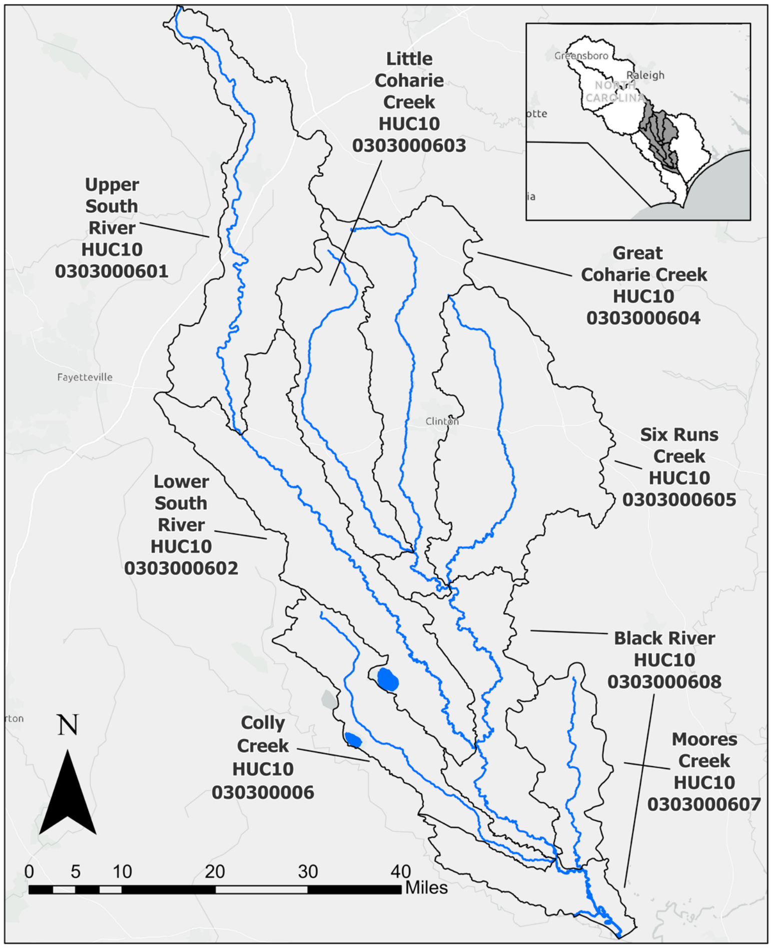

DRAFT
Chapter 10
Black River Subbasin
HUC 03030006

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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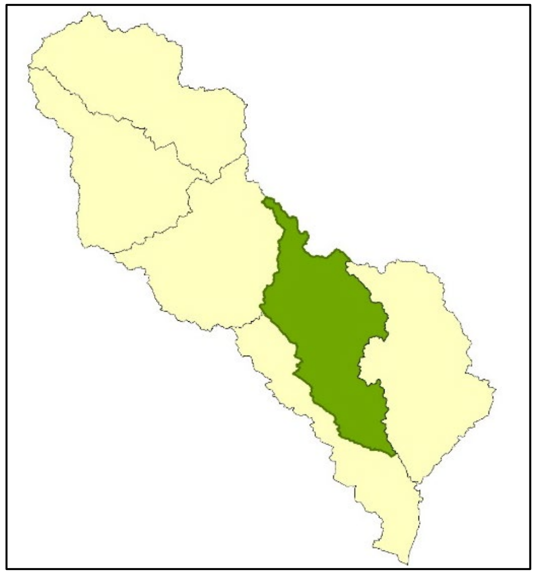
10 Black River Subbasin (HUC8 03030006)

10.1 General Description



The Black River subbasin is in the southeastern portion of the Cape Fear River Basin. This 8-digit hydrologic unit code (HUC) boundary (03030006) covers 1,574 square miles (mi^2), or 1,007,360 acres, encompassing most of Sampson and western Duplin counties, as well as the eastern portions of Harnett, Cumberland, Wake, Johnston and Bladen counties. Major municipalities in the subbasin include Clinton, Newton Grove, Warsaw, Salemburg, Turkey and Roseboro. Rural residential properties and communities are also scattered throughout the subbasin.

The major rivers that flow through the Black River subbasin include Little Coharie Creek, Great Coharie Creek and Six Runs Creek, and their confluence forms the Black River. The South River, Colly Creek and Moores Creek are also found in this subbasin. The drainage areas for these seven major waterbodies form the eight 10-digit HUC watersheds that comprise the Black River subbasin. Rivers, streams and creeks in the Black River subbasin have been described "as among the most beautiful and least disturbed of North Carolina's coastal plain rivers" (NCDEQ, 1996). In recognition of the exceptional ecological and recreational significance, the Black River from its source to the Cape Fear River, and Six Runs Creek below Quewiffle Creek, were reclassified as Outstanding Resource Waters (ORWs) in 1994 (NCDEQ, 1996). This subset of the High Quality Waters (HQW) classification is intended to protect unique and special waters having excellent water quality and being of exceptional state or national ecological or recreational significance.

In relation to the Level III Ecoregions scale, the Black River subbasin represents the transition zone from the Southeastern Plains to the Middle Atlantic Coastal Plain. These coastal areas are east of the "Fall Line" and contain many wetlands with tannin-stained, slow-moving streams underlain by sedimentary rocks. On a finer scale, Level IV Ecoregions, this subbasin lies in the Rolling Coastal Plain, Southeastern Floodplains and Low Terraces, Carolina Flatwoods, Mid-Atlantic Floodplains and Low Terraces. Included in these areas are Singletary Lake State Park, Bay Tree Lake State Natural Area, and Bladen Lakes State Forest in Bladen County (see Chapter 1, Section 1.5.5 Regions of Ecological Significance).

There is at least one surface water quality monitoring station in the major waterbodies of this subbasin, which records either physical, chemical and/or biological monitoring data. This coverage results in approximately 38% (389.2 miles) of the freshwater river miles and 100% (2,030.6 acres) of the freshwater lake acres being monitored across the subbasin. The location of permitted facilities and ambient and biological monitoring stations are overlayed on a map of all classified waterbodies and their overall status as per the 2022 Integrated Report (IR) (*Figure 10-1*). The 2022 Integrated Report for the Black River subbasin is summarized on *Table 10-1* and categorized by parameter in *Table 10-2*.

Water resource-related findings and issues identified in the Black River subbasin during the timeframe of this plan (2002 to 2020) include:

- Population declines in all of the 10-digit watersheds found in the subbasin (Section 10.2).
- In 2017, Sampson County had the third highest poultry production contract numbers (Section 10.2).
- The Black River subbasin has the second highest concentration of permitted animal feeding operations, highest permitted live weight and more lagoons than any other subbasin. In total, over 25% of the 4,046 permitted (statewide) lagoons and waste ponds are found in this subbasin (Section 10.3).
- Cypress Creek (Section 10.6.1), Hornet Swamp (Section 10.6.2), an unnamed tributary to Bearskin Swamp (Section 10.6.2) and Six Runs Creek (Section 10.6.4) had measurable concentrated animal feeding operations manure effects (Harden, 2015) (Section 10.3).
- Elevated fecal coliform bacteria levels were detected in South River (Section 10.6.1.2), Little Coharie Creek (Section 10.6.2.1), Great Coharie Creek (Section 10.6.3.1), Six Runs Creek (Section 10.6.4.1), Colly Creek (Section 10.6.5.1), and Black River (Section 10.6.7.1) during 2016 to 2020.
- Elevated and increasing fecal coliform bacteria, as well as nutrient(s) (total phosphorus and/or nitrate+nitrite) concentrations were detected at monitoring station(s) in the South River (Section 10.6.1), Little Coharie Creek (Section 10.6.2), Great Coharie Creek (Section 10.6.3), Six Runs Creek (Section 10.6.4), and Black River (Section 10.6.7) based on data from 2000 – 2019.
- Ammonia concentrations in Colly Creek tended to be elevated in the spring, summer, and early fall seasons with lower concentrations observed in the winter (Section 10.6.5).
- Water quality in the Moores Creek watershed is poorly understood due to a lack of consistent surface water quality monitoring in this watershed (Section 10.6.6).
- Fecal coliform bacteria, total nitrogen and total phosphorus concentrations appear to decline from upstream to downstream as the Black River flows through forested riparian areas and gathers additional streamflow, which dilutes concentrations, except in 2019 and 2020. Colly Creek influenced Black River through exceptionally high total phosphorus loads flowing from that watershed (Section 10.6.7).
- Efforts to improve dissolved oxygen levels in Black River could improve the dissolved oxygen levels in the Cape Fear River and potentially the Cape Fear River Estuary (Section 10.8.2).
- Total Kjeldahl nitrogen concentrations comprise a large portion of the total nitrogen concentrations found at many surface water quality monitoring stations and additional inputs from nitrate+nitrite either from point or nonpoint sources elevate the total nitrogen concentrations to exceed concentrations considered normal for minimally impacted streams (Section 10.8.3).
- Mallin et al. 2004 concluded that additions of nitrogen and phosphorus into blackwater systems potentially increases biological oxygen demand by photosynthetic and heterotrophic activity that can subsequently reduce dissolved oxygen concentrations through increased biological oxygen demand (Section 10.8.3).

Figure 10-1: General Map of Monitoring Stations and Permitted Facilities in the Black River Subbasin.

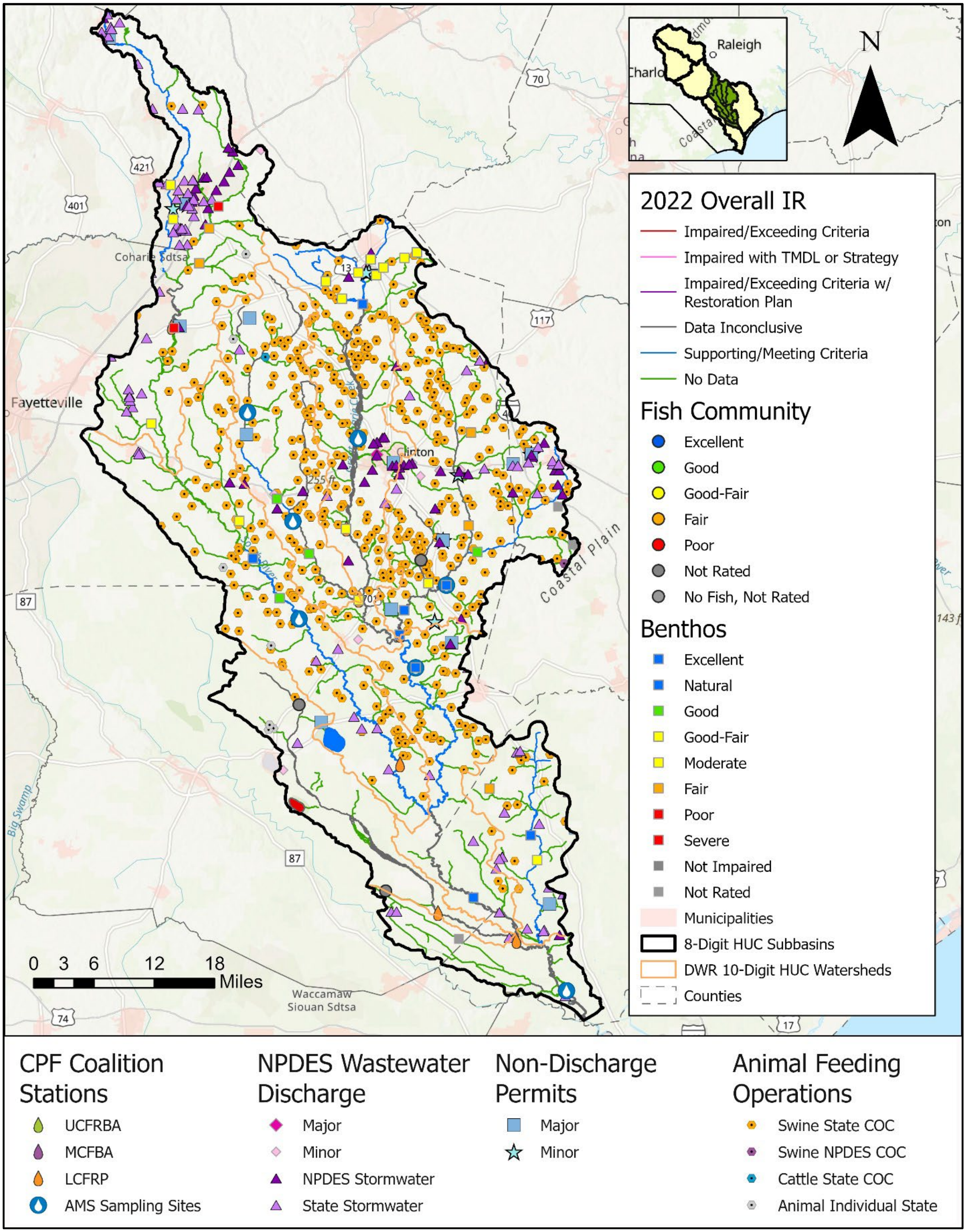


Table 10-1: Black River Subbasin 2022 Integrated Report Summary.

Assessment Unit[1]	Map Color	Freshwater Miles	Freshwater Acres
Total	All Colors Combined	1,029.7	2,030.6
Total Monitored	Combined Blue, Gray, and Red	389.2	2,030.6
Not Monitored	Green	640.5	0.0
Meeting Criteria (Category 1)	Blue	183.6	1,454.5
Data Inconclusive (Category 3)	Gray	205.6	0.0
Exceeding Criteria 303(D) (Category 5)	Red	0.0	576.1
% Exceeding of Monitored Exceeding	Red / Total	0.0	28.4%

[1] All waterbodies in North Carolina are impaired for Fish Tissue Mercury and not included in Category 4 and 5 impairments totals on this table.

Based on the data collected in the monitored waterways, Singletary Lake is the only waterway in this subbasin with a water quality impairment for excursions of the pH water quality standard as listed in *Table 10-2*. All waterbodies statewide are impaired for mercury in fish tissue and a Total Maximum Daily Load (TMDL) in place (NCDEQ, 2012). The impairment for fish tissue mercury is not included in tables or maps. Excess nutrients (nitrogen and phosphorus) and fecal coliform bacteria from both point (industrial and municipal wastewater systems) and nonpoint sources (land use and land cover, stormwater management systems, and animal feeding operations) are all concerns for water quality throughout this subbasin and will be discussed throughout this chapter.

Table 10-2: Black River Subbasin 2022 Impairments by Parameter (Category 5).

PARAMETER (Category 5)[1,2]	Freshwater Miles	Freshwater Acres
pH (4.3 s.u., AL, Sw)	0.0	576.1

[1]Waterbody Uses: AL – Aquatic Life.
[2]Waterbody Type: Sw - Swamp Waters.

There are three class B waterways in the Black River subbasin, which have best uses as primary contact recreation. Waters designated as primary recreation (Class B) are used for swimming, diving, water skiing, and similar uses involving human body contact with water where such activities take place in an organized manner or on a frequent basis. These Class B waterways are Caesar Swamp (Williams Lake) from the source to the dam at Williams Lake, Rice Swamp (Rye Swamp/Laurel Lake) from the source to the dam at Laurel Lake, and Singletary Lake from the source to the lake drain. Caesar Swamp (Williams Lake) and Rice Swamp (Rye Swamp/Laurel Lake) span a combined 7.6 miles and Singletary Lake spans 576.1 acres (*Table 10-3*). All waterways carry a Class C designation. Best intended uses for Class C waters include secondary contact recreation, aquatic life propagation/protection, and agriculture. All the surface waters that are monitored in this subbasin have the supplemental swamp water (Sw) classification. This classification is due to the natural characteristics of swamps such as low dissolved oxygen and low pH. More information about dissolved oxygen in the Black River subbasin and adjoining watersheds can be found in Section 10.8.2.

Table 10-3: Black River Subbasin Surface Water Classifications by River Miles and Acres.

Classification*	Freshwater Miles	Freshwater Acres
C	1,029.6	2,030.6
B	7.6	576.1
ORW	129.5	0.0
Sw	1,024.2	2,030.6

*Waterbody Classification C - Aquatic life propagation and secondary recreation, B - Primary contact recreation, ORW - Outstanding Resource Waters, Sw - Swamp Waters

10.2 Population and Land Use

The Black River subbasin drainage area is 1,574 square miles across eight watersheds (*Table 10-4*). These watershed drainage areas range from 92 to 274 square miles. Between 2010 and 2020 each 10-digit hydrologic unit code (HUC 10) watershed decreased in population. The losses range from 61 to 2,247. Based on the 2020 Census data, population in the Black River subbasin is estimated to be 104,199 (*Table 10-4*). The largest population change was identified in the Upper South River watershed.

A state designated tribal statistical area (SDTSA) is a parcel identified and delineated for the U.S. Census Bureau by a liaison for the governor's office in each state where there are American Indian tribes that are recognized by the state but don't have a reservation delineated (U.S. Census Bureau 2022). An SDTSA has a concentration of people that identify with the tribe and have organized activities. The Coharie SDTSA, which has parcels within the Black River subbasin, has a reported population of 64,187 (U.S. Census Bureau 2021).

Table 10-4: Estimated Population of the Watershed Boundary Scale.

HUC10 Watershed Name	HUC 10	Land Area (mi^2)	Pop. 2010	Pop. 2020	Population Density 2020 (pop/mi^2)	2010 - 2020 Pop. Change
Upper South River	**0303000601**	234	41,335	39,088	167	-2,247
Lower South River	**0303000602**	260	10,508	9,716	37	-792
Little Coharie Creek	**0303000603**	159	10,590	10,154	64	-436
Great Coharie Creek	**0303000604**	221	22,959	21,567	98	-1,392
Six Runs Creek	**0303000605**	274	17,796	15,965	58	-1,831
Colly Creek	**0303000606**	122	1,120	1,059	9	-61
Moores Creek	**0303000607**	92	3,751	3,374	37	-377
Black River	**0303000608**	212	3,928	3,276	15	-652
Total		**1,574**	**111,987**	**104,199**	**66**	**-7,788**

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

As of 2019, the land cover across this subbasin is dominated by approximately 506 square miles of agricultural lands (32%), 442 square miles of wetlands (28%), and 381 square miles of forest land (24%). The remaining land cover is 126 square miles of grassland/shrub (8%), 106 square miles of developed land (6.7%), 12 square miles of open water (8%), and 1 square mile of barren land (0.06%) (*Table 10-5). Figure 10-2* displays the spatial distribution of land cover as per 2019 in the Black River subbasin. This land cover provides a perspective for which to view the water quality in this subbasin. Agricultural lands, forest land, wetlands, and developed land all engage with the environment to influence the water quality. The complex interactions between water and these different landscapes are observable in the elevated nutrient and fecal coliform bacteria concentrations detected in some waterways in this subbasin.

Table 10-5: Land Cover of Black River Subbasin

Land Cover[1]	2001	2011	2019	% Change 2001-2019	Change 2001-2019 (mi^2)	Total 2019 (mi^2)
Agriculture	32.27%	32.06%	32.12%	**-0.45%**	**-2.28**	**505.65**
Barren Land[2]	0.05%	0.05%	0.06%	**20.14%**	**0.17**	**0.99**
Developed	6.24%	6.54%	6.73%	**7.88%**	**7.74**	**106.00**
Forest	24.64%	25.24%	24.20%	**-1.81%**	**-7.02**	**380.88**
Grassland/Shrub	7.96%	7.27%	8.03%	**0.89%**	**1.11**	**126.40**
Open Water	0.78%	0.82%	0.77%	**-1.37%**	**-0.17**	**12.18**
Wetlands	28.05%	28.02%	28.08%	**0.10%**	**0.46**	**441.93**
Total (mi^2)						**1,574.01**

[1]Data was 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, cutover land, and bare rock areas.

The Cape Fear River Basin has many diverse wetland habitats with close to 90% located in the lower half of the basin in the Coastal Plain ecoregion of the Black River, Lower Cape Fear River, and Northeast Cape Fear River subbasins. The Black River subbasin accounts for 28% of the wetland cover. Common freshwater wetland types in the Cape Fear River Basin include riverine swamp forests, bottomland hardwoods, pocosins, Carolina bays, and pine flatwoods. Many of the Carolina bays, primarily found in the lower part of Colly Creek and South River watersheds, have been converted to agriculture. Riverine swamps and bottomland hardwood forests buffer many of the rivers and creeks in the basin. Riverine swamps are more common in the Coastal Plain, including the Black River and its Little Coharie, Great Coharie, and South River tributaries. The most expansive areas of swamp forest occur at the confluence between the Cape Fear River and Black River, as well as along the lower part of the Northeast Cape Fear River. Many of the Carolina bays are in the Lower Cape Fear River and Black River subbasins with the most concentrated presence in Bladen County (Powell, 2006) between the Cape Fear and South rivers (See Chapter 1 for more information on basinwide land cover and wetlands).

The watersheds of the Black River subbasin are diverse including watersheds with primarily agricultural land use, forested landscapes, and watersheds covered in wetlands (*Table 10-6*). The Upper South River, Little Coharie Creek, Great Coharie Creek, and Six Runs Creek watersheds all have greater than 40% of their land cover dedicated to agriculture. These are also the most developed watersheds with between 7 and 12% of the land dedicated to developed land. These four watersheds also contain some of the lowest percentages of wetlands with between 20 and 24% of the land cover containing wetlands. The primarily wetland-covered watersheds include the Lower South River, Colly Creek, and Black River watersheds with greater than 30% of the land cover composed of wetlands. The Black River and Moores Creek watersheds have the highest percentages of forest land with greater than 30%. Notably, these two watersheds also contain the highest percentages of grassland/shrub.

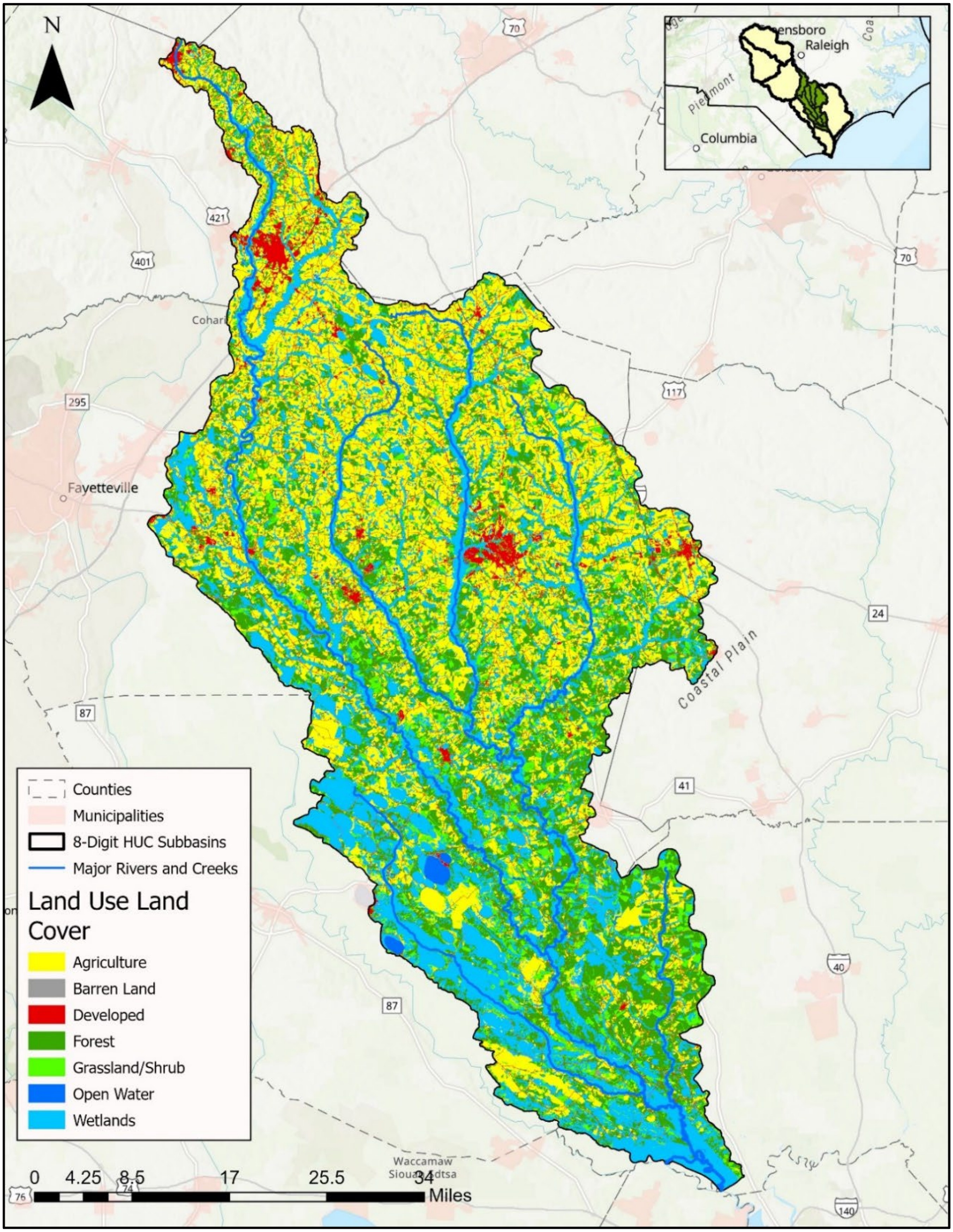
Table 10-6: Land Cover in the Watersheds of the Black River Subbasin

Watershed[1]	Land Area (mi^2)	Agriculture	Barren Land[2]	Developed	Forest	Grassland / Shrub	Open Water	Wetlands
Upper South River	234	41.41%	0.08%	12.30%	16.29%	5.07%	0.68%	24.18%
Lower South River	260	27.04%	0.02%	4.78%	25.92%	9.28%	1.43%	31.52%
Little Coharie Creek	159	44.91%	0.06%	7.26%	20.10%	6.36%	0.43%	20.89%
Great Coharie Creek	221	43.09%	0.03%	9.17%	20.67%	6.02%	0.49%	20.53%
Six Runs Creek	274	40.12%	0.02%	7.11%	25.72%	7.88%	0.45%	18.69%
Colly Creek	122	9.92%	0.18%	2.57%	17.85%	8.72%	0.86%	59.90%
Moores Creek	92	17.25%	0.03%	3.86%	43.23%	12.36%	0.40%	22.88%
Black River	212	15.97%	0.14%	3.21%	30.96%	11.03%	1.16%	37.53%

[1]Data was 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, cutover lands, and bare rock areas.

Figure 10-2: Land Cover in the Black River Subbasin



10.3 Permits

As of May 2022, there were 14 National Pollutant Discharge Elimination System (NPDES) wastewater, 22 non-discharge and land application, 57 NPDES stormwater, 104 State stormwater, and 498 AFO permits issued in the Black River subbasin (*Table 10-7*). *Figure 10-3* shows the location of the permitted facilities in the Black River subbasin.

The Black River subbasin has a total permitted as-built discharge of approximately 8 million gallons per day (MGD) (*Table 10-7*). There is one major permitted NPDES municipal wastewater treatment plant (WWTP) for the City of Clinton, permitted to discharge up to 5 MGD to Williams Old Mill Branch. There are also 13 minor NPDES industrial and municipal wastewater permits in the subbasin.

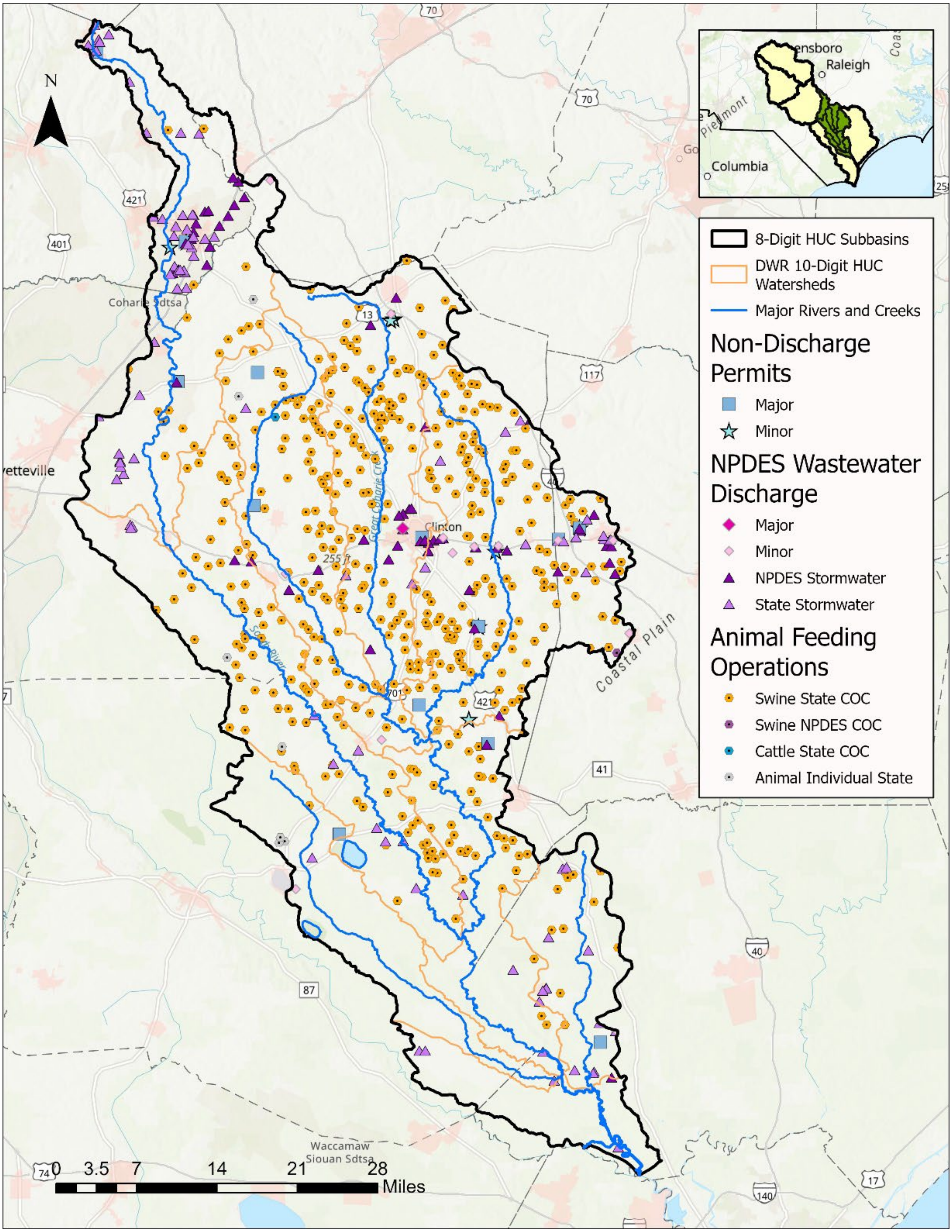
The Black River subbasin accounts for about 15% of the total permitted field acreage (21,771 acres) for non-discharge and residual land application permits in the Cape Fear River Basin. Permitted fields are primarily used for land application of residual solids. Granville Farms Inc. facility (WQ0002890) has the highest number of permitted field acres in both the Black River subbasin and the entire basin with 1,122 acres used for the land application of residual solids.

Table 10-7: Permitted Facilities and Associated Information in the Black River Subbasin.

Number of Permits[1]		Permit Information[1]	
NPDES Wastewater Discharge[2]			
Major	**Minor**	**Permitted As-Built (MGD)**	
1	13	8	
Non-Discharge and Land Application[3]			
Major	**Minor**	**Field Number**	**Field Acres**
14	8	178	3,387.10
Stormwater			
State	**NPDES**	**NPDES Outfalls**	
104	57	113	
Animal Feeding Operations			
Number of Permits		**Allowable Headcount**	**Allowable Weight (lbs)**
498		2,611,484	340,002,861

[1]Active and expired permitted facilities and associated permit data were queried from the DWR Basinwide Information Management System (BIMS) in May 2022. Expired permits remain in effect until a renewed permit is issued by DWR.
[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
[3] Some permitted fields are associated with facilities located outside of the Cape Fear River Basin.

Figure 10-3: NPDES Wastewater, NPDES Non-Discharge, NPDES Stormwater, and Animal Operations Permits in the Black River Subbasin.



Several NPDES and state stormwater permits are located near the towns of Dunn and Benson and the City of Clinton. A section of Benson's extraterritorial jurisdiction (ETJ) boundary follows Mingo Swamp in the Black River subbasin. The town's land use plan also includes areas of the subbasin (Town of Benson, 2021). Benson's NPDES Municipal Separate Stormwater Sewer Systems (MS4) stormwater permit is the only one in this 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. More information about Urbanized Areas can be found in Chapter 3. A complete list of permits can be found in the Chapter 3 Appendix.

Permitted AFOs have a significant presence in the Black River subbasin. The Black River subbasin has the second highest concentration of permitted AFOs in the basin (and statewide) with 498 operations, second only to the Northeast Cape Fear River subbasin. The permitted AFOs are primarily swine with 488 Swine State Certificates of Coverage (COC), one Swine NPDES COC, one Cattle State COC, and eight Animal Individual State permits. The highest total permitted live weight (340 million pounds) can be found in this subbasin, and this amount accounts for 45% of the total permitted live weight in the entire Cape Fear River Basin. There are 1,094 lagoons associated with AFOs in the subbasin, the highest in the basin and the state. These lagoons account for over 25% of all the lagoons and waste ponds (4,046 statewide) in North Carolina. Overall basin maps and summary tables are available in Chapter 1, section 1.5.1, Chapter 1 Appendix and permit maps and tables are in Chapter 3, Section 3.6.

In addition to permitted animal feeding operations, the US Department of Agriculture (USDA) 2022 Census of Agriculture data indicates there are numerous poultry and swine operations in the counties located entirely or partially within the Black River subbasin. Many of these operations are considered deemed permitted under North Carolina Administrative Code (NCAC) 15A NCAC 02T .103. Deemed permitted is defined as "a facility that is considered to have a needed permit and to be in compliance with the permitting requirements of General Statute 143-215.1(a) even though it has not received an individual permit for its construction or operation." The Census of Agriculture can be used to help evaluate which counties have the highest agricultural activity. It can also be used to evaluate historic agricultural trends to formulate policies, develop programs, and identify and allocate local and national funds for agricultural programs.

To understand animal agriculture in the subbasin, Sampson County was queried for poultry and swine numbers (*Table 10-8)*. Between the 2007 and 2017 census years, Sampson County's poultry numbers for inventory and production contracts remained fairly similar, changing by less than 2% for both USDA data items (*Table 10-8*). There was however, a large 190% increase in chicken inventory and 181% increase in chicken production numbers under contract between 2017 and 2022 (*Table 10-8*). This is the largest increase of all counties within the Cape Fear River Basin. Sampson County had the second highest inventory and production numbers in the basin with only Duplin County being higher in 2022 (22 million in inventory and 96 million in production, respectively) (*Figure 10-4*, *Figure 10-5*). The 19.2 million in chicken inventory accounts for 23.4% of the basin chicken inventory and 9.2% of the statewide chicken inventory (209.6 million).

Sampson County also had the second highest swine inventory (1.85 million) with Duplin County being the highest (1.89 million) (*Figure 10-6*). Sampson County produces 38% (1.85 million) of the Cape Fear River Basin's swine inventory (4.9 million) and 23.4% of the statewide inventory (7.9 million). DWR has minimal information on the location of deemed permitted facilities or the location of where manure is transported and land applied. More information about counties queried for the Census of Agriculture can be found in Chapter 1 and the Chapter 1 Appendix and animal operations permit maps and tables in Chapter 3, section 3.6.

Table 10-8: USDA Census Data for Chicken/Poultry and Swine in Black River Subbasin Counties

USDA Data	Sampson[3]
Poultry 2007	
Inventory[1]	6,565,462
Contract[2]	26,872,699
Poultry 2012	
Inventory[1]	6,690,283
Contract[2]	32,574,128
Poultry 2017	
Inventory[1]	6,642,351
Contract[2]	27,326,349
Poultry 2022	
Inventory[1]	19,226,111
Contract[2]	76,808,922
Swine (Hogs) 2007	
Inventory[1]	2,156,254
Contract[2]	7,177,565
Swine (Hogs) 2012	
Inventory[1]	1,858,801
Contract[2]	4,467,515
Swine (Hogs) 2017	
Inventory[1]	1,884,585
Contract[2]	4,703,185
Swine (Hogs) 2022	
Inventory[1]	1,854,202
Contract[2]	5,220,132

[1] USDA Inventory numbers represent a point in time (End of December) when the census data was collected. Poultry includes broilers, layers, pullets, and roosters.
[2] USDA Production Contract numbers are "totals for the portion of agriculture production raised and delivered under production contract" (USDA, 2022). Chicken production accounts for data items associated with broilers, layers, and pullet for 2012 to 2022 and broilers and pullet for 2007. Production Contract and Inventory represent different data items and cannot be combined or added.
[3] The counties included in this table had >45% land area within the Cape Fear River Basin.

Figure 10-4: USDA Census of Agriculture Chicken/Poultry Inventory (USDA, 2022)

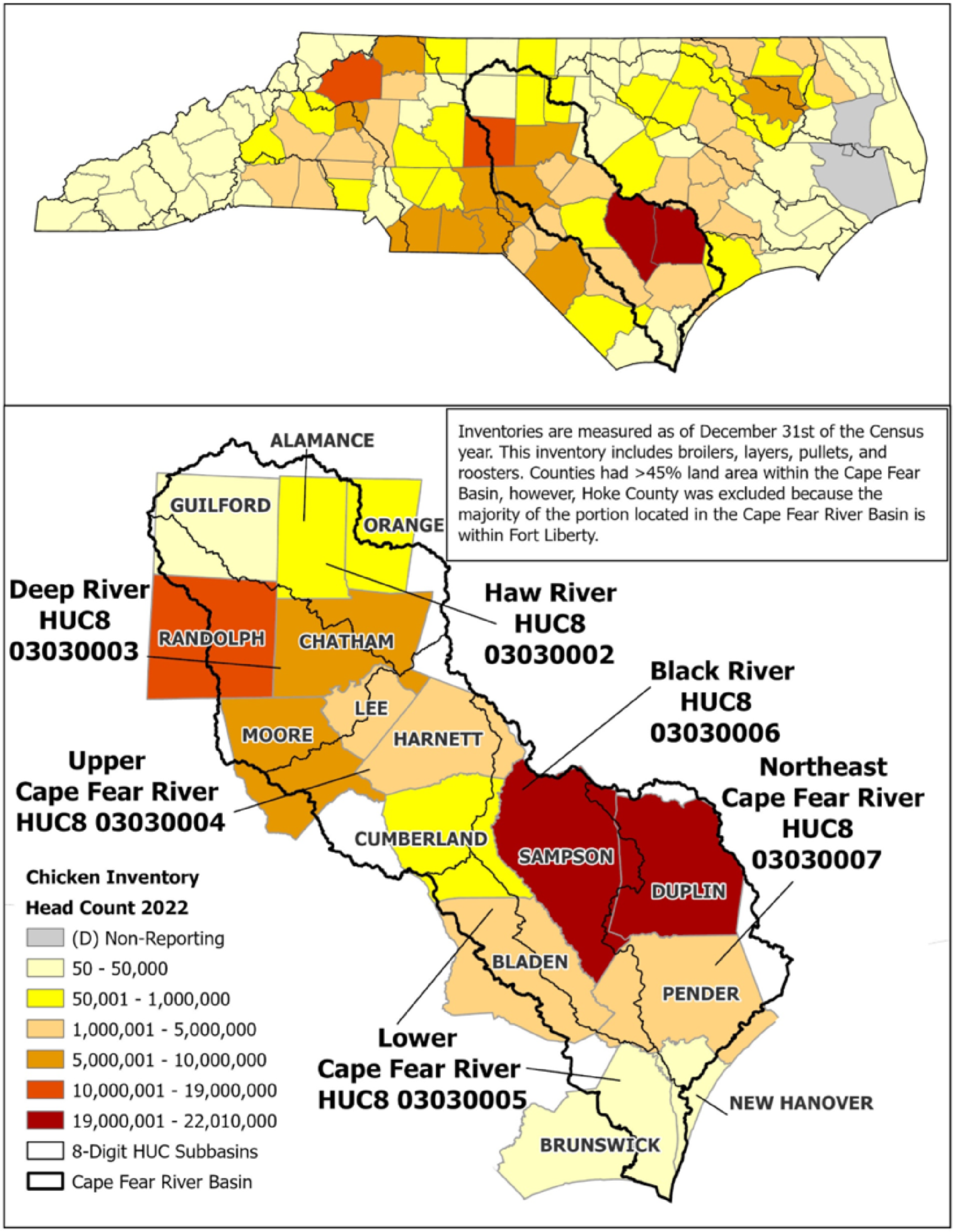


Figure 10-5: USDA Census of Agriculture Chicken/ Poultry Production (USDA, 2022)

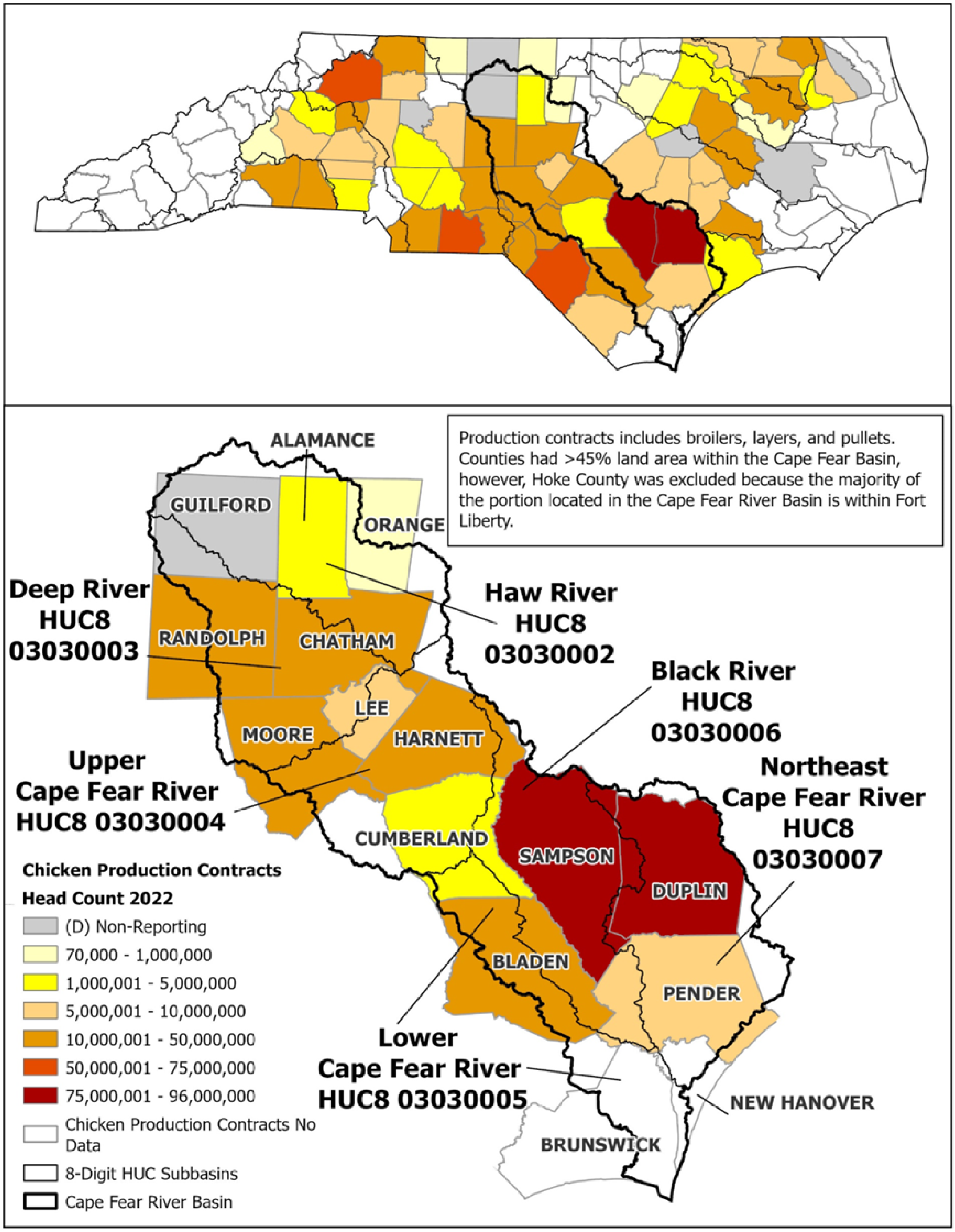
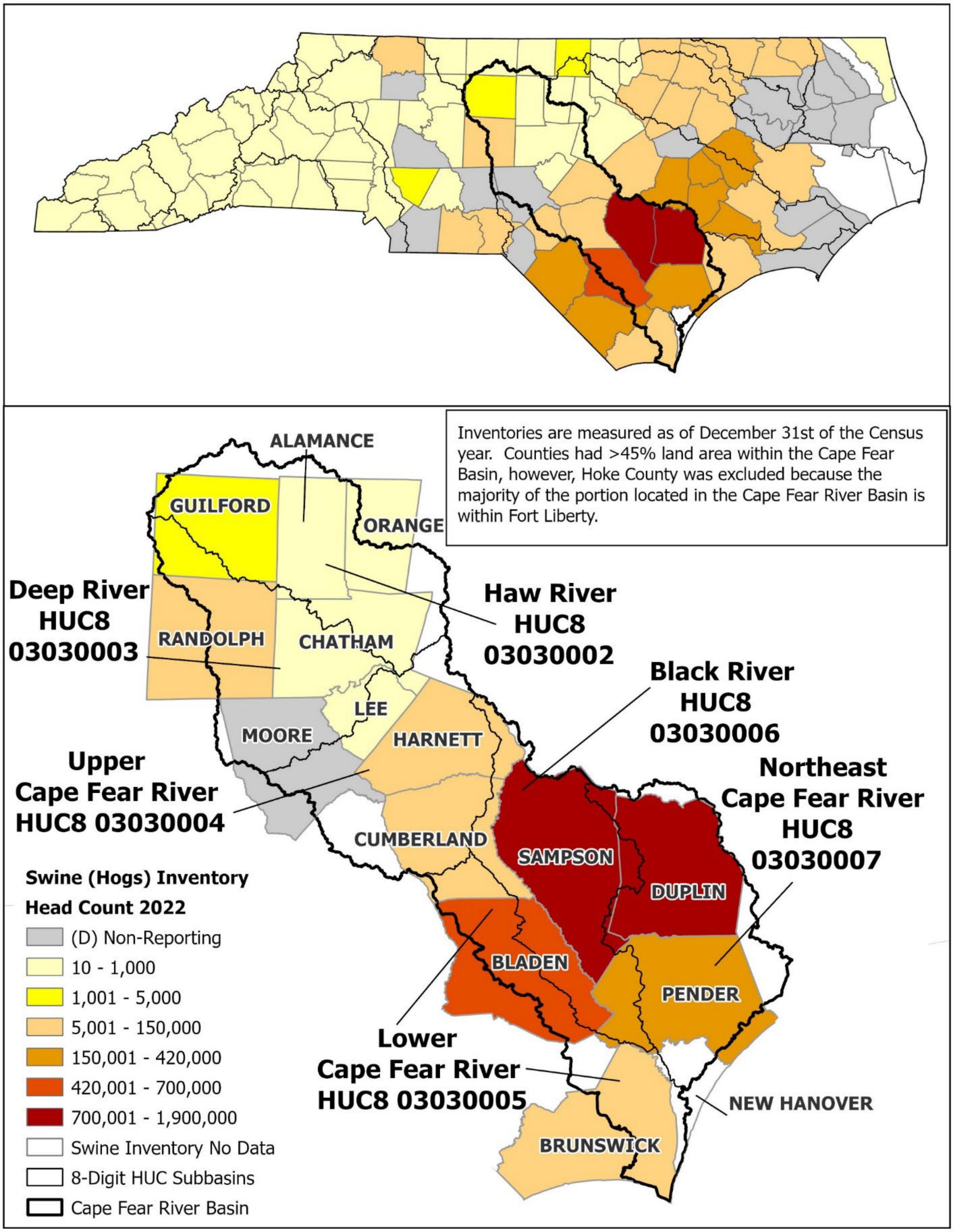


Figure 10-6: USDA Census of Agriculture Swine (Hog) Inventory (USDA, 2022)



The United States Geological Survey (USGS), with financial support from an EPA Section 319 grant, conducted a study and produced a report titled *Surface-Water Quality in Agricultural Watersheds of the North Carolina Coastal Plain Associated with Concentrated Animal Feeding Operations*. This study compared 54 agricultural watersheds, with drainage areas less than 20 square miles, that either received drainage from areas with swine AFOs or streams receiving primarily inorganic fertilizers inputs (Harden, 2015). The study provided needed information "from a large number of sites over a broader geographic area to better understand relations between swine CAFOs [concentrated animal feeding operations] and stream water quality in eastern North Carolina" (Harden, 2015). Included in this study were the Black River, Northeast Cape Fear River, and Lower Cape Fear River subbasins. The full report is available online at https://pubs.usgs.gov/sir/2015/5080/pdf/sir2015-5080.pdf. This study identified waterways with "measurable concentrated animal feeding operations manure effects" (Harden, 2015). As this chapter focuses on the Black River subbasin, we will briefly highlight the waterways that were identified in this subbasin by stream name, stream index, and associated site number used in the USGS report in *Table 10-9.*

Table 10-9: USGS Stations with Measurable Concentrated Animal Feeding Operations Manure Effects.

Stream name	Stream Index	USGS Site Name	Watershed
Hornet Swamp	18-68-1-17-3	SW-09	Little Coharie Creek
Cypress Creek	18-68-12-12	SP-09	Lower South River
Unnamed tributary to Bearskin Swamp	NA	SP-10	Little Coharie Creek
Six Runs Creek	18-68-2-(0.3)	SP-11	Six Runs Creek

"SW – 00" – Swine site and number
"SP – 00" – Swine and poultry site and number

The USGS study conclusions state: "On the basis of the results of this study, it is apparent that land-applications of waste manure at swine CAFOs influenced ion and nutrient chemistry in many of the North Carolina Coastal Plain streams that were studied. In particular, sodium+potassium concentrations coupled with δ15N values of nitrate+nitrite were useful water-quality indicators for distinguishing sites with measurable CAFO manure effects." (Harden, 2015). "On the basis of the comparisons of sodium+potassium concentrations, nitrate+nitrite concentrations, and the δ15N and δ18O of nitrate+nitrite values, 10 of the 36 CAFO sites (28%) had results similar to background conditions, and 21 of the sites (58%) had results with measurable CAFO manure effects. Note that the identification of those SW [swine] or SP [swine and poultry] watersheds as being similar to background conditions does not necessarily imply that CAFOs in those watersheds have no local influence on water quality, only that no distinction was noted at the watershed sampling location for the constituents that were examined." (Harden, 2015). "Five of the SW and SP sites (14%) had limited or indeterminate results for determining whether they were similar to background or manure influenced." (Harden, 2015). "Interestingly, some individual SW and SP sites did not appear to be affected by animal-waste manures." (Harden, 2015). The study also states: "it would be beneficial to base future similar analyses on a larger number of samples that more fully reflect hydrologic and seasonal variability in water-quality conditions among sites of interest." (Harden, 2015). In addition to the data presented in this chapter and associated studies, the reader is encouraged to review the numerous research articles dedicated to the water quality in these blackwater rivers and tidal creeks of these watersheds. Brown et al, 2020 investigated the spatial nutrient variability and seasonal variability of nutrients in the Black, Northeast Cape Fear, and Lower Cape Fear rivers using δ15N isotopes. The reader is encouraged to review the text that is available online at https://pubmed.ncbi.nlm.nih.gov/32666139/.

DWR has little to no information on deemed permitted facilities. *To better understand how these facilities are impacting our water resources, more information (i.e., water quality data, source identification) is needed throughout the basin. Data collected could be used by an interagency workgroup consisting of water resource professionals, the agricultural community, researchers (academia), database managers, and interested community members to review the existing regulatory framework, identify which BMPs are most effective at reducing the amount of sediment, bacteria, and nutrients leaving a site, and how best to manage and track waste generated on the farm.*

10.4 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 are 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 Black River subbasin, three assessment methodologies were used: Swamp (primarily), EPT, and Full Scale. Fish community IBIs have not been developed for the Coastal Plain ecoregion where the Black River subbasin is located therefore the fish community results cannot be rated. See the Benthic Standard Operating Procedures (SOP) available through DWR Water Sciences Section (WSS) for more information on biological monitoring and bioclassification ratings and Chapter 2 for more information on basinwide biology sampling. The Biological Assessment Branch monitors each basin on a rotating five-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. All monitoring stations in the Northeast Cape Fear River subbasin with their current ratings are displayed on *Figure 10-7*.

10.4.1 Benthic Macroinvertebrates

The Black River subbasin benthos monitoring results for the four-cycle years are displayed in *Figure 10-7*. Basin station monitoring results for 2009 were also combined with 2008 as some stations were sampled (or resampled) in 2009 due to drought in 2008. Moderate results were more common during the first two sample cycles as compared to the last two cycles when Fair ratings were the most common. Additionally, more stations were sampled during the first two cycle years than in the last two cycles.

Two benthic macroinvertebrate community stations were sampled in either 2013 or 2018 with comparable stations sampled in 2003 or 2008. These stations were previously sampled during the prior rounds of sampling, providing a recent metric to determine if these waterways have improved, declined, or not changed. The results from these two stations indicate these waterways did not change in rating with Moores Creek rating Natural and Little Coharie Creek rating Good.

Three sites were not resampled in 2013 or 2018: Black River, Six Runs Creek, and South River. A total of 13 stations were sampled as special studies within the Black River subbasin between 2002 and 2010. These stations were on the following water bodies: Beaverdam Swamp; Black River; Great Coharie Creek; Kill Swamp; Sevenmile Swamp; South River; Stewarts Creek; unnamed tributary of Kill Swamp; and an unnamed tributary of Sevenmile Swamp. These special studies are discussed later in this chapter. Numerous historically monitored sites were not resampled in 2013 and 2018 due to reductions in staff. All benthos station results from 2002 to 2021 are available in the Chapter 2 Appendix.

Figure 10-7: Biological Community Monitoring Stations for Benthos and Fish in the Black River Subbasin.

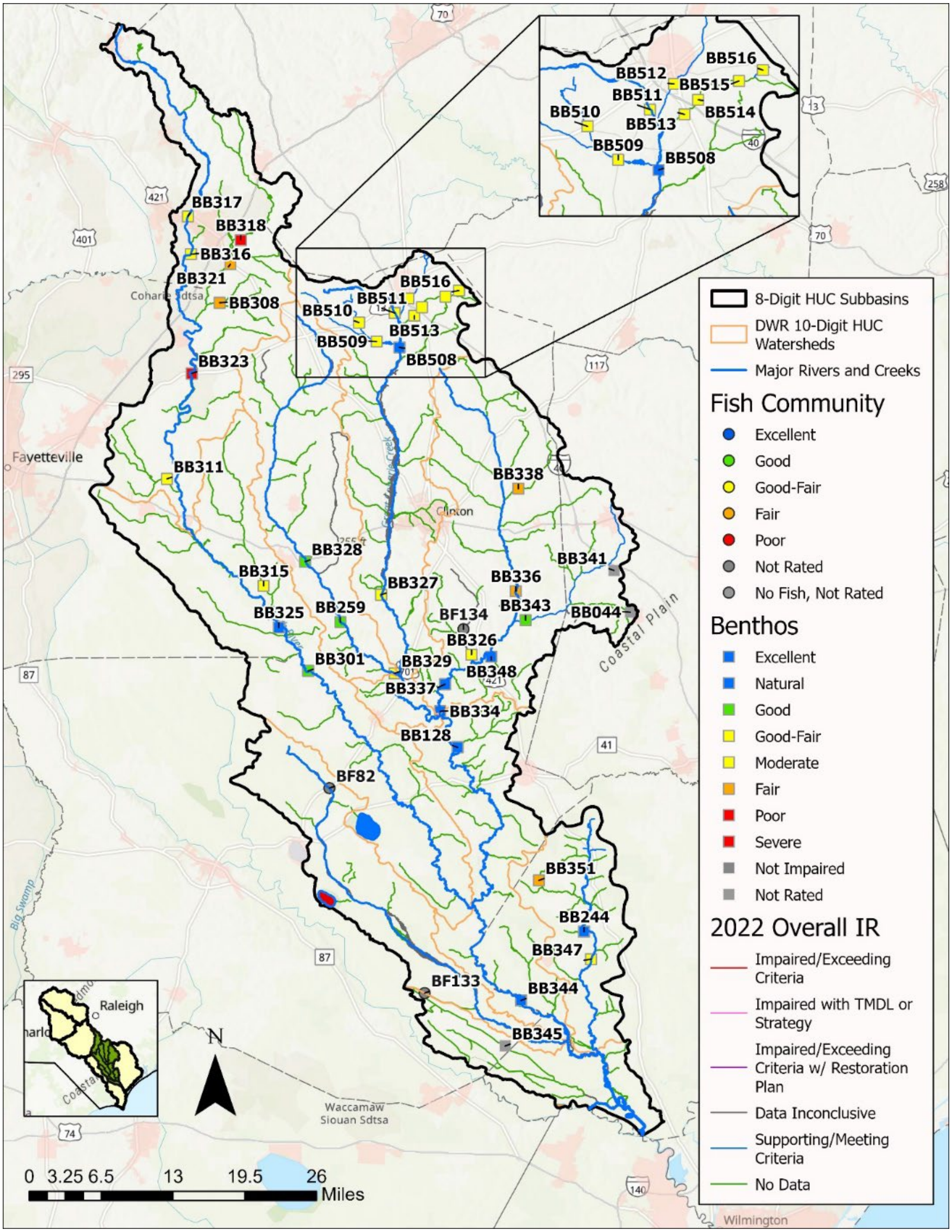
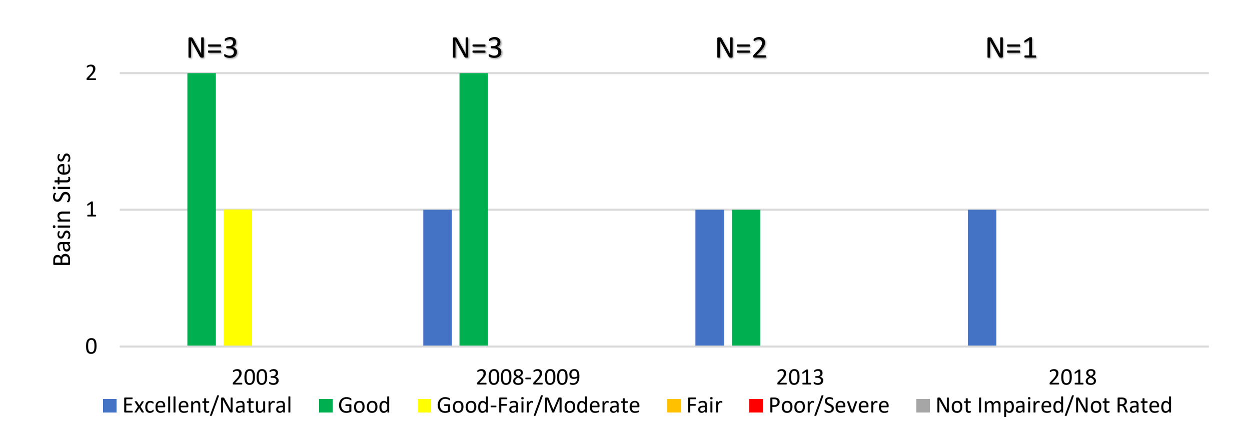


Figure 10-8: Black River Subbasin Benthos Bioclassification Ratings 2003, 2008-2009, 2013, and 2018 for Basin Sites.



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.

10.5 Ambient Water Quality

Monthly chemical and physical samples are taken by DWR through the Ambient Monitoring System (AMS) stations coalitions of NPDES permit holders that are active in the Cape Fear River Basin. The Lower Cape Fear River Program (LCFRP) collects ambient samples in the Black 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% 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 results not collected using a 5-in-30 methodology are used for screening purposes only.

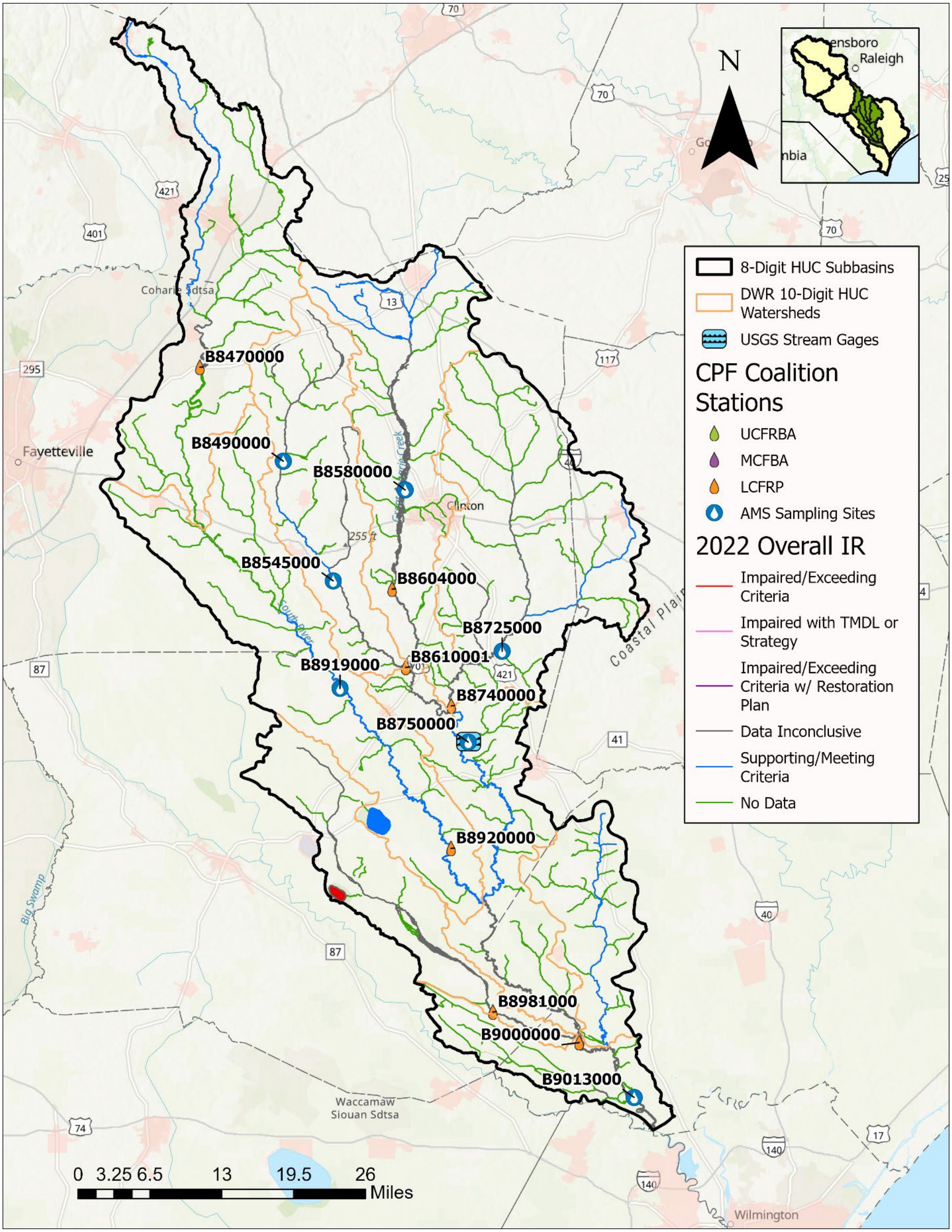
There is currently, seven AMS and seven LCFRP stations being monitored in the Black River subbasin (*Table 10-10* and *Figure 10-9*). Three short-term surface water quality stations were established for a two-year period between 2015-2016 as part of the Random Ambient Monitoring System (RAMS) Program and one special study station as part of the Stocking Head Creek study. See Chapter 11 for more information on the Stocking Head Creek study. A complete list of all ambient monitoring stations from 2000 to 2020 is available in Chapter 2 Appendix.

While the LCFRP primarily collects instream monitoring information in waterways with point source dischargers, it also maintains several voluntary instream monitoring stations in the Black River subbasin not directly associated with a facility/discharger to understand the impacts of nonpoint sources in the Cape Fear River Basin. The LCFRP stations are sampled monthly in this subbasin. DWR recognizes the importance of this work and encourages continued monitoring of these stations.

Table 10-10: Ambient Monitoring Stations in the Black River Subbasin (HUC8: 03030006).

Station ID	Station Location	Ecoregion	Stream AU#	Stream Classification
B8470000	SOUTH RIV AT US 13 NR COOPER	Southeastern Plains	18-68-12-(0.5)a	C; Sw
B8490000	LITTLE COHARIE CRK AT SR 1414 MINNIE HALL RD NR SALEMBURG	Southeastern Plains	18-68-1-17a1	C; Sw
B8545000	LITTLE COHARIE CRK AT SR 1240 NR ROSEBORO	Southeastern Plains	18-68-1-17a2	C; Sw
B8580000	GREAT COHARIE CRK AT SR 1311 NR CLINTON	Southeastern Plains	18-68-1b	C; Sw
B8604000	GREAT COHARIE CRK AT SR 1214 NR BUTLER CROSSROADS	Southeastern Plains	18-68-1b	C; Sw
B8610001	LITTLE COHARIE CRK AT SR 1207 NR INGOLD	Southeastern Plains	18-68-1-17b	C; Sw
B8725000	SIX RUNS CRK AT SR 1960 NR TAYLORS BRIDGE	Southeastern Plains	18-68-2-(11.5)	C; Sw, ORW
B8740000	SIX RUNS CRK AT SR 1003 NR INGOLD	Southeastern Plains	18-68-2-(11.5)	C; Sw, ORW
B8750000	BLACK RIV AT NC 411 NR TOMAHAWK	Southeastern Plains	18-68a	C; Sw, ORW
B8919000	SOUTH RIV AT SR 1503 NR PARKERSBURG	Southeastern Plains	18-68-12-(8.5)	C; Sw, ORW
B8920000	SOUTH RIV AT SR 1007 ENNIS BRIDGE RD NR KERR	Middle Atlantic Coastal Plain	18-68-12-(8.5)	C; Sw, ORW
B8981000	COLLY CRK AT NC 53 AT COLLY	Middle Atlantic Coastal Plain	18-68-17	C; Sw
B9000000	BLACK RIV AT NC 210 AT STILL BLUFF	Middle Atlantic Coastal Plain	18-68b	C; Sw, ORW
B9013000	BLACK RIV AT RACCOON ISLAND NR HUGGINS	Middle Atlantic Coastal Plain	18-68b	C; Sw, ORW

Figure 10-9: Ambient Monitoring System, Coalition, and Lower Cape Fear River Partnership Water Quality Monitoring Stations in the Black River Subbasin.



An overall comparison of the Black River HUC10 watershed scale ambient water quality results for samples collected in the basin from 2016 to 2020 is shown in *Table 10-11.* 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 10-11* also shows the HUC8 mean levels for these parameters from 2016 to 2020 in the Black 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 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) 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 10-11* are described in-depth in their respective watershed chapters spanning chapters 6 through 11 of this report.

At the watershed scale for five-year (2016-2020) means, Six Runs Creek watershed (HUC 10: 0303000605) had the highest conductivity, nitrate+nitrite, and total nitrogen levels of all the subbasin watersheds (*Table 10-11*). The Colly Creek watershed (HUC 10: 0303000606) had the highest five-year mean values for ammonia and total Kjeldahl nitrogen with concentration of 0.27 mg/L and 1.44 mg/L, respectively (*Table 10-11*). The Colly Creek watershed had the highest five-year mean ammonia and total Kjeldahl nitrogen levels across all watersheds in the Cape Fear River Basin (*Table 10-11*). The Upper South River watershed (HUC 10: 0303000601) also had notably high five-year mean total Kjeldahl nitrogen and ammonia concentrations, which were second highest in this subbasin (*Table 10-11*). The Upper South River watershed had the second highest five-year mean fecal coliform bacteria levels, second only to Goshen Swamp watershed in the Northeast Cape Fear River subbasin (*Table 10-11*). Great Coharie Creek and Six Runs Creek watersheds also had high five-year mean fecal coliform bacteria values, exceeding 1,100 colonies/100 mL (*Table 10-11*). The Great Coharie Creek watershed (HUC 10: 0303000604) had the highest five-year mean total phosphorus levels, primarily measured in the downstream section of the river (*Table 10-11*). The Upper South River watershed had the highest five-year mean turbidity levels (*Table 10-11*).

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.

Table 10-11: Black 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
03030006*	**HUC 8 Black River Watershed**	14	6.14	7.06	101	0.07	0.86	0.43	1.29	0.13	4.83		754
0303000601	Upper South River	1	6.21	5.74	83	0.12	1.00	0.15	1.14	0.10	7.86		1,458
0303000602	Lower South River	2	5.76	7.29	70	0.04	0.78	0.21	0.99	0.07	3.28		510
0303000603	Little Coharie Creek	3	6.43	7.10	98	0.04	0.76	0.51	1.26	0.09	4.02		659
0303000604	Great Coharie Creek	2	6.45	6.59	129	0.05	0.78	0.41	1.19	0.21	3.51		1,106
0303000605	Six Runs Creek	2	6.62	8.00	137	0.08	0.83	0.90	1.73	0.17	6.46		1,337
0303000606	Colly Creek	1	3.97	6.42	57	0.27	1.44	0.03	1.47	0.18	5.45		581
0303000607	Moores Creek	0											
0303000608	Black River	3	6.28	7.31	108	0.04	0.77	0.49	1.26	0.14	4.61		176
EPA Nutrient Criteria – Coastal+									0.72	0.032			
Minimally Impacted Streams**						<0.05	<0.5	<0.3	<0.8	<0.05			

+ USGS Circular #1350 – The Quality of Our Nation's Water – Nutrients in the Nation's Streams and Groundwater, 1992-2004. Neil Dubrovsky et al., 2010.
** DWQ ESS- ISU Special Study. March 14, 2005, Lower Cape Fear River/Estuary TMDL Study.
^Ambient stations with a minimum of data collected for five years from 2016 to 2020 and 40 average-day records were included in the analysis.
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.

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.

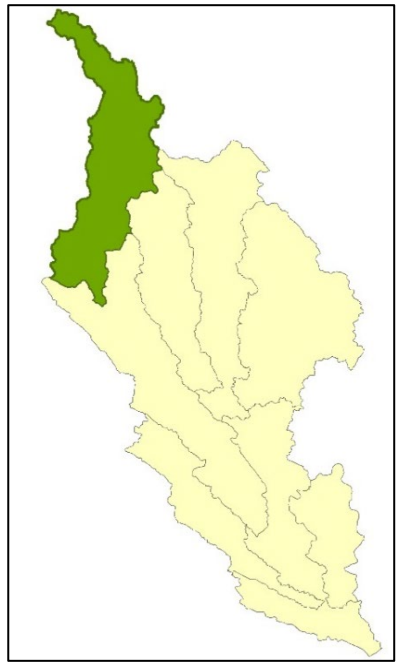
Due to the changing nature of the science and due to the extent and magnitude of PFAS contaminants found in the Cape Fear River Basin as well as what corrective actions to take, PFAS was not discussed in detail within the subbasin chapters of this plan. A PFAS specific chapter was completed after finalizing 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.

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.

10.6 Water Quality on the Watershed Scale (HUC 10)

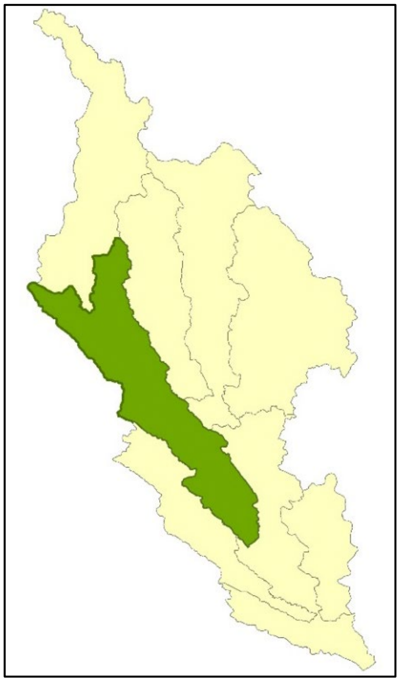
To determine the source of pollutants in a watershed, it is useful to evaluate them on a smaller scale. Smaller-scale evaluations can also help identify where monitoring and restorations are needed, being conducted or beneficial. North Carolina assigns numbers to surface waterbodies. For water quality 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 scale (HUC 10). 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 watershed strategies along with recommendations to protect and improve water resources in the watershed.

10.6.1 Upper South River (0303000601) and Lower South River (0303000602) Watersheds



The Upper South River watershed spans 234 square miles of land across portions of Harnett, Wake, Johnston, Sampson, and Cumberland counties. The upper reaches of this watershed are the "little" Black River, which flows south to confluence with Mingo Swamp forming the South River. As the South River flows southeast, it crosses the hydrologic unit boundary dividing the Upper South River watershed from the Lower South River watershed. Upon crossing this boundary, the South River obtains the Outstanding Resource Water (ORW) stream classification. Since the South River flows through both these watersheds, they are discussed together in this section. The primary land covers in this watershed are agricultural land (41.4%), forest land (16.3%), and wetlands (24.2%), followed by developed land (12.3%), grassland/shrub (5.1%), barren land (<0.1%), and open water (0.7%).
There were many permitted facilities and fields located in the Upper South River watershed as of May 2022.

A total of 19 AFOs with total allowable head count of 138,026, allowable weight of 12.2 million pounds and 41 lagoons were scattered across the entire watershed. There are six non-discharge permitted facilities (four major and two minor) with 47 fields covering approximately 1.42 square miles along the entire length of the mainstem waterway that flows through this watershed. Many of these facilities are located near the "little" Black River, Juniper Creek near the confluence with the South River, and along the South River just below the confluence with Williamson Swamp. There is one NPDES wastewater permit for industrial process and commercial wastewater discharge into an unnamed tributary of Mingo Swamp. This facility has received only one limit violation for total suspended solids since 2010, this limit violation was handled through the National Pollutant Discharge Elimination System (NPDES) process. There are also 17 NPDES stormwater and 42 state stormwater permits.



The Lower South River watershed spans 260 square miles of drainage into the South River in Cumberland, Sampson, and Bladen counties. The South River ultimately merges with the "larger" Black River as it discharges from the Lower South River watershed. There is one ambient water quality monitoring station and one biological community monitoring station in the Lower South River watershed. These converging coastal plain rivers are composed of smaller, slow-moving tannin-stained streams that drain wetland areas. Bay Tree Lake and Horsepen Lake are the only lakes of note in the Lower South River watershed. The primary land covers in this watershed are agricultural land (27.0%), forest land (25.9%), and wetlands (31.5%), followed by developed land (4.8%), grassland/shrub (9.3%), barren land (<0.1%), and open water (1.4%).

There were many permitted facilities and fields located in the Lower South River watershed as of May 2022. A total of 85 AFOs with total allowable head count of 459,770, allowable weight of 65.2 million pounds and 207 lagoons were scattered across the entire watershed. There are 17 fields for the land application of residual solids covering approximately 0.43 square miles near Sandy Creek and along Beaver Dam Creek. There are no NPDES-permitted wastewater facilities in this watershed. There is one NPDES stormwater and 12 state stormwater permits.

10.6.1.1 "Little" Black River Biological Monitoring

The "little" Black River from the source to South River spans approximately 29.9 river miles [AU#: 18-68-12-1a and 18-68-12-1b]. The "little" Black River is a class C water with a supplemental swamp classification due to the natural characteristics of swamps, such as low dissolved oxygen and pH. There are no surface water monitoring stations and two biological monitoring stations for benthic macroinvertebrates on this river. The "little" Black River was on the impaired waters list until 2008 when new data documented that applicable water quality standards are being met (NCDEQ, 2010a). Since then, it has not appeared again on the impaired waters list for any water quality standards violation. The two biological monitoring stations, i.e., BB316 and BB317, were last sampled in 2009 with both monitoring stations receiving a Moderate rating (*Table 10-12* and *Table 10-13*).

Historically, two benthic macroinvertebrate community special studies were conducted in the "little" Black River in 2004 (NCDEQ, 2004) and 2009 (NCDEQ, 2009). The 2004 TMDL Stressor Study states "the combined effects of low or no flow conditions, agricultural and urban runoff, as well as the historic discharge from the WWTP have resulted in this present TMDL investigation in an effort to (if possible) determine and characterize potential stressors in the Black River catchment" (NCDEQ, 2004). The results of the study suggested "the benthic community as a whole was not compromised by these inputs" (NCDEQ, 2004). In 2009, there was another special study in this river to respond to "recent Sanitary Sewer Overflows just south of U.S. 421 in the proximity of the towns of Dunn and Erwin" (NCDEQ, 2009). The results of that study were that "overall, biotic index values were not notably different when comparing sampling sites upstream and downstream of the Sanitary Sewer Overflows" (NCDEQ, 2009).

Table 10-12: Biological Community Analysis in the "little" Black River at Station BB316.

Year	Study	Sample Type	EPT BI	Biotic Index	Bioclassification
1984	N/A	Full Scale	5.93	6.78	Fair
2004	Special Study	Swamp	5.84	6.76	Moderate
2009	Special Study	Swamp	5.66	6.65	Moderate

Link to the biological report: https://www.ncwater.org/?page=672&SiteID=BB316

Table 10-13: Biological Community Analysis in the "little" Black River at Station BB317.

Year	Study	Sample Type	EPT BI	Biotic Index	Bioclassification
1989	N/A	EPT	5.36	5.36	Not Rated
2004	Special Study	Swamp	4.81	6.12	Moderate
2009	Special Study	Swamp	5.81	6.82	Moderate

Link to the biological report: https://www.ncwater.org/?page=672&SiteID=BB317

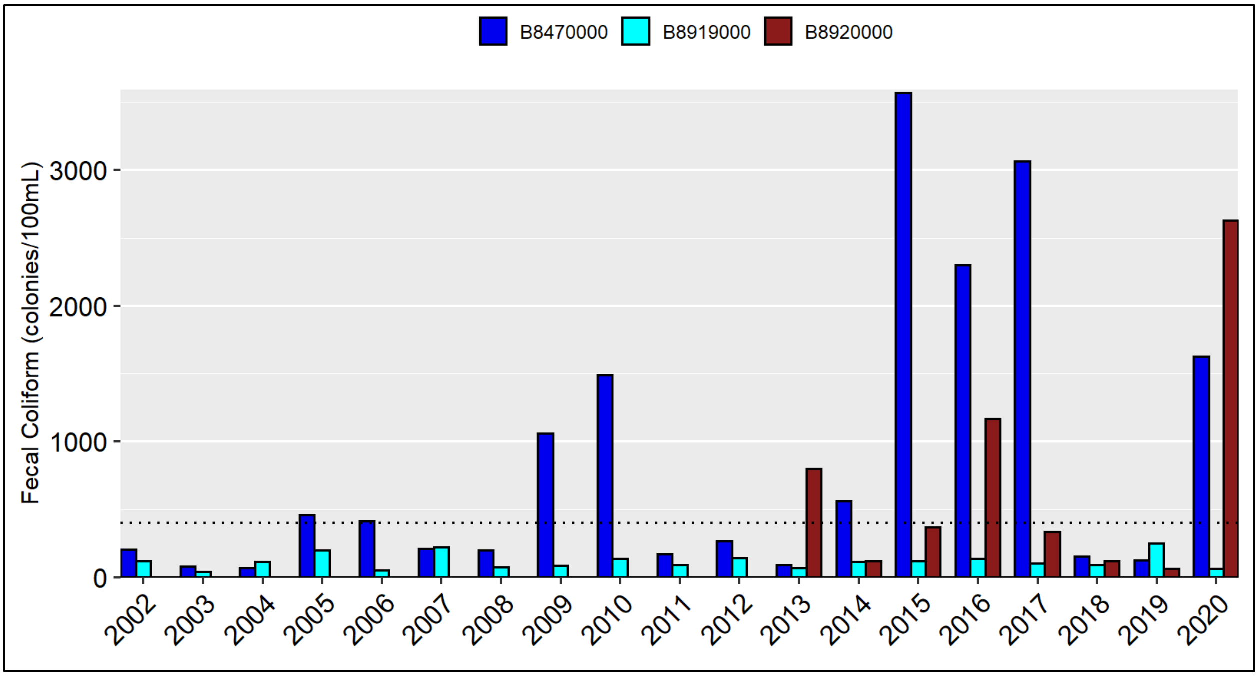
10.6.1.2 South River Physical, Chemical Monitoring, and Biological Monitoring

The South River from source to the Big Swamp spans approximately 33.8 river miles [AU#: 18-68-12-(0.5)a and 18-68-12-(0.5)b]. The South River is a class C water with a supplemental swamp classification due to the natural characteristics of swamps, such as low dissolved oxygen and pH. Information regarding dissolved oxygen in waterways of the Black River subbasin can be found in Section 10.8.2. As the South River flows south from the confluence with Big Swamp towards the larger Black River, it crosses the hydrologic unit boundary from the Upper South River (HUC10: 03030000601) to the Lower South River (HUC10: 03030000602) south of the town of Autryville. As this river crosses this hydrologic boundary, the river gains the supplemental stream classification of Outstanding Resources Waters.

In total, there are three surface water quality monitoring stations and one biological community monitoring station along the entire length of the South River. The most upstream surface water quality monitoring station is B8470000. Downstream from this station is the biological monitoring station BB301. Further downstream, two surface water monitoring stations, i.e., B8919000 and B8920000, are located on the lowermost portions of the South River. Station B8920000 is located downstream of station B8919000.

From 2016 to 2020, fecal coliform bacteria values were highest in the upper reaches at station B8470000 with approximately 25% (14 of 57) of samples exceeding the 400 colonies/100 mL water quality standard. The next two downstream stations were less impacted by high fecal coliform with 6% and 12% of samples exceeding the water quality standard during the same 5-year period. These exceedances are reflected in the elevated mean values observed in *Figure 10-10*. Turbidity levels were relatively low with few values that exceeded the 50 NTUs water quality standard.

Figure 10-10: Annual Mean Fecal Coliform Results for Stations on the South River (B8470000, B8919000, and B8920000) between 2002 and 2020.



Overall, the annual mean total nitrogen concentrations at these three surface water quality monitoring stations were not considerably different and hovered around 1 mg/L (*Figure 10-11*). These concentrations are higher than those considered normal for minimally impacted streams. As the different species of nitrogen are reviewed, higher total Kjeldahl nitrogen and ammonia concentrations were recorded in the upper reaches (B8470000) (*Figure 10-12* and *Figure 10-13*); higher nitrate+nitrite concentrations were recorded at downstream monitoring stations B919000 and B8920000 (*Figure 10-14*). Annual mean total phosphorus concentrations were reasonably close to concentrations considered normal for minimally impacted streams, except in 2018 and 2019 when annual mean total phosphorus concentrations exceeded 0.1 mg/L (*Figure 10-15*).

DWR conducted screening level Mann-Kendall trend seasonal tests for total Kjeldahl nitrogen and specific conductance at stations B8470000 and B9190000 that resulted in significant increasing trends calculated at 95% confidence from data collected from 2000-2019 at both stations. Mallin et al. (2022), reported significant increases in nitrate and fecal coliform bacteria based on a series of statistical analyses conducted on data collected from 2000 – 2019 at station B8470000. The DWR screening level Mann-Kendall trend seasonal test for nitrate+nitrite and fecal coliform concurred with this significant increasing trend from data collected from 2000-2019 at station B8470000. Notably, the DWR screening level Mann-Kendall trend non-seasonal test for nitrate+nitrite resulted in a significant increasing trend from data collected between 2000-2019 in South River downstream at station B9190000.

Figure 10-11: Annual Mean Total Nitrogen Results for Stations on the South River (B8470000, B8919000, and B8920000) between 2002 and 2020.

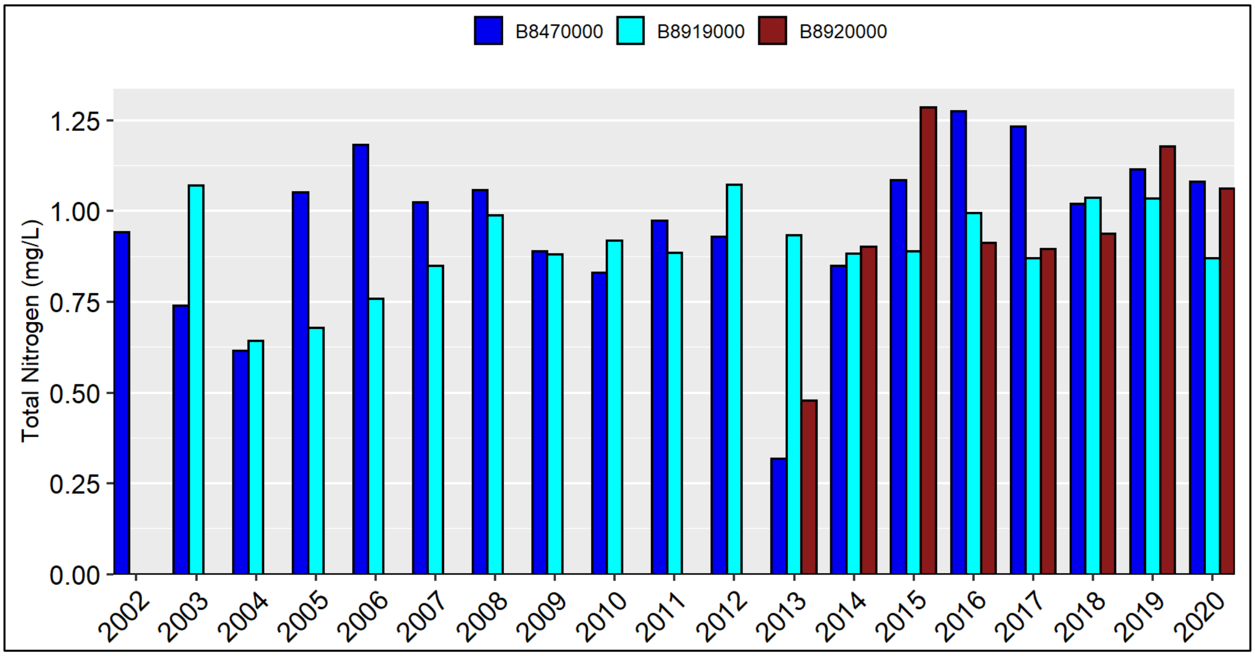


Figure 10-12: Annual Mean Total Kjeldahl Nitrogen Results for Stations on the South River (B8470000, B8919000, and B8920000) between 2002 and 2020.

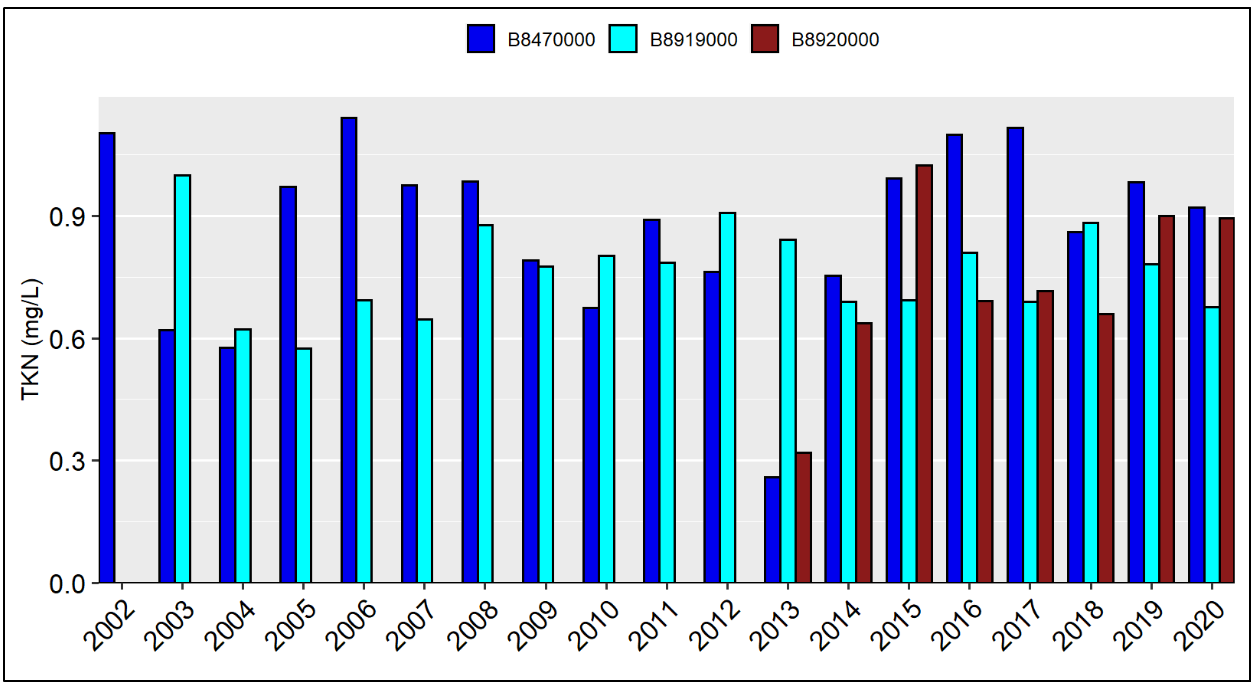


Figure 10-13: Annual Mean Total Ammonia Results for Stations on the South River (B8470000, B8919000, and B8920000) between 2002 and 2020.

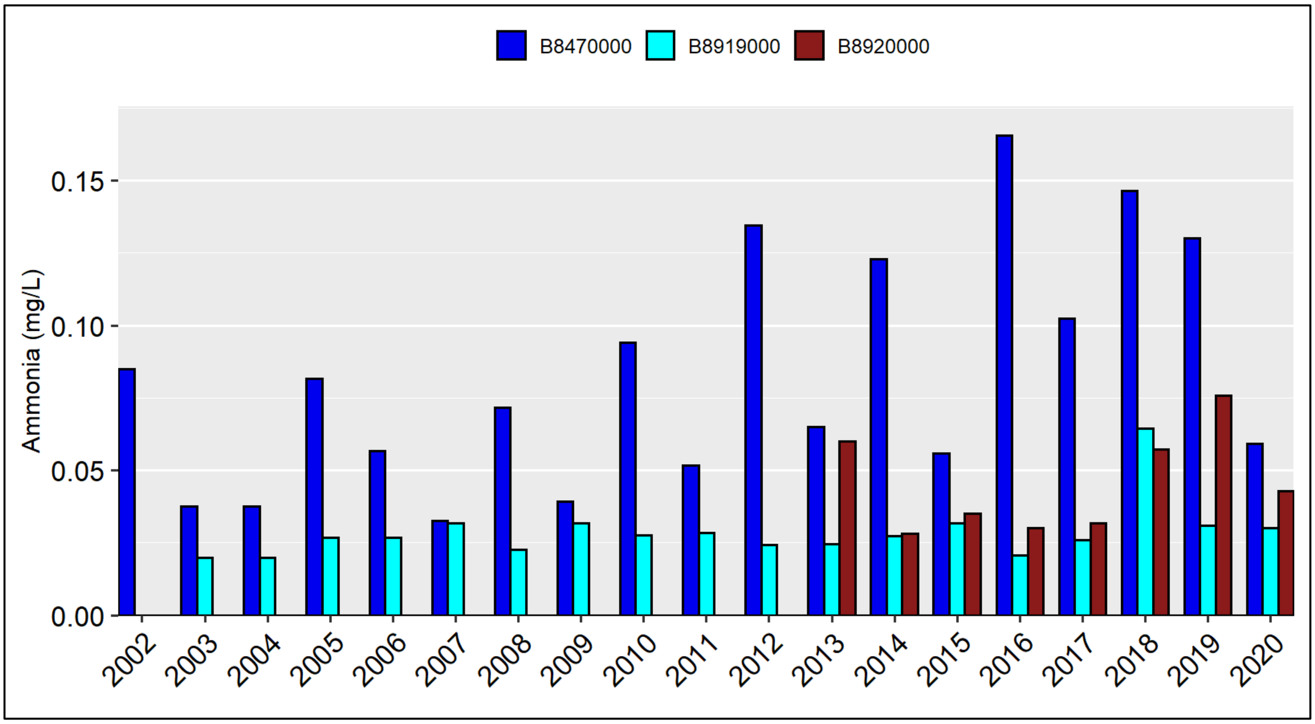


Figure 10-14: Annual Mean Nitrate+Nitrite Results for Stations on the South River (B8470000, B8919000, and B8920000) between 2002 and 2020.

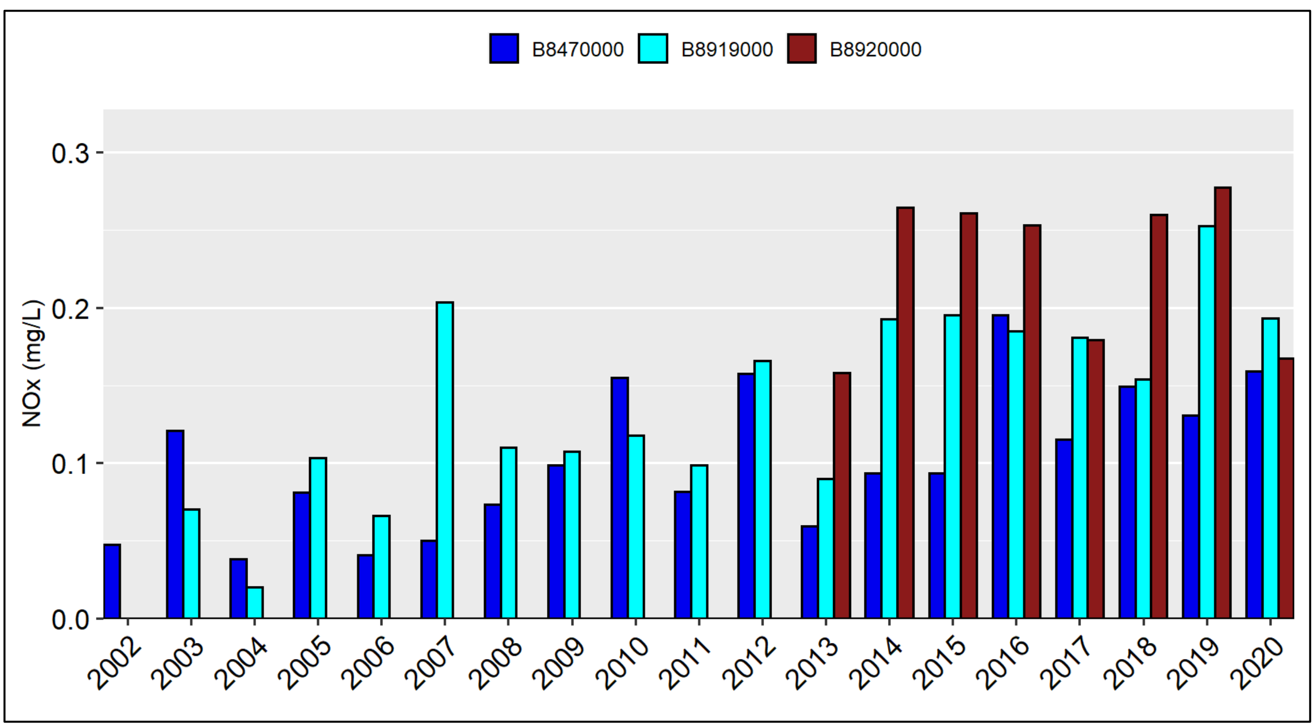
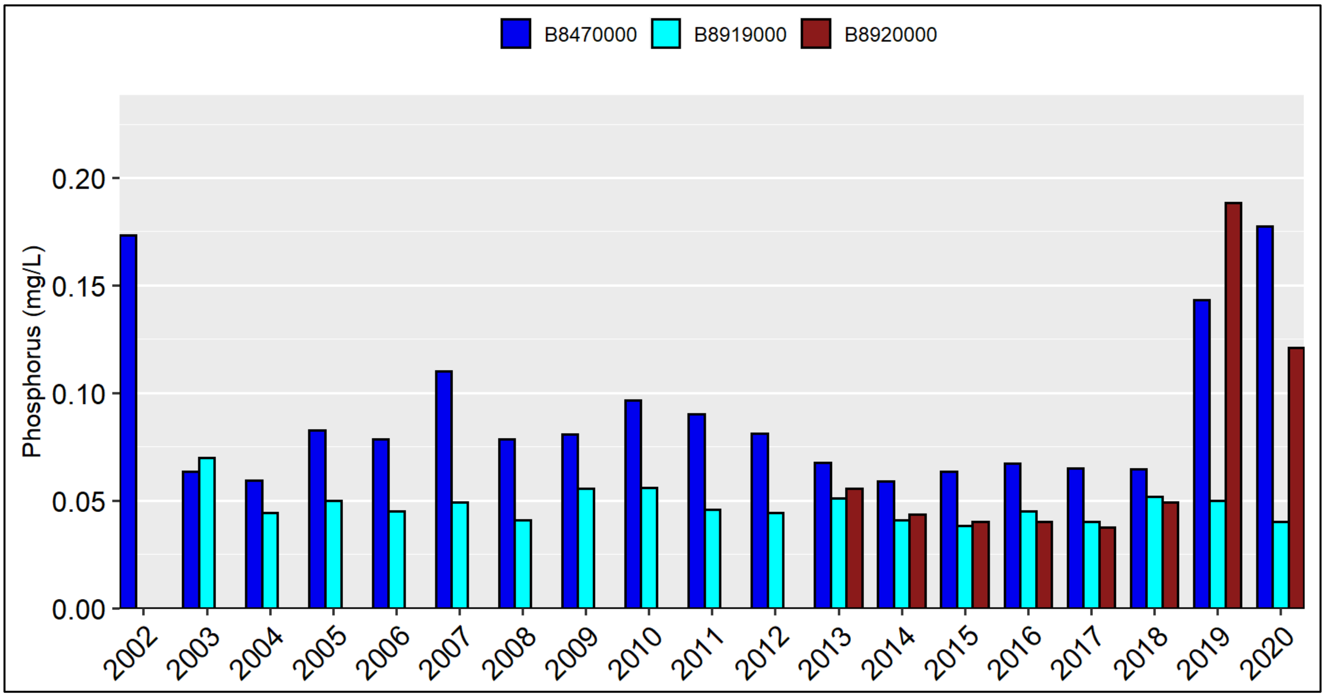


Figure 10-15: Annual Mean Total Phosphorus Results for Stations on the South River (B8470000, B8919000, and B8920000) between 2002 and 2020.



The biological community monitoring station on the South River [AU#: 18-68-12-(0.5)b] has maintained a rating of Good or Excellent since monitoring began in 1983 (*Table 10-14*). The exception was a special study in 2002 that resulted in a Not Rated bioclassification based on a less intensive Ephemeroptera, Plecoptera, and Trichoptera sampling methodology. The most recent sampling event was in 2008, receiving a Good bioclassification.

Table 10-14: Biological Community Analysis in the South River at Station BB301.

Year	Study	Sample Type	EPT BI	Biotic Index	Bioclassification
1983	N/A	Full Scale	4.28	5.5	Good
1985	N/A	Full Scale	3.9	5.32	Excellent
1987	N/A	Full Scale	3.96	5.39	Excellent
1993	Basin Sample	Full Scale	3.78	5.42	Good
1998	Basin Sample	Full Scale	4.52	5.73	Good
2002	Special Study	EPT	4.46	4.46	Not Rated
2008	Basin Sample	Full Scale	4.31	5.64	Good

Link to biological report: https://www.ncwater.org/?page=672&SiteID=BB301

10.6.1.3 Black Lake (Bay Tree Lake) Physical and Chemical Monitoring

Bay Tree Lake [AU#: 18-68-17-1-1] is a class C water with a supplemental swamp classification due to the natural characteristics of swamps, such as low dissolved oxygen and pH. "Bay Tree Lake (also called Black Lake) is a shallow, natural lake located near Elizabethtown, North Carolina. Typical of Carolina bay lakes, Bay Tree Lake receives no significant overland inflows. The surrounding land is flat and composed of wetlands, upland forests and a network of drainage canals built on its northern and eastern shores. A private gated residential community is located along the northern and northeastern shoreline of the lake and access to the lake is not open to the public. Bay Tree Lake was sampled monthly from May through September 2018 by DWR field staff" (NCDEQ. 2018). "Based on data collected in 2018, Bay Tree Lake appears to be meeting its designated uses. This lake is dystrophic, and the North Carolina Tropic State Index (NCTSI) scores could not be accurately calculated due to the naturally dark, tannic waters." (NCDEQ, 2018).

In 2012, a fish kill event occurred on the east side of Bay Tree Lake with a total mortality of 72,000. The event was estimated to have been occurring for days prior to investigation. Fish were in an advanced state of decomposition. All affected fish were identified as yellow (raccoon) perch and located on the east side of the lake. Investigators reported no evidence of algal blooms or unusual water quality measurements (NCDWQ, 2012). Similar die-offs of yellow perch were observed in White Lake during the Spring of 2012.

10.6.1.4 Upper and Lower South River (0303000601 & 0303000602) Watershed Summary

The water quality in the South River is impacted by point and nonpoint sources of pollution. The point source impacts to the South River are limited to one permitted facility that has a good overall history of compliance with permit limits. Nonpoint sources of pollution in this watershed include both swine and poultry feeding operations, agriculture practices, manure applications to cropland, septic systems and/or straight pipes, domestic animals and wildlife.

Fecal coliform bacteria in the upper section of the South River are concerning because 1 in 4 samples collected throughout the five-year period had concentrations exceeding the 400 colonies/100 mL standard, and statistical trend analysis indicates increasing concentrations over time. These high concentrations could be the result of pulse-loading events related to water flowing over the land and carrying fecal coliform bacteria to the river from nonpoint sources. While streamflow in the South River appears to mitigate some of the nonpoint source pollution impacts by upstream sources, the monitoring station furthest downstream near the confluence with the Black River recorded elevated fecal coliform bacteria levels. A more detailed investigation is needed to determine the sources of fecal coliform, and efforts should be made to minimize transport of human and animal waste surrounding the South River and adjoining tributaries. Notably, Cypress Creek in the Lower South River watershed has been identified as containing measurable manure effects from swine and poultry animal feeding operations (Harden, 2015).

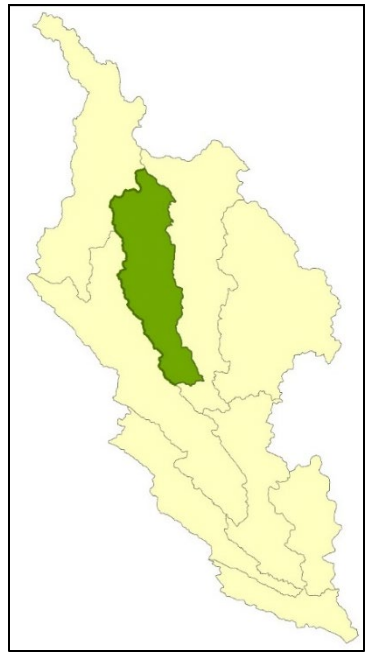
Total nitrogen concentrations are primarily composed of total Kjeldahl nitrogen in the South River, which is typical for waters in this region. Elevated ammonia concentrations were identified in the upper South River at station B8470000. The point and/or nonpoint sources of these elevated ammonia concentrations is currently unclear, however, possible sources include industrial discharge, groundwater, failing septic and sewer systems, animal feeding operations, agriculture, and atmospheric deposition. Nitrate+nitrite concentrations were higher in the lower South River possibly from numerous nonpoint sources described earlier. While higher nitrate+nitrite concentrations were detected downstream, both the upper and lower South River water quality displayed increasing statistical trends for this parameter.

Annual mean phosphorus concentrations were reasonably close to concentrations considered normal for minimally impacted streams during most years. During the years 2019 and 2020, phosphorus concentrations in the South River displayed some of the highest annual average concentrations compared to historical records. Both upstream and downstream stations on the South River recorded values greater than those considered normal for minimally impacted streams.

While these waters are not impaired, attention and resources should be focused on these waters to prevent additional degradation through elevated fecal coliform bacteria and increasing nutrient concentrations. Localized water quality monitoring and best management practices to address the fecal coliform bacteria levels and nutrients are necessary to improve water quality in this watershed. Additional recommendations for the Upper and Lower South River watersheds include:

- Stream walking much of the watershed to assist in identifying sources of water quality problems.
- Working with the local county health department in having straight pipes identified during stream walks removed and septic systems repaired.
- Partnering with agencies such as the local county Soil and Water Conservation Districts and the US Department of Agriculture – Natural Resources Conservation Service to help facilitate communication with landowners and encourage them to implement agricultural best management practices.
- Reduction of nonpoint source pollution runoff through forested buffers alongside streams, wetland and stream restoration, erosion and sediment control best management practices, and implementation of agriculture BMPs where needed (e.g., cover crops, grassed waterways, livestock exclusion, filter strips and field borders).
- Determining the primary source of fecal coliform bacteria and limiting fecal coliform bacteria loading through source identification, education and outreach, and best management practices installation.

10.6.2 Little Coharie Creek Watershed (0303000603)



The Little Coharie Creek watershed spans 159 square miles in eastern Sampson County. The headwater of this watershed is the Little Coharie Creek, which flows south to meet Sinclair Lake. Downstream from Sinclair Lake, Little Coharie Creek continues to flow south and is joined by several swamp-classified tributaries, including Long Branch, Hornet Swamp, and Bearskin Swamp. There are three surface water quality monitoring stations on this river and one biological community monitoring site. These converging coastal plain rivers comprise smaller slow-moving tannin-stained streams that drain wetland areas. The primary land covers in this watershed are agricultural land (44.9%), forest land (20.1%), and wetlands (20.9%), followed by developed land (7.3%), grassland/shrub (6.4%), barren land (<0.1%), and open water (0.4%).

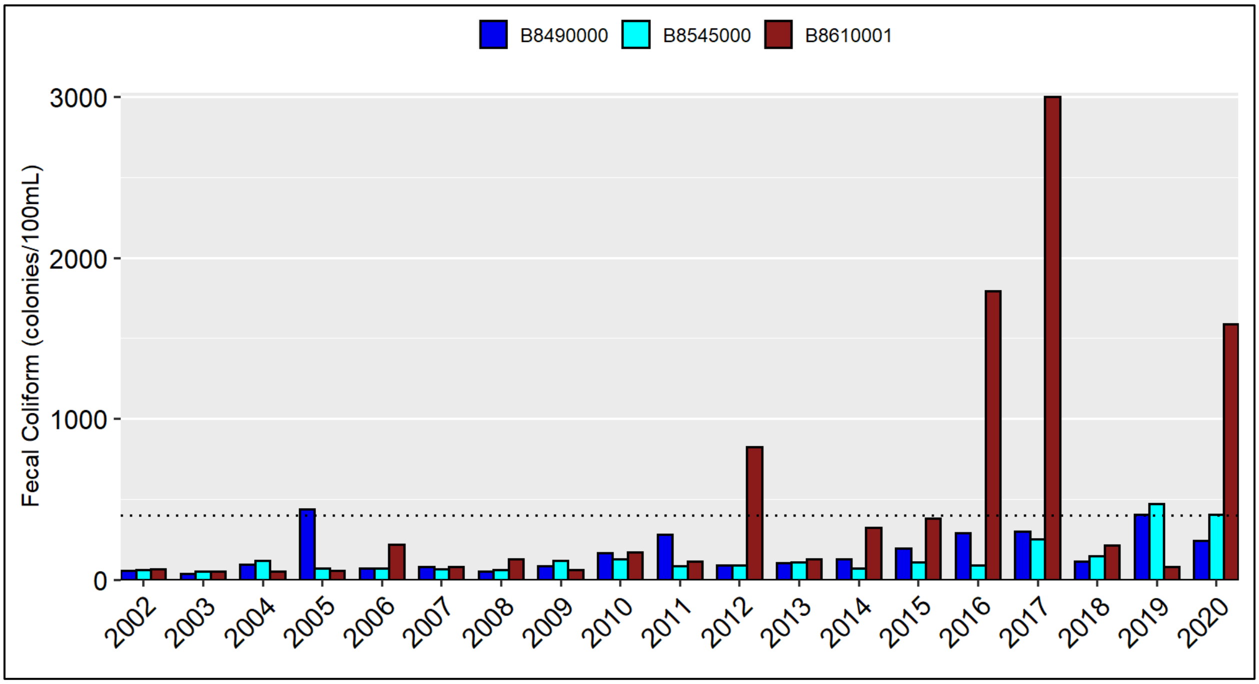
As of May 2022, there were many permitted facilities and application fields located in the Little Coharie Creek watershed. A total of 77 AFOs with total allowable head count of 323,809, allowable weight of 36 million pounds and 148 lagoons were scattered across the entire watershed. There are two major non-discharge permitted facilities with 21 application fields covering approximately 1.09 square miles located along Caesar Swamp (Williams Lake) and the mainstem of the Little Coharie Creek (Sinclair Lake) below the confluence with Betty Branch. There is also a single NPDES permit, Roseboro WWTP, discharging into Little Coharie Creek northeast of the Town of Roseboro with an as-built flow totaling 700,000 gallons per day (GPD). There are also three NPDES stormwater and two state stormwater permits.

10.6.2.1 Little Coharie Creek Physical, Chemical Monitoring, and Biological Monitoring

Little Coharie Creek from the source to the Great Coharie Creek confluence spans approximately 40.8 river miles [AU#: 18-68-1-17a1, 18-68-1-17a2, and 18-68-1-17b]. Little Coharie Creek is a class C water with a supplemental swamp classification due to the natural characteristics of swamps such as low dissolved oxygen and pH. Information regarding dissolved oxygen in waterways of the Black River subbasin can be found in Section 10.8.2. The most upstream surface water quality monitoring station (B8490000) is located downstream from Sinclair Lake and additionally receives drainage from multiple headwater swamp-classified tributaries. Downstream from water quality monitoring station B8490000 is surface water quality monitoring station B8545000 on Little Coharie Creek followed by station B8610001. The lowermost station (B8610001) captures approximately 99% of the water draining from the landscape in the Little Coharie Creek watershed just before joining Great Coharie Creek. In 2019, the land cover draining to this most downstream water quality monitoring station was composed of agricultural lands (45%), wetlands (21%), forest land (20%), developed land (7%), and grassland/shrub (6%). Since 2001, there has not been significant change in the land cover draining to this monitoring station.

During 2016 to 2020, approximately 23% of the fecal coliform bacteria sampling events at the most downstream station on Little Coharie Creek recorded values greater than the 400 colonies/100 mL water quality standard. This frequency is higher than the two upstream surface water quality monitoring stations (B8490000 and B8545000) on Little Coharie Creek. These elevated fecal coliform bacteria concentrations occurred more often in the most recent 10 years on record compared to the historical record as seen in the elevated mean values in *Figure 10-16*.

Figure 10-16: Annual Mean Fecal Coliform Bacteria Concentrations from the Little Coharie (B8490000, B8545000, B8610001) from 2002 to 2020.



Annual mean total nitrogen concentrations in Little Coharie Creek were often around 1 mg/L (*Figure 10-17*). Recently, these concentrations have exceeded 1 mg/L more often, driven primarily by higher nitrate+nitrite concentrations (*Figure 10-18*). Total Kjeldahl nitrogen concentrations have fluctuated over time but have not changed considerably (*Figure 10-19*). Ammonia concentrations spiked in 2019 with a maximum value of 0.39 mg/L, however, ammonia concentrations were low historically in this waterway with annual mean values typically below 0.05 mg/L. Total nitrogen concentrations are typically higher than concentrations considered normal for minimally impacted streams.

Phosphorus annual mean concentrations were often around 0.05 mg/L, which is reasonably close to concentrations considered normal for minimally impacted streams. While these values are typically low, occasionally higher phosphorus concentration were recorded during the more recent years of sample collection as displayed by the elevated mean values in *Figure 10-20*.

DWR conducted screening level Mann-Kendall trend seasonal tests for fecal coliform, nitrate+nitrite, specific conductance, and total phosphorus at the downstream station (B8610001) on Little Coharie Creek that resulted in a significant increasing trend calculated at 95% confidence for data collected from 2000-2019. Mallin et al. (2022) also found significant increases in fecal coliform, nitrate, and total phosphorus at this same station using the LCFRP monitoring data collected between 2000-2019. The DWR screening level Mann-Kendall seasonal tests for fecal coliform and specific conductance for the upstream station (B8545000) on the Little Coharie Creek resulted in a significant increasing trend for data collected from 2000-2019.

Figure 10-17: Annual Mean Total Nitrogen Concentrations from the Little Coharie (B8490000 and B8610001) from 2002 to 2020.

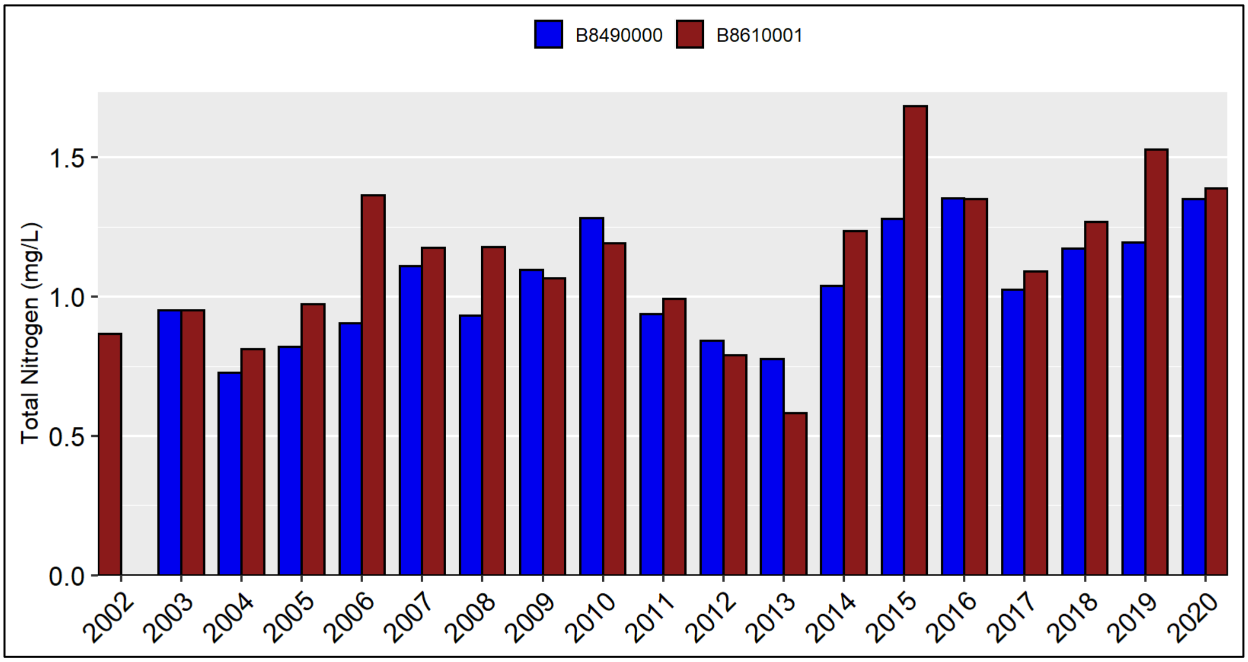


Figure 10-18: Annual Mean Nitrate+Nitrite Concentrations from the Little Coharie (B8490000 and B8610001) from 2002 to 2020.

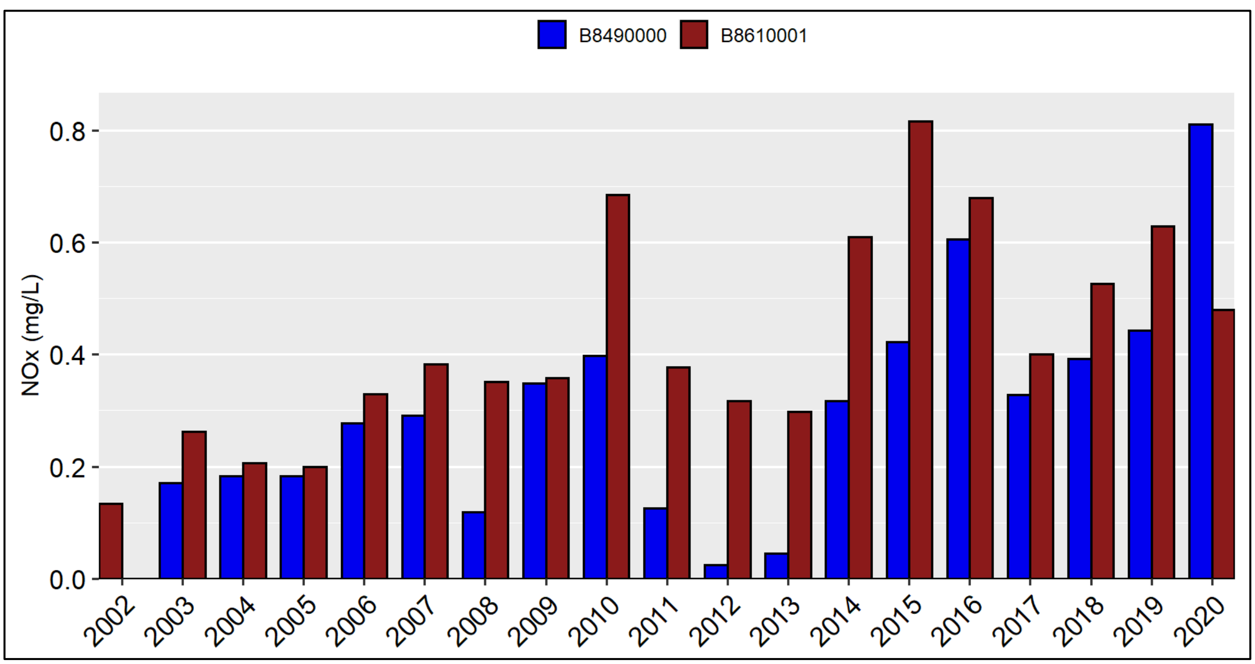


Figure 10-19: Annual Mean Total Kjeldahl Nitrogen Concentrations from the Little Coharie (B8490000 and B8610001) from 2002 to 2020.

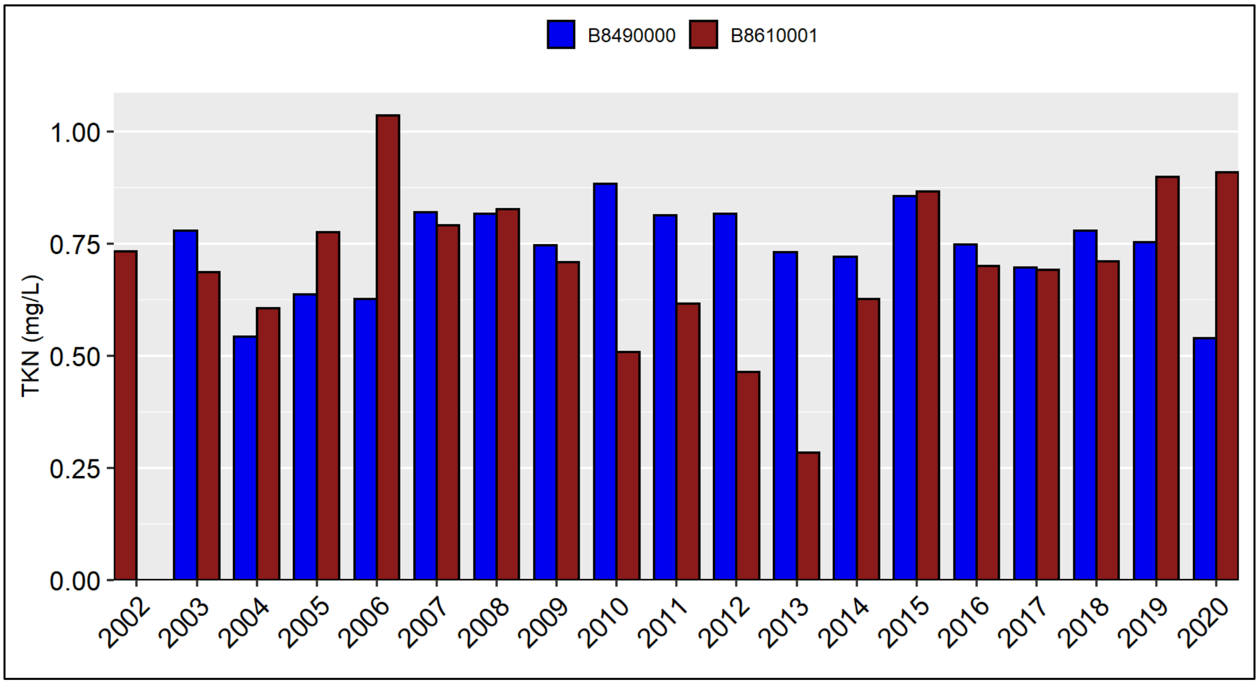
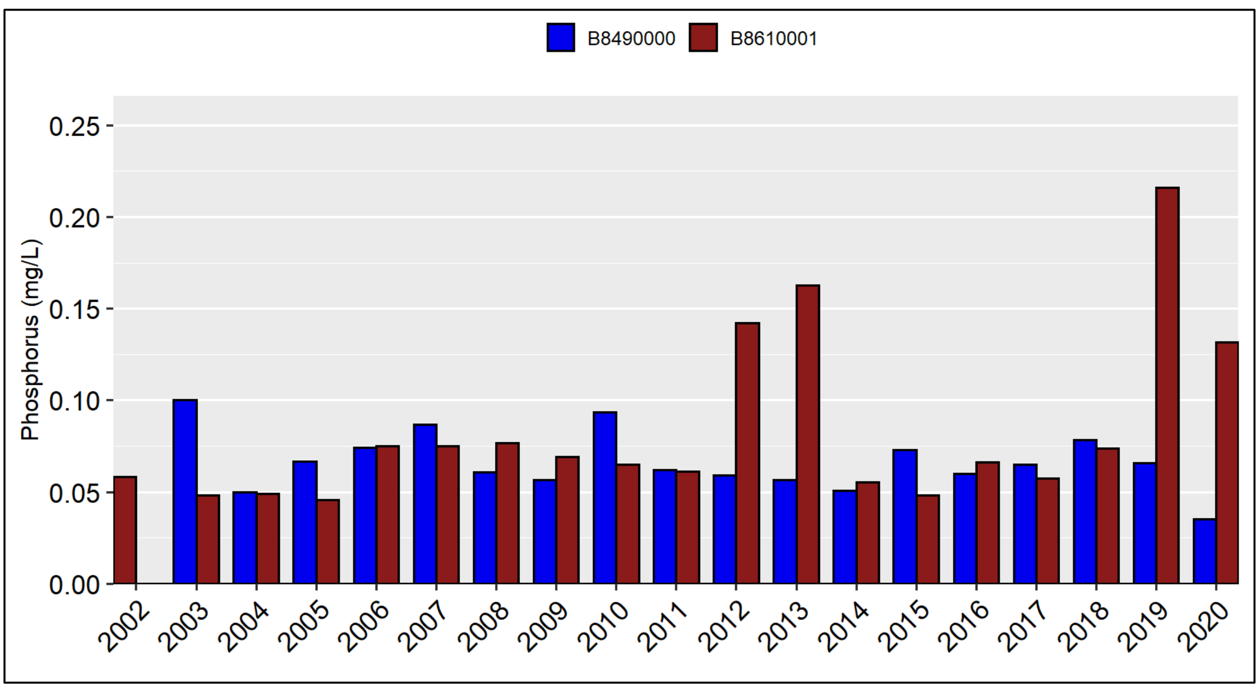


Figure 10-20: Annual Mean Total Phosphorus Concentrations from the Little Coharie (B8490000 and B8610001) from 2002 to 2020.



In addition to the long-term monitoring stations established in Little Coharie Creek, there was a temporary water quality monitoring station (B8484000) established in the headwaters of Bearskin Swamp (Stream Index: 18-68-1-17-10, Stream Class: C; Sw), which flows into Little Coharie Creek. The headwaters of Bearskin Swamp recorded high total nitrogen concentrations ranging from 0.63 to 12.53 mg/L. A large fraction of the total nitrogen concentrations was composed of nitrate+nitrite which ranged from 0.2 to 12 mg/L in concentration.

Downstream from the Roseboro WWTP is a biological community monitoring station BB259 [AU#: 18-68-1-17b]. This biological community site has healthy in-stream macroinvertebrate habitat and a wide riparian area. The EPT richness has remained stable, indicating relatively stable water quality. Of note is the higher EPT BI in 2008, which is indicative of a more pollution-tolerant community. This was attributed to extreme drought conditions in 2007 and 2008. The most recent sampling in Little Coharie Creek maintained a bioclassification of Good for 2013 (*Table 10-15*).

Table 10-15: Biological Community Analysis in the Little Coharie Creek at Station BB259.

Year	Study	Sample Type	EPT BI	Biotic Index	Bioclassification
2003	Basin Sample	EPT	4.07	4.07	Good
2008	Basin Sample	EPT	4.83	4.83	Good
2013	Basin Sample	EPT	4.04	4.04	Good

Link to the Biological Report: https://www.ncwater.org/?page=672&SiteID=BB259

10.6.2.2 Little Coharie Creek Watershed Summary

Water quality in Little Coharie Creek is impacted by both point and nonpoint sources of pollution. There is one point-source discharger, Roseboro WWTP, which discharges to the river. Nonpoint sources of pollution in this watershed include swine and poultry feeding operations, agriculture practices, manure applications to cropland, septic systems and/or straight pipes, domestic animals, and wildlife.

Fecal coliform bacteria concentrations in the Little Coharie Creek exceed the 400 colonies/100 mL water quality standard at least 1 out of 5 samples collected during the most recent five years on record. These concentrations have also increased since the year 2000. A review of the compliance history for the only point-source discharger indicates several notices of violation and enforcement cases for exceeding the fecal coliform bacteria weekly mean permit limit between 2010 and 2020. These effluent limit violations alone may not fully explain all the elevated fecal coliform bacteria concentrations recorded in Little Coharie Creek. One example case occurred in 2017 when the Roseboro WWTP did not have any limit violations for fecal coliform bacteria, and the effluent concentrations ranged from 4 to 182 colonies/100 mL; however, high fecal coliform bacteria concentrations were recorded in Little Coharie Creek indicating possible nonpoint pollution sources.

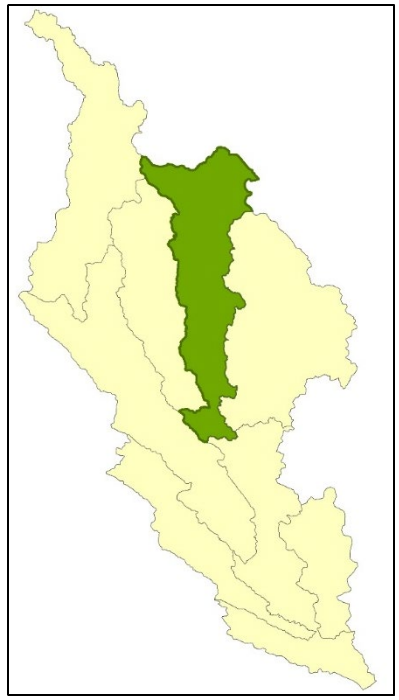
Ammonia concentrations in Little Coharie Creek spiked in 2019. This could have been impacts from the Roseboro WWTP as the ammonia concentration in their effluent was considerably higher in 2019 (range: 0.2 – 30.4 mg/L) compared to the historical record between 2010 and 2018 (range: 0.02 – 7.9 mg/L).

Possible nonpoint sources of these high ammonia concentrations include groundwater, failing septic and sewer systems, animal feeding operations, agriculture, and atmospheric deposition. Nitrogen concentrations in Little Coharie Creek were elevated primarily due to recent occurrences of high nitrate+nitrite concentrations. These nitrate+nitrite concentrations exceed the concentrations considered normal for minimally impacted streams. Nonpoint sources of pollution are contributing to these elevated nitrogen concentrations as seen in the unnamed tributaries of Bearskin Swamp, which lacks point source dischargers. Tributaries of Bearskin Swamp, which flow into Little Coharie Creek, were identified as having measurable manure effects from swine and poultry animal feeding operations (Harden, 2015). Hornet Swamp is another tributary of Little Coharie Creek with a measurable manure effect from swine animal feeding operations (Harden, 2015). While phosphorus concentrations were typically low, occasionally high values were recorded more often in years 2012, 2013, 2019 and 2020.

The increasing fecal coliform bacteria, and nutrient (total phosphorus and nitrate+nitrite) concentrations detected at the most downstream monitoring station in Little Coharie Creek are concerning as these contribute flow to the Great Coharie Creek. Poor water quality from elevated fecal coliform bacteria levels and nutrients are caused by both point and nonpoint sources of pollution in this watershed. *Localized water quality monitoring and best management practices to address the nutrients and fecal coliform bacteria levels are necessary to improve water quality in this watershed. Additional recommendations for the Little Coharie Creek watershed include*:

- Stream walking much of the watershed to assist in identifying sources of water quality problems.
- Working with the local county health department in having straight pipes that were identified during stream walks removed and septic systems repaired.
- Partnering with agencies such as the local County Soil and Water Conservation District and the US Department of Agriculture – Natural Resources Conservation Service to help facilitate communication with landowners and encourage them to implement agricultural best management practices.
- Reduction of nonpoint source pollution runoff through forested buffers alongside streams, wetland and stream restoration, erosion and sediment control best management practices, and implementation of agriculture BMPs where needed (e.g., cover crops, grassed waterways, livestock exclusion, filter strips and field borders).
- Improving operations at the Roseboro WWTP to prevent fecal coliform limit violations and elevated ammonia concentrations from impacting the Little Coharie Creek water quality.

10.6.3 Great Coharie Creek Watershed (0303000604)



The Great Coharie Creek watershed drains a 221 square mile area in central Sampson County. The upper reaches of this watershed are the Great Coharie Creek, Beaverdam Swamp, and Kill Swamp, which come together in northern Sampson County. Downstream from this confluence, the Great Coharie Creek continues to flow south with contributing swamp-classified tributaries, including Ward Swamp, William Old Mill Branch, and Rocky Marsh Creek. There are two surface water quality monitoring stations on this river but no routinely sampled biological community monitoring sites in the Great Coharie Creek watershed. These converging coastal plain rivers comprise smaller slow-moving tannin-stained streams that drain wetland areas. The primary land covers in this watershed are agricultural land (43.1%), forest land (20.7%), and wetlands (20.5%), followed by developed land (9.2%), grassland/shrub (6.0%), barren land (<0.1%), and open water (0.5%).

As of May 2022, there were many permitted facilities and application fields located in the Great Coharie Creek watershed. A total of 105 AFOs with total allowable head count of 459,776, allowable weight of 59.9 million pounds and 214 lagoons scattered across this entire watershed. There are three non-discharge permitted facilities (one major and two minor) with 23 fields covering approximately 1.84 square miles in this watershed near Beaverdam Swamp and Williams Old Mill Branch. Notably, there are two NPDES permitted facilities located near these same two streams and a third facility located east of the Town of Garland. These three NPDES-permitted facilities have a combined as-built flow totaling 5.326 MGD. There are also 13 NPDES stormwater permits and one state stormwater permit.

In 2010, as part of the Environmental Enhancement Program to support the Great Coharie Creek Watershed Management Plan, a special study was conducted on several streams located in the headwaters of the Great Coharie Creek watershed (NCDEQ, 2010b). Additionally, there was a Water Quality Integrated Analysis Report for the Great Coharie Creek Local Watershed Plan completed in 2013. In addition to the Great Coharie Creek Local Watershed Plan, there are researchers from North Carolina State University working on a study titled ***Fecal Contamination Source Tracking and Forecasting to Support Recreational and Cultural Development in the Black River Watershed*** (Weblink).

In 2019, the Coharie Tribe was acknowledged by the North Carolina Wildlife Federation's Governor's Conservation Achievement Awards as the Water Conservationist of the Year. "After hurricanes and decades of neglect closed off access to the Coharie River, a cultural and community touchstone for this southeastern North Carolina tribe, Native American leaders marshalled grant funding, community involvement, academics, and scientists to help clear the river for small-scale boat navigation and reconnect the tribe to its ancestral waters. Bringing together cultural, historical, and natural assets, the tribe dedicated three years and 5,000 volunteer hours to restore access to the river." (Weblink) (NCWF, 2019).

10.6.3.1 Great Coharie Creek Physical, Chemical Monitoring, and Biological Monitoring

The Great Coharie Creek from the source to the Black River spans approximately 42.6 river miles across central Sampson County [AU#: 18-68-1a and 18-68-1b]. Great Coharie Creek is classified as class C with a supplemental classification of swamp due to the natural characteristics of swamps, such as low dissolved oxygen and pH. Information regarding dissolved oxygen in waterways of the Black River subbasin can be found in Section 10.8.2. There are two surface water quality monitoring stations but no routinely sampled biological community stations in Great Coharie Creek.

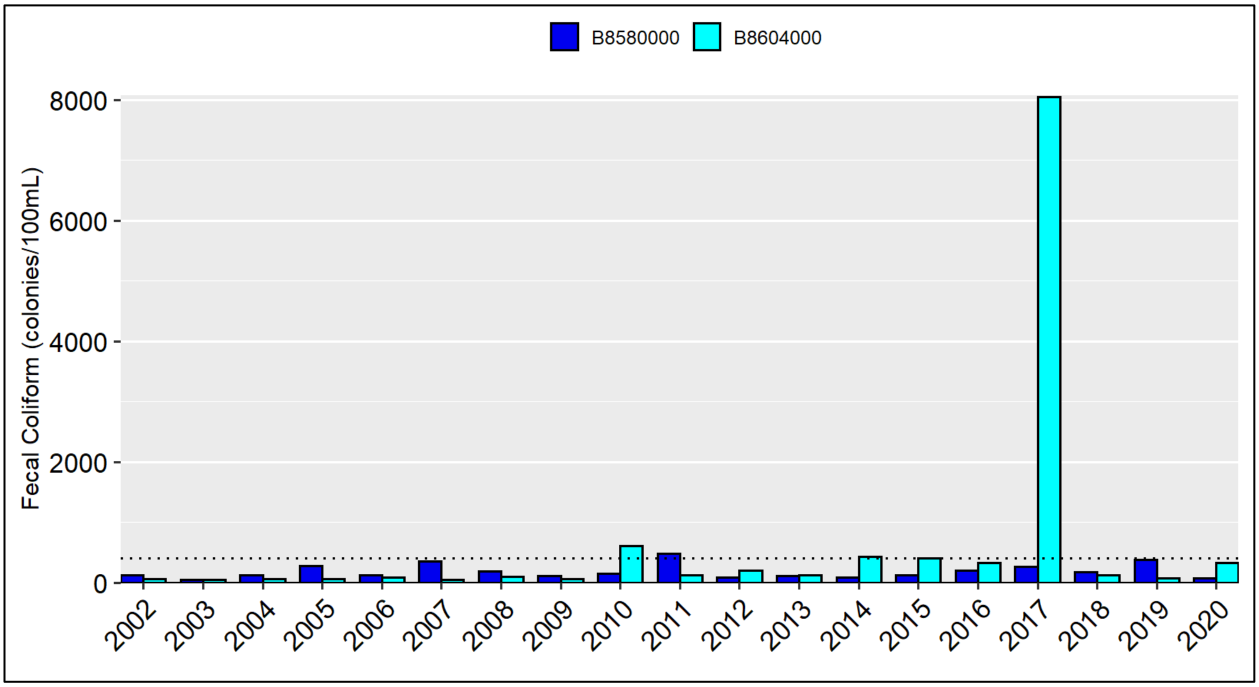
Although there are no routinely sampled biological community monitoring stations, there was a special study using biological community stations conducted in the Great Coharie Creek watershed in 2010 for the development of a Local Watershed Plan (NCDEQ, 2010b). The study stations were located on Sevenmile Swamp, Kill Swamp, Great Coharie Creek, and Beaverdam Swamp. The biologists concluded that none of the benthic sites in this study received a classification of Severe, though two-thirds (six out of nine) of the stations received swamp scores of four and were therefore near the threshold between Moderate and Severe. The most downstream station (BB508) in the study area received both the lowest biotic index value and the best bioclassification of Natural, an indication that the effects from any potential stressors in the remainder of the area are not carried downstream. Habitat differences may be playing a larger role than water quality in the composition of the benthic communities at the nine sites sampled for this study (NCDEQ, 2010b).

The most upstream surface water quality monitoring station B8580000 receives drainage from approximately 61% of this watershed area. Downstream from this water quality monitoring station is station B8604000. Station B8604000 receives drainage from approximately 82% of the watershed area. As of 2019, the land cover draining to this downstream station was primarily composed of agricultural land (46%), wetlands (20%), forest land (19%), developed land (10%), grassland/shrub (5%) and open water (1%). Since 2001, land cover draining to this station had not changed significantly.

From 2016 to 2020, approximately 14% of the fecal coliform bacteria samples had concentrations greater than 400 colonies/100 mL at station B8580000 and 16% at station B6040000. While elevated fecal coliform bacteria levels were detected at both sections of Great Coharie Creek, annual mean fecal coliform bacteria levels were typically less than the 400 colonies/100 mL water quality standard (*Figure 10-21*). Between these two surface water quality monitoring stations on Great Coharie Creek is the confluence with Williams Old Mill Branch.

Williams Old Mill Branch (Stream Index: 18-68-1-10) receives runoff from the Town of Clinton; the largest municipality in Sampson County. Additionally, Williams Old Mill Branch receives discharge from the Norman H. Larkins WPCF (water pollution control facility) (Permit Number: NC0020117) with an as-built discharge of 5 MGD. During February 2014 through January 2019, 24 violations were reported, including: five biological oxygen demand, 10 fecal coliform, two ammonia-nitrogen, and six total suspended solids. Among the reported violations, 15 resulted in violation action. Notably, the effluent discharge from Normal H. Larkins WPCF had fecal coliform bacteria concentrations that ranged from less than 1 to 52,000 colonies/100 mL. The NPDES compliance process will be used to address the significant permit violations noted above.

Figure 10-21: Annual Mean Fecal Coliform Bacteria Concentrations in the Great Coharie Creek (B8580000 and B8604000) between 2002 and 2020.



Annual mean total nitrogen concentrations at both surface water quality monitoring stations fluctuated around and slightly above 1.0 mg/L (*Figure 10-22*). Total Kjeldahl nitrogen is the primary nitrogen species present in the total nitrogen signature for Great Coharie Creek, with concentrations typically below 1 mg/L (*Figure 10-23*). Annual mean total nitrogen concentrations have reached and exceeded 1.5 mg/L when higher nitrate+nitrite concentrations are recorded in this waterway (*Figure 10-24*). Upstream ammonia, as well as nitrate+nitrite concentrations, were typically lower compared to downstream water quality (*Figure 10-24* and *Figure 10-25*).

Annual mean total phosphorus concentrations remained mostly below 0.1 mg/L at the most upstream station (B8580000), except for two occurrences in 2007 and 2011; however, concentrations remained chiefly above 0.2 mg/L at the downstream monitoring station (B8604000), except for a single episode in 2003 (*Figure 10-26*). In 2011, the upstream station exceeded the downstream station, which was also true for a majority of the other parameters sampled. At the most downstream surface water quality monitoring station on Great Coharie Creek, the highest annual mean total phosphorus concentrations were observed in 2016 to 2019 when compared to all monitored waterways in the Black River subbasin watersheds. In 2020, this same station recorded the second highest annual mean total phosphorus concentrations, second only to Colly Creek. These annual mean nutrient values at the most downstream station were greater than concentrations considered normal for minimally impacted streams.

Figure 10-22: Annual Mean Total Nitrogen Concentrations in the Great Coharie Creek (B8580000 and B8604000) between 2002 and 2020.

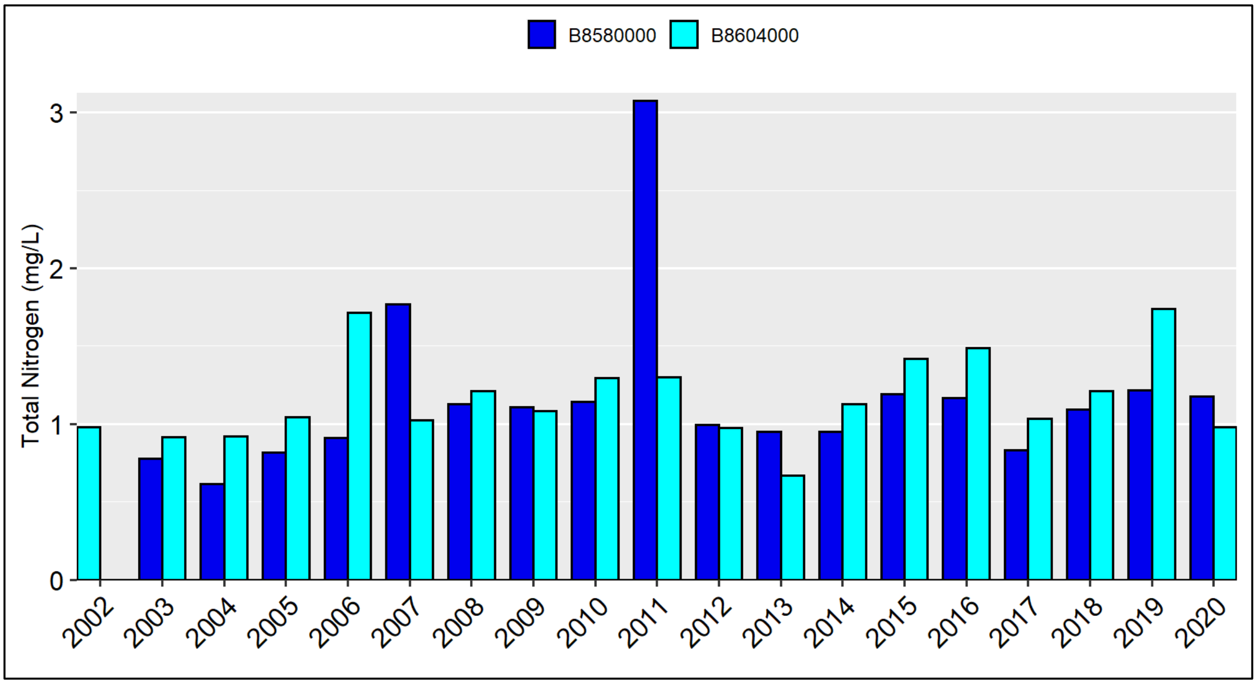


Figure 10-23: Annual Mean Total Kjeldahl Nitrogen Concentrations in the Great Coharie Creek (B8580000 and B8604000) between 2002 and 2020.

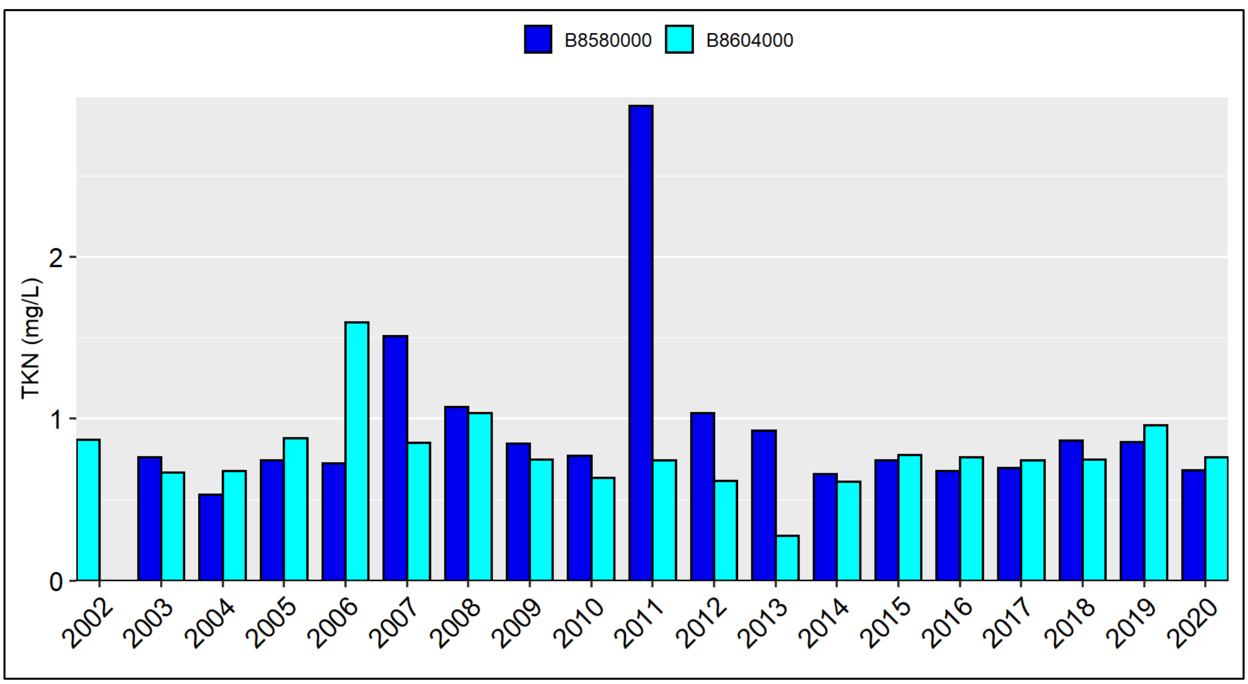


Figure 10-24: Annual Mean Nitrate+Nitrite Concentrations in the Great Coharie Creek (B8580000 and B8604000) between 2002 and 2020.

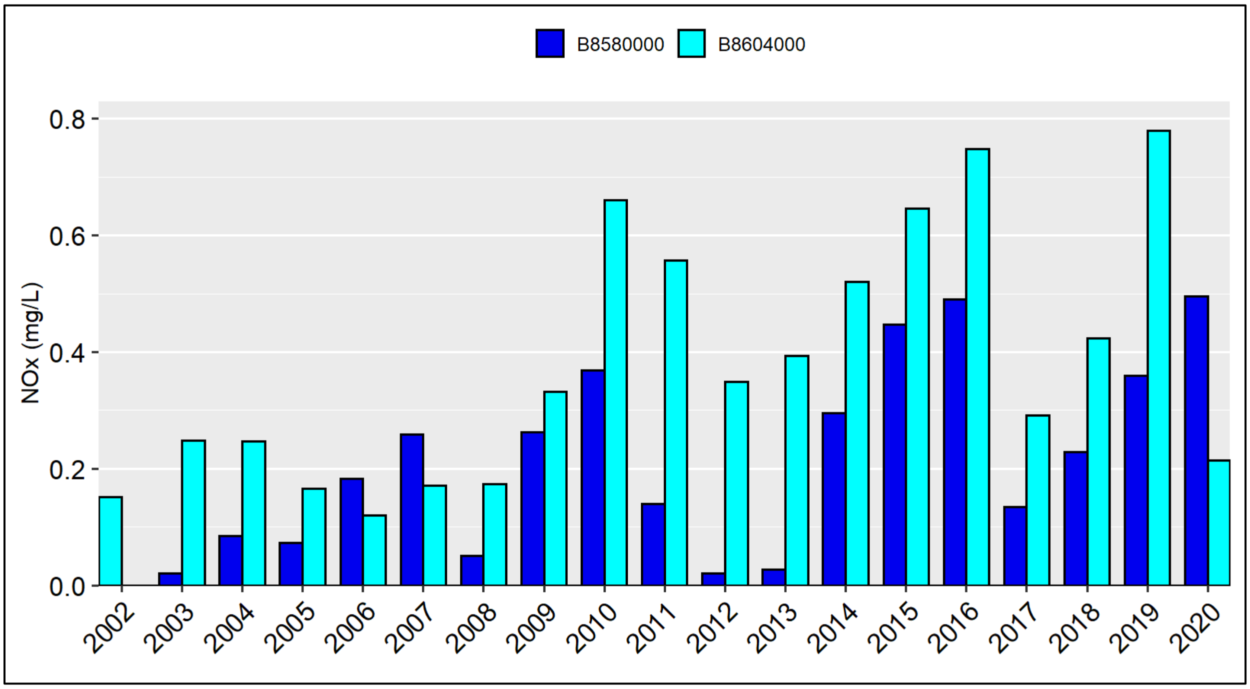


Figure 10-25 Annual Mean Ammonia Concentrations in the Great Coharie Creek (B8580000 and B8604000) between 2002 and 2020.

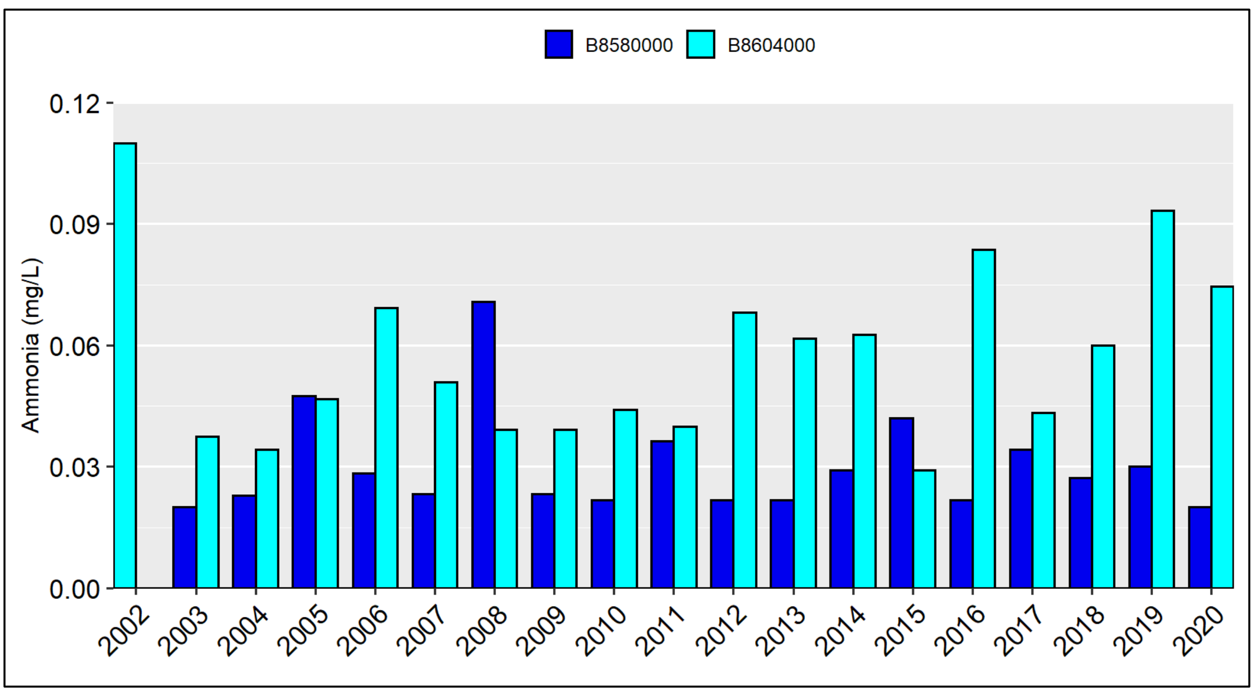
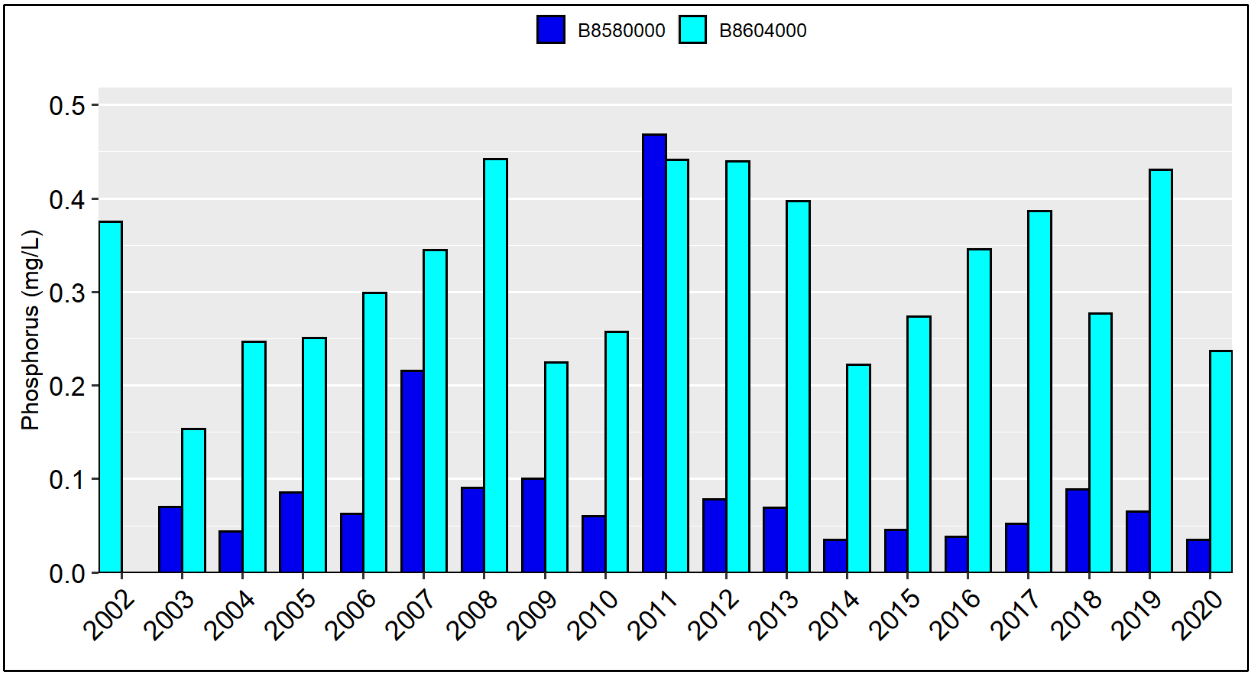


Figure 10-26: Annual Mean Total Phosphorus Concentrations in the Great Coharie Creek (B8580000 and B8604000) between 2002 and 2020.



DWR conducted screening level Mann-Kendall trend seasonal tests for dissolved oxygen, pH, fecal coliform, nitrate+nitrite, specific conductance, and total phosphorus at the downstream station (B8604000) on Great Coharie Creek with significant increasing trends calculated at 95% confidence for data collected from 2000-2019. A significant decreasing trend was calculated for ammonia. Mallin et al. (2022) also found significant increases in fecal coliform, nitrate, total nitrogen, and total phosphorus at this same station using the LCFRP monitoring data collected from 2000-2019. Mallin et al. (2022) also found a significant decrease in ammonia.

10.6.3.2 Great Coharie Creek Watershed Summary

Water quality in Great Coharie Creek is impacted by both point and nonpoint sources of pollution. There are several point source dischargers, including one major permitted facility (Norman H. Larkins WPCF; NC0020117), which discharges into the Williams Old Mill Branch, a tributary of Great Coharie Creek. Effluent concentrations from this facility exceeded its permitted fecal coliform bacteria limit with values exceeding 50,000 colonies/100 mL. Nonpoint sources of pollution in this watershed include animal feeding operations, agriculture practices, manure applications to cropland, septic systems and/or straight pipes, domestic animals, and wildlife.

The headwaters of Great Coharie Creek watershed had a local watershed plan developed highlighting the primary concerns for the planning area that included Sevenmile Creek, Kill Swamp, Great Coharie Creek, and Beaverdam Swamp. "The primary water quality concerns in this planning area are nutrient and sediment inputs from agriculture. High nutrient and sediment loads enter the fluvial system from the network of ditches and waterways, especially where there are no buffers. The forests and seasonally flooded riparian floodplains along the mainstem streams provide the highest hydrology, water quality and habitat watershed functions within the study area. They slow flood waters, releasing water during lower flows; significantly improve water quality, especially in the saturated root zones of woody riparian vegetation; and provide important aquatic and riparian habitat. These wide mainstem swamps act as natural filters, sustaining and improving water quality as water moves through the system.

Efforts to restore and protect the Great Coharie Creek local watershed should focus on two primary goals:

1. Reduce runoff and erosion by slowing and filtering water, nutrients, and sediment at their source in the fields. This could be accomplished through agricultural best management practices (BMPs), installing vegetated buffers along ditches and waterways, and allowing ditches to become naturally vegetated with plants.
2. Protect the riparian floodplains. "These seasonally flooded mainstem riparian zones are the most important feature of the Great Coharie Creek and provide tremendous ecological functions. They help sustain the rich natural heritage in the Great Coharie Creek and the Black River." (NCDEQ, 2014).

Included in the Great Coharie Creek Local Watershed Plan was a table of stressors with primary sources and management measures (*Table 10-16*). While the headwaters of the Great Coharie Creek watershed have a local watershed plan developed, a better understanding of the downstream impacts to water quality is needed.

In the downstream section of Great Coharie Creek, fecal coliform bacteria concentrations exceeded the 400 colonies/100 mL water quality standard for approximately 1 out of 6 samples during the 2016 to 2020 period. While this frequency is less than the nearby Little Coharie Creek, the fecal coliform bacteria concentrations collected in Great Coharie Creek are higher. Downstream, elevated total nitrogen and total phosphorus concentrations were also observed. These elevated fecal coliform bacteria concentrations are most likely from a combination of contributions from both point and nonpoint sources.

Poor water quality from elevated fecal coliform bacteria levels and nutrients are caused by both point and nonpoint sources of pollution in this watershed flowing into the Black River. *Localized water quality monitoring and best management practices to address the nutrients and fecal coliform bacteria levels are necessary to improve water quality in this watershed. Additional recommendations for the Great Coharie Creek watershed include:*

- Stream walking much of the watershed to assist in identifying sources of water quality problems.
- Working with the local county health department in having straight pipes that were identified during stream walks removed and septic systems repaired.
- Partnering with agencies such as the local County Soil and Water Conservation District and the US Department of Agriculture – Natural Resources Conservation Service to help facilitate communication with landowners and encourage them to implement agricultural best management practices.
- Reduction of nonpoint source pollution runoff through forested buffers alongside streams, wetland and stream restoration, erosion and sediment control best management practices, and implementation of agriculture BMPs where needed (e.g., cover crops, grassed waterways, livestock exclusion, filter strips and field borders).

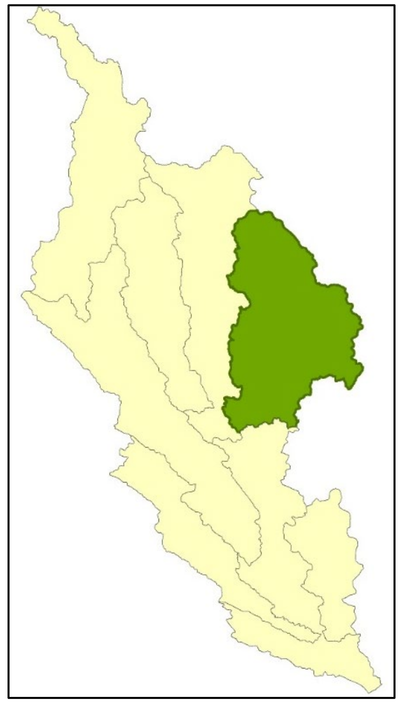
- Improving operations at the Norman H. Larkins WPCF (NC0020117) to prevent violations of the permitted limits and eliminate impacts to Great Coharie Creek water quality.

Table 10-16: Stressor, Primary Sources, and Management Measures for Great Coharie Creek Watershed (NCDEQ, 2014)

Stressors	Primary Sources	Management Measures
Loss of riparian buffer	Removal of riparian vegetation; land use development	Implement stream and wetland restoration and enhancement projects; implement stream and wetland preservation projects; implement agricultural BMPs; establish a ditch and buffer management education program; develop a landowner resource guide; restore native riparian buffer
Invasive aquatic vegetation	Native and exotic plant matter transported by flow and animals as well as natural propagation	Control invasive aquatic plants: educate boaters, paddlers and fishermen about invasives and how to avoid spreading them
Loss of in-stream habitat	Channel modifications and dredging; sedimentation	Implement stream and wetland restoration and enhancement projects; implement stream and wetland preservation projects; implement agricultural BMPs; establish a ditch and buffer management education program; develop a landowner resource guide
Erosion / sedimentation	Overland runoff from agriculture and spoil areas; stream bank erosion; livestock access to streams; channel modification; riparian disturbance	Implement stream and wetland restoration and enhancement projects; implement agricultural BMPs and reduce erosion; establish a ditch and buffer management education program; recognize watershed stewards; develop a landowner resource guide; restore native riparian buffers
Loss of floodplain connection	Channel modification and dredging	Implement stream and wetland restoration and enhancement projects; implement stream and wetland preservation projects; implement agricultural BMPs that increase the flood-prone area of channels; establish a ditch and buffer management education program
Restricted aquatic species movement	Stream blockages; invasive aquatic plants; impoundments (beaver and man-made); exposed utility crossings	Control invasive aquatic plants; encourage water-based recreation and community engagement; manage beaver impacts when appropriate; install utility crossings underground; clear flow obstructions

Stressors	Primary Sources	Management Measures
Flow alterations	Channel straightening and dredging; impoundments (beaver and man-made); overland runoff; subsurface drainage tiles; stormwater runoff; ditches	Implement stream and wetland restoration and enhancement projects; implement stream and wetland preservation projects; implement agricultural BMPs; control invasive aquatic plants; manage beaver impacts; establish a ditch and buffer management education program; recognize watershed stewards; develop a landowner resource guide; remove drainage tiles
Elevated inorganic nitrogen and total phosphorus; Elevated pathogen loads	Livestock access to streams; agricultural runoff and subsurface flows; failing septic systems; improperly managed livestock operations or swine lagoons; wind-blown fertilizer	Implement stream and wetland restoration and enhancement projects; implement stream and wetland preservation projects; exclude livestock from channels; establish a ditch and buffer management education program; recognize watershed stewards; develop a landowner resource guide
Low DO	Stream blockages; excessive algae growth; invasive aquatic plants; impoundments (beaver and man-made); excessive nutrients	Implement stream and wetland restoration and enhancement projects; implement stream and wetland preservation projects; implement agricultural BMPs; control invasive aquatic plants; manage beaver impacts; establish a ditch and buffer management education program; develop a landowner resource guide
Loss of high value forest and wetlands	Sedimentation from agriculture, spoil areas, and stream bank erosion; livestock access to riparian zone; channel modification and dredging; riparian disturbance and removal of riparian vegetation; land use development; ditching and draining wetlands for agricultural or timber production; impoundments (beaver and manmade); timber harvesting	Implement stream and wetland restoration and enhancement projects; implement stream and wetland preservation projects; encourage water-based recreation and community engagement; promote natural heritage; establish a ditch and buffer management education program; recognize watershed stewards; develop a landowner resource guide; establish conservation easements on large forest tracts

10.6.4 Six Runs Creek Watershed (0303000605)



The Six Runs Creek watershed drains most of eastern Sampson County and a fraction of western Duplin County. The upper reaches of this watershed are the Six Runs Creek, Kinas Branch, and Hoe Swamp, which come together northwest of Poplar Grove. Downstream from this confluence, Six Runs Creek continues to flow south with contributing swamp-classified streams, including Rowan Branch, Stewarts Creek, and Quewhiffle Creek. These converging coastal plain rivers comprise smaller, slow-moving tannin-stained streams that drain wetland areas. There are two surface water quality monitoring stations on this river and two biological community monitoring stations in this watershed. The primary land covers in this watershed are agricultural land (40.1%), wetlands (18.7%), and forest land (25.7%), followed by developed land (7.1%), grassland/shrub (7.9%), barren land (<0.1%), and open water (0.45%).

There were many permitted facilities and application fields located in the Six Runs Creek watershed as of May 2022. A total of 159 AFOs with total allowable head count of 984,268, allowable weight of 126.1 million pounds and 390 lagoons scattered across this entire watershed. There are four non-discharge permitted facilities in this watershed located along Highway 24 from Warsaw to Moltonville. There are an additional four non-discharge permitted facilities near Cane Creek, Gaddy Branch and Robinson Mill Branch. All these rivers converge with Six Runs Creek. These eight non-discharges permitted facilities have a combined 65 application fields covering approximately 0.41 square miles.

There are seven NPDES permitted facilities in this watershed with as-built flows totaling 1.165 MGD. These minor permitted facilities individually discharge less than 1.0 MGD. Magnolia WWTP (NC0020346) discharges into an unnamed tributary in the headwaters of Stewarts Creek with an as-built flow of 250,000 GPD. The Town of Warsaw WWTP (NC0021903) discharges directly to Stewarts Creek with an as-built flow of 915,000 GPD. The Magnolia WWTP and Warsaw WWTP both have generally good histories of compliance based on monitoring data collected between April 2017 through December 2020. The Parson-Anders WTP discharges to Rowans Branch, which is located west of Moltonville. The other four permitted facilities are minor non-contact cooling, boiler blowdown wastewater discharge permitted facilities. There are also 20 NPDES stormwater and 26 state stormwater permitted facilities in this watershed.

In November 2022, the Cape Fear River Watch (CFRW) submitted a report to NC DEQ titled *Improper Poultry Litter Storage Impacts Surface Water of the Cape Fear River Basin*. CFRW writes that the "report provides a case study demonstrating negative water quality impacts that result from the improper waste management of poultry litter at one location in the Cape Fear basin." (CFRW, 2022). The report highlights six surface water sampling events taken from an unnamed tributary of Six Runs Creek downstream from an "uncovered dry litter site in Sampson County" (CFRW, 2022). Surface water quality results indicated "fecal coliform levels doubled state (water quality) standards [200 colonies/100mL] four out of six times" (CFRW, 2022). Additionally, "the presence of antibiotics in samples further supports the notion that elevated bacteria levels in downstream surface waters are a result of runoff from the litter piles upstream of the sample site. Antibiotics are not found in natural systems at the concentrations found in collected samples." (CFRW, 2022). According to the report, tetracycline and danofloxacin were detected at levels ranging from 9.0 to 245 ug/L and 9.6 to 25 ug/L, respectively. "Danofloxacin and Tetracycline are frequently used in veterinary treatment of confined animals, with Tetracycline being the most commonly used antibiotic treatment for poultry related diseases. The concentrations of these antibiotics in collected samples were higher than previously sampled sites in the Piedmont region of North Carolina." (CFRW, 2022). The study also found elevated organic nitrogen (TKN) concentrations ranging from 0.7 to 1.9 mg/L with an average of 1.18 mg/L over the five-month sampling period (Feb-June 2022). Total phosphorus was also elevated with an average concentration of 0.22 mg/L. For comparison, the Black River subbasin 5-year (2016-2020) mean nutrient concentrations for TKN and TP respectively are approximately half of the observed values at 0.86 and 0.13 mg/L, respectively. These concentrations are higher than those observed in minimally impacted streams (*Table 10-11*). CFRW concluded that "due to the size of the waste piles and visible drainage patterns from aerial images, it is likely that runoff from the site is affecting water quality in the downstream tributary of Six Runs Creek." (CFRW, 2022).

10.6.4.1 Six Runs Creek Physical and Chemical Monitoring

Six Runs Creek from its source to Quewhiffle Creek spans approximately 37.7 river miles [AU#: 18-68-2-(0.3)a, 18-68-2-(0.3)b, and 18-68-2-(11.5)]. This upstream section of Six Runs Creek is classified as class C with a supplemental classification of swamp due to the natural characteristics of swamps, such as low dissolved oxygen and pH. Information regarding dissolved oxygen in waterways of the Black River subbasin can be found in Section 10.8.2. Six Runs Creek from Quewhiffle Creek to Black River [AU#: 18-68-2-(11.5)] has an additional supplemental classification as ORW due to the water's outstanding national and state ecological and recreational significance. Immediately downstream from the confluence of Six Runs Creek with Quewhiffle Creek are co-located surface water quality and biological community monitoring stations. These stations receive drainage from approximately 82% of the watershed. Downstream from the water quality monitoring station (B8725000) is a second water quality monitoring station (B8740000). This water quality monitoring station is positioned to capture drainage from nearly 100% of the Six Runs Creek watershed. The land draining to this most downstream surface water quality monitoring station is primarily composed of agricultural land (40%), forest land (26%), and wetlands (19%), followed by grassland/shrub (8%), and developed land (7%). Since 2001, there has not been a significant change in land cover.

During the 2016 to 2020 period at station B8725000, high fecal coliform bacteria events were detected in approximately 22% of the surface water sampling events (*Figure 10-27*). These high fecal coliform events are not the highest found in the Black River subbasin; however, during 2019, four of the sampling events recorded values more than 1,000 colonies/100 mL. At station B8740000, like the upstream station, high fecal coliform bacteria were detected in approximately 26% of the sampling events between 2016 and 2020. Notably, a value of 60,000 colonies/100 mL was detected at station B8740000 during this 5-year period. This single value is the highest value measured across all surface water quality monitoring stations in this subbasin. During 2016 to 2020, 15 sampling events recorded fecal coliform bacteria levels greater than 400 colonies/100 mL. Five of these 15 samples recorded fecal coliform bacteria levels greater than 10,000 colonies/100 mL.

During 2016 to 2020, the total nitrogen concentrations recorded at both surface water monitoring stations in Six Runs Creek were concerning as this river recorded the highest annual means in 2017, 2018 and 2020 of all the long-term monitored rivers in the Black River subbasin (*Figure 10-28*). These elevated total nitrogen concentrations are primarily driven by higher than historical readings of nitrate+nitrite nitrogen concentrations as seen in the annual mean values that approach and exceed 1 mg/L (*Figure 10-29*). These elevated annual mean nitrate+nitrite concentrations are higher than the total Kjeldahl nitrogen concentrations, which are typically less than 1 mg/L (*Figure 10-30*). Total phosphorus concentrations were also high during 2016 to 2020 with annual mean concentrations consistently exceeding 0.1 mg/L with some years approaching or exceeding 0.2 mg/L (*Figure 10-31*). These annual mean nutrient concentrations (total nitrogen and phosphorus) are higher than concentrations considered normal for minimally impacted streams.

Overall, annual mean turbidity at stations B8725000 and B8740000 were generally low values (*Figure 10-32*). A maximum turbidity value of 39.9 NTUs was detected at station B8740000. This is the second highest measurement at a long-term water quality monitoring station in the Black River subbasin and approaches the water quality standard of 50 NTU.

DWR conducted screening level Mann-Kendall trend seasonal tests for specific conductance, nitrate+nitrite and phosphorus at stations B8725000 and B8740000 with significant increasing trends calculated at 95% confidence from data collected from 2000 to 2019. A screening level Mann-Kendall trends non-seasonal test for fecal coliform at stations B8725000 and B8740000 produced a significant increasing trend calculated at 95% confidence from data collected from 2000 to 2019. Mallin et al. (2022) also found significant increases in fecal coliform, nitrate, ammonia, total nitrogen, and total phosphorus at this same station using the LCFRP monitoring data collected between 2000 and 2019.

Figure 10-27: Annual Mean Fecal Coliform Bacteria Concentrations in Six Runs Creek (B8725000 and B8740000) between 2002 and 2020.

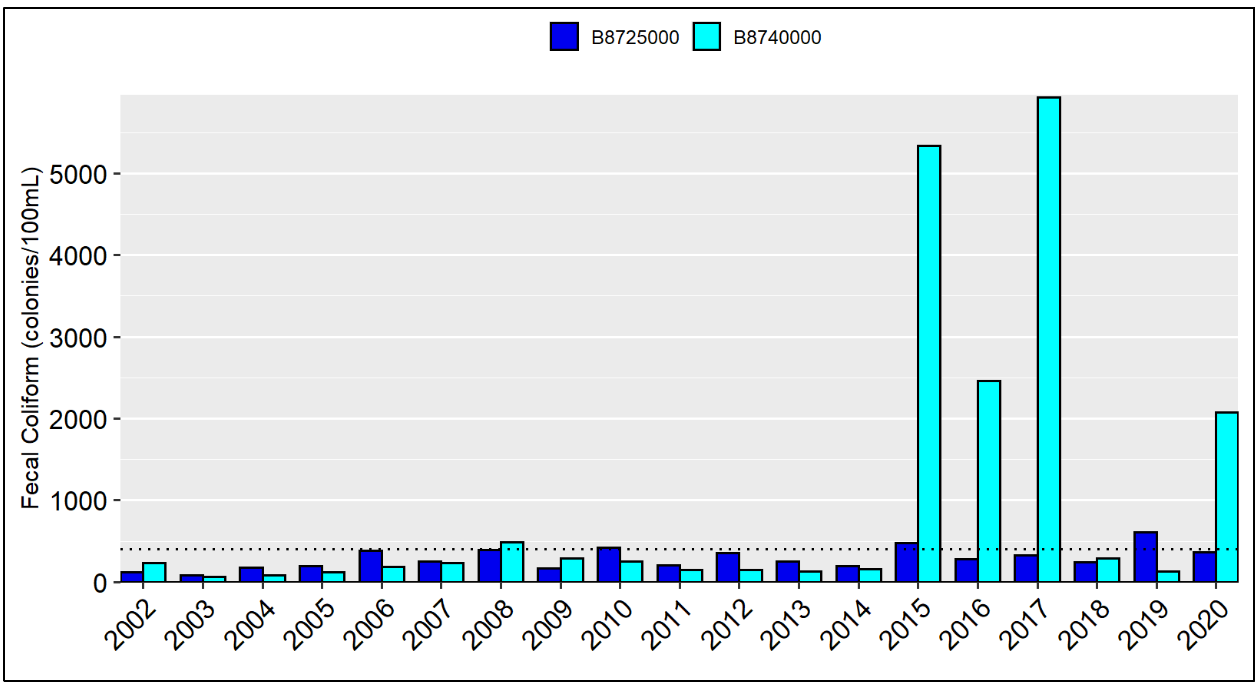


Figure 10-28: Annual Mean Total Nitrogen Concentrations in Six Runs Creek (B8725000 and B8740000) between 2002 and 2020.

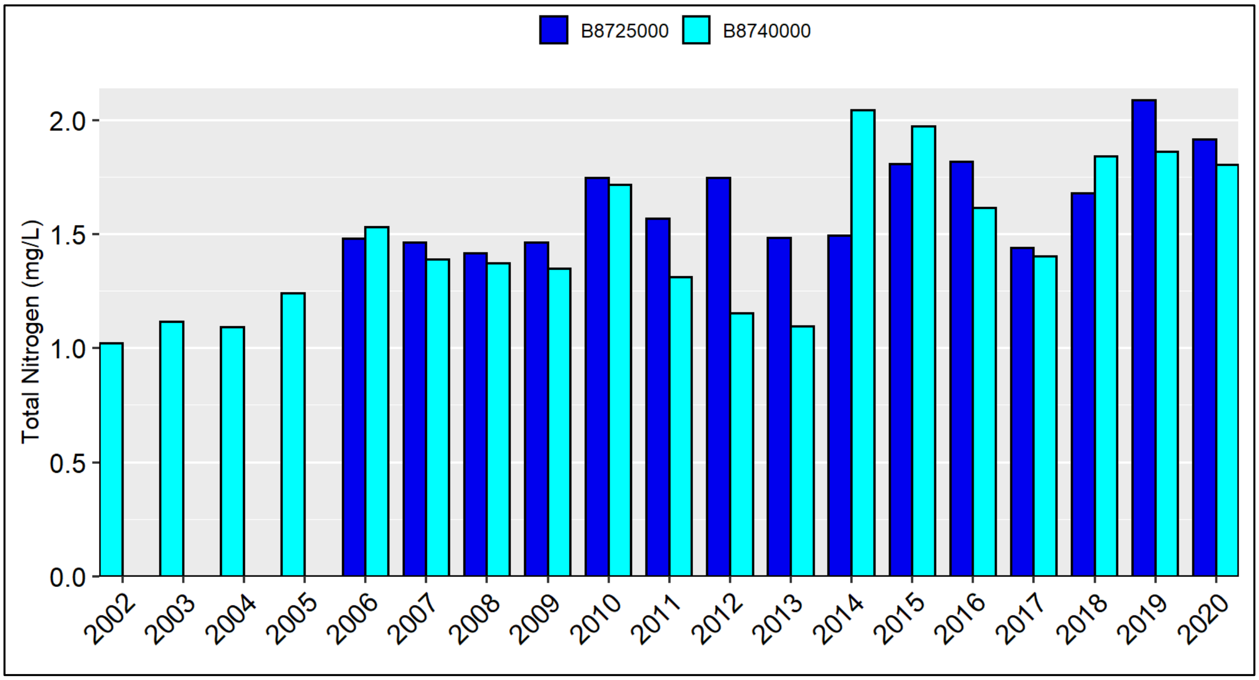


Figure 10-29: Annual Mean Nitrate+Nitrite Concentrations in Six Runs Creek (B8725000 and B8740000) between 2002 and 2020.

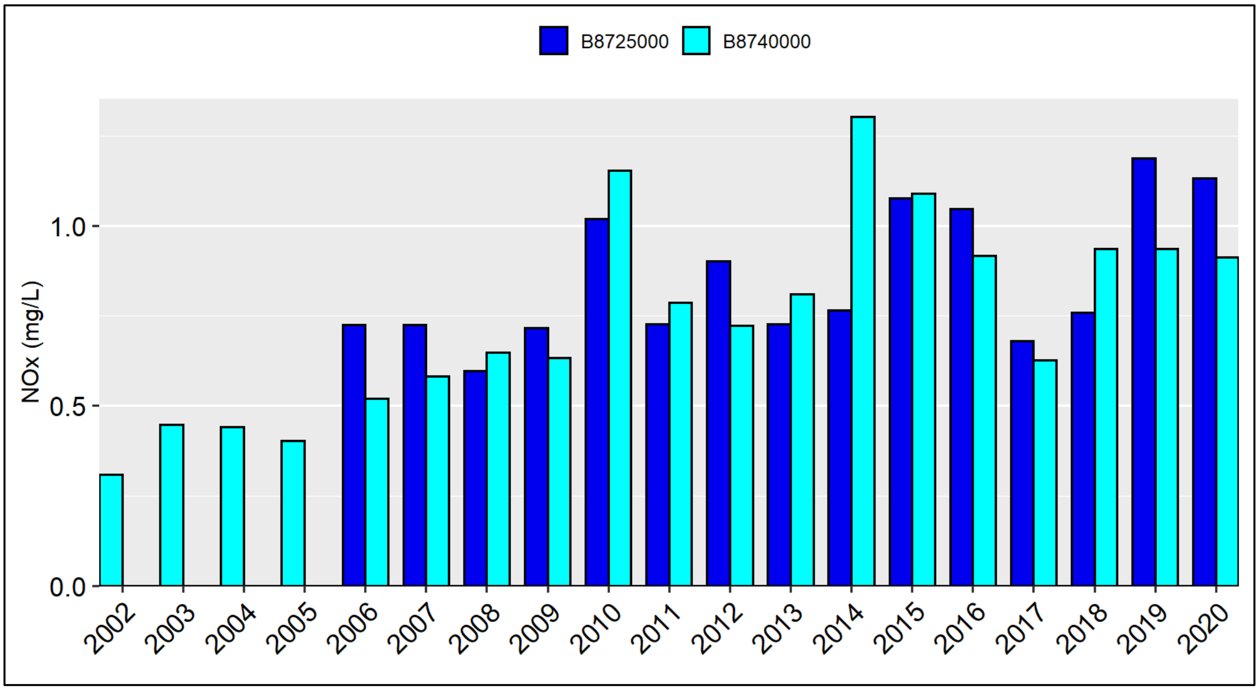


Figure 10-30: Annual Mean Total Kjeldahl Nitrogen Concentrations in Six Runs Creek (B8725000 and B88740000) between 2002 and 2020.

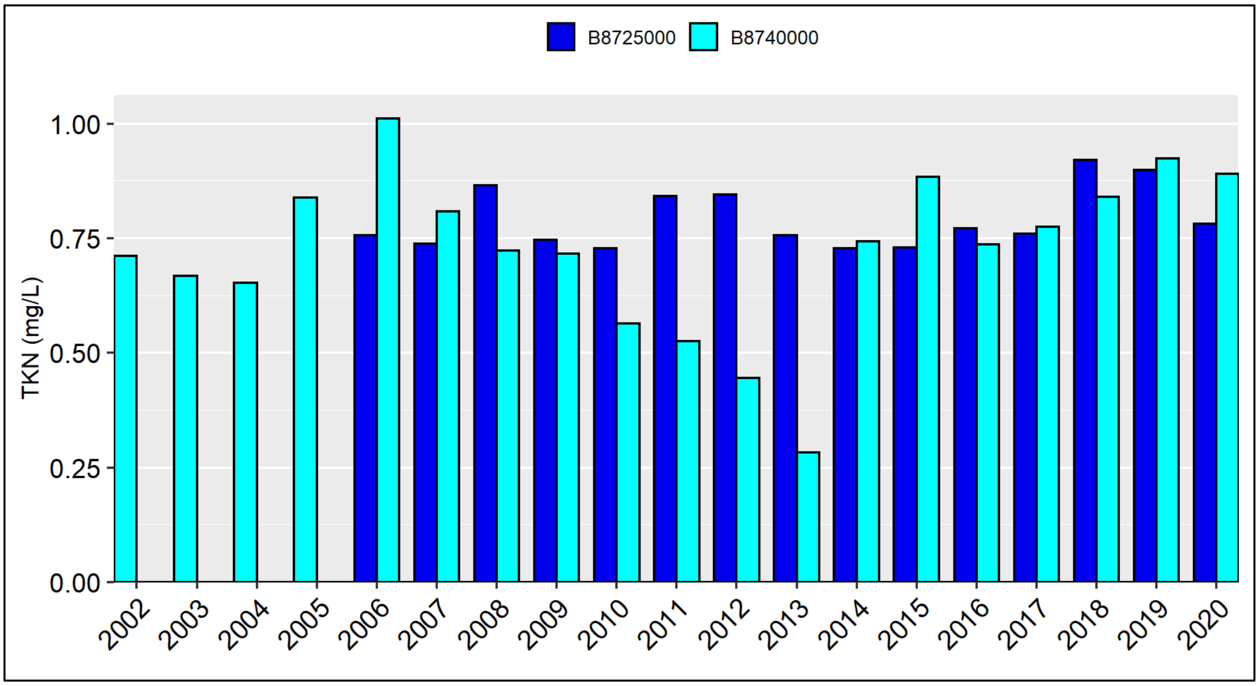


Figure 10-31: Annual Mean Total Phosphorus Concentrations in Six Runs Creek (B8725000 and B8740000) between 2002 and 2020.

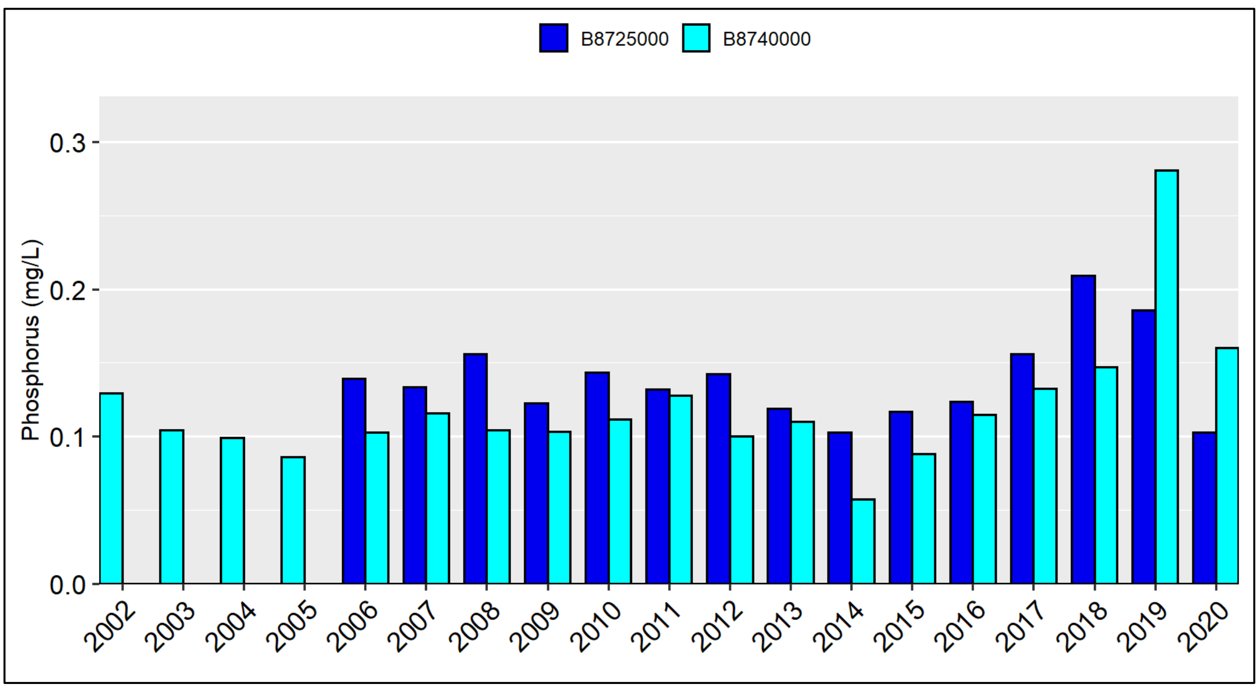
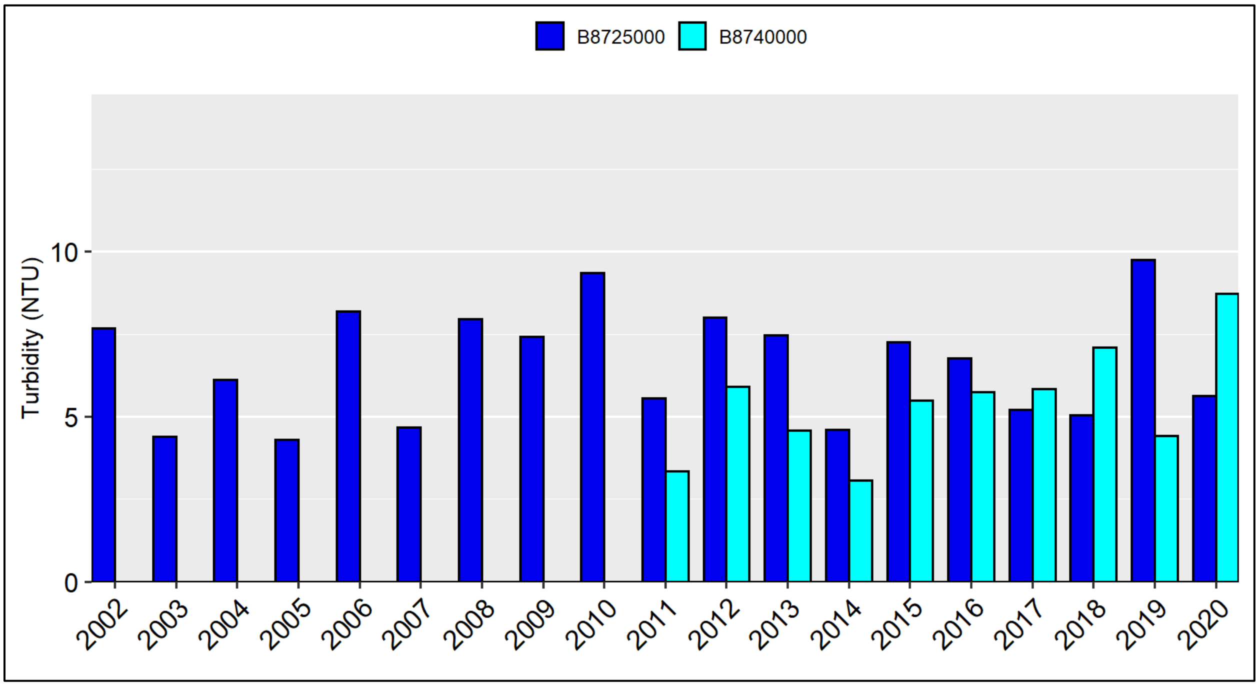


Figure 10-32: Annual Mean Turbidity Levels in Six Runs Creek (B8725000 and B8740000) between 2002 and 2020.



10.6.4.2 Six Runs Creek and Stewarts Creek Biological Community Monitoring

The biological community monitoring station BB348 is co-located at the confluence of Six Runs Creek and Quewhiffle Creek [AU#: 18-68-2-(11.5)] and was last sampled in 2009. This sampling event recorded an Excellent bioclassification although the EPT BI and biotic index were higher than in 1993 when this station last recorded an Excellent bioclassification (*Table 10-17*). Between 1993 and 2009, this station has fluctuated between Excellent, Good, and Good-Fair. Stewarts Creek, a tributary of Six Runs Creek, also has a biological community monitoring station (BB343). This station was last sampled in 2003 and recorded a Good rating.

Table 10-17: Biological Community Analysis in the Six Runs Creek at Station BB348.

Year	Study	Sample Type	EPT BI	Biotic Index	Bioclassification
1993	Basin Sample	EPT	3.61	3.61	Excellent
1998	Basin Sample	EPT	4.57	4.57	Good
1998	Special Study	EPT	5.5	5.5	Good-Fair
2003	Basin Sample	EPT	4.54	4.54	Good
2009	Basin Sample	EPT	4.5	4.5	Excellent

Link to the Biological Report: https://www.ncwater.org/?page=672&SiteID=BB348

10.6.4.3 Six Runs Creek Watershed Summary

Water quality in Six Runs Creek is impacted by both point and nonpoint sources of pollution. Point source dischargers include seven NPDES permitted facilities. Nonpoint sources of pollution in this watershed include both swine and poultry feeding operations, agriculture practices, manure applications to cropland, septic systems and/or straight pipes, domestic animals, and wildlife.

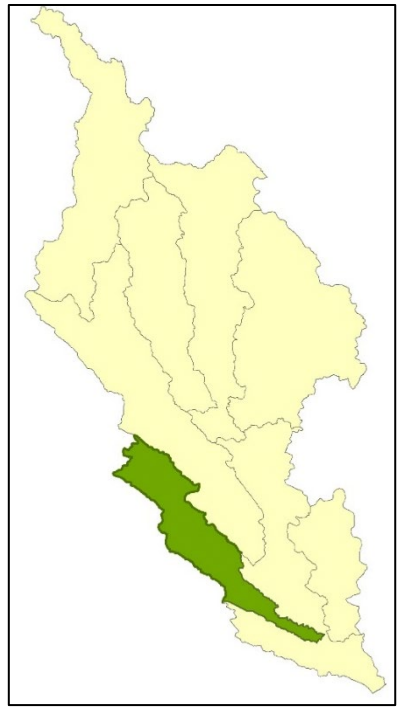
The Excellent bioclassification rating in 2009 is a good indication pollution sources were not significantly impacting the biological community; however, this is the most recent biological community monitoring data collected in this waterway. Beyond the year 2009, nutrient (total nitrogen and phosphorus) concentrations are typically higher and are increasing over time. These concentrations are typically higher than concentrations considered normal for minimally impacted streams.

Six Runs Creek has documented elevated and increasing fecal coliform bacteria concentrations. In the downstream section of Six Runs Creek, fecal coliform bacteria concentrations exceeded the 400 colonies/100 mL water quality standard for approximately 1 out of 4 samples during the 2016 to 2020 period. This watershed also has the second highest 5-year mean value for fecal coliform bacteria concentrations; second only to Great Coharie Creek. Fecal coliform bacteria concentrations in Six Runs Creek appear to be more impacted by nonpoint sources of pollution compared to point source dischargers based on compliance history of the two domestic waste discharge permitted facilities. Determining the nonpoint sources of pollution will require additional investigations. Notably, the headwaters of Six Runs Creek have been identified as containing measurable manure effects from swine and/or poultry animal feeding operations (Harden, 2015).

Source identification is necessary to help ameliorate degradation caused by nutrient enrichment and high fecal coliform bacteria in these waterways. Determining the source of these elevated fecal coliform bacteria and nutrient runoff would allow targeted best management practices in the region to mitigate the impact on downstream receiving waters. *Localized water quality monitoring and best management practices to address the nutrients and fecal coliform bacteria levels are necessary to improve water quality in this watershed. Additional recommendations for the Six Runs Creek watershed include*:

- Stream walking much of the watershed to assist in identifying sources of water quality problems.
- Working with the local County Health Department in having straight pipes that were identified during stream walks removed and septic systems repaired.
- Partnering with agencies such as the local County Soil and Water Conservation District and the US Department of Agriculture – Natural Resources Conservation Service to help facilitate communication with landowners and encourage them to implement agricultural best management practices.
- Reduction of nonpoint source pollution runoff through forested buffers alongside streams, wetland and stream restoration, erosion and sediment control best management practices, and implementation of agriculture BMPs where needed (e.g., cover crops, grassed waterways, livestock exclusion, filter strips and field borders, waste management).
- As resources allow, DWR should pursue sampling of Six Runs Creek benthic macroinvertebrate community to determine if the aquatic life in this creek has remained Excellent.

10.6.5 Colly Creek Watershed (0303000606)



The Colly Creek watershed drains 122 square miles in western Bladen County and a fraction of western Pender County. The upper reaches of this watershed are Colly Creek and Little Colly Creek. Downstream from the confluence of these two creeks, Colly Creek continues to flow south with contributing swamp classified streams including Johns Swamp Branch, Lake Drain, and Lyon Swamp Canal. There is one Carolina bay lake named Singletary Lake. There is one surface water quality monitoring station on this river and one biological community monitoring station. These converging coastal plain rivers are comprised of smaller slow-moving tannin-stained streams that drain wetland areas. The primary land covers in this watershed are agricultural land (9.9%), forest land (17.9%), and wetlands (59.9%), followed by developed land (2.6%), grassland/shrub (8.7%), barren land (0.2%), and open water (0.9%).

As of May 2022, there were many permitted facilities and fields located in this watershed. There were a total of four AFOs with total allowable head count of 13,760, allowable weight of 1.1 million pounds and six lagoons. Animal feeding operations are less prevalent in this watershed with one facility located near the upper reaches of Colly Creek and three near Little Colly Creek. There is one non-discharge permitted facility located near the Colly Creek tributary, Lake Drain, northwest of Bay Tree Lake State Park with five fields covering approximately 0.007 square miles. There is also a single NPDES permit, White Lake WWTP, near the southeastern side of White Lake with an as-built flow totaling 800,000 GPD. There are two state stormwater permits in this watershed.

10.6.5.1 Colly Creek Physical and Chemical Monitoring

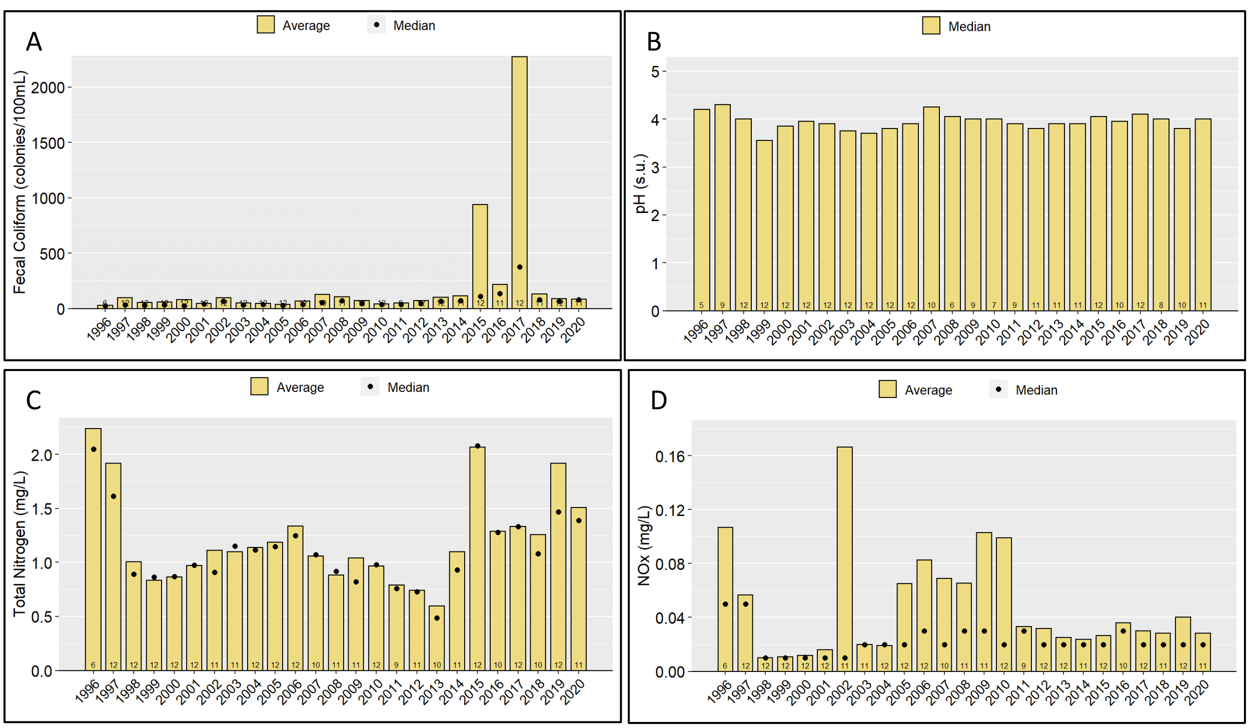
Colly Creek from the source to the Black River spans approximately 34.9 river miles [AU#: 18-68-17]. Colly Creek is a class C water with a supplemental swamp classification due to natural characteristics of swamps such as low dissolved oxygen and pH. There are also acidic streams draining natural bay lakes. There is one surface water quality monitoring station located on Colly Creek B8981000. Historically, Colly Creek was on the impaired waters list for violating the pH water quality standard; however, in 2014 a decision was made that the water quality standard violation was the result of natural conditions, and the creek was removed from the impaired waters list (NCDEQ, 2014). The natural conditions assessment is available via the NCDEQ website. Annual mean pH values typically hover around 4 s.u. (*Figure 10-33B*). This station receives drainage from 84% of the watershed. In addition to the surface water quality monitoring station in Colly Creek, there is a fish community monitoring station BF82. The fish community was last sampled in 2008 with a rating of Not Rated.

As of 2019, the land cover draining to this monitoring station is primarily composed of wetlands (62%), forest land (18%), grassland/shrub (9%), agriculture land (8%), developed land (3%), and 1% is open water. Since 2001, land cover draining to this surface water monitoring station has not changed significantly. There is one minor NPDES facility located southeast of White Lake. This facility has a good history of fecal coliform bacteria limit compliance with only two enforcement cases for violating the effluent limit between 2010 and 2020. Fecal coliform bacteria concentrations in the effluent during this same period were often below 50 colonies/100 mL.

During 2016 to 2020, fecal coliform bacteria levels exceeded the water quality standard of 400 colonies/100 mL for approximately 16% of the sampling events. Notably, the annual mean fecal coliform bacteria level in 2017 was 2,272 colonies/100 mL due to six samples having values greater than 400 colonies/100 mL (*Figure 10-33A*). During this same 2016 to 2020 period, this waterway maintained an annual average total nitrogen concentration that approached or exceeded 1 mg/L (*Figure 10-33C*).

These elevated total nitrogen concentrations are primarily driven by elevated total Kjeldahl nitrogen concentrations and ammonia concentrations (*Figure 10-33E, F*). These elevated total Kjeldahl nitrogen concentration maybe the result from the breakdown of organic material in this waterway, wetlands of which many are bays with organic soil including several nearby that have been ditched and converted to agriculture and/or leaking sewer systems. Annual mean nitrate+nitrite concentrations are typically lower than concentrations considered normal for minimally impacted streams after 2010 (*Figure 10-33D*). Total phosphorus concentrations have approached and exceeded 0.1 mg/L during 2016 to 2020 with values exceeding 0.2 mg/L for the most recent two years on record (*Figure 10-33G*). Additional data obtained from the monitoring coalition suggests these elevated total phosphorus concentrations continued to occur through 2022 (*Figure 10-34*). These elevated total nitrogen and total phosphorus concentrations are higher than those considered normal for minimally impacted streams.

Figure 10-33: Annual Mean and Median Fecal Coliform Bacteria, Total Nitrogen, Nitrate+Nitrite, Total Kjeldahl Nitrogen, Ammonia, Total Phosphorus Results for Station B8981000 from 1996 to 2020.



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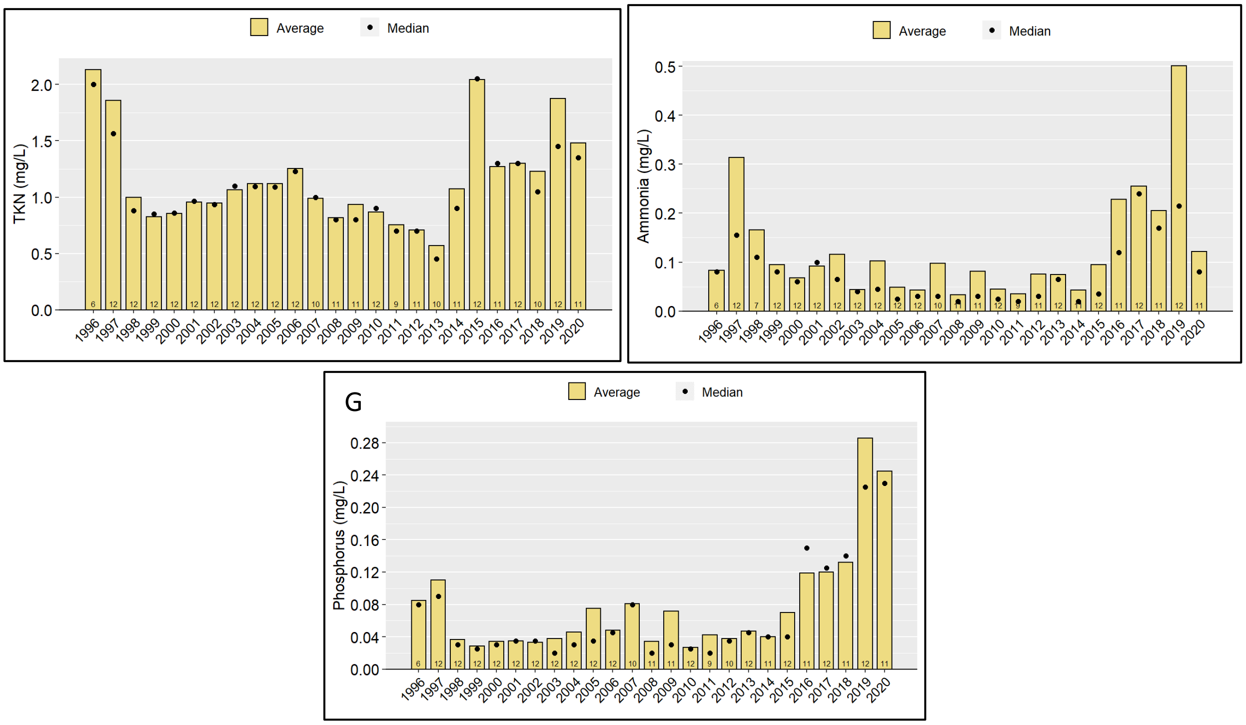
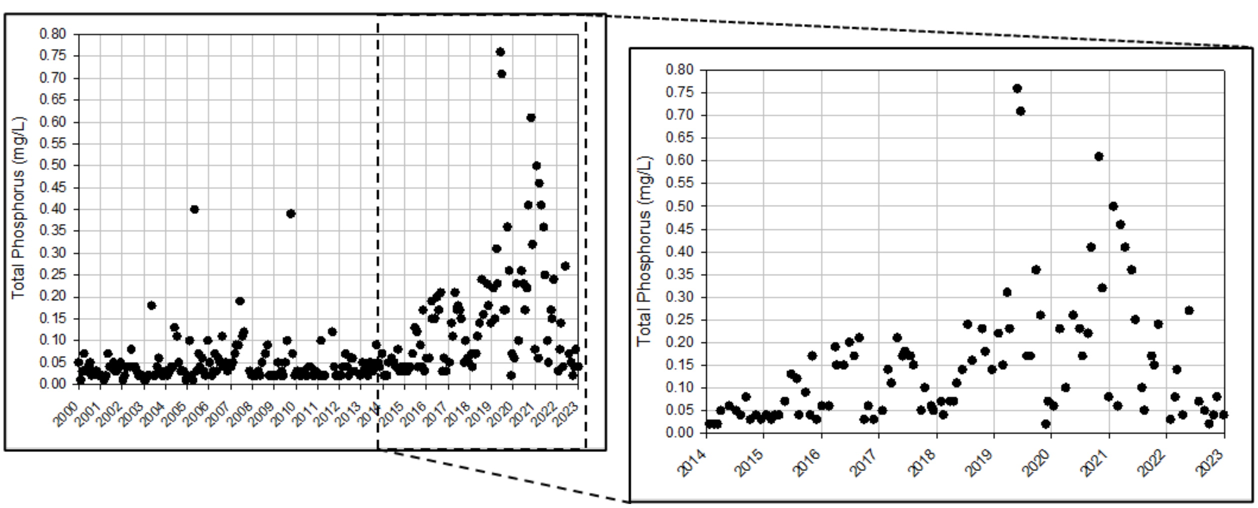
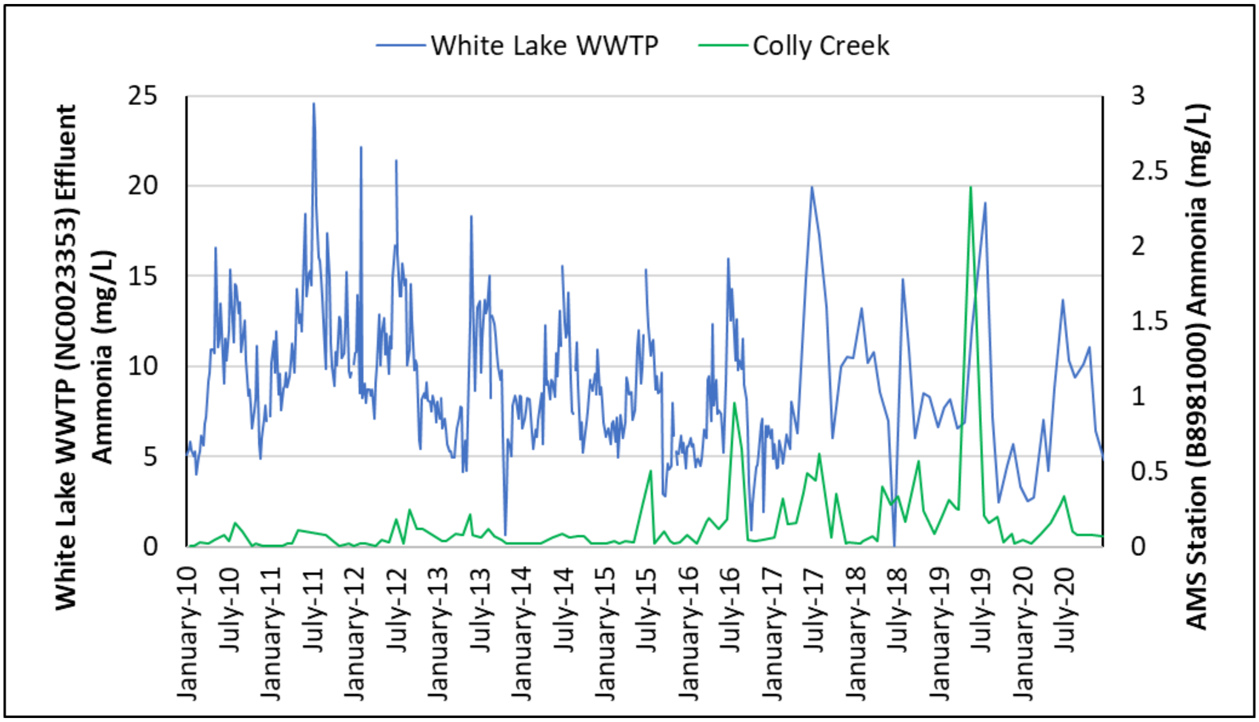


Figure 10-34 Total Phosphorus Concentrations for Data Collected at Station B8981000 from 2000 to 2023.



Ammonia concentrations in Colly Creek tended to be elevated in the spring, summer and early fall seasons with lower concentrations observed in the winter (*Figure 10-35*). Similar increases were observed in the White Lake WWTP (NC0023353) effluent. Alongside the effluent discharge from the White Lake WWTP flowing into Colly Creek, nonpoint sources such as failing sewer and septic systems could be contributing to the elevated ammonia concentrations. The periodic nature of these elevated ammonia spikes could also be attributed to influxes of tourists to the area in and around White Lake.

Figure 10-35 Ammonia concentrations recorded from White Lake Wastewater Treatment Plant (NC0023353) and downstream surface water quality monitoring station on Colly Creek (B8981000) between 2010 and 2020.



10.6.5.2 Singletary Lake Physical and Chemical Monitoring

Singletary Lake [AU#: 18-68-17-5-1] from the source to Lake Drain spans approximately 1 square mile (576.1 acres) and is classified for primary recreation (B) and swamp waters (Sw). This lake was placed on the impaired waters list in 2020 after it was determined with statistical confidence that the pH exceeded water quality standards. This lake was removed from the 2022 impaired waters list because more recent/new data was obtained (NCDEQ, 2022 Delisting). Singletary Lake is a large Carolina bay lake located within Singletary Lake State Park and is used for public swimming, boating, and fishing. This lake is a naturally acidic and dark-colored shallow lake common within the southeastern part of North Carolina. The surrounding terrain is flat and swampy with almost no overland water inputs. Singletary Lake appears to be meeting its designated uses. This lake is dystrophic and the NCTSI scores could not be accurately calculated due to the naturally dark, tannic waters (NCDEQ, 2018).

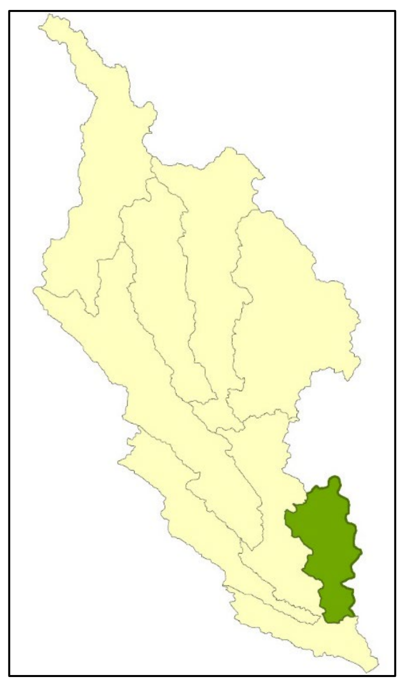
10.6.5.3 Colly Creek Watershed Summary

The water quality in Colly Creek is impacted by both point and nonpoint sources of pollution. While the only point source discharger in this watershed has exceeded their effluent fecal coliform bacteria limit, the facility does not appear to be the only source of high fecal coliform bacteria concentrations in this watershed. Nonpoint sources of pollution in this watershed include animal feeding operations, agriculture practices, manure applications to cropland, developed land, stormwater, septic systems and/or straight pipes, domestic animals, and wildlife.

Fecal coliform bacteria concentrations in this watershed are relatively low compared to the other monitored Black River subbasin watersheds. While there are occurrences of elevated values related to nonpoint source pollution, annual mean values are typically below the 400 colonies/100 mL water quality standard. Nutrients (total nitrogen and total phosphorus) concentrations were higher than those considered normal for minimally impacted streams. *Localized water quality monitoring and an understanding of the reason for the high ammonia levels is necessary to improve water quality in this watershed. Additional recommendations for the Colly Creek watershed include*:

- Stream walking much of the watershed to assist in identifying sources of water quality problems.
- Reduction of nonpoint source pollution runoff through forested buffers alongside streams, wetland and stream restoration, erosion and sediment control best management practices, and implementation of agriculture BMPs where needed (e.g., cover crops, grassed waterways, livestock exclusion, filter strips and field borders).
- Instream monitoring for nitrate and nitrite, ammonia, and total Kjeldahl nitrogen, and total phosphorus, as well as ammonia effluent limits and toxicity testing requirements should be considered for inclusion in the White Lake WWTP permit (NC0023353) during the next permit renewal.

10.6.6 Moores Creek Watershed (0303000607)



The Moores Creek watershed drains 92 square miles in western Pender County and a fraction of southeastern Sampson County. The upper reaches of this watershed contain Moores Creek, White Oak Branch, Taylor Branch, and Bear Den Branch. These streams converge west of the Town of Costin. Downstream from the confluence of these four creeks, Moores Creek continues to flow south with contributing swamp-classified streams, including Buxton Branch, Mill Branch, Deer Valley Branch, and Big Branch. There are no surface water quality monitoring stations in this watershed. There is one biological community monitoring station. These converging coastal plain rivers are comprised of smaller slow-moving tannin-stained streams that drain wetland areas. The primary land covers in this watershed are agricultural land (17.3%), forest land (43.2%), and wetlands (22.9%), followed by developed land (3.9%), grassland/shrub (12.4%), barren land (<0.1%), and open water (0.4%).

As of May 2022, there were many permitted facilities and fields located in this watershed. A total of 13 AFOs with total allowable head count of 67,184, allowable weight of 14.9 million pounds and 17 lagoons are located across the watershed. There is one non-discharge permitted facility located in the eastern side of this watershed near Deer Valley Branch with four fields covering approximately 0.1 square miles. There is a single NPDES permit for non-contact cooling and boiler blowdown wastewater discharge in the watershed. There are also two NPDES stormwater and 13 state stormwater permits.

10.6.6.1 Moores Creek Physical, Chemical Monitoring, and Biological Monitoring

Moores Creek [AU#: 18-68-18a1, 18-68-18a2, and 18-68-18b] does not have an established surface water quality monitoring station. Moores Creek is a class C water with a supplemental swamp classification due to natural characteristics of swamps, such as low dissolved oxygen and pH. The latest data generated by DWR for this watershed is from 1985 to 1988 (Mallin and McIver, 2009). In 1996, the National Park Service Water Resources Division collected additional water quality data (Mallin and McIver, 2009). The most recent sampling DWR is aware of was conducted by the University of North Carolina at Wilmington in 2009. The 2009 study focused specifically on the Moores Creek National Battlefield, located approximately halfway between the headwaters and the mouth of Moores Creek. A summary of the hydrologic information, biological resources, an assessment of point and nonpoint source pollution, and other areas of concern are captured in the Assessment of Water Resources and Watershed Conditions in Moores Creek National Battlefield, North Carolina. Mallin and McIver (2009) listed their number one priority for Moores Creek as: "conduct a yearlong sampling program of Moores Creek, within the park [Moores Creek National Battlefield].

Moores Creek from the source to the Black River spans approximately 22.9 river miles [AU# 18-68-18a1, 18-68-18a2, and 18-68-18b]. There is one biological community monitoring station for benthic macroinvertebrates on this river [AU#: 18-68-18a2]. This site was found to have good macroinvertebrate habitat and normal water quality parameters during the biological assessment in 2013 (*Table 10-18*). The insect community was relatively rich for a swamp stream and included some perennial indicators suggesting that flow may remain during the summer months of high flow years. However, the EPT BI did increase in 2013 due to the absence of stoneflies, which had previously been found in 2003, indicating a more tolerant EPT community was present. However, Moores Creek garnered its first Natural bioclassification in 2013. This creek received another Natural bioclassification in 2018; however, the EPT BI did increase again indicating a more tolerant EPT community was present.

Table 10-18 The Biological Community Analysis in the Moores Creek at Station BB244.

Year	Study	Sample Type	EPT BI	Biotic Index	Bioclassification
2003	Basin Sample	Swamp	5.24	6.91	Moderate
2013	Basin Sample	Swamp	5.51	6.17	Natural
2018	Basin Sample	Swamp	5.75	6.21	Natural

Link to Biological Report: https://www.ncwater.org/?page=672&SiteID=BB244

10.6.6.2 Moores Creek Watershed Summary

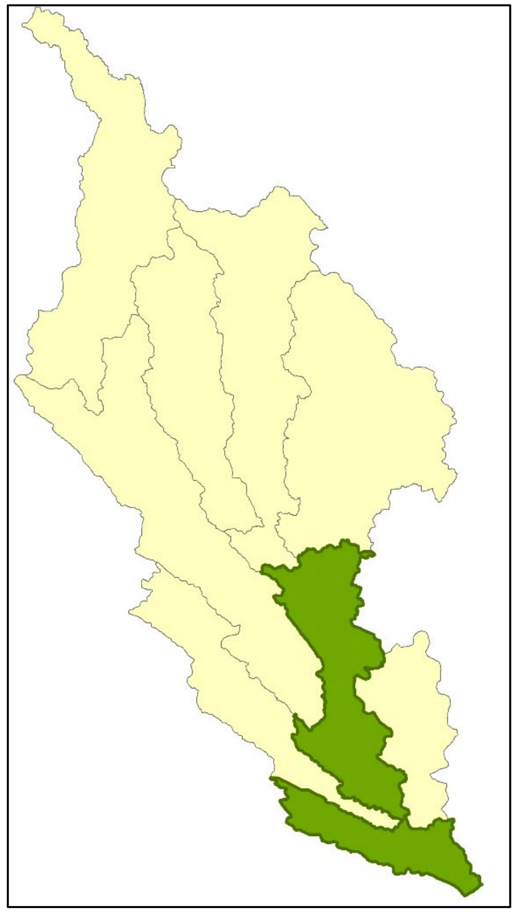
Water quality in this watershed is poorly understood due to a lack of consistent surface water quality monitoring in this watershed. The most recent surface water quality sampling was conducted in 2009 by researchers at the University of North Carolina at Wilmington (Mallin and McIver, 2009). While the data has been limited in this watershed, the 2009 study identified several existing and potential stressors that affect Moores Creek National Battlefield habitats.

The 2009 study highlighted existing problems in the Moores Creek National Battlefield reach, including: hypoxia (low oxygen levels), erosion, fecal coliform bacteria, habitat disruption, and mercury metal contamination based on fish tissue consumption advisory (Mallin and McIver, 2009). The study also noted potential problems with nutrient loading, airborne ammonium, and sedimentation (Mallin and McIver, 2009). A full list of the potential stressors is available in their publication. The most recent biological samples were collected in 2018, recording a Natural rating. While the biological community continues to record a Natural rating, it has shifted to more pollution-tolerant species in recent years of monitoring.

Recommendations for the Moores Creek watershed include:

- Continue to monitor Moores Creek biological community to capture changes in water quality over time.
- Conduct sampling of Moores Creek (from the reproduced battlefield site bridge) for standard water quality parameters (water temperature, dissolved oxygen, pH, salinity, fecal coliform bacteria, enterococcus, total nitrogen, ammonium, nitrate, total phosphorus, orthophosphate, BOD5, chlorophyll *a*) on a monthly basis for one year. Monthly sampling (n = 12) would make the data comparable to the DWR – required monthly sampling by the Lower Cape Fear River Program conducted at nearby Colly Creek and the Black River at Highway 210. Sampling the creek sediments for potential toxins (metals, pesticides, PCBs, PAHs) should be performed at least once to judge whether the benthic and fish communities are at risk from these pollutants." (Mallin and McIver, 2009).

10.6.7 Black River Watershed (0303000608)



The Black River watershed encompasses 212 square miles of southern Sampson, eastern Bladen, and western Pender counties; this does not include the drainage area from the adjoining Black River subbasin watersheds. Including all the adjoining Black River subbasin watersheds results in a drainage area of 1,574 square miles. The upper reaches of this watershed include Little Coharie Creek, which flows to meet Great Coharie Creek. Six Runs Creek converges with the Great Coharie Creek north of the Town of Clear Run to form Black River. Black River continues to flow south with contributing swamp-classified rivers, including South River, Colly Creek, and Moores Creek. These converging coastal plain rivers are comprised of smaller slow-moving tannin-stained streams that drain wetland areas. The primary land covers in this watershed are forest land (31%), agricultural land (16.0%), and wetlands (37.5%), followed by developed land (3.2%), grassland/shrub (11.0%), barren land (0.1%), and open water (1.2%).

There are three surface water quality monitoring stations in this watershed and one biological community monitoring station. In addition to water quality and biological community monitoring, the United States Geological Survey maintains a streamflow gaging station that records the amount of water flow in Black River. There are no NPDES permitted facilities in the Black River HUC 10 watershed. The entire length of Black River (Six Runs Creek below the confluences with Quewhiffle Creek) and South River (which joins Black River north of the Town of Rowan) have supplemental classifications as Outstanding Resources Waters. Black River is designated a Natural Heritage Significant Aquatic Habitat and contains many aquatic species of concern. The lower section of Black River is also listed as Primary Nursery Area waters as described in 15A NCAC 03R .0103.

As of May 2022, there were many permitted facilities and fields located in this watershed. A total of 36 AFOs with total allowable head count of 164,891, allowable weight of 24.1 million pounds and 71 lagoons are scattered across the upper reaches of this watershed; however, the lower reaches have significantly fewer permitted facilities. There is one non-discharge permitted facility located near New Hope Creek in the northeastern corner of this watershed. There are no NPDES wastewater permits in this watershed. There is a single NPDES stormwater permit and six state stormwater permits.

10.6.7.1 Black River Physical, Chemical, and Biological Community Monitoring

Black River from the confluence of Great Coharie Creek and Six Runs Creek to the Cape Fear River spans approximately 40.5 river miles [AU#: 18-68a and 18-68b]. This waterway is classified for secondary recreation (C), swamp (Sw), and Outstanding Resources Waters (ORW). There are three surface water quality monitoring stations located on the Black River. The first surface water quality monitoring station named B8750000 captures drainage from approximately 677 square miles, including the upstream watersheds of Little Coharie Creek, Great Coharie Creek, and Six Runs Creek. There is also a co-located biological community monitoring site named BB128 and the only streamflow gaging station in the Black River subbasin named 02106500. The co-located biological community monitoring station (BB128) was last sampled in 2002 and recorded an Excellent Bioclassification.

Black River flows from station B8750000 to the surface water quality monitoring station B9000000. Station B9000000 is located downstream of where South River joins Black River and receives drainage from approximately 1,407 square miles. The third surface water quality monitoring station B9013000 is the last surface water quality monitoring station on the Black River before discharging to Bulldog Cut, which flows into the Cape Fear River. This station receives drainage from approximately 96% of the Black River watershed, including all the ten-digit hydrologic unit code watersheds in the Black River subbasin. As of 2019, the land covers that drains to station B9000000 are agricultural land (33%), wetlands (27%), forest land (24%), grassland/shrub (8%), developed land (7%), and open water (1%). Since 2001, there has not been significant change in the land cover draining to this water quality monitoring station.

During 2016 to 2020, at station B8750000, approximately 11% of the samples collected exceeded the 400 colonies/100 mL standard. This reflects the fecal coliform bacteria levels carried by Great Coharie Creek, Little Coharie Creek and Six Runs Creek. As mentioned previously, high fecal coliform bacteria were detected in approximately 26% of the sampling events in Six Runs Creek, 16% of the sampling events in Great Coharie Creek and 23% of the sampling events in Little Coharie Creek during 2016 to 2020. Fecal coliform bacteria levels were often highest near the formation of Black River at station B8750000 compared to downstream stations in Black River.

Comparing the annual mean fecal coliform concentrations at this most upstream water quality monitoring station B8750000 to the next two downstream water quality monitoring stations--B9000000 and B9013000--shows that dilution by runoff from landscapes with developed and agriculture land cover and less dense animal feeding operations is helping to abate these high fecal coliform bacteria concentrations in Black River *(Figure 10-36*). Notably, the South River and Colly Creek confluences with Black River both had spikes in fecal coliform bacteria. The elevated fecal coliform bacteria concentrations from adjoining tributaries appears to have influenced the fecal coliform bacteria concentrations in Black River at station B9000000, specifically in 2017 (*Figure 10-36*).

During 2016 to 2020, the most upstream surface water monitoring station B8750000 on Black River displayed the highest annual mean total nitrogen and total phosphorus concentrations compared to the two downstream stations B9000000 and B9013000 (*Figure 10-37* and *Figure 10-38*). Fecal coliform bacteria, total nitrogen, and total phosphorus concentrations appear to decline as Black River flows through forested riparian areas and gathers additional streamflow, which dilutes concentrations. Total phosphorus concentrations in 2019 and 2020 are the exception to this case as Colly Creek influenced Black River through exceptionally high total phosphorus loads flowing from that watershed (*Figure 10-38*). Although these two nutrient concentrations are decreasing as the river flows, the annual mean concentrations have fluctuated around 1.0 mg/L and 0.1 mg/L. These nutrient concentrations are higher than those considered normal for minimally impacted streams.

Figure 10-36 Annual Mean Fecal Coliform Bacteria Concentrations from the South River (B8920000), Colly Creek (B8981000), Black River (B8750000, B9000000, B9013000) from 2002 to 2020.

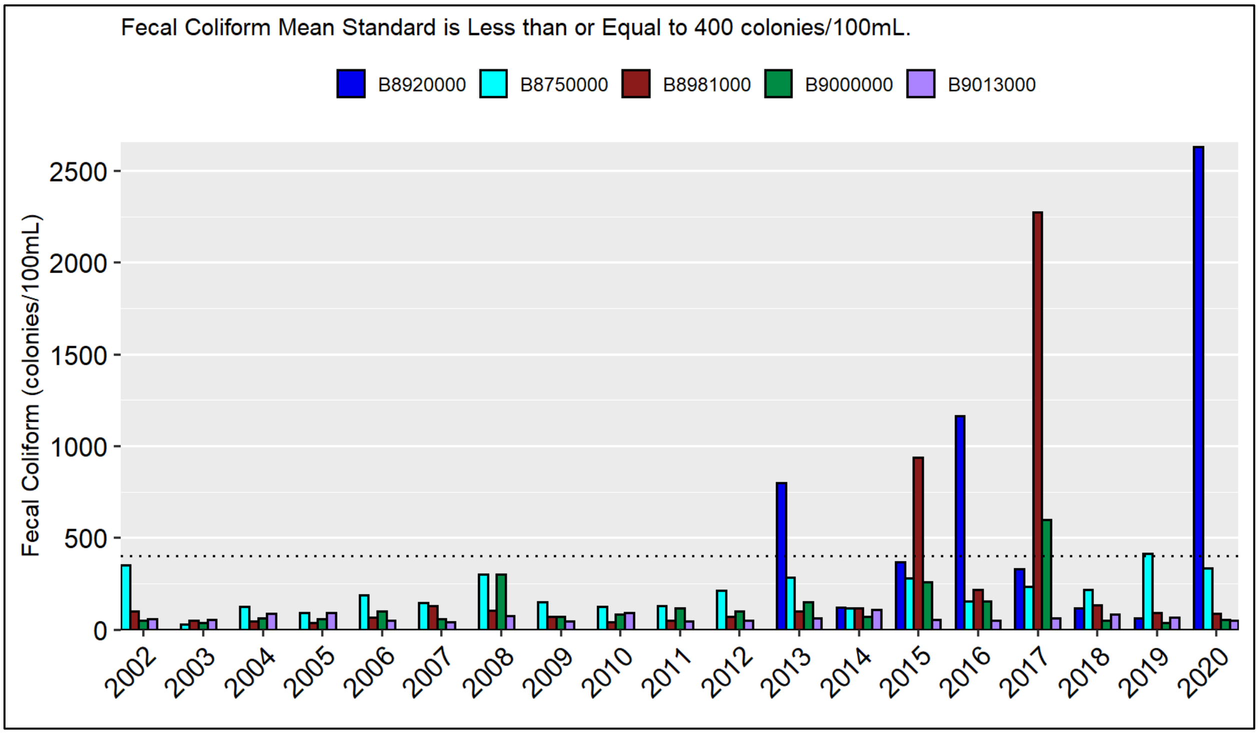


Figure 10-37 Annual Mean Total Nitrogen Concentrations from the South River (B8920000), Colly Creek (B8981000), Black River (B8750000, B9000000, B9013000) from 2002 to 2020.

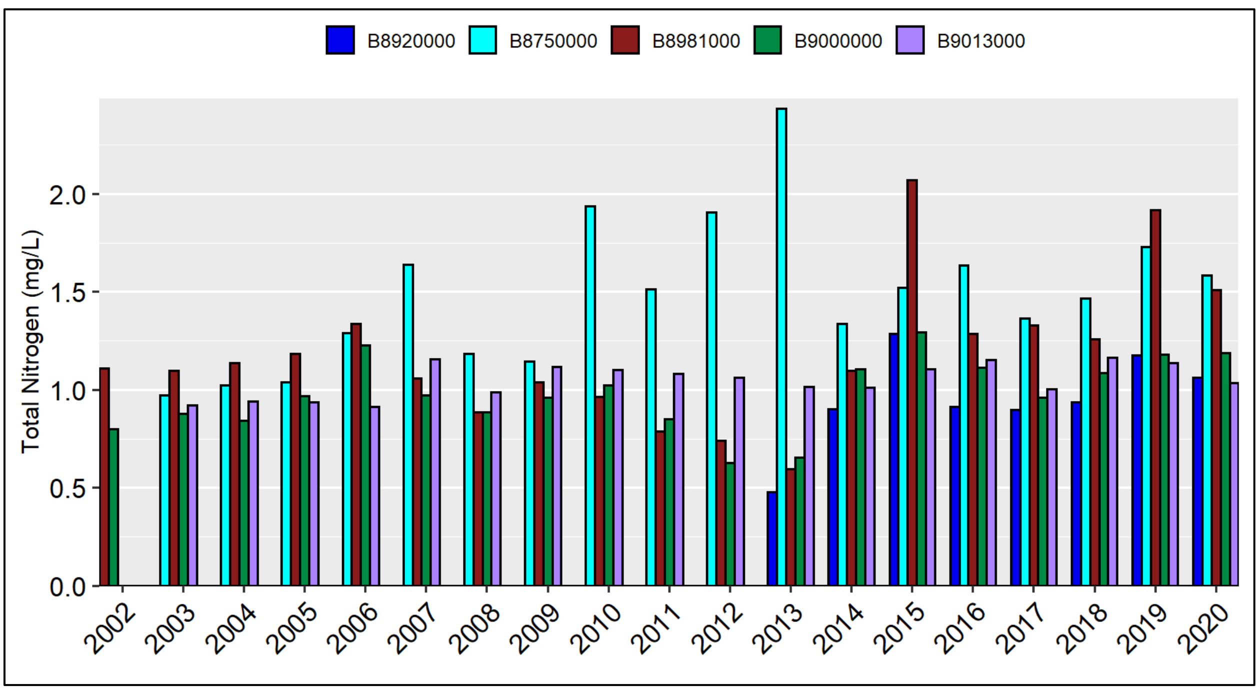
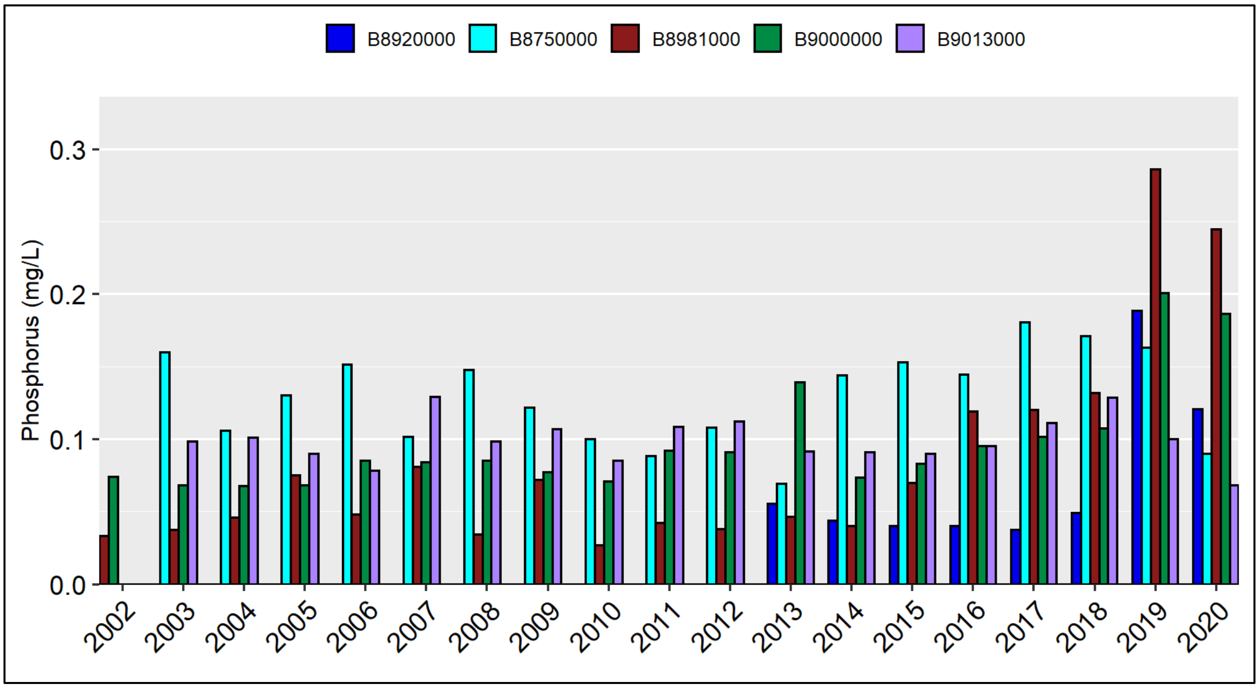


Figure 10-38 Annual Mean Total Phosphorus Concentrations from the South River (B8920000), Colly Creek (B8981000), Black River (B8750000, B9000000, B9013000) from 2002 to 2020.



DWR conducted screening level Mann-Kendall trend seasonal tests for specific conductance, nitrate+nitrite, and total phosphorus at stations B8750000 and B9000000, which produced a significant increasing trend calculated at 95% confidence from data collected from 2000 to 2019. This seasonal statistical test also showed an increasing trend for total Kjeldahl nitrogen at stations B8750000 and B9013000, as well as decreasing trends in ammonia at these two stations. A screening level Mann-Kendall trends non-seasonal test for fecal coliform at station B8750000 and a seasonal test at station B9000000 produced a significant increasing trend calculated at 95% confidence from data collected from 2000 to 2019. Mallin et al. (2022) also found significant increases in fecal coliform, nitrate, total nitrogen, and total phosphorus at station B9000000 using the LCFRP monitoring data collected between 2000 and 2019. The screening level Mann-Kendall trend test did not show a significant change in these parameters at the station furthest downstream on Black River (B9013000).

10.6.7.2 Black River Watershed Summary

Little Coharie Creek, Great Coharie Creek, and Six Runs Creek join to form Black River. After combining to form Black River, additional tributaries to this waterway include South River, Colly Creek, and Moores Creek. All these waterways have recorded impacts by elevated fecal coliform bacteria and most are impacted by elevated nutrient (total nitrogen and total phosphorus) runoff from possibly both point and nonpoint sources of pollution. Point sources contributing to pollution in Black River include all NPDES permitted facilities that discharge to waterways in this subbasin; however, much of Black River is classified as an Outstanding Resource Water. The special protection measures that apply to North Carolina Outstanding Resources Waters are set forth in 15A NCAC 2B .0225. At a minimum, no new discharges or expansions are permitted, and a 30-foot vegetated buffer or stormwater controls for new developments are required.

Elevated fecal coliform bacteria levels were detected in approximately 26% of the sampling events in Six Runs Creek; 16% of the sampling events in Great Coharie Creek; 23% of the sampling events in Little Coharie Creek; 11% of the sampling events in Black River; 6% of the sampling events in South River; and 16% of the sampling events in Colly Creek during 2016 to 2020. Although the standard value requires a 5-in-30 sampling methodlogy, the standard value provides a useful benchmark for screening water quality in these rivers. The recent years of monitoring data which approach and exceed this fecal coliform bacteria standard value should be an indication that source identification is necessary to prevent continued excursions of the fecal coliform bacteria water quality standard.

The Great Cohaire Creek watershed has the highest annual mean total phosphorus concentrations of all the rivers in the Black River subbasins during 2016 to 2020. Great Coahaire Creek annual mean total phosphorus concentrations were often above 0.3 mg/L, which is higher than the concentrations considered normal for minimally impacted streams. These elevated phosphorus concentrations add to Black River's after the confluence with Six Runs Creek. Additionally, elevated total phosphorus concentrations in the middle sections of Black River are influenced by high total phosphorus concentrations stemming from Colly Creek. Dilution assists in reductions as Black River flows through forested riparian areas and gathers additional streamflow from landscapes with less developed and agriculture land cover and less dense animal feeding operations before flowing into the Cape Fear River.

Annual mean total nitrogen concentrations in rivers of the Black River subbasin with water quality monitoring often hover around 1 mg/L. The Black River at station B8750000 had the highest annual mean total nitrogen values beginning in 2010. Because Black River at station B8750000 is directly downstream from Little Coharie, Great Coharie, and Six Runs creeks, then the sources of elevated nitrogen are most likely within those watersheds. In reviewing the total nitrogen concentrations from those three rivers, Six Runs Creek maintained the highest annual mean total nitrogen concentrations during 2016 to 2020. Dilution from adjoining tributaries and interaction with the extensive forested riparian buffer appear to lower Black River total nitrogen concentrations as observed in stations B9000000 and B90130000.

Recommendations for the Black River watershed include:

- Reducing nitrogen loads to prevent nutrient enrichment downstream.
- Continuing to implement best management practices that focus on nitrogen reductions and address the sources of nitrogen.
- Adopting best management practices to reduce total phosphorus concentrations in the Great Coahrie Creek and Colly Creek watershed and prevent phosphorus-laden runoff from flowing into waterways and being transported, ultimately being deposited in the Cape Fear River.

10.7 Black River Subbasin Water Use

Water resources in the Cape Fear River Basin include surface and ground water, 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 ground water 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.

10.7.1 Water Use and Availability Reported in Local Water Supply Plans

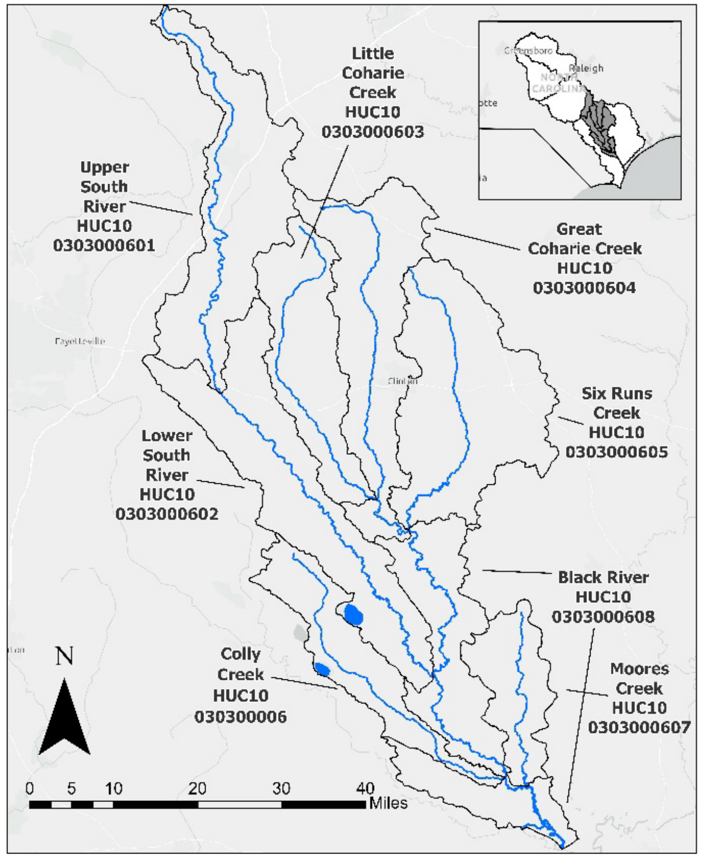
The information presented in this section quantifies water demand/use and available water supply on a subbasin scale based on public water supply systems that submitted local water supply plans in the Black River subbasin. Per North Carolina General Statutes §143-355(l), the Local Water Supply Planning 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.

Eighteen (18) water systems are included in the Black River Subbasin. Based on the information reported by users, not including ecological flow, domestic users, non-reporters, and other unknown usages, there are no apparent water supply issues in the Black River subbasin. The 2020 Black River subbasin population served by public water supply systems was 54.893. The public water supply systems in this subbasin had a combined average daily water demand of 6.97 MGD in 2020. Comparing this to the total available supply reported these by these 18 public water supply systems in 2020 of 22.54 MGD, the combined average daily demand of the public water supply systems in the Black River subbasin was approximately 31% of available supply. The City of Clinton is the largest system in the subbasin, with an average daily water demand in 2020 of 1.68 MGD, or approximately 24% of the combined subbasin demand. A detailed description of the public water supply availability, demand, and projections for the Black River subbasin is in Chapter 5.

10.8 Protecting Water Resources in the Black River Subbasin

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 restoration activities that reduce nutrients, bacteria, sediment loads, and runoff flow volume to the receiving waterbodies.

10.8.1 Fecal Coliform Bacteria in the Black River



The highest fecal coliform bacteria concentrations were identified in the Upper South River, Six Runs Creek, and Great Coharie Creek watersheds. While the Little Coharie Creek watershed does not have the highest fecal coliform bacteria concentrations, the frequency of concentrations exceeding the water quality standard is concerning. The Lower South River, Colly Creek and Black River watersheds were impacted less by consistently high fecal coliform concentrations; however, pulses of elevated fecal coliform bacteria were recorded. Moores Creek does not have consistent water quality monitoring; however, a 2009 study of the Moores Creek National Battlefield noted fecal coliform bacteria was an existing problem in this waterway (Mallin and McIver, 2009).

"Water quality standards for fecal coliform bacteria are intended to ensure safe use of waters for recreation" (refer to Administrative Code Section 15A NCAC 02B .0200). The North Carolina fecal coliform standard for freshwater is 200 colonies/100ml based on the geometric mean of at least five consecutive samples taken during a 30-day period and not to exceed 400 colonies/100ml in more than 20% of the samples during the same period. This standard applies to all class B and C waters. Since many of the rivers, streams, and creeks of the Black River subbasin are classified as secondary recreational waters, class C, these are not prioritized for fecal coliform 5-in-30 sampling due to DWR staff limitations and a focus on class B waters.

As time and resources allow, a special study should be conducted in the waters of the Black River watershed to determine the source(s) of fecal coliform bacteria. This special study could be led by state government, federal government, local stakeholders, or any group with an interest in protecting the waters of this watershed. Identifying where people recreate in the Black River subbasin, and the fecal coliform concentrations observed at these locations would help protect the health of citizens where bodily contact occurs in these waterways. Potential sources of fecal coliform include wastewater treatment dischargers, failing sanitary sewer lines, failing on-site wastewater management systems (septic systems), animal feeding operations, and stormwater runoff.

When resources and technology allow, bacterial sources tracking should be used to help identify sources throughout the basin. Initiatives should be made to reduce the bacterial loading from all sources.

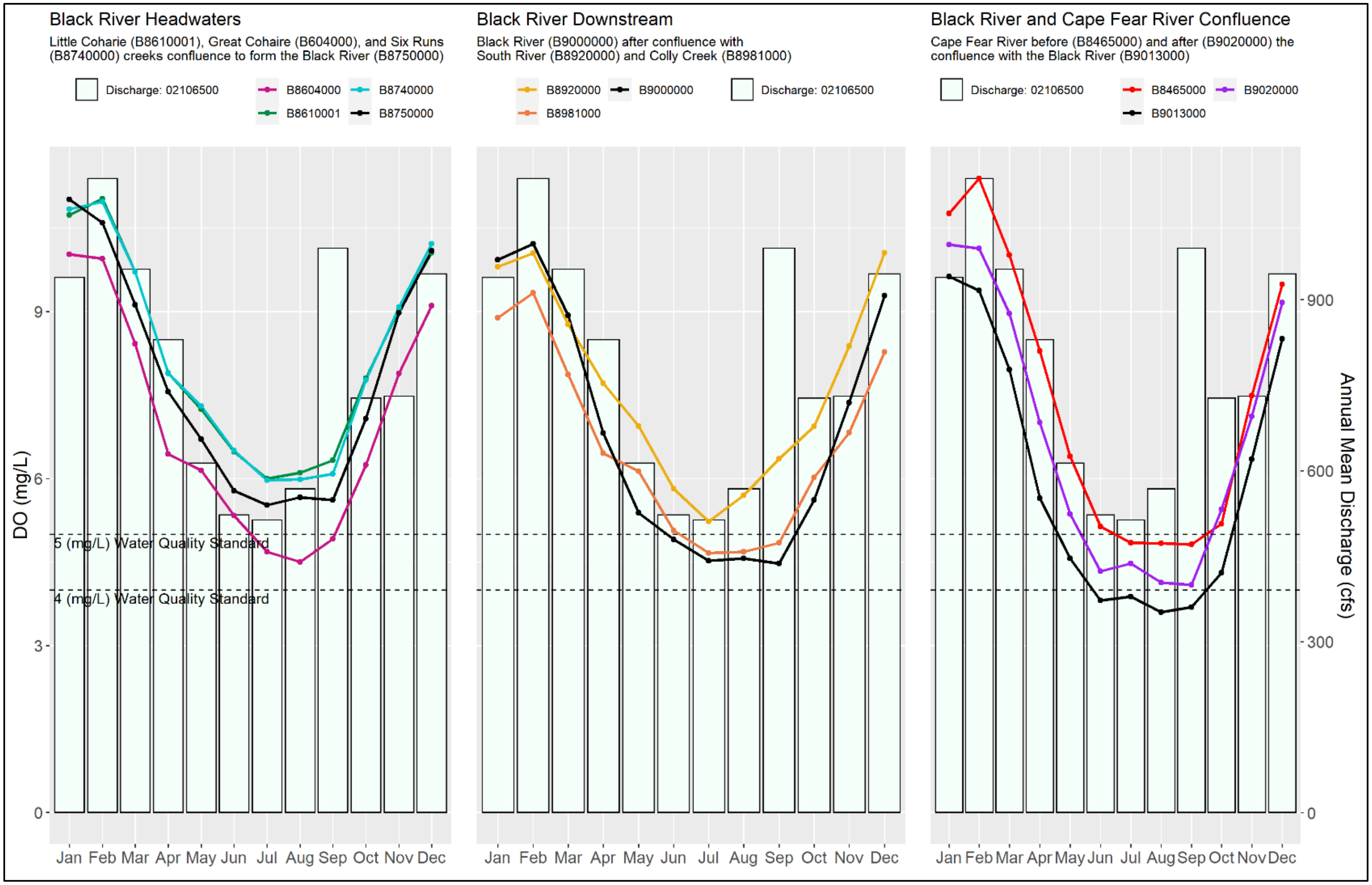
10.8.2 Dissolved Oxygen in the Black River

Black River is a swamp-classified river with low dissolved oxygen levels throughout much of the summer months when flows are at their lower point in the year (*Figure 10-39*). Black River dissolved oxygen is monitored from the confluence of Great Coharie and Six Runs creeks to its mouth before it joins the Cape Fear River. Dissolved oxygen levels monitored at these stations have recorded a river with progressively less dissolved oxygen as the river flows downstream.

The monthly average dissolved oxygen concentration based on surface water quality monitoring data from 2002 to 2020 is presented in *Figure 10-39*. The dissolved oxygen levels in the Black River at surface water quality monitoring station B8750000 begin as a combination of Little Coharie, Great Coharie, and Six Runs creeks with an average minimum summer value of 5.5 mg/L (*Figure 10-39*). Monitoring of the Black River is continued at station B9000000 after the South River and Colly Creek confluences. Interestingly, Colly Creek and South River have higher average minimum summer dissolved oxygen levels when compared to the Black River, but the Black River maintains a lower average minimum summer value of 4.5 mg/L at station B9000000. The furthest downstream surface water quality monitoring station in the Black River, station B9013000, has the lowest average minimum value generally for dissolved oxygen at 3.6 mg/L.

Black River converges with the Cape Fear River after flowing past station B9013000. There are surface water quality monitoring stations upstream and downstream of this confluence. The surface water quality monitoring station upstream of the Black River and Cape Fear River confluence is B8465000 and downstream from the confluence is B9020000. In reviewing the average monthly values for stations in the Black River against those in the Cape Fear River, low dissolved oxygen concentrations from the Black River appear to be influencing the Cape Fear River (*Figure 10-39*). Efforts to improve dissolved oxygen levels in the Black River could improve the dissolved oxygen levels in the Cape Fear River and potentially the Cape Fear River Estuary (*Figure 10-39*). One possible explanation for the low dissolved oxygen levels in the Black River is explained by research analyzing water from the Black River and Northeast Cape Fear River watersheds. Researchers have worked to determine both photosynthetic and heterotrophic pathways for inorganic and organic fractions of nutrients (nitrogen and phosphorus) in blackwater systems. A summary of their work is presented below; however, this is not a comprehensive review, and the reader is encouraged to review additional publications on this topic.

Figure 10-39: Mean Monthly Dissolved Oxygen Levels in the Black River



Stations are examined from upstream and downstream based on data collected between 2002 and 2020 at surface water quality monitoring stations. Each panel in the graphic represents either the upstream (headwaters), downstream, or Black River and Cape Fear River confluence per panel. Monthly mean discharge values are based on data collected between 2002 and 2020 from USGS gaging station 02106500 which is in the Black River. Discharge values were influenced by Hurricanes that occurred in September.

10.8.3 Nutrient Research and Modeling in Black River

The Black River receives nutrient runoff from both point and non-point sources of pollution. These nutrients include nitrogen and phosphorus that are transported in the rivers and streams that drain the surrounding Black River subbasin. Alongside nutrient transportation over the land surface, atmospheric deposition of nutrients also occurs (see Chapter 2 for information regarding atmospheric deposition). The highest total nitrogen concentrations were recorded in Six Runs Creek and Colly Creek; however, these two waterways have different species of nitrogen influencing these high total nitrogen concentrations. In the Six Runs Creek watershed nitrate+nitrite is the primary species of nitrogen, while total Kjeldahl nitrogen is the primary species of nitrogen in Colly Creek. This is largely a reflection of the point and nonpoint sources of pollution contributing to these waterways and the land cover.

Interestingly, another species of nitrogen, ammonia, has spiked in concentration in Colly Creek, as well as the Upper South River watershed, contributing to the higher total Kjeldahl nitrogen concentrations. Similar to Six Runs Creek watershed, the Little Coharie Creek, Great Coharie Creek, and Black River watersheds have high nitrate+nitrite concentrations contributing to high total nitrogen concentrations in those rivers. Notably, while total Kjeldahl nitrogen concentrations comprise a large portion of the total nitrogen concentrations found at many surface water quality monitoring stations, when waterways in this subbasin received additional inputs from nitrate+nitrite either from point or nonpoint sources the total nitrogen concentrations exceed concentrations considered normal for minimally impacted streams. The highest total phosphorus concentrations were recorded in Great Coharie Creek, primarily in the lower section of the waterway. In the year 2019 and 2020, total phosphorus concentrations spiked in the Upper South River, Lower South River, Little Coharie Creek, Six Runs Creek, Colly Creek, and Black River watersheds.

Since the Black and Northeast Cape Fear rivers are both blackwater river systems, they present a unique challenge in understanding how contributing nutrients interact with these waterways. Mallin et al. 2004 concluded that additions of nitrogen and phosphorus into blackwater systems potentially increases biological oxygen demand by photosynthetic and heterotrophic activity that can subsequently reduce dissolved oxygen concentrations through increased biological oxygen demand.

Previous work by Mallin et al., 2002 supported the photosynthetic pathway for nitrogen: "Based on field and experimental data, we contend that algal blooms do occur in blackwater streams. These blooms occur only in spring or summer, primarily in shallow streams. However, these blooms die upon entering the deep, light-limited main channels and become a source of BOD [biological oxygen demand]. Thus, nutrient loading, through the photosynthetic pathway, can indirectly exacerbate low dissolved oxygen problems in blackwater rivers." (Mallin et al., 2002).

Research by Mallin et al. (2004) continued to support the photosynthetic pathway that nitrogen stimulates biological oxygen demand through photosynthetic activity, meaning the growth and subsequent death and decay of algal blooms, followed by bacterial increase, then increased biological oxygen demand. Mallin et al. (2002) also found: "Significant stimulation of chlorophyll *a* and BOD occurred with additions of 0.2 - 0.5 mg nitrate-N/L, and significant stimulation of chlorophyll *a* and BOD also occurred in Great Coharie Creek with inputs of TN as low as 0.2 mg-N/L. Significant stimulation of BOD occurred with additions of either 0.5 or 1.0 mg-P/L as TP. Previous experiments conducted on water from the Black and Northeast Cape Fear Rivers using additions of 1.0 mg/L of N [nitrogen] or P [phosphorus] also showed significant stimulation of chlorophyll a (by N) and adenosine triphosphate (ATP) by P or N." Mallin and Cahoon (2020) supported the heterotrophic pathway for phosphorus: "Significant positive field correlations between total P and BOD in a variety of Coastal Plain lotic and lentic systems suggest an influence of P on hypoxia in these aquatic ecosystems. Targeted nutrient addition experiments using water from several different Coastal Plain watercourses demonstrated significant P stimulation of bacterial growth and associated increases in BOD and ATP concentrations as ecosystem-level effects. From a management perspective, the findings indicate that in systems affected by low dissolved oxygen, the direct contribution of P enrichment to hypoxia must be considered when devising total maximum daily loads required for remediation of impaired waters."

These two pathways increased biological oxygen demand that can then result in a decrease in dissolved oxygen (Mallin et al., 2004). "Without increased attention paid to controlling both nutrients, deterioration of water quality can be expected in the extensive blackwater systems characterizing the U.S. Coastal Plain, and likely other ecosystems as well" (Mallin et al., 2004). Preservation and expansion of these riparian buffer areas along Black River will be vital to keep nutrient (total nitrogen and phosphorus) concentrations from increasing prior to discharging into the Cape Fear River.

10.8.4 Black River Subbasin Recommendations

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

- Proper maintenance of onsite waste disposal systems (such as septic systems).
- Perform wastewater collection system maintenance and repairs to eliminate inflow and infiltration (I&I) as well as leakages.
- Elimination of direct unpermitted discharges of domestic sewage wastes (straight pipes) to streams.
- Encourage local health departments to routinely monitor waters known to be used for full body contact recreation (i.e., swimming and tubing).
- 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 fecal coliform in waterways.
- 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.

- Enhance coordination and provide financial and technical support to local governments to effectively manage and improve stormwater and wastewater infrastructure.
- Identify and expand educational opportunities to work with private landowners on nutrient management and the benefits of implementing BMPs, maintaining riparian buffers and conducting soil tests to minimize over application of fertilizers.
- Promote BMPs to reduce the loading of phosphorus into the whole Cape Fear River system, with a focus on reducing phosphorus bound to sediments that can increase instream total phosphorus concentrations during runoff events.

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