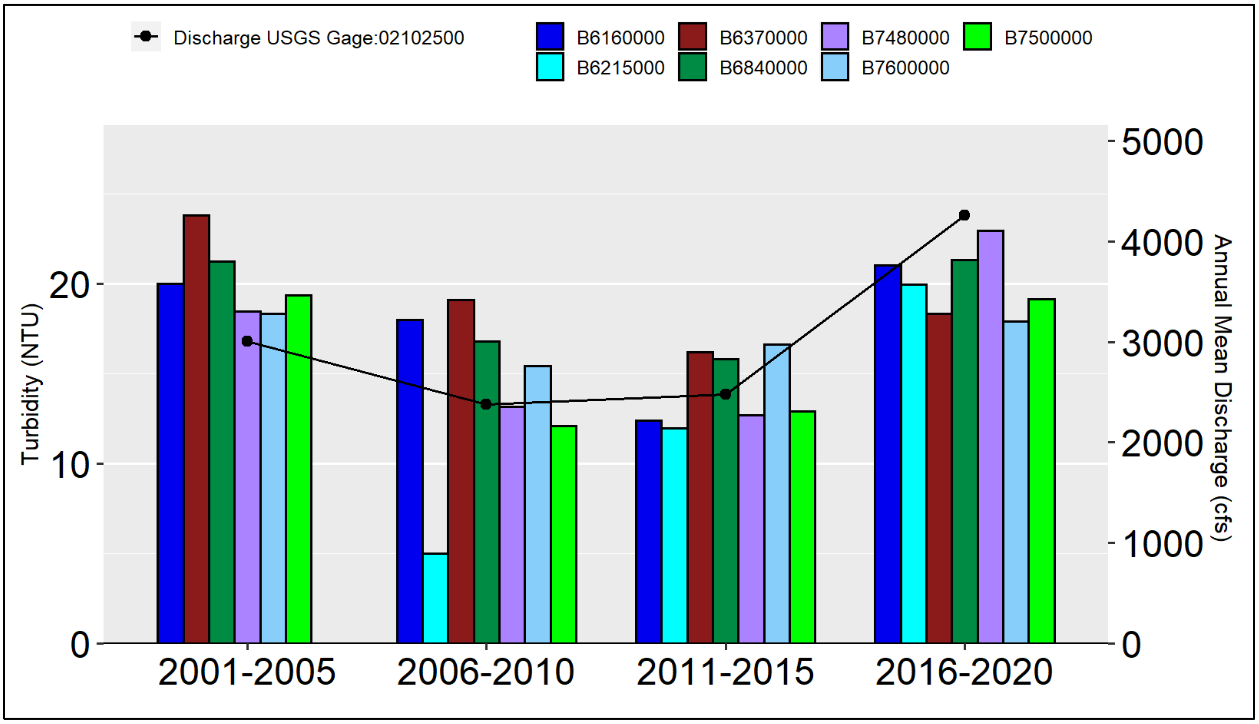


Figure 8-76: Upper Cape Fear Mainstem Stations Annual Mean Turbidity.

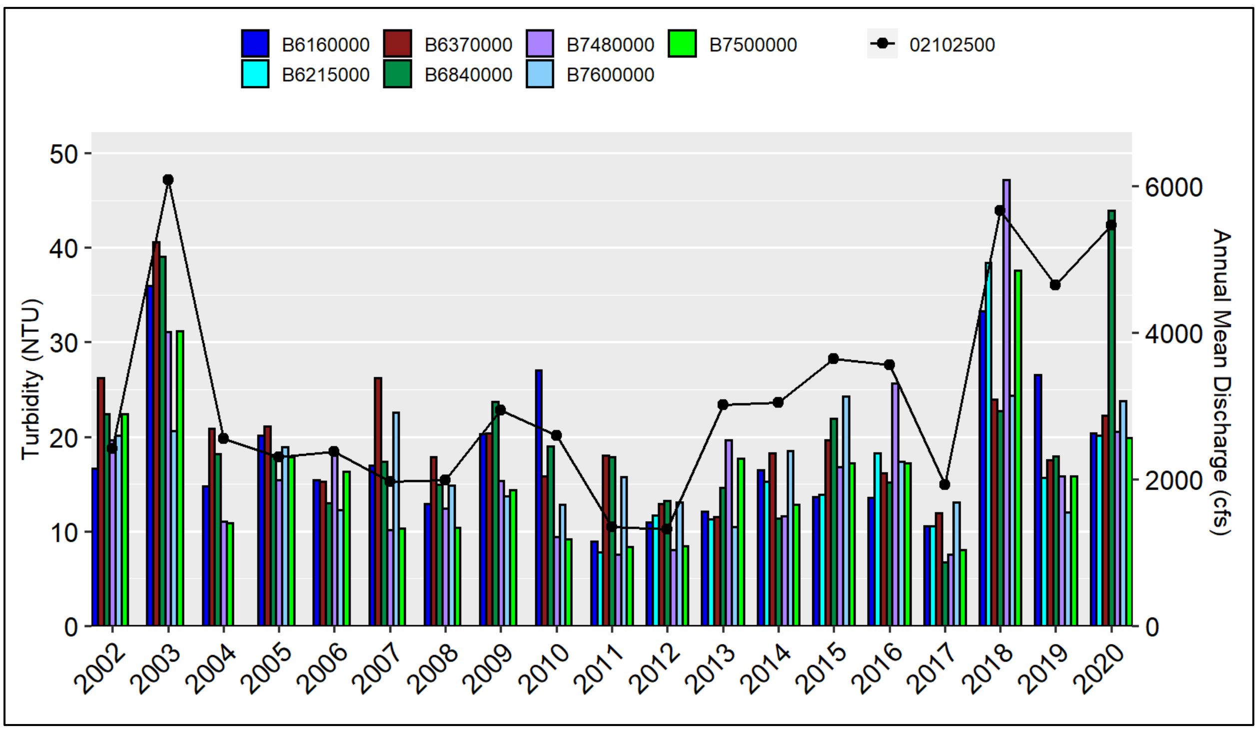


Figure 8-77: Upper Cape Fear Mainstem Stations Sample Percentages that Exceed the 50 NTU Water Quality Standard for Turbidity.

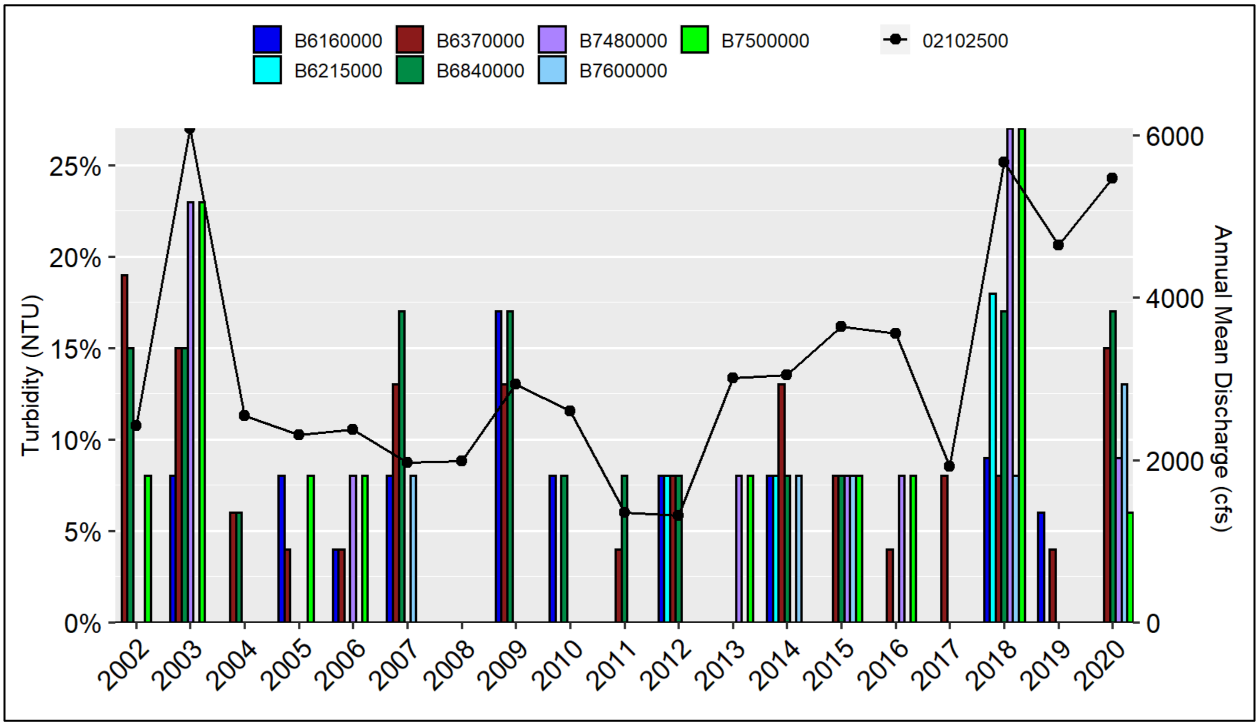


Figure 8-78: Upper Cape Fear Mainstem Stations Five-Year Median for Ph.

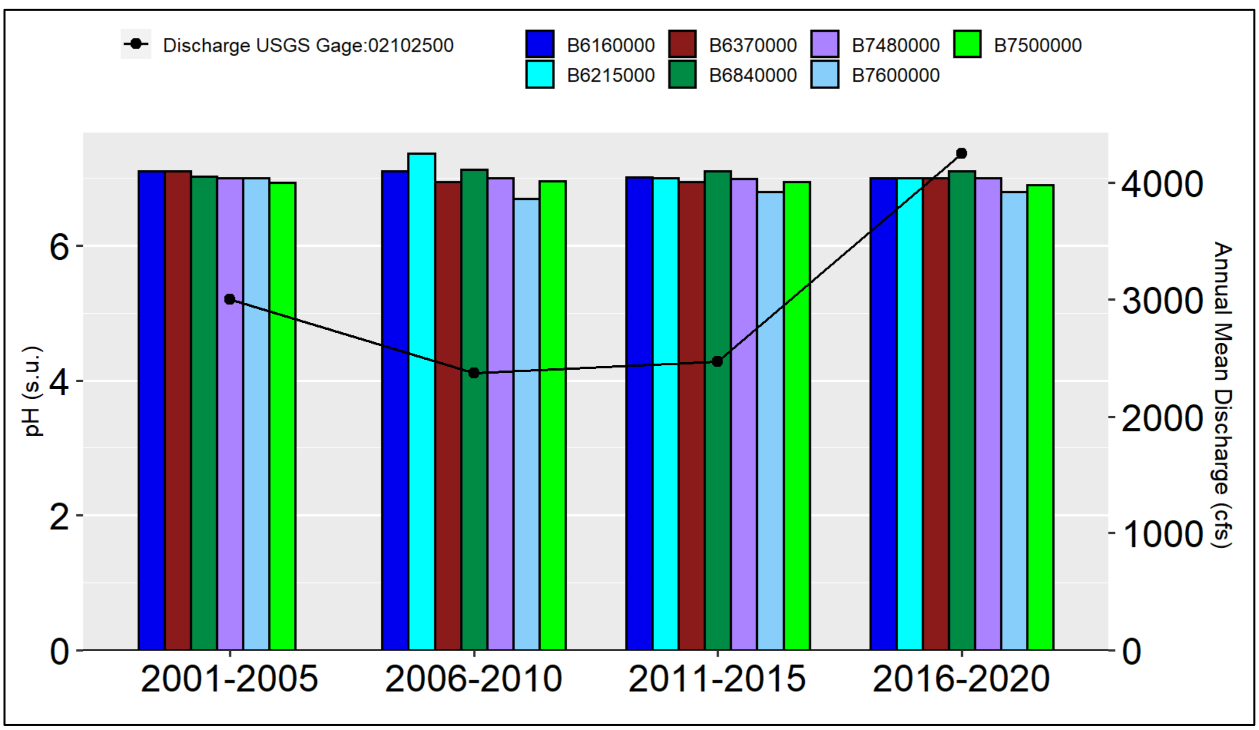


Figure 8-79: Upper Cape Fear Mainstem Stations Annual Median pH.

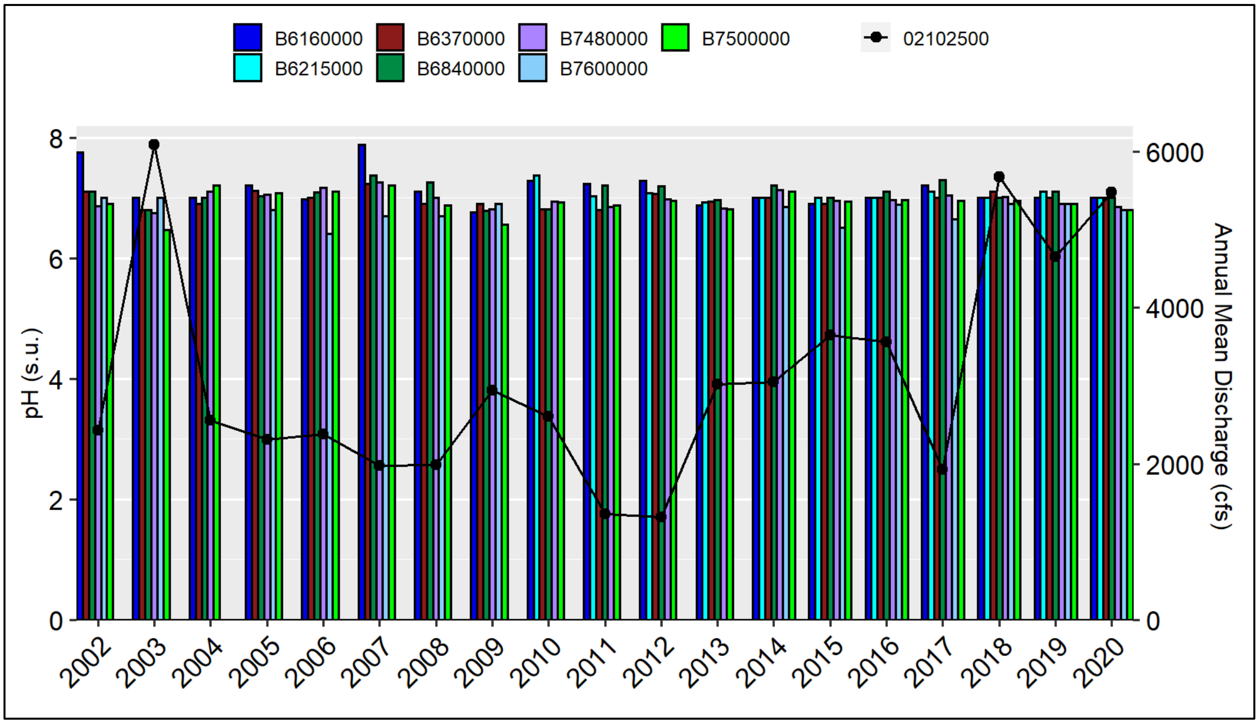


Figure 8-80: Upper Cape Fear Mainstem Stations Sample Percentages that Exceeded the 6 to 9 S.U. Water Quality Standard for pH.

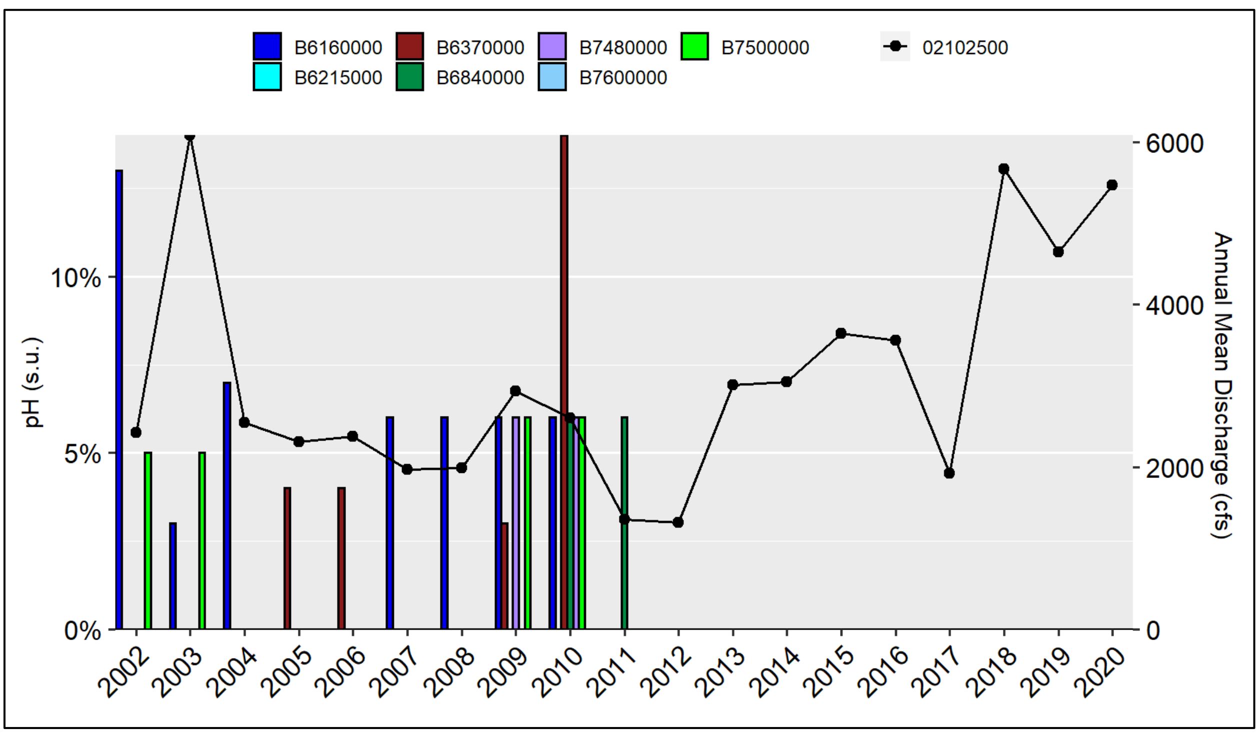


Figure 8-81: Upper Cape Fear Mainstem Stations Five-Year Mean for Dissolved Oxygen.

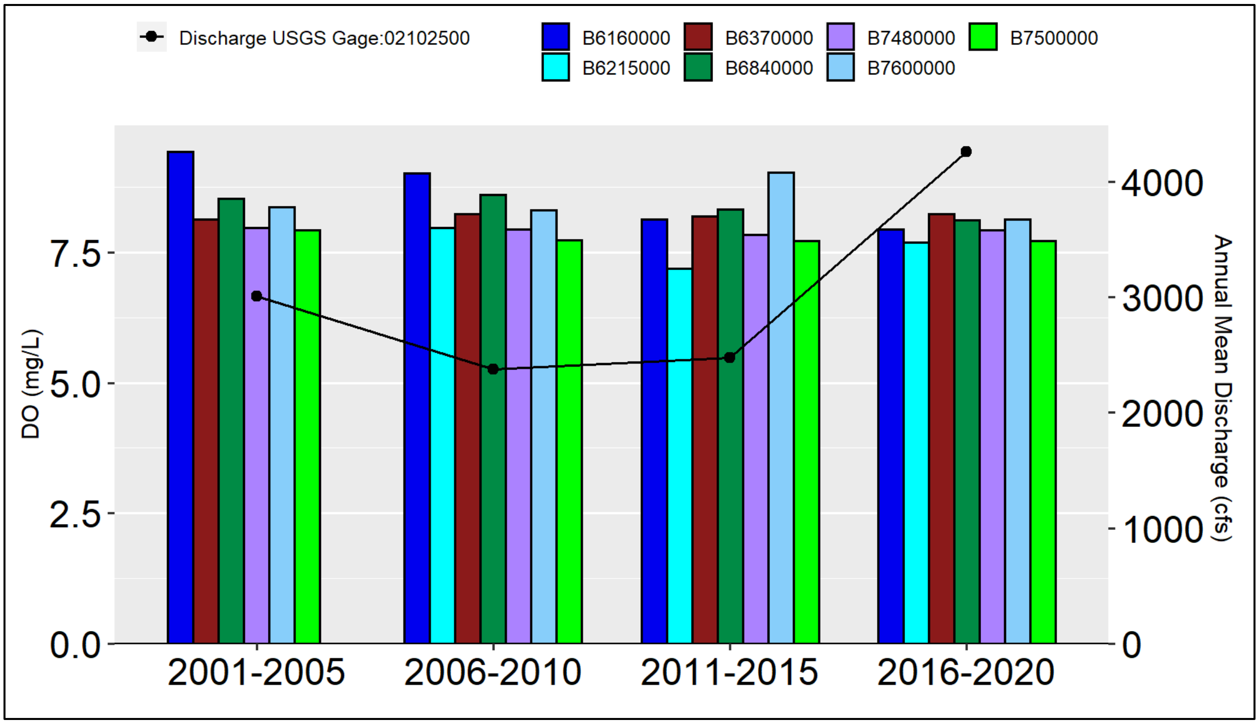


Figure 8-82: Upper Cape Fear Mainstem Stations Annual Mean Dissolved Oxygen.

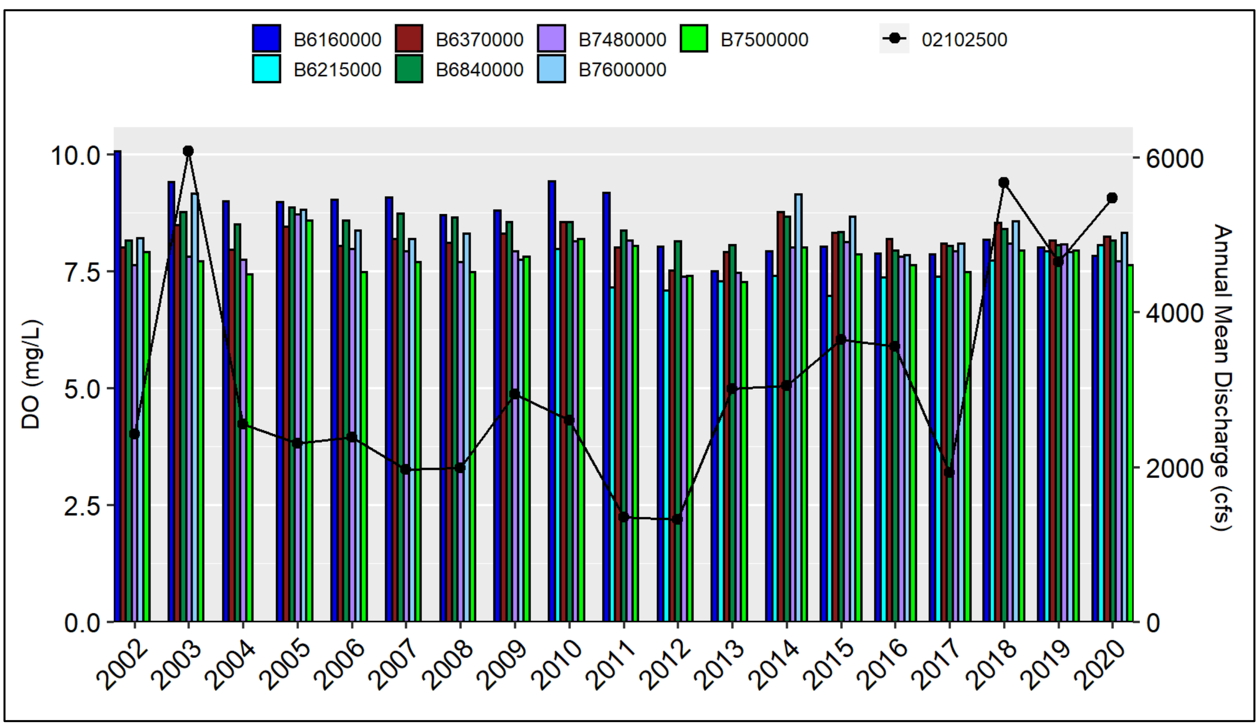


Figure 8-83: Upper Cape Fear Mainstem Stations Sample Percentages that Exceeded the 4 mg/L Dissolved Oxygen Water Quality Standard.

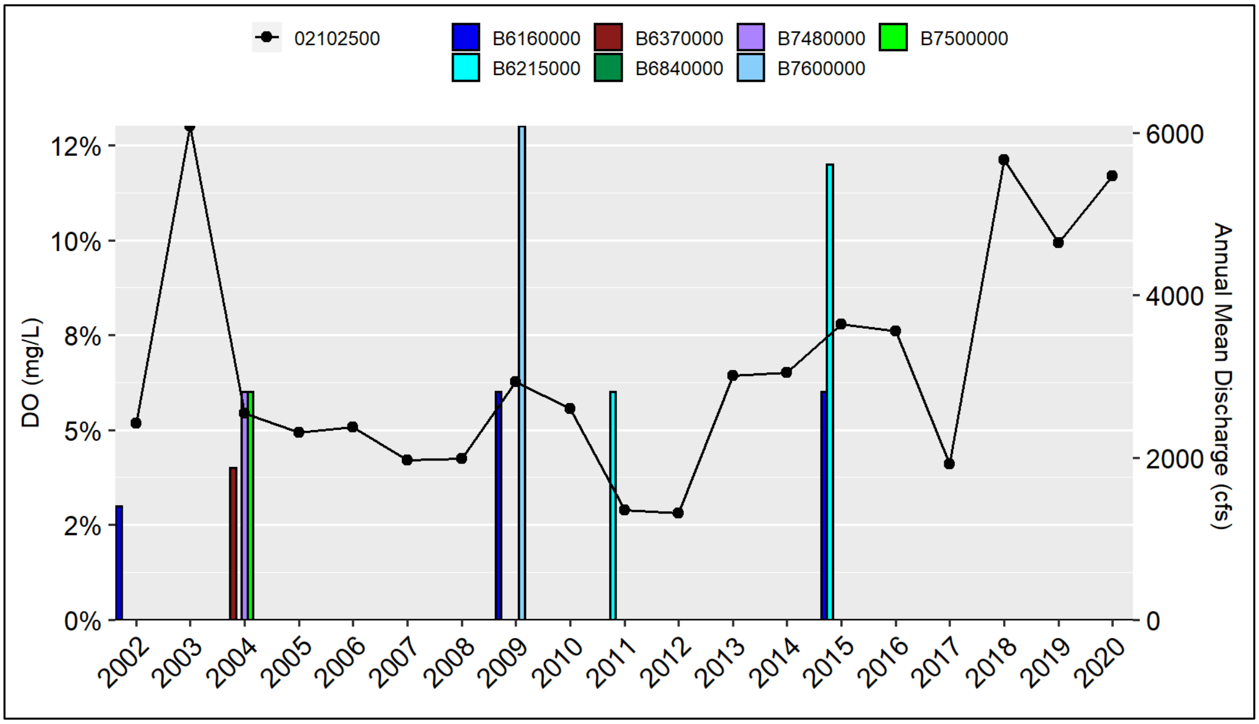


Figure 8-84: Upper Cape Fear Mainstem Stations Sample Percentages that exceeded the 400 colonies/100 ml Standard for Fecal Coliform Bacteria.

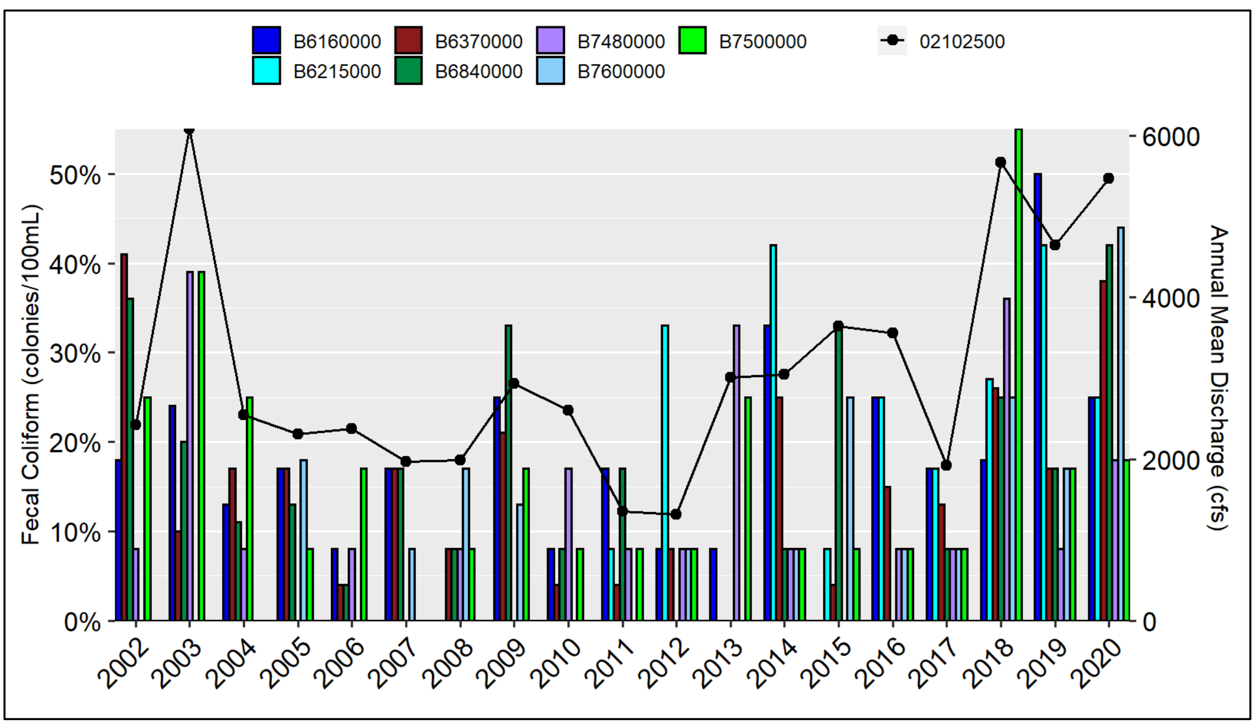


Figure 8-85: Upper Cape Fear Mainstem Stations Five-Year Mean for Fecal Coliform Bacteria.

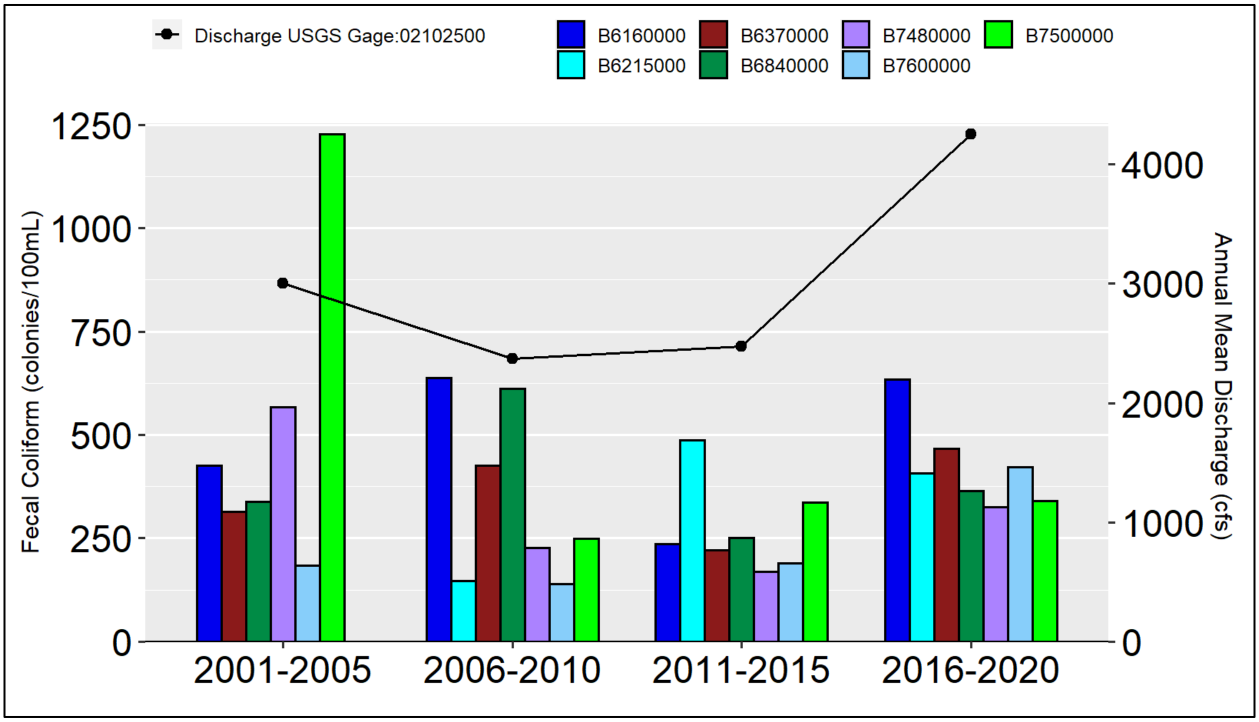


Figure 8-86: Upper Cape Fear Mainstem Stations Annual Fecal Coliform Bacteria (FCB) (400 colonies/100 ml standard for FCB is shown on graph figure).

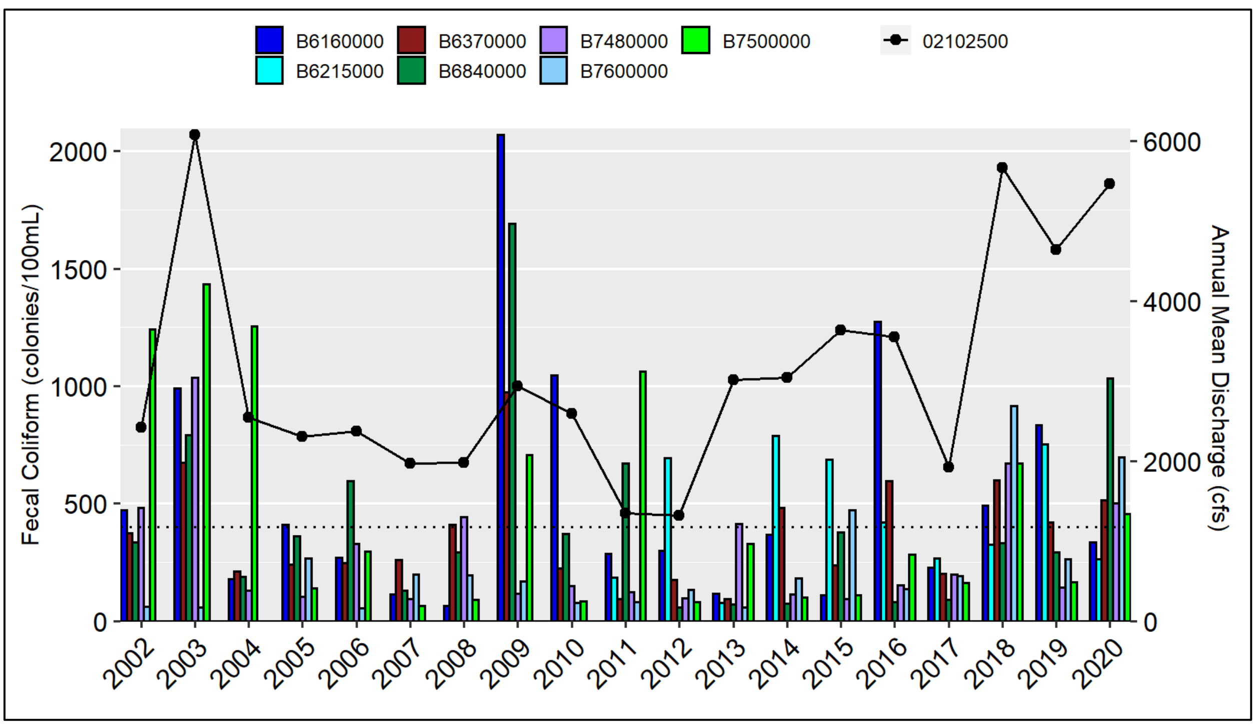


Figure 8-87: Upper Cape Fear Mainstem Stations Fecal Coliform Bacteria Annual Geomeans (Geomean standard is 200 colonies/100 mL).

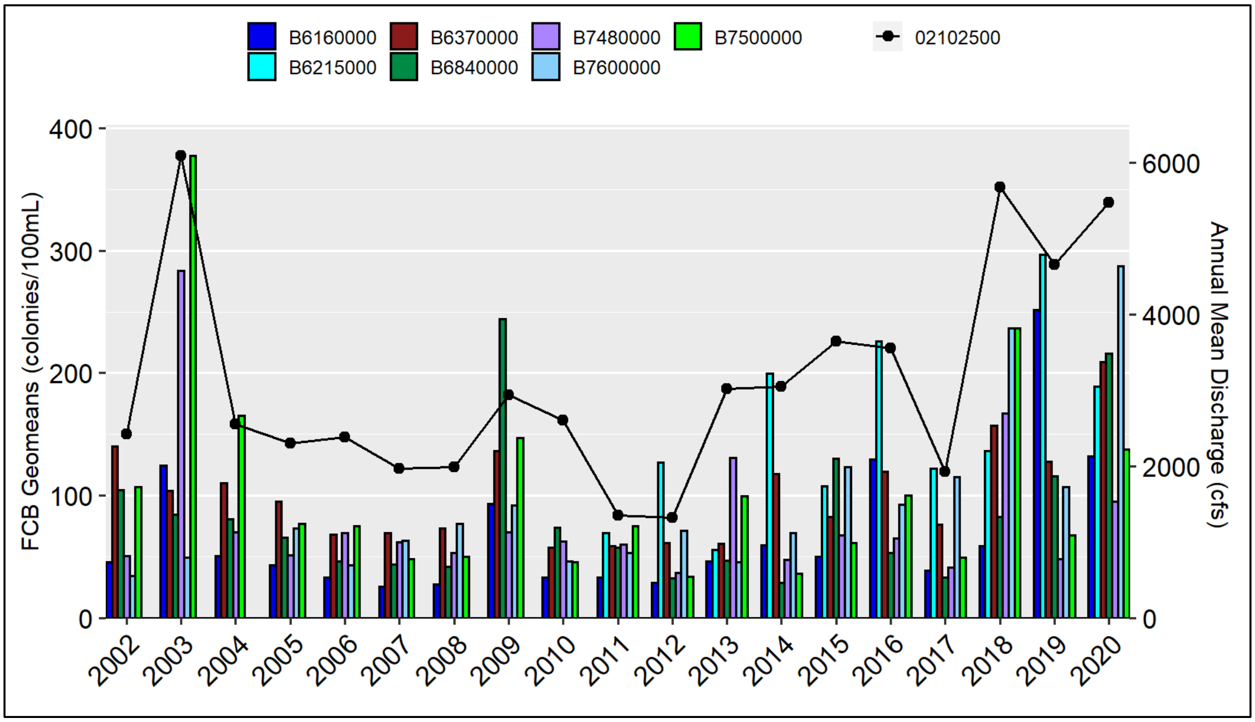


Figure 8-88: Upper Cape Fear Mainstem Stations Five-Year Mean for Specific Conductance.

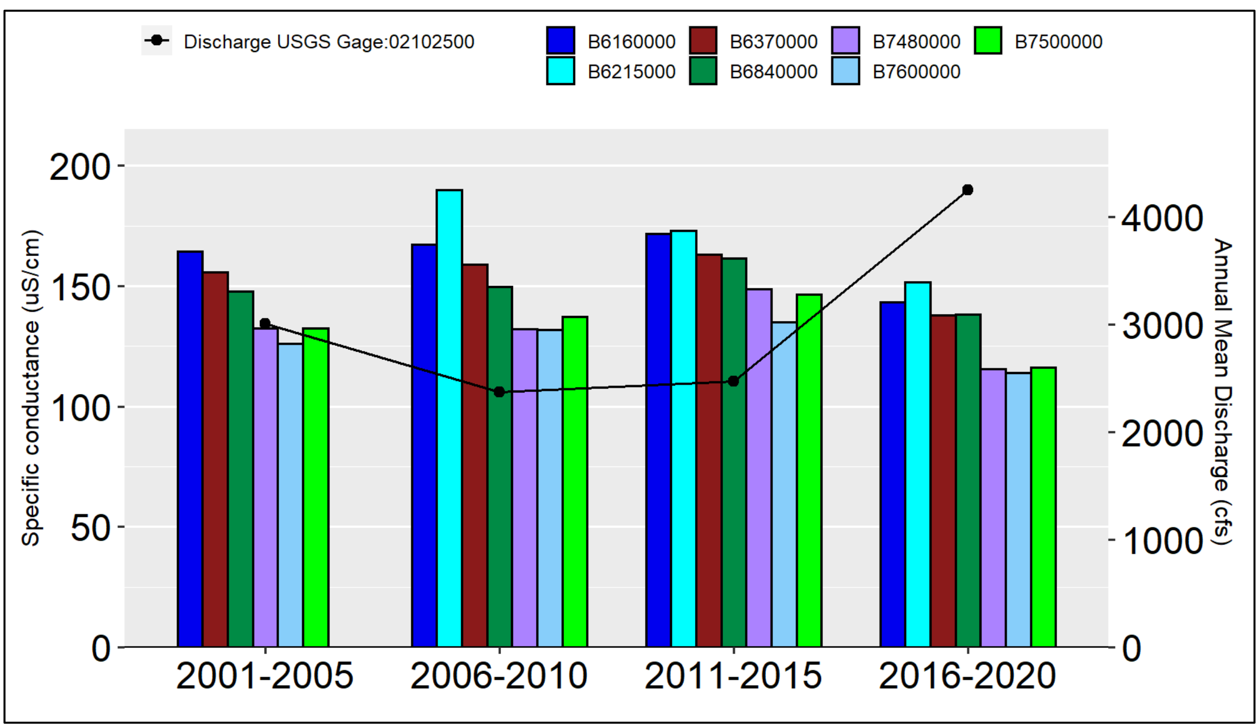


Figure 8-89: Upper Cape Fear Mainstem Stations Annual Mean Specific Conductance.

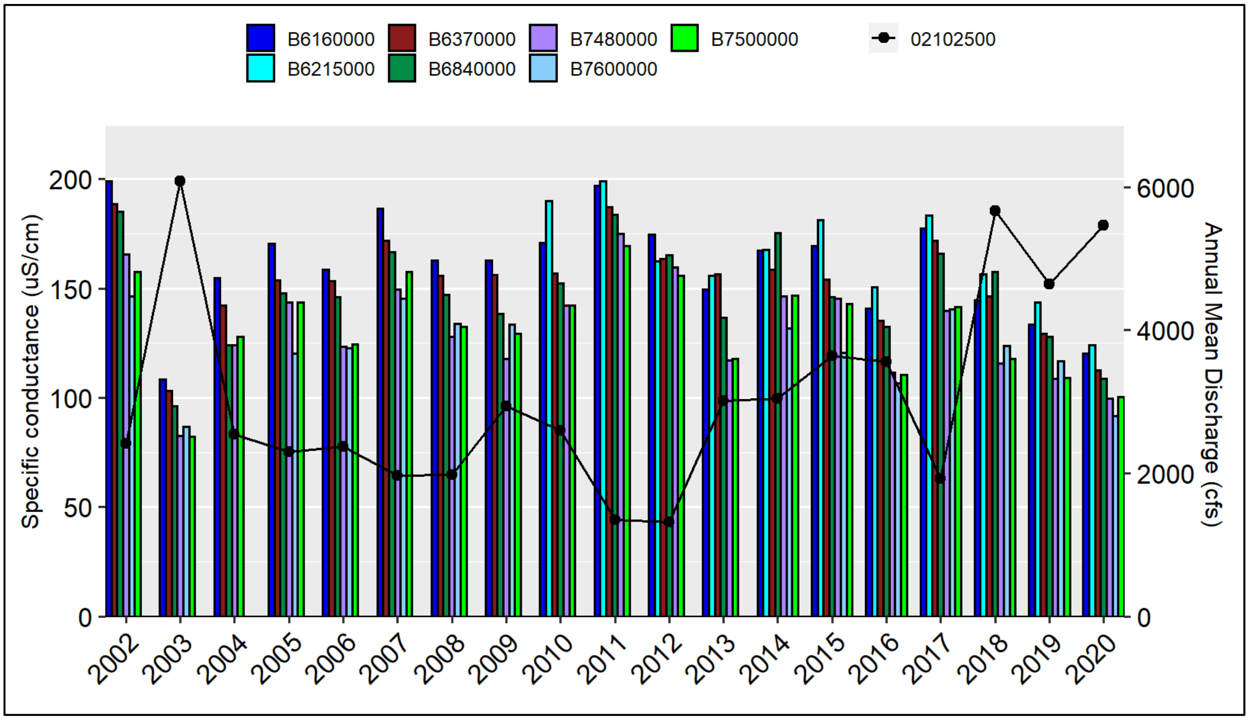


Figure 8-90: Upper Cape Fear Mainstem Stations Five-Year Mean for Total Kjeldahl Nitrogen.

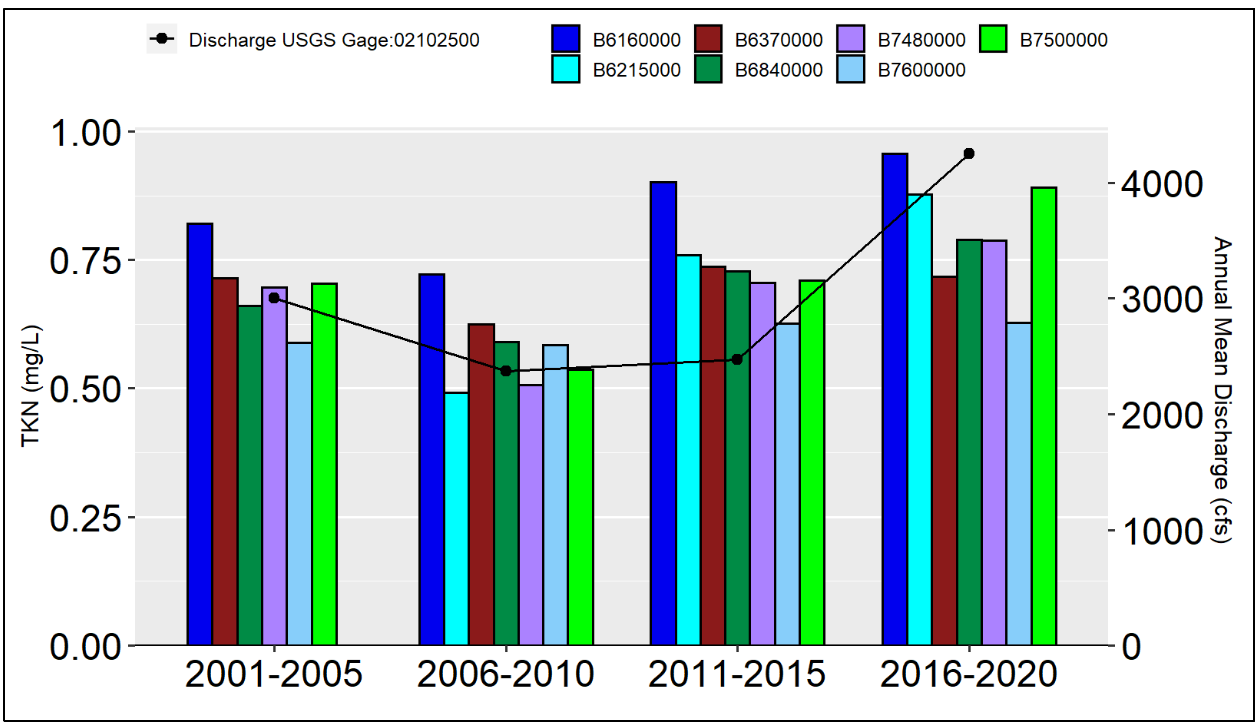


Figure 8-91: Upper Cape Fear Mainstem Stations Annual Mean total Kjeldahl nitrogen (TKN).

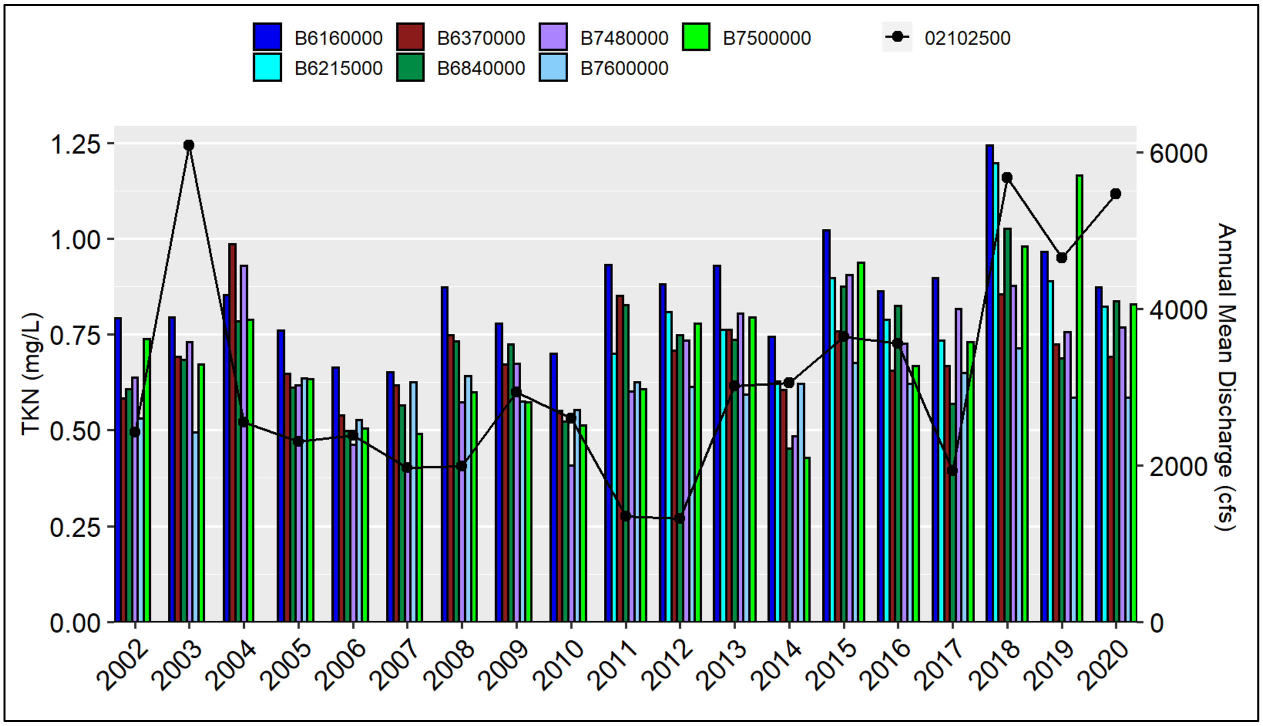


Figure 8-92: Upper Cape Fear Mainstem Stations Five-Year Mean for Ammonia.

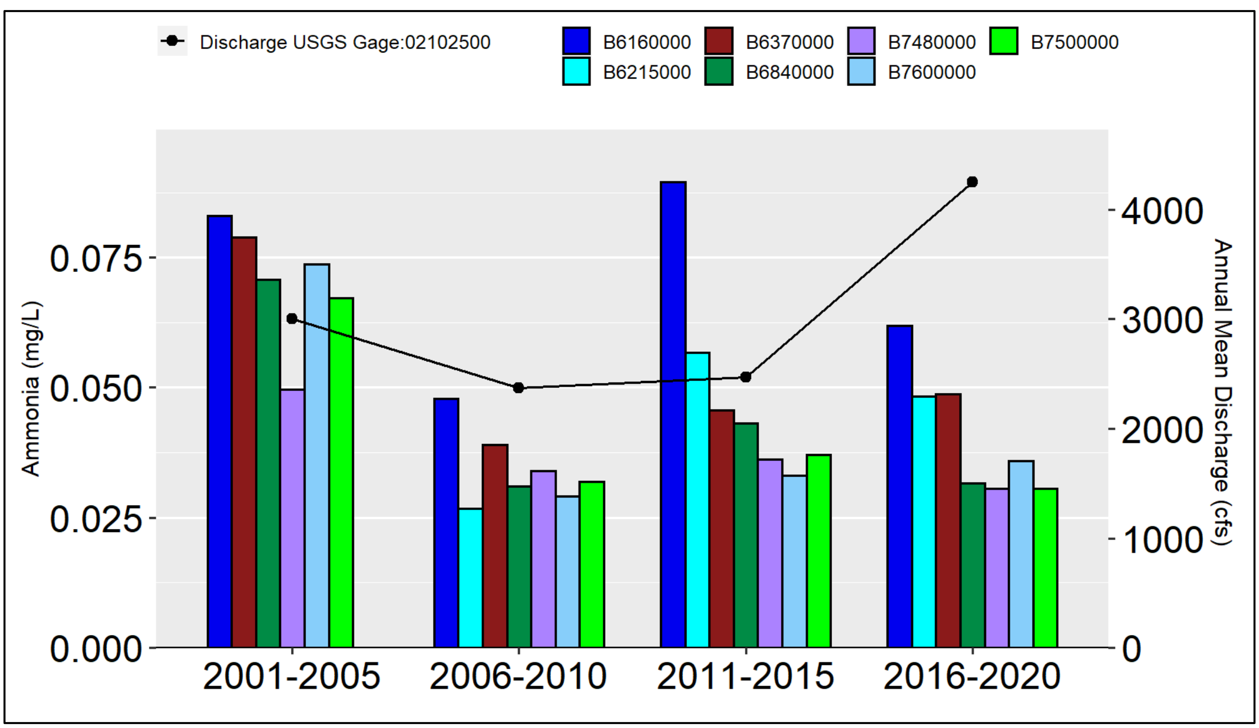


Figure 8-93: Upper Cape Fear Mainstem Stations Annual Mean Ammonia.

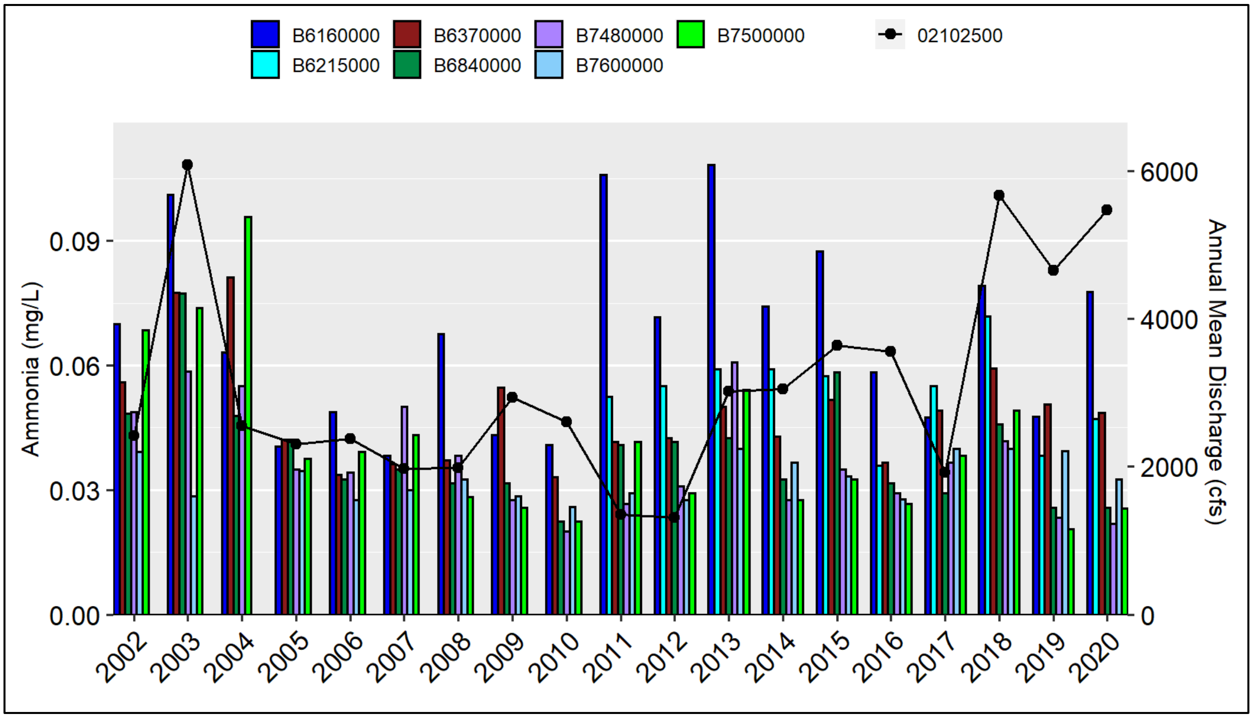


Figure 8-94: Upper Cape Fear Mainstem Stations Five-Year Mean for Nitrate+Nitrite (NOx).

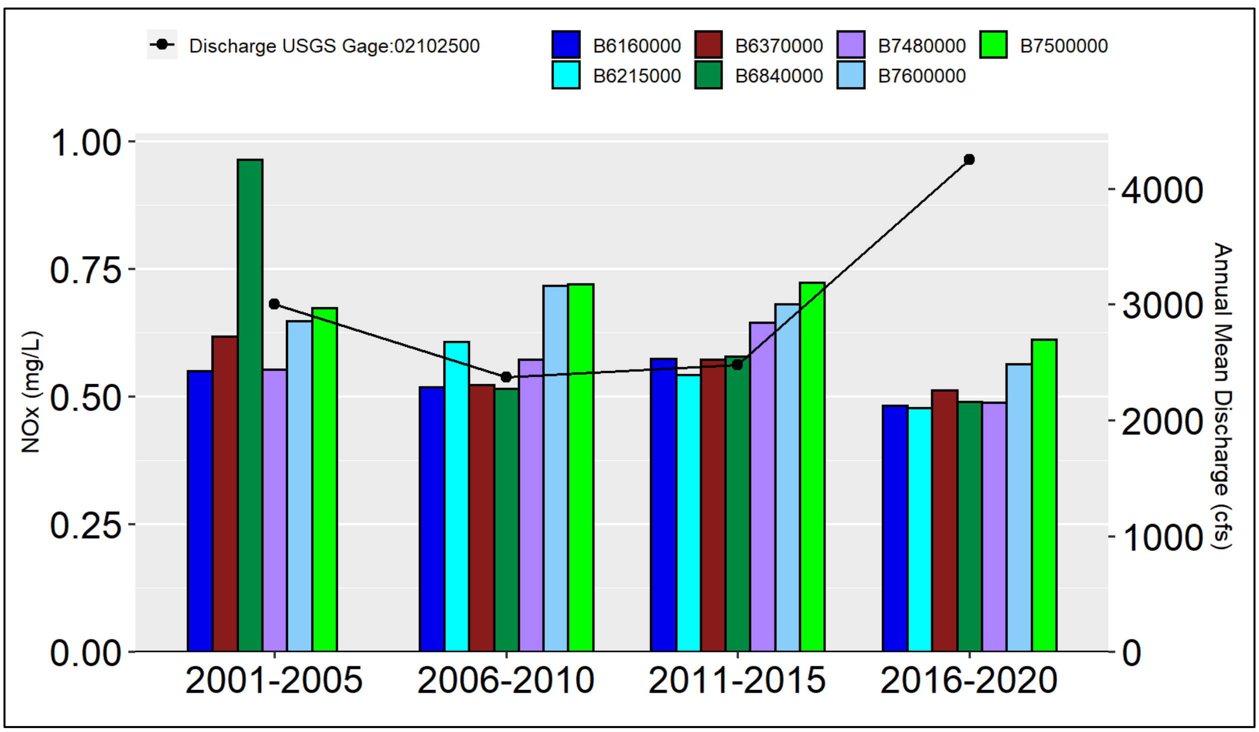


Figure 8-95: Upper Cape Fear Mainstem Stations Annual Mean for Nitrate+Nitrite (NOx).

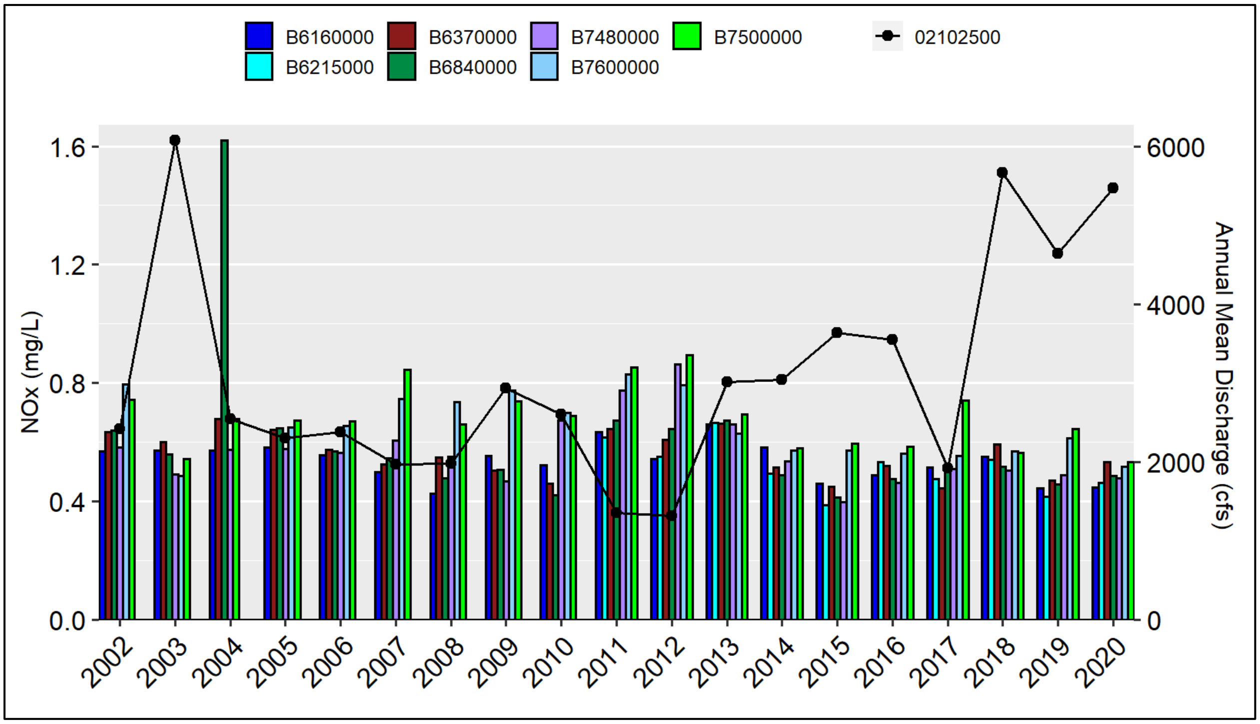


Figure 8-96: Upper Cape Fear Mainstem Stations Five-Year Mean for Total Nitrogen.

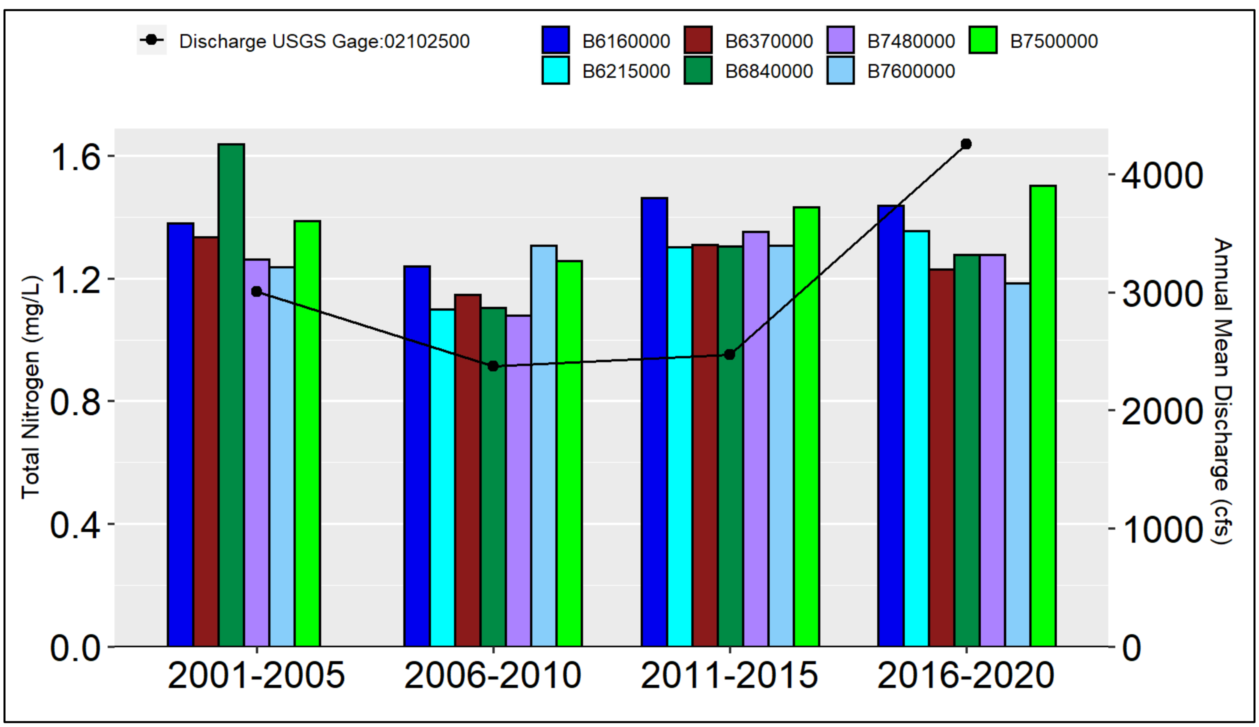


Figure 8-97: Upper Cape Fear Mainstem Stations Annual Mean for Total Nitrogen.

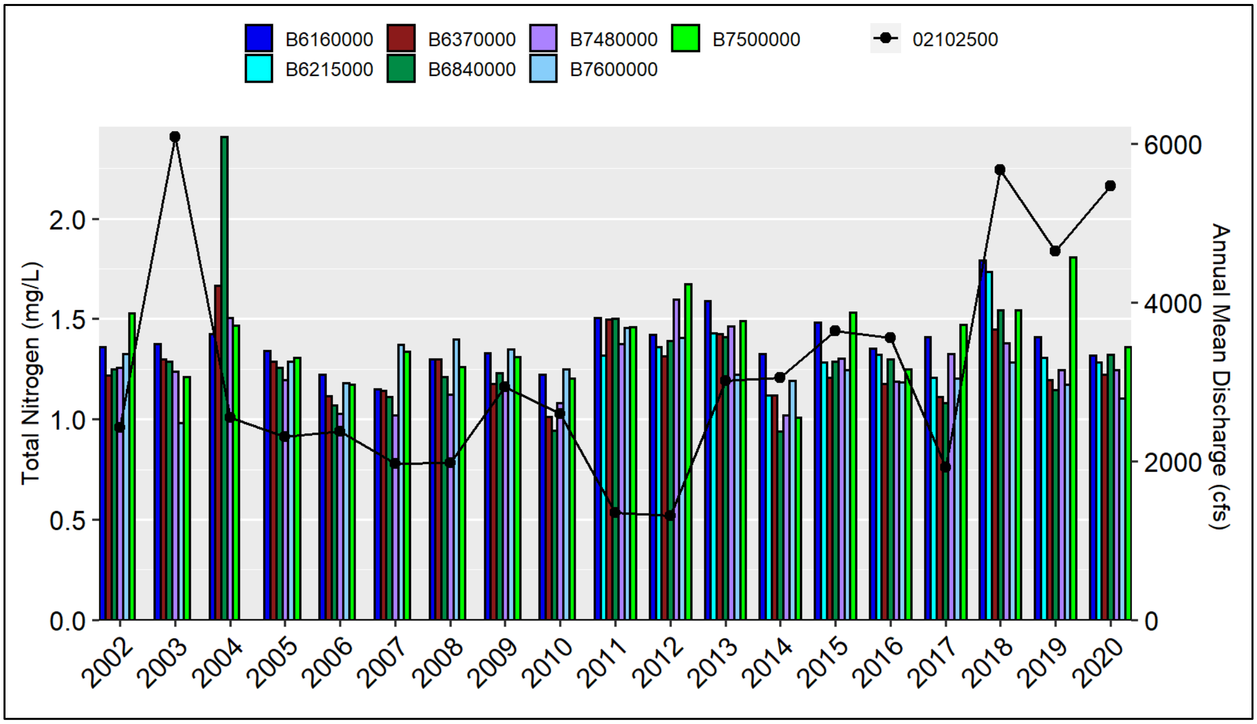


Figure 8-98: Total Kjeldahl Nitrogen and Nitrate+Nitrite Concentrations for all Stations Along the Mainstem Cape Fear River in the Upper Cape Fear River Subbasin.

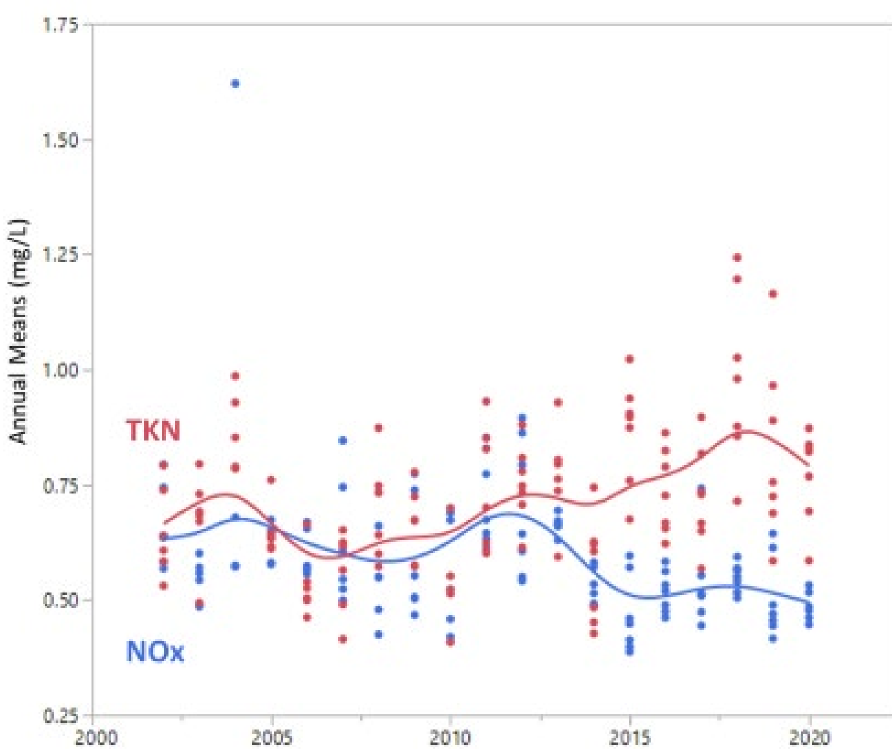


Figure 8-99: Upper Cape Fear Mainstem Stations Five-Year Mean for Total Phosphorus.

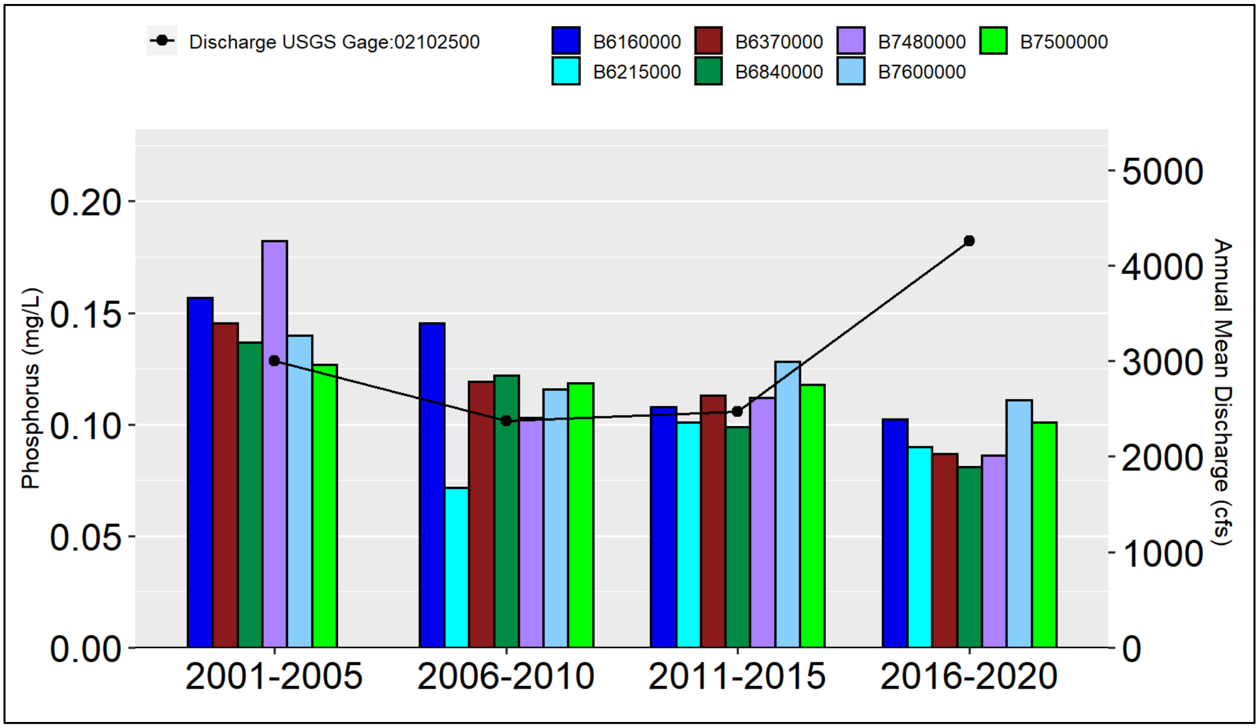


Figure 8-100: Upper Cape Fear Mainstem Stations Annual Mean for Total Phosphorus.

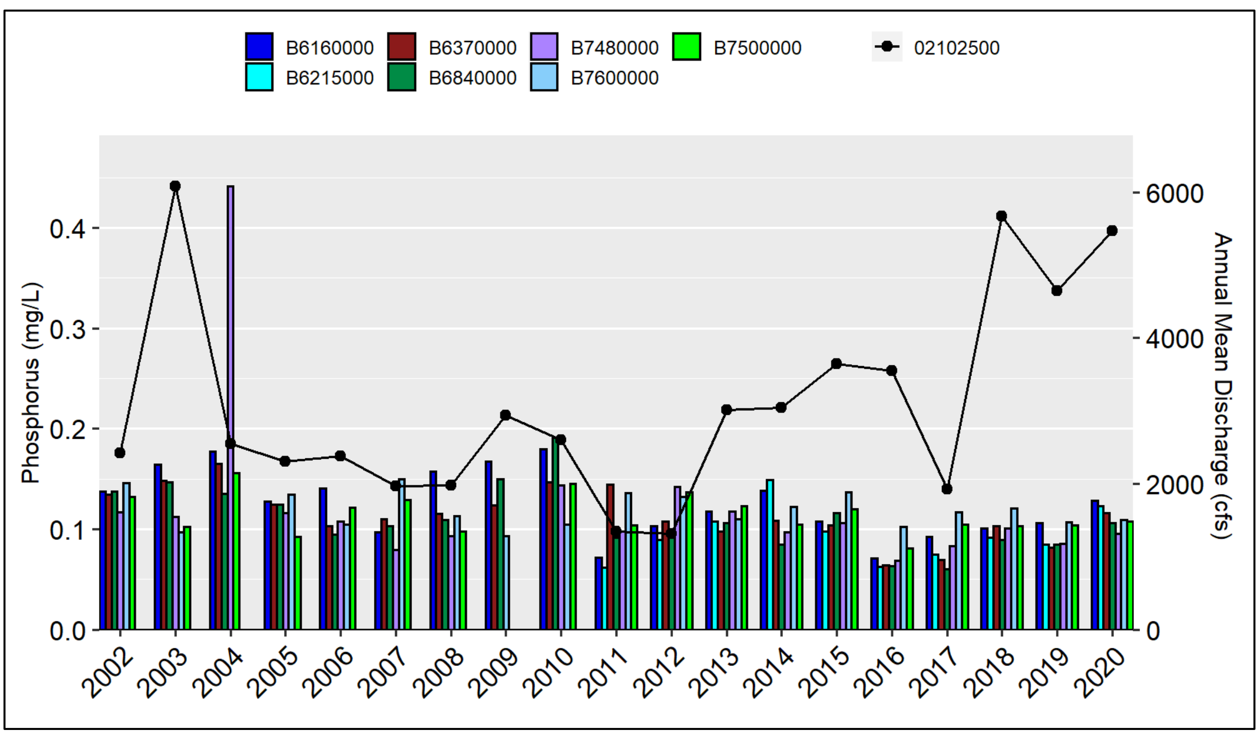
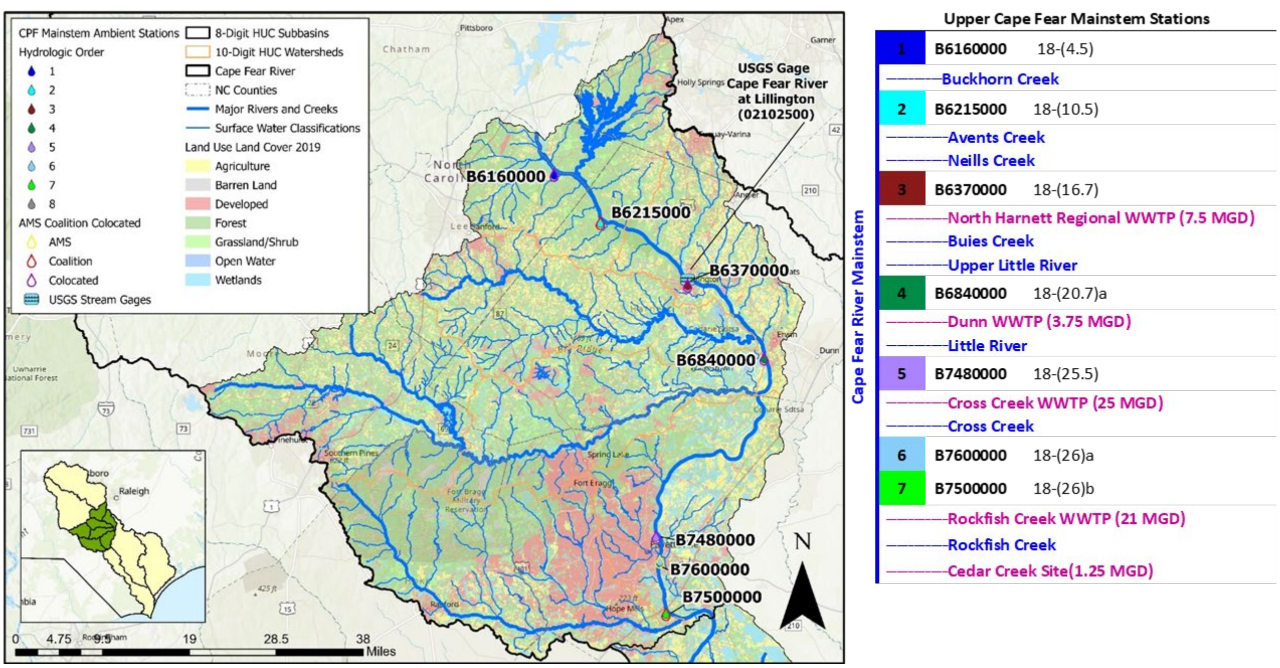


Table 8-16: Upper Cape Fear Mainstem Station Screening-Level Mann-Kendall Tests for Significance.

Parameter		TKN		Ammonia		NOx		Total Phosphorus	
Year		2000-2019	2010-2019	2000-2019	2010-2019	2000-2019	2010-2019	2000-2019	2010-2019
1	B6160000	significant increase	significant increase	not significant	not significant	not significant	significant decrease	significant decrease	not significant
Buckhorn Creek									
2	B6215000	not tested	significant increase	not tested	not significant	not tested	significant decrease	not tested	not significant
Avents Creek									
Neills Creek									
3	B6370000	significant increase	not significant	not significant	significant increase	significant decrease	significant decrease	significant decrease	significant decrease
North Harnett Regional WWTP (7.5 MGD)									
Buies Creek									
Upper Little River									
4	B6840000	significant increase	not significant	significant decrease	not significant	not significant	not significant	significant decrease	significant decrease
Dunn WWTP (3.75 MGD)									
Little River									
5	B7480000	significant increase	significant increase	significant decrease	not significant	not significant	significant decrease	significant decrease	significant decrease
Cross Creek WWTP (25 MGD)									
Cross Creek									
6	B7600000	significant increase	not significant	not significant	significant increase	not significant	significant decrease	significant decrease	significant decrease
7	B7500000	not significant	significant increase	significant decrease	not significant	not significant	significant decrease	significant decrease	not significant
Rockfish Creek WWTP (21 MGD)									
Rockfish Creek									
Cedar Creek Site (1.25 MGD)									

Screening-level Mann-Kendall tests were conducted by DWR Modeling and Assessment Branch. Stations had a minimum of six months of data ("good year") in the beginning and ending trend year and at least 70% of the years with the trend period have to be "good years." Trends were determined using the nonparametric seasonal and non-seasonal version of the Mann-Kendall test at 95% confidence.



8.8.1.11 1,4-Dioxane

1,4-Dioxane is a clear liquid that is highly miscible in water. It has historically been used as a solvent stabilizer and is currently used for a wide variety of industrial and manufacturing purposes. 1,4-Dioxane does not readily biodegrade in the aquatic environment and is readily transported downstream because of a unique combination of physical and chemical properties that make it highly mobile and resistant to natural degradation. As a result, when 1,4-dioxane enters a waterway, it remains dissolved and travels long distances, leading to widespread contamination of surface water resources. Conventional wastewater treatment processes and techniques typical of Publicly Owned Treatment Works (POTWs) do not remove 1,4-dioxane and it generally passes through treatment plants and are discharged with wastewater effluent to receiving streams.

Results from several EPA and DWR studies found elevated concentrations of 1,4-dioxane in NC drinking water supplies and surface waters in the Cape Fear River Basin. Elevated levels of 1,4-dioxane were documented mainly downstream of the Asheboro, Greensboro and Reidsville wastewater treatment plants (WWTP). See Chapter 13 for detailed description of these study results and actions taken to reduce 1,4-dioxane in surface waters.

To understand the prevalence of 1,4-dioxane in the environment, DWR has collected surface water samples at locations throughout the state since November 2017. Three Cape Fear River ambient water quality monitoring stations and one lake station on the mainstem Cape Fear River behind Buckhorn Dam were sampled for 1,4-dioxane in the Upper Cape Fear River subbasin. All four stations are located in water supply waters (WS-IV).

As part of the Intensive Survey Branch (ISB) routine basinwide Ambient Lakes Monitoring Program in the Cape Fear River Basin, 1,4-dioxane samples were collected in 2018 (n=1) and 2023 (n=5), at station CPFBDL1 near the water supply intake behind Buckhorn Dam on the mainstem Cape Fear River [AU# 18-(4.5)]. The Cape Fear River behind Buckhorn Dam is the water supply for TriRiver Water which supplies treated drinking water to several communities in the area. The 1,4-dioxane concentration ranged between <1 and 1.8 µg/L with three of the six samples below the PQL of 1 µg/L. The 1,4-dioxane concentration for May 2018 was 1.4 µg/L and in June and August 2023 was 1.8 and 1.3 µg/L, respectively. The three samples below the PQL were collected in May, July and September 2023. TriRiver Water tests their drinking water supplies for 1,4-dioxane and provides reports on their website.

The other three ambient water quality stations monitored for 1,4-dioxane are on the mainstem Cape Fear River below Buckhorn Dam and collected between November 2017 and December 2024. Of the 67 samples collected at station B8 (Cape Fear River [AU# 18-(16.3)]) located at the Harnett County Public Utilities intake, 44 (65.7%) were below the PQL of 1 µg/L and the remaining 23 ranged between 1 and 5.7 µg/L with an average 1,4-dioxane concentration of 2.3 µg/L (See table in chapter 13 for data summary). Of the 43 samples at station B6370000 (Cape Fear River [AU# 18-(16.7)]) at US-401 in Lillington, 28 (65.1%) were below the PQL of 1 µg/L and the remaining 15 ranged between 1.1 and 5.7 µg/L with an average 1,4-dioxane concentration of 2.3 µg/L (See Table 13-3 in chapter 13 for data summary).

Further downstream at station B7480000 (Cape Fear River [AU#18-(25.5)]) located at the Hofer WTP intake in Fayetteville, 49 (74.2%) of the 66 samples collected were below the PQL of 1 µg/L and the remaining 17 ranged between 1.0 and 9.1 µg/L, with an average 1,4-dioxane concentration of 2.4 µg/L (See Table 13-3 in chapter 13 for data summary).

All the four mainstem Cape Fear River stations listed above are in water supply classified waters (WS-IV) therefore all the samples reported above the PQL exceed the EPA health-based drinking water concentration representing a 1-in-a-million (1 x10^{-6}) cancer risk level for 1,4-dioxane of 0.35 µg/L (EPA IRIS, 2013).

Reducing 1,4-dioxane to these water supplies is necessary and relies on NPDES discharges upstream to work with their SIUs to eliminate the contaminant to their systems and protect downstream users. The source of 1,4-dioxane after 2021 is likely to be SIUs discharging to the City of Asheboro and High Points WWTPs. DWR continues to work with upstream dischargers to identify and reduce the source of 1,4-dioxane at the source of the contaminant. For more information on 1,4-dioxane, see Chapter 2 (section 2.13.2) and Chapter 13 for summary tables and figures for 1,4-dioxane in the Cape Fear River Basin between 2016 and 2024.

8.9 Upper Cape Fear River Subbasin Water Use

Water resources in the Cape Fear River Basin include surface and groundwater, as well as water moving through built infrastructure. North Carolina has a diverse array of water users throughout the state including public and private water supply systems that supply drinking water to their customer base, 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. 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 North Carolina 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), 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 Chapter 3 and Chapter 5.

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 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. Information included in this section is taken from the Water Quantity Assessment and Planning in the Cape Fear River Basin, Chapter 5.

8.9.1 Water Use and Availability Reported in Local Water Supply Plans

The information presented in this section quantifies water demand/use and available water supply on a subbasin scale based on public water supply systems that submitted local water supply plans in the Upper Cape Fear River subbasin. Per North Carolina General Statutes §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. See Chapter 5 for more information on water use and availability along with data qualifications and methodologies.

Twenty-eight (28) water systems are included in the Upper Cape Fear River subbasin. The 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. The 2020 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 reported by these 28 public water supply systems in 2020 of 170.91 MGD, 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. The City of Fayetteville is the largest system in the subbasin with an average daily water demand in 2020 of 25.54 MGD, or approximately 44% of the total subbasin demand. A detailed description of the public water supply availability, demand, and projections for the Upper Cape Fear River subbasin is in Chapter 5.

8.10 Protecting Water Resources in the Upper Cape Fear River Watershed

The Basin Planning Branch (BPB) continually works with the Nonpoint Source Planning Branch (NPSPB), Soil and Water Conservation Districts (SWCD), Natural Resources Conservation Service (NRCS), and various stakeholders throughout the region to improve our understanding of point and nonpoint sources of pollution and encourage continued efforts to implement best management practices (BMPs) and restore beneficial nutrient concentrations, sediment loads, and flow volumes to the receiving waterbodies.

Recommendations and actions to improve and protect water quality are listed in detail throughout the Upper Cape Fear subbasin chapter. Some of the key recommendations include:

- Implement stormwater BMPs to reduce pollutant runoff and reduce peak flows throughout the subbasin. This could include strengthening ordinances controlling stormwater runoff, encouraging low impact development within the local jurisdictions, and promoting financial and technical support to local governments to effectively manage and improve infrastructure.
- Maintain existing effective regulatory strategies, such as the use of vegetated buffers and stormwater controls, throughout the river basin to reduce nonpoint source pollution and minimize cumulative losses of fish and benthos habitat and impacts to water quality.
- Evaluate the need for a natural conditions assessment to determine whether low pH levels in the Upper Little River, Little River, and Rockfish Creek are the result of natural conditions or anthropogenic influences.

- Publicly Owned Treatment Works (POTWs) must work with DWR to determine if their Pretreatment Program is sufficiently evaluating indirect dischargers to protect against accepting waste with potential emerging contaminants.

- Existing WWTPs are encouraged to pursue nutrient optimization to improve nutrient removal processes at existing treatment plants. This should include an evaluation of existing treatment components and operations and identifying additional opportunities to improve and optimize nitrogen and phosphorus reduction. Existing WWTPs are also encouraged to develop a standard operating procedure to mitigate treatment inefficiencies associated with staff turnover and promote consistent high performance.

- As directed by the EPA, DWR will continue to work with the Nutrient Criteria Development Plan (NCDP) Scientific Advisory Council (SAC) to develop appropriate instream criteria and response variables to accurately assess the health and protect both small streams and large riverine systems. This could include the development of TMDLs and/or nutrient management strategies as needed to reduce nutrient loading from point and nonpoint sources to protect designated uses throughout the basin.

- Expand existing data collection (including source identification) to include agricultural watersheds with high concentrations of deemed permitted animal operations. DWR has little to no information on deemed permitted facilities making it difficult to determine if they are having an impact on water quality. Data could also be used by multiple local, state, and federal agencies to review the existing regulatory framework as it relates to deemed permitted facilities and help target BMP implementation.

- Provide sufficient funding to existing state and federal cost share programs (urban, agriculture, and forestry) for technical assistance and the voluntary implementation of BMPs. This includes cost share programs managed by the NCDA&CS Division of Soil & Water Conservation (DSWC) and NC Forest Service (NCFS) and federal programs managed by the USDA Natural Resources Conservation Service (NRCS). Programs should promote BMPs that reduce nutrients, turbidity, and bacteria in waterways.

8.11 References

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