Contents

Chapter 3 Northern Shore of the Albemarle Sound

3.1 General Description

The area north of the Albemarle Sound contains the headwaters from the Great Dismal Swamp, Pasquotank, Little, and Perquimans rivers. This area also includes eight watersheds (HUC 10): Edenton Bay-Albemarle Sound, Yeopim River-Albemarle Sound, Perquimmans River, Little River, Pasquotank River, Dismal Swamp Canal-Lake Drummond, North River, Northwest River (Figure 3-1). These watersheds encompass 1,441 square miles of area in the Pasquotank River basin. Ecologically, the area contains characteristics of the Chesapeake-Pamlico lowlands and tidal marshes, as well as nonriverine swamps and peatlands. Most streams are of low relief, silt and sand substrate, swampy, and channelized ditches are common. Southward, a significant portion of the waters are brackish estuarine, including Albemarle Sound.

3.2 Biological Health

Benthic macroinvertebrate communities are composed of aquatic insects and crustacean species such as crayfish, mollusk-like mussels, clams, and snails, and aquatic worms. Aquatic benthic species are useful for biological monitoring as they are found in all aquatic environments and are less mobile than many other groups of organisms and are easily collectable. Aquatic benthic communities respond to a wide array of potential pollutants. The sedentary nature of benthic macroinvertebrates also ensures that exposure to a pollutant or stress in the environment accurately shows local conditions and allows for the comparison of sites, even within near proximity of each other. DWR biologists incorporated species richness, abundance, composition, and pollution indicator species into the benthic biocriteria used to calculate Index of Biological Integrity (IBI) scores and bioclassification ratings (Table 3-1). Certain species of benthos, like mayflies (Ephemeroptera), stoneflies (Plecoptera), and caddisflies (Trichoptera), referred to in combination as EPT, are typically highly sensitive to pollution and their presence or absence can be an indicator of water quality condition. EPT species presence has been incorporated into the biocriteria and is used to evaluate some monitoring sites. As previously mentioned, biocriteria (i.e. the methods used to calculate the IBI score), bioclassification assignment, and sampling methodology can vary with region and stream condition.

Figure 3-1 Benthic macroinvertebrate sampling sites (2006 – 2015). Stations are located either on the western side or northern side of the Albemarle Sound.

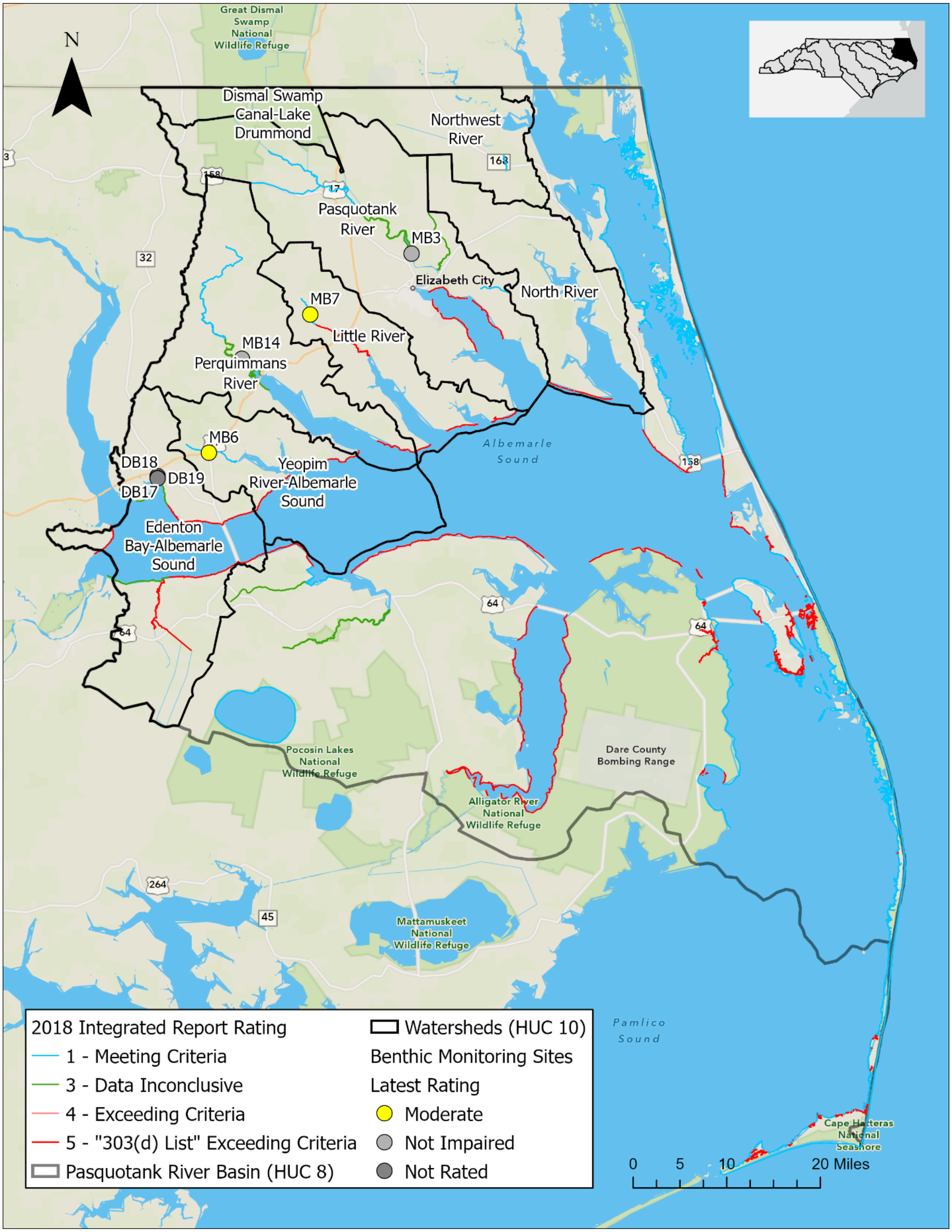


Table 3-1 Biological monitoring data results – benthic macroinvertebrates (2006 – 2015). Stations are located either on the western side or northern side of the Albemarle Sound. Results from 2005 are displayed if the station was resampled in 2010.

Station ID	Waterbody Name	Assessment Unit Number	Drainage Area (mi^2)	Assessment Method	Sample Date	Bioclassification
MB3	Pasquotank River	30-3-(3)	393	Boat	8/24/2005	Fair
					7/23/2010	Not Impaired
					7/14/2015	Not Rated
MB6	Burnt Mill Creek	30-8-1	4.9	Swamp	2/21/2005	Moderate
					3/2/2010	Moderate
MB7	Little River	30-5-(1)	33.9	Swamp	2/23/2005	Moderate
					3/1/2010	Moderate
					2/3/2015	Moderate
MB14	Perquimans River	30-6-(1)	127	Boat	8/23/2005	Fair
					7/22/2010	Not Impaired
MB9	Main Canal	30-9-4	2.56	Swamp	2/21/2005	Severe
					3/2/2010	Moderate
DB17*	FILBERT CR	-	1.53	Qual 4	4/18/2006	Not Rated
DB18*	FILBERT CR	-	1.56	Qual 4	4/18/2006	Not Rated
DB19*	FILBERT CR	-	1.62	Qual 4	4/18/2006	Not Rated
*Special Study monitoring not part of 5-year Basin Cycle Monitoring						

3.3 Ambient Water Quality

Monthly chemical and physical samples are taken by DWR through the Ambient Monitoring System (AMS) stations. 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. Each stream classification has an associated set of standards the parameters must meet in order to be considered supporting the waterbody's designated uses. Ten sample results are required within the five-year data collection window in order to evaluate the water quality parameter and compare it to the water quality standards. Stressors are either chemical parameters or physical conditions that at certain levels prevent waterbodies from meeting the standards for their designated use. Ambient stations are listed in Table 3-2, and their locations are found in Figure 3-2 below.

Figure 3-2 Ambient monitoring, random ambient monitoring, and lakes ambient monitoring stations. Stations are located either on the western side or northern side of the Albemarle Sound.

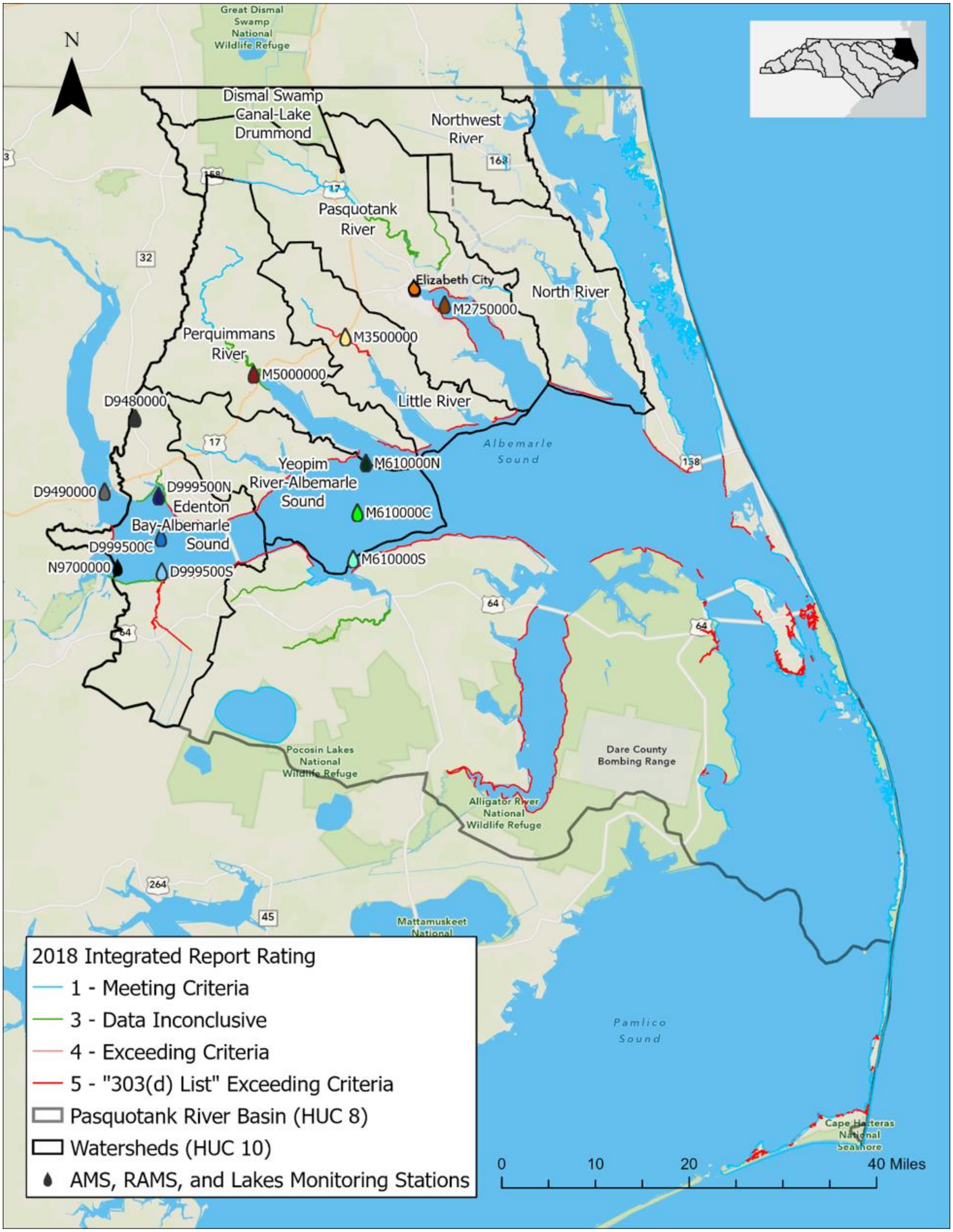


Table 3-2 Ambient stations in the Pasquotank River basin. Stations are located either on the western side or northern side of the Albemarle Sound.

Station ID	Station Location	Active Date	County	Stream AU#	Stream Classification
D999500C	ALBEMARLE SOUND NR EDENTON MID CHANNEL	1997-Present	Washington	26	B, NSW
D999500N	ALBEMARLE SOUND NR EDENTON N SHORE	1997-Present	Chowan	26-1	C, NSW
D999500S	ALBEMARLE SOUND NR EDENTON S SHORE	1997-Present	Chowan	30	SB
D9490000	CHOWAN RIVER AT US 17 AT EDENHOUSE	1969-Present	Bertie	25c	B, NSW
M2750000*	PASQUOTANK RIV AT ELIZABETH CITY	1968-2014	Camden	30-3-(12)	SB
M2490000	PASQUOTANK RIV AT MOUTH OF CHARLES CRK AT ELIZABETH CITY	2015-Present	Camden	3-3-(7)	SC
M3500000	LITTLE RIV AT SR 1367 AT WOODVILLE	1973-Present	Pasquotank	30-5-(1)	C, Sw
M390000C	ALBEMARLE SOUND NR FROG ISLAND MID CHANNEL	1997-Present	Tyrrell	30	SB
M390000N	ALBEMARLE SOUND NR FROG ISLAND N SHORE	1997-2014	Camden	30	SB
M390000S	ALBEMARLE SOUND NR FROG ISLAND S SHORE	1997-2014	Tyrrell	30	SB
M5000000	PERQUIMANS RIV AT SR 1336 AT HERTFORD	1968-Present	Perquimans	30-6-(3)	SC
N9700000	ALBEMARLE SOUND AT BATCHELOR BAY NR BLACK WALNUT	1974-Present	Washington	30	SB
Note: Ambient Monitoring Stations with a letter as the eighth digit indicates a spatial location in context of other stations (i.e. N = North, C = Center, and S = South) *Station was relocated in January 2015					

During the 2007 – 2019-time period, there was one additional short-term (2-year) Random Ambient Monitoring System (RAMS) stations (Table 3-3). The RAMS program does not routinely collect nutrients and chlorophyll *a* samples at stations, but a few nutrient samples were collected at station D9480000 before staff limitations restricted nutrient sampling (Appendix III). This station was also used to monitor for pesticides, semi-volatiles and volatile organic compounds, dissolved metals and low-level mercury as well as physical parameters.

Table 3-3 Random ambient monitoring stations in the Pasquotank River basin.

Station ID	Station Location	County	RAMS Year	Stream AU#	Stream Classification
D9480000	UT Pollock Swamp nr SR 1316 Coffield Rd nr Valhalla	Chowan	2019-2020	-	-

3.4 How to Read the Watershed (HUC 10) Sections

There are six entire and two partial watersheds (HUC 10) described in this chapter. To determine the source of pollutants in a watershed, it is useful to evaluate them on a smaller-scale. Smaller-scale evaluations can also help identify where monitoring and restoration is needed or being conducted. Within each watershed, NC 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, in an effort to target the water quality assessment and the data associated with it. Assessment unit numbers overlap with stream index segments that have a primary surface water classification and can have supplemental water classifications appropriate to the best-intended uses of that water.

The following sections will begin with a description of the watershed (HUC 10) followed by a breakdown of each AU# that is monitored by DWR (Figure 3-3). This plan to does not discuss all the streams within a watershed nor are all waterbodies monitored by DWR. DWR does, however, use qualitative information from stakeholders throughout the basin to understand what is impacting water quality in a particular area. Special attention should be paid to streams that are listed in impaired waters list tables. Recommendations for each of these impaired streams are provided at the bottom of each AU# section.

The Basin Planning Branch (BPB) continually work 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, sediment loads, and flow volume to the receiving waterbodies. Table 3-4 list's the number of benthic and ambient monitoring sites that were sampled in the 2007-2019 time period by watershed. Nutrients, chlorophyll *a*, algal blooms, and nutrient-related recommendations for the Albemarle Sound, Pasquotank River, Perquimans River, Little River, Scuppernong River, Alligator River, and Kendrick Creek are discussed in Chapter 6 of this basin plan.

Table 3-4 Summary table of water quality monitoring in the Pasquotank River basin by HUC 10 (2020).

Watershed	Area (mi^2)	Benthic Sites	AMS Stations (Active)	RAMS Stations	Lakes Stations
Edenton Bay-Albemarle Sound	241	1	5	1	0
Perquimmans River	219	1	1	0	0
Yeopim River-Albemarle Sound	182	1	1	0	0
Little River	134	1	1	0	0
Dismal Swamp Canal-Lake Drummond*	47	0	0	0	0
Pasquotank River	344	1	1	0	0
North River	166	0	0	0	0
Northwest River*	108	0	0	0	0
*Denotes watersheds that are partially in North Carolina					

Figure 3-3 Rivers monitored by DWR ambient monitoring and benthic monitoring programs (2020)

3.5 Edenton Bay-Albemarle Sound (HUC: 0301020501)

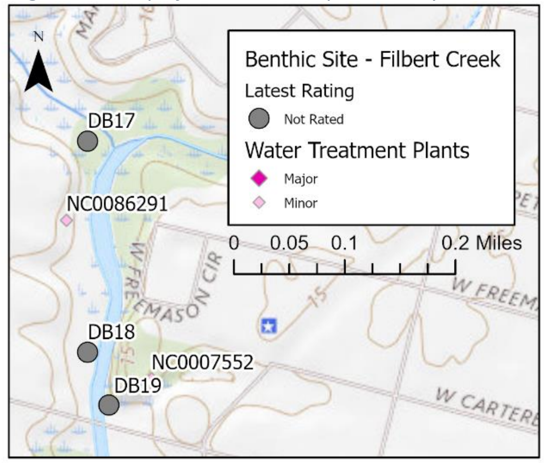
The Edenton Bay-Albemarle Sound watershed drains approximately 241 square miles of eastern Bertie, southern Chowan, and northern Washington counties (Figure 3-3). This watershed includes the confluences of the Chowan and Roanoke rivers where they meet to form the Albemarle Sound. Major tributaries include Pembroke Creek and Queen Anne Creek which drain into Edenton Bay, as well as, Kendrick Creek which drains into Swan Bay. The land cover in this watershed is predominantly agriculture (29.7%) and open water (29.6%) followed by wetland (20.6%), forest (13.2%), developed (4.7%), and grassland/shrub (2.1%) and barren land (0.1%). There are five ambient monitoring stations and three benthic macroinvertebrate monitoring sites. In addition to the DWR ambient monitoring sites there are five water quality monitoring stations maintained by the Albemarle Resource Conservation and Development Council, Inc. (ARCD) (see Chapter 8 for more information about citizen science water quality data collection). Between 2012 and 2020, a total of $164,226 dollars were used to fund Best Management Practices by the State Cost Share Programs in the Edenton Bay-Albemarle Sound watershed (Table 3-5).

Table 3-5 Best Management Practices Funded by State Cost Share Programs in the Edenton Bay-Albemarle Sound (HUC: 0301020501) (June 2012 - June 2020).

Best Management Practice	Unit type	6/1/2012 - 6/30/2015			7/1/2015 - 6/30/2020		
		Units Implemented	# of Contracts	Cost Share	Units Implemented	# of Contracts	Cost Share
Ag Water Collection System					1	1	$6,615
Cover Crops	ACRE	1481.8	11	$32,490	676.45	7	$34,057
Crop Residue Management	ACRE	365.57	2	$5,484			
Cropland Conversion - Trees	ACRE				2.7	1	$549
Land Smoothing	ACRE	185.96	7	$34,197	220.02	7	$35,827
Nutrient Scavenger Crop	ACRE				250	1	$5,000
Water Control Structure	EACH	1	1	$10,007			
Grand Total		**2034.33**	**21**	**$82,178**	**1150.17**	**17**	**$82,048**

3.5.1 UT to Edenton Bay (Filbert Creek) [AU# 26-1ut2; Length is 1.4 river miles]

Figure 3-4 Map of Filbert Creek special study.



Year	Station ID	Bioclassification
2006	DB17	Not Rated
	DB18	
	DB19	

In 2006, Unnamed tributary to Edenton Bay (Filbert Creek) was the subject of a special study conducted by the Biological Assessment Branch at the request of the US Fish and Wildlife Service. The special study was conducted because it was unknown whether the effluent from nearby water treatment plants was negatively impacting Filbert Creek. Filbert Creek, located in Edenton, NC, is a small stream with less than two square miles of drainage area at the special study sampling locations (DWR BAB, 2006). There are two permitted dischargers on Filbert Creek, Freemason Water Treatment Plant (WTP) (NC0007552) and Beaver Hill WTP (NC0086291). Both facilities, which are located within a couple hundred feet of each other and both use a deionization process to desalinate the water for water supply use. Three benthic samples were collected as follows: one upstream of Beaver Hill WTP outfall (DB17), one between the two WTP outfalls (DB18), and one downstream of Freemason WTP outfall (DB19) (Figure 3-4). The results from the special study were inconclusive. Additionally, potential impacts from the WTPs were masked by the natural conditions of the stream or the possible impacts from urban runoff.

The Freemason WTP (NC0007552) and Beaver Hill WTP (NC0086291) both discharge into the Unnamed Tributary to Edenton Bay (Filbert Creek). In order to address this issue and aging infrastructure these facilities obtained grants/loans for the renovation and updates to the towns two water treatment plants (Table 8-7). The changes to this facility will aim to bring them back into compliance with their NPDES permit. In February of 2018, these facilities reported to NCDEQ on a Discharge Alternatives Evaluation for the Freemason Water Treatment Plant and Beaver Hill Water Treatment Plant.

The Town of Edenton Wastewater Treatment Facility (WWTF) (WQ0004332) wastewater irrigation system is designed not to discharge to surface waters of the state. Although, this facility is currently operating under a Special Order by Consent (SOC) effective since December, 1 2019. The SOC (S17-001) states "The Town is currently in noncompliance with permit conditions where the spray irrigation fields have not been properly maintained and show signs of surface runoff, ponding and vegetation crop issues." (NC EMC, 2019). In 2020, the Town received USDA Rural Development $1.998M grant/$4.006M loan to support sprayfield improvements. The Town is also working on projects to improve inflow and infiltration in their collection systems.

3.6 Perquimans River (HUC: 0301020503)

The Perquimans River watershed drains approximately 219 square miles of land from eastern Chowan, southeastern Gates, and Perquimans counties (Figure 3-3). The primary land cover in this watershed is agriculture (45%) followed by wetland (26.5%), open water (11.9%), forest (11.5%), developed (3.8%), and grassland/shrub (1.2%). The Perquimans River originates in the Great Dismal Swamp and flows south meeting Goodwin Creek, Mill Creek, and Sutton Creek before emptying into Albemarle Sound. Most streams are low gradient with substrates of silt and sand. Currently, there is one ambient monitoring station and one benthic macroinvertebrate site. In addition to the DWR ambient monitoring station, water samples are collected by the ARCD at three stations in this watershed (see Chapter 8 for more information about citizen science water quality data collection). Between 2012 and 2020, a total of $418,143 dollars were used to fund Best Management Practices by the State Cost Share Programs in the Perquimmans River watershed (Table 3-6).

The Holiday Island WWTP (WQ0002519) near Minzies Creek entered into an SOC (S13-003) in 2014, however they formally requested withdrawal from the SOC in 2018 (NCDEQ, 2018). The SOC reported "the currently permitted wastewater treatment plant is not capable of adequately treating wastewater generated by the Minzies Creek Sanitary Sewer District and the evaporative ponds are not capable of disposing of the treated wastewater with discharging to the surface waters. The Permittee [Minzies Creek Sanitary Sewer District] is unable to comply with final limitations for effluent quality, flow, freeboard in their ponds and the disposal of their wastewater while preventing discharge of wastewater from the evaporative ponds to the surface water." (NC EMC, 2014). Since at least 2014, this facility has recorded multiple monitoring reporting violations for biological oxygen demand, total suspended solids, and flow (NCDEQ, 2015).

Table 3-6 Best Management Practices Funded by State Cost Share Programs in the Perquimmans River (HUC: 0301020503) (June 2012 - June 2020).

Best Management Practice	Unit type	6/1/2012 - 6/30/2015			7/1/2015 - 6/30/2020		
		Units Implemented	# of Contracts	Cost Share	Units Implemented	# of Contracts	Cost Share
Agricultural Pond Sediment Removal	EACH				1	1	$5,000
Agricultural Water Supply/Reuse Pond	EACH	2	2	$30,000			
Conservation Irrigation Conversion	ACRE				1	1	$9,788
Cover Crops	ACRE				1066.85	12	$31,965
Crop Residue Management	ACRE	3109.6	19	$48,350	1564.46	8	$25,846
Cropland Conversion - Grass	ACRE	2.5	1	$655			
Cropland Conversion - Trees	ACRE				13.2	1	$3,267
Emergency Access Restoration	EACH				1	1	$2,232
Land Smoothing	ACRE	394.75	12	$60,781	769.18	25	$120,053

Best Management Practice	Unit type	6/1/2012 - 6/30/2015			7/1/2015 - 6/30/2020		
		Units Implemented	# of Contracts	Cost Share	Units Implemented	# of Contracts	Cost Share
Long-Term No-till	ACRE				20	1	$3,000
PRECISION AGRICHEMICAL APPLICATION	EACH	4	4	$8,170	3	3	$3,849
Precision Nutrient Management	ACRE				1764.13	6	$29,996
Three Year Conservation Tillage for Grain and Cotton	ACRE	358.4	2	$21,504			
Water Control Structure	EACH				1	1	$2,916
Water Supply Well & Pump	EACH				2	2	$10,771
Grand Total		**3871.25**	**40**	**$169,460**	**5206.82**	**62**	**$248,683**

3.6.1 Perquimans River [AU# 30-6-(1)a1, 30-6-(1)a2, and 30-6-(1)b; Primary Surface Water Classification: C, Supplemental Classification: Sw, Length is 24 river miles], [AU# 30-6-(3); Primary Surface Water Classification: SC, Area is 693 freshwater acres]

Sampling Year	Bioclassification (MB14)
2005	Fair
2010	Not Impaired

The benthic macroinvertebrate community monitoring site (MB14) on the Perquimans River was sampled in 2005 and resampled in 2010. Although total taxa richness at this location has been stable since benthic assessments started in 2000, the 2010 sample resulted in a doubling of intolerant EPT taxa. During the 2010 sampling event, several EPT taxa were collected for the first time at this location including caddisflies (*Hydroptila spp*, *Triaenodes injustus*, and *Cyrnellus fraternus*). Given the provisional status of biocriteria for large, non wadeable coastal plain rivers, the 2010 sample was assigned a Not Impaired rating. However, for purposes of inter-year comparison, the 2010 collection would have received a Good-Fair bioclassification.

The water quality of the Perquimans River is monitored through one AMS station located near the town of Hertford (M5000000) (Figure 3-2). The 2018 IR reports that no water quality standards were exceeded in the Perquimans River aside from mercury in fish tissue; however dissolved oxygen, iron, and pH are data inconclusive. This reach of the Perquimans River receives drainage from swamp waters, which can contribute to low pH and low DO conditions. Nutrients, sediment, and bacteria are also parameters of interest in his stream reach. The annual mean ammonia/ammonium nitrogen + organic nitrogen (Total Kjeldahl Nitrogen-TKN) values have nearly doubled since the early 2000's (Appendix-III). Annual geometric mean for fecal coliform and annual mean turbidity values have also increased since the early 2000's

(Appendix-III). In 2019, an algal bloom was reported in the Perquimans River (Appendix VI). Overall, water quality conditions reflect that natural conditions and land use activities are influencing water quality.

3.7 Yeopim River-Albemarle Sound (HUC: 0301020504)

Yeopim River – Albemarle Sound watershed drains approximately 182 square miles of land from eastern Chowan and western Perquimans counties (Figure 3-3). The primary land cover in this watershed is open water (58.6%) followed by forest (14.4%), agriculture (11.5%), wetland (10.4%), developed (2.7%), and grassland/shrub (2.4%). This watershed contains Bethel, Burnt Mill, and Middleton creeks which come together to form the Yeopim River which flows to meet the Albemarle Sound. Currently, there is one ambient monitoring station in the center channel of the Albemarle Sound and one benthic macroinvertebrate site on Burnt Mill Creek. In addition to the DWR ambient monitoring, the ARCD is collecting water quality samples from three sites in this watershed (see Chapter 8 for more information about citizen science water quality data collection). Between 2012 and 2020, a total of $69,080 dollars were used to fund Best Management Practices by the State Cost Share Programs in the Yeopim River-Albemarle Sound watershed (Table 3-7).

Table 3-7 Best Management Practices Funded by State Cost Share Programs in the Yeopim River-Albemarle Sound (HUC: 0301020504) (June 2012 - June 2020).

Best Management Practice	Unit type	6/1/2012 - 6/30/2015			7/1/2015 - 6/30/2020		
		Units Implemented	# of Contracts	Cost Share	Units Implemented	# of Contracts	Cost Share
Agricultural Water Collection System	EACH				1	1	$10,649
Cover Crops	ACRE	358.2	1	$7,164	68.35	2	$7,194
Crop Residue Management	ACRE	513.33	5	$7,701	151	1	$2,235
Land Smoothing	ACRE	91.1	3	$16,637	101	3	$17,500
Grand Total		**962.63**	**9**	**$31,502**	**321.35**	**7**	**$37,578**

3.7.1 Burnt Mill Creek [AU# 30-8-1; Primary Surface Water Classification: C, Supplemental Classification: Sw, Length is 5 river miles]

Sampling Year	Bioclassification (MB6)
2005	Moderate
2010	Moderate

In Burnt Mill Creek at the benthic macroinvertebrate community site (MB6), the total species richness (ST) has varied somewhat since 1995 and biotic index (BI) has remained very stable (Figure 3-1). Several pollution tolerant taxa have been present at this location from each of the four collection events and including: damselfly (*Enallagma spp*), beetle (*Peltodytes spp*), midge (*Chironomus spp*), bivalve (*Pisidium spp*) and the gastropod (*Physa spp*). The largely pollution tolerant invertebrate community present here since 1995 is consistent with the elevated specific conductivity data over the same general time frame: 216 µS/cm in 2000, 277 µS/cm in 2005, and 190 µS/cm in 2010. The high BI and specific conductance values suggest anthropogenic disturbance in this catchment. There is currently no ambient water quality monitoring in this creek. The 2018 IR reports that fish tissue mercury is the only exceeding criteria parameter.

3.8 Little River (HUC: 0301020505)

Little River watershed drains approximately 134 square miles of land from west-central Pasquotank and east-central Perquimans counties (Figure 3-3). Predominant land use in this watershed consists of agriculture (55.4%) followed by wetland (18%), open water (14.4%), forest (6.8%), developed land (4.7%), and grassland/shrub (0.7%). The Halls, Deep, and Symonds creeks all flow to meet the Little River which flows from the northern most extent of this watershed to the Albemarle Sound. There is one DWR ambient monitoring station and one benthic macroinvertebrate monitoring site. In addition to the DWR ambient monitoring station in this watershed, water quality is being monitored by the ARCD at ten stations (see Chapter 8 for more information about citizen science water quality data collection). Approximately 7.9 river miles of the Little River is currently impaired for Chlorophyll *a* since 2010 (Figure 3-3 and Table 3-8). Between 2012 and 2020, a total of $175,536 dollars were used to fund Best Management Practices by the State Cost Share Programs in the Little River watershed (Table 3-9).

Table 3-8 Impaired Waters in the Little River Watershed.

AU Name	AU Number	Stream Class	Parameter of Interest	303d Year
Little River	30-5-(1)b	C; Sw	Chlorophyll a (40 µg/l, AL, NC)	2010

Table 3-9 Best Management Practices Funded by State Cost Share Programs in the Little River (HUC: 0301020505) (July 2012 – July 2020).

Best Management Practice	Unit type	6/1/2012 - 6/30/2015			7/1/2015 - 6/30/2020		
		Units Implemented	# of Contracts	Cost Share	Units Implemented	# of Contracts	Cost Share
Cover Crops	ACRE				135.78	2	$5,431
Critical Area Planting	ACRE				4	1	$463
Crop Residue Management	ACRE	123.53	1	$1,853	147.1	1	$3,000
Grade Stabilization Structure	EACH				1	1	$2,232
Land Smoothing	ACRE	213.93	5	$32,089	700.53	16	$101,810
Long-Term No-till	ACRE	90.1	2	$13,515			
PRECISION AGRICHEMICAL APPLICATION	EACH				1	1	$6,000
Water Control Structure	EACH				4	2	$9,143
Grand Total		**427.56**	**8**	**$47,457**	**993.41**	**24**	**$128,079**

3.8.1 Little River [AU# 30-5-(1)a and 30-5-(1)b; Primary Surface Water Classification: C, Supplemental Classification: Sw, Length is 11 river miles]

Sampling Year	Bioclassification (MB7)
2005	Moderate
2010	Moderate
2015	Moderate

The Little River benthic macroinvertebrate community site (MB7) has been monitored since 1983. The Little River primarily drains the Great Dismal Swamp and much of the watershed has been converted to agriculture decades ago. While the amount of land in agriculture has remained stable, since the 1990s there has been a decline in the amount of forest land in the watershed and a small increase in the amount of developed land, likely in the western outskirts of Elizabeth City. This small change in land use has not been large enough to be reflected in the bioclassification at this site; which has remained stable at a Moderate rating since criteria were applied in 2000.

The Little River ambient water quality is monitored at a station located near the town of Woodville (M3500000) (Figure 3-2). The Upper Little River [AU# 30-5-(1)], was first listed on the 1998 303(d) list of impaired waters for a water quality standards violation (low dissolved oxygen). Potential sources were identified as non-irrigated crop production, onsite wastewater systems, off-farm animal holding and/or management areas and land development. Swamp conditions combined with agricultural runoff were thought to be contributing to the low dissolved oxygen levels. DWR continues to recommend additional sampling in order to evaluate natural and anthropogenic impacts on dissolved oxygen levels in the Little River. Growth management to protect water quality from future development activities is also encouraged. Currently, annual mean dissolved oxygen levels in this stream remain significantly lower than the nearby Pasquotank and Perquimans rivers.

The 2018 IR reports that the Little River was placed on the impaired waters list in 2010 for chlorophyll *a* and fish tissue mercury. Dissolved oxygen and iron were data inconclusive. In 2018 and 2019, annual geometric mean fecal coliform values appear to be elevated compared to values from 2000 through 2017 (Appendix-III). There have also been many reported algal blooms occurring in the Little River system over the last several years (Appendix VI). Nutrients (nitrate-nitrite, ammonia, TKN, and phosphorus), as well as, chlorophyll *a* and algal blooms are discussed in Chapter 6. Overall, the Little River reflects the land use in this watershed. DWR continues to recommend conservation of riparian buffers in swamp forest, agriculture, and developed land to aid filtering of stormwater runoff, promote infiltration, and protect water quality.

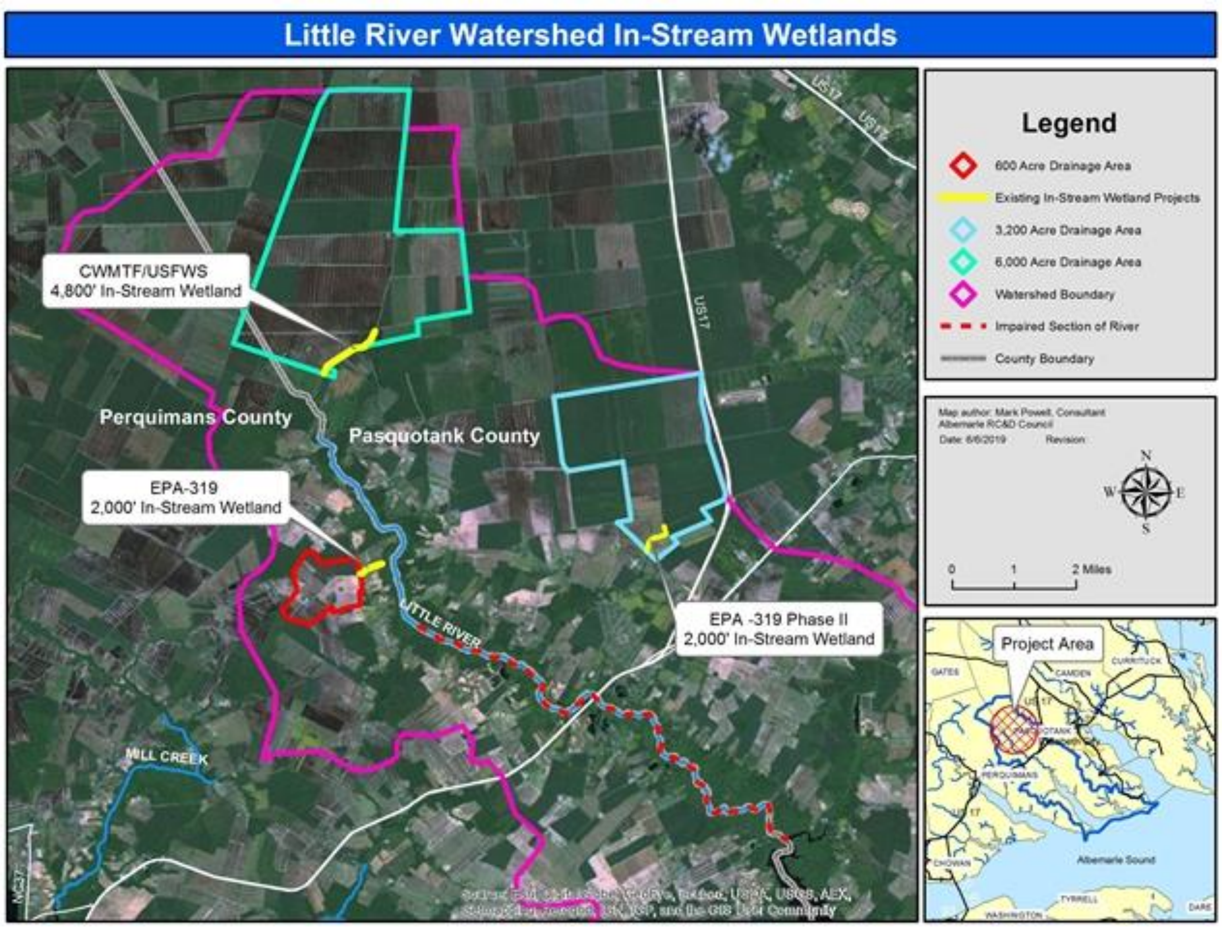
Albemarle Resource Conservation and Development Council (ARCD), Inc. has partnered with Camden, Chowan, Currituck, Dare, Gates, Hyde, Pasquotank, Perquimans, Tyrrell, and Washington counties since 1972 on many projects to improve drainage and water quality. In 2016, the ARCD, Pasquotank County, and Pasquotank Soil and Water Conservation District (SWCD) used grants from the Clean Water Management Trust Fund (CWMTF) and US Fish and Wildlife Service (USFWS) to construct 4,800 ft. of in-stream wetland on a farm canal in the upper part of the Little River watershed (ARCD, 2019) (Figure 3-5). At the same time, the ARCD, Perquimans County, and Perquimans SWCD used an EPA 319 grant to construct 2,000 ft. of in-stream wetland on a farm canal just above the impaired section of the Little River (ARCD, 2019). A second EPA 319-funded in-stream wetland was constructed in 2018 along 2,000 ft. of privately-owned canal that drains approximately 3,200 acres of agricultural land and solar farms on the Pasquotank County side of the Little River watershed (ARCD, 2019) (Figure 3-5).

Two objectives of these in-stream wetland projects were (ARCD, 2015; ARCD, 2019).:

1. To monitor their effectiveness for removing nitrogen and phosphorus, and capturing sediment
2. To educate the general public about the importance of these types of wetlands for protecting and improving water quality in the Little River watershed

The three projects also included improvements to drainage and water management on adjacent cropland, which helped show the land owners that they would get better crop production even though they had to give up some land for the wetlands and buffers (ARCD 2015; ARCD, 2019). During these projects, the instream wetlands became integral components of the farmers' overall efforts to improve drainage and water management on their cropland (ARCD 2015; ARCD, 2019). Water quality monitoring of two in-stream wetlands during their plant establishment phase showed only minor nutrient concentration changes for each pollutant parameter (ARCD, 2015; ARCD, 2019). Total Suspended Solids reduction appeared to be the highest among pollutants evaluated in both studies (ARCD, 2015; ARCD 2019). Although initial results indicate minor nutrient concentration changes, ARCD notes that a longer period of monitoring is needed, four to five years, to effectively measure the water quality performance of these instream wetlands under natural conditions (ARCD, 2015). Additional information about this project can be found on the ARCD website (https://www.albemarlercd.org/).

Figure 3-5 Little River Watershed In-Stream Wetlands



3.9 Dismal Swamp Canal-Lake Drummond (HUC: 0301020506)

The Dismal Swamp Canal – Lake Drummond watershed drains approximately 47 square miles of land in North Carolina from northwestern Camden, northern Pasquotank, and northeastern Gates counties (Figure 3-1 and Figure 3-2). The predominant land use is wetland (78.4%) followed by agriculture (10.7%), forest (7.7%), developed (1.3%), grassland/shrub (1.0%), and open water (0.9%). There are no NC based ambient or benthic macroinvertebrate community monitoring stations in this watershed. Between 2015 and 2020, a total of 7,500 dollars were used to fund cover crops on 187.5 acres in the Dismal Swamp Canal-Lake Drummond watershed.

The Dismal Swamp National Wildlife Refuge comprises a large portion of this watershed. Between Virginia (~86,000 acres) and North Carolina (~26,000 acres) this refuge encompasses 111,203 acres of important habitat for wildlife (US FWS, 2006). This swamp is characterized by seasonal flooding of a forested wetland (USGS, 2018). Fertilizer and pesticides used on corn, soybeans, cotton, and peanuts, runoff from hog operations, and sediment from agriculture and timberlands are potential sources of water quality concerns in this area (US FWS, 2006). In addition to water quality concerns, timber harvesting, wildfires, hydrologic modification as a result of drainage ditches with adjacent spoil piles have altered the forest ecosystem (USGS, 2018). The US Fish and Wildlife Service (US FWS) has established a goals in their comprehensive conservation plan for this area that will be active since 2006, before revising the document after 15 years. The entire document is available on their website for the Great Dismal Swamp.

1. Manage the area for the primary purpose of protecting and preserving a unique and outstanding ecosystem, as well as protecting and perpetuating the diversity of animal and plant life therein.
2. Protect and enhance Service trust resources and other significant species.
3. Provide protection and restoration of those areas within the Great Dismal Swamp ecosystem that are remnants of the Great Dismal Swamp and/or are restorable to Great Dismal Swamp habitat while providing support to the protection and restoration of all its components and adjacent habitats that directly affect the vitality and viability of the ecosystem.
4. Establish a public use program that will encourage awareness, understanding, appreciation and stewardship of the Great Dismal Swamp NWR ecosystem while complementing the refuge resource management objectives.

The natural hydrology and original extent of the Great Dismal Swamp, believed to have been 10-times larger by some accounts have been significantly altered through many years of substantial ditching and drainage projects, starting in the late 1700s. One of the earliest projects of note was the construction of the 22-mile long Dismal Canal which is the oldest operating artificial waterway in the US. The canal was completed in 1805 to provide transportation from North Carolina to the tidewater region of Virginia and to promote the drainage of the Dismal Swamp for agriculture. Recently, between 2010 and 2016 the use of water control structures with adjustable weirs in the Great Dismal Swamp area has expanded and the USGS built a three-dimensional numerical model to simulate groundwater and surface-water in the Great Dismal Swamp area of Virginia and North Carolina (USGS, 2018). Today, the remaining the Great Dismal Swamp, although drier than it once was, is managed by the US FWS as a wildlife refuge (175 square miles) and the North Carolina Division of Parks and Recreation, as the Dismal Swamp State Park (22 square miles). A large fire after droughts in 2008 and 2011 smoldered peat soils for weeks, releasing carbon into the atmosphere and caused the conversion of forested and shrub covered wetlands to freshwater marsh

(Hutchins, 2011, US FWS, 2008, Balaraman, 2017). Other common wetlands habitats found in the Great Dismal Swamp today include pocosins, bottomland hardwood, non-riverine swamp forest, wet pine flats (NC DWR, 2018, NC DCM, 2020).

Peat soils in North Carolina's wetlands are excellent for retaining flood waters and sequestering carbon. The largest known forested wetland restoration project east of the Mississippi River was completed, in 2013, at the Great Dismal Swamp. A vast 9,580 acres of wetlands were restored on state and federal lands with the installation of two large water control structures (weirs) at the Kim Saunders and South Martha Washington ditches located in the Dismal Swamp State Park (US FWS, 2013, BIMS, 2017). These water control structures successfully restored hydrology to peat lands drained over 60 years earlier. Within eight months, carbon emissions were reduced by the equivalent of annual emissions by 16 million cars. It is anticipated the restored hydrology will reduce the risk of wildfires and improve the management of some at risk species (e.g. Atlantic white cedar, US FWS, 2013).

3.10 Pasquotank River (HUC: 0301020507)

Pasquotank River watershed drains approximately 344 square miles of land from eastern Pasquotank and western Camden counties (Figure 3-3). Primary land cover in this watershed is agriculture (41.7%) followed by wetland (32.4%), open water (11.0%), developed (7.2%), forest (6.9%), and grassland/shrub (0.8%). Currently, there is one ambient monitoring station and one benthic macroinvertebrate site. Approximately 9,186 saltwater acres are impaired for dissolved oxygen, pH, and copper (Table 3-10). Between 2012 and 2020, a total of $463,413 dollars were used to fund Best Management Practices by the State Cost Share Programs in the Pasquotank River watershed (Table 3-11). Water quality monitoring is also conducted by the ARCD from six sites in this watershed (see Chapter 8 for more information about citizen science water quality data collection).

Table 3-10 Impaired Waters in the Pasquotank Watershed

AU Name	AU Number	Stream Class	Parameter of Interest	303d Year
Pasquotank River	30-3-(12)	SB	Copper (3 µg/l, AL, SW)	2008
Pasquotank River	30-3-(12)	SB	Dissolved Oxygen (5 mg/l, AL, SW)	2018
Pasquotank River	30-3-(12)	SB	pH (6.8 su, AL, SW)	2014

Table 3-11 Best Management Practices Funded by State Cost Share Programs in the Pasquotank River (HUC: 0301020507) (June 2012 - June 2020)

Best Management Practice	Unit type	6/1/2012 - 6/30/2015			7/1/2015 - 6/30/2020		
		Units Implemented	# of Contracts	Cost Share	Units Implemented	# of Contracts	Cost Share
Abandoned Well Closure	EACH				1	1	$780
Agricultural Water Supply/Reuse Pond	EACH	1	1	$14,063			
Cisterns	EACH	1	1	$2,969			
Cover Crops	ACRE	85	1	$3,400	1737.61	11	$69,505

Best Management Practice	Unit type	6/1/2012 - 6/30/2015			7/1/2015 - 6/30/2020		
		Units Implemented	# of Contracts	Cost Share	Units Implemented	# of Contracts	Cost Share
Crop Residue Management	ACRE	6872.4	29	$103,086	4436.5	12	$66,569
Cropland Conversion - Grass	ACRE				19.1	1	$5,730
Cropland Conversion - Trees	ACRE				11	1	$701
Grade Stabilization Structure	EACH				2	2	$6,930
Grassed Waterway	ACRE				0.28	1	$1,167
Land Smoothing	ACRE	225.2	4	$33,780	1170.65	14	$89,993
Long-Term No-till	ACRE				75.4	1	$11,310
Nutrient Management	ACRE				1451.4	2	$26,117
Pet waste receptacle	EACH	3	3	$3,022			
PRECISION AGRICHEMICAL APPLICATION	EACH	2	2	$3,670	1	1	$2,839
Three Year Conservation Tillage for Grain and Cotton	ACRE	116.6	4	$6,996			
Water Control Structure	EACH				3	2	$10,786
Grand Total		**7306.2**	**45**	**$170,986**	**8908.94**	**49**	**$292,427**

3.10.1 Pasquotank River [AU# 30-3-(1); Primary Surface Water Classification: WS-V, Supplemental Classification: Sw; Length is 16 river miles], [AU # 30-3-(3); Primary Surface Water Classification: WS-IV, Supplemental Classification: Sw; Length is 11 river miles], [AU # 30-2-(12); Primary Surface Water Classification: SB; Area is 9,186 acres]

Sampling Year	Bioclassification (MB3)
2005	Fair
2010	Not Impaired
2015	Not Rated

The benthic macroinvertebrate community site (MB3) in the Pasquotank River was sampled in 2015, but was given a Not Rated bioclassification based on the provisional status of the biocriteria. Previously, the 2010 sample at this site showed a large decline in overall taxa richness relative to the 2005 collection, but the EPT richness was the highest on record. In addition to the increased EPT richness, the BI and EPTBI both reached all-time lows for this location. During the 2010 sampling event, several intolerant EPT taxa were collected for the first time at this location including the caddislies (*Oecetis persimilis*, *Cyrnellus fraternus*, and *Polycentropus spp)*. However, several tolerant taxa present from the 2000 and 2005 samples were absent in the 2010 collection including several dragonflies (*Neurocordulia obsoleta*, *Tetragoneuria spp*, *Pachydiplax longipennis*), the chironomdis *Glyptotendipes spp*, *Kiefferulus dux*, and the oligochaete *Stylaria lacustris*. Combined, these data suggest improved conditions here relative to previous samples and the 2010 sample was assigned a Not Impaired rating. However, for purposes of inter-year comparison, the 2010 collection would have received a Good-Fair bioclassification based on the provisional criteria.

Downstream from the benthic community site is an ambient monitoring station (M2750000) (Figure 3-2). In 2015, this station was relocated upstream from its mid-channel position to the mouth of Charles Creek. This station was also renamed M2490000 due to the difference in water quality. The Pasquotank River was placed on the 303(d) list of impaired water for copper in 2008, followed by a pH impairment in 2014, and dissolved oxygen impairment in 2018. Low pH values are not unexpected in the Pasquotank River since it receives water from many classified swamp streams including the Great Dismal Swamp. Swamp waters naturally show low pH levels, which can impact freshwater and saltwater found in the Pasquotank River. Freshwater runoff is the most significant factor affecting water quality in this region and can be associated with agricultural runoff or natural runoff from swamp waters following heavy rains. The dissolved oxygen impairment should be reassessed during future Integrated Report periods to ensure the station relocation did not influence the 303(d) impaired waters listing for this assessment unit 30-3-(1).

In November 2014, as part of the Triennial Review process, the Environmental Management Commission approved new water quality standards for dissolved metals. These dissolved metal standards became effective as part of the North Carolina Administrative Code at the start of 2015. EPA approved the water quality standards for dissolved metals for North Carolina in April 2016. Pasquotank River was listed based analysis of total metals samples and because new standards for copper in class SB waters are based on dissolved metals samples, then the ambient station M2750000 on Pasquotank River was placed on a priority list for sampling. The necessary data is expected to be used in future Integrated Reports. DWR recommends collecting these dissolved metals samples until enough data is collected to reassess this stream segment with the new dissolved metals standards. After reassessing the metals impairment, if copper criteria exceedances are confirmed by assessing the dissolved fraction then a source identification and abatement project is recommended.

The 2007 Pasquotank River Basin Water Quality Management Plan recommended that the Elizabeth City Wastewater Treatment Plant address issues it had at the time with inflow and infiltrations (I/I). The Permittee noted in their 2017 renewal application that approximately 700,000 gallons per day flowed into the treatment works from I&I and that services are being surveyed to identify problem pipes to address this issue (NCDEQ, 2018). NCDEQ also analyzed the upstream and downstream data ranging from May 2016 to August 2018 data was conducted for this permitted facility. This analysis included reviewing the temperature, dissolved oxygen, pH, conductivity, salinity, total nitrogen, total phosphorus, chlorophyll a, and enterococci. Students t-tests were run at a 95% confidence interval to analyze relationships between instream samples. A statistically significant difference is determined when the t-test p-value result is < 0.05. It was concluded with 95% confidence that no statistically significant difference exists between upstream and downstream dissolved oxygen, salinity, conductivity, pH, total nitrogen, total phosphorus, and enterococci. However, the analysis concluded that effluent temperature does appear to influence downstream temperature on occasion, and that a statically significant difference exists between upstream and downstream chlorophyll a. The last facility inspection in October 2020 reported that this facility was non-compliant due to the number of NPDES permit violations over the review period (October 2018 – October 2020).

Elizabeth City received four grants totaling approximately 2.2 million dollars for infrastructure projects funded by the State Water Infrastructure Authority. Elizabeth City received $123,992 dollars to focus on detecting and locating nonrevenue water in their distribution system and updating their capital improvement plan based on the study's findings. The deliverable was approved by the Division of Water Infrastructure on October 26, 2020. Another 150,000 grant offer for sewer asset inventory and assessment in 2020 focused on resolving I/I issues in the collection system; however no deliverable has been submitted as of June 2021. Finally, the Drinking Water State Revolving Fund and Community Development Block Grant for Infrastructure awarded approximately 2 million dollars for raw water reservoir rehabilitation and replacement of a portion of the raw water transmission main. As of June 2021, no funds have been dispersed for the raw water reservoir rehabilitation. The raw water transmission main included replacement of a portion of the City's raw water cast iron transmission main and six valves at the City's wellfield pump house. Please refer to Chapter 8 for more information about these grants.

3.11 North River (HUC: 0301020510)

The North River watershed drains approximately 166 square miles of land from eastern Camden and western Currituck counties (Figure 3-1). This watershed is primarily composed of wetlands (54.4%) agriculture (23.5%) and open water (16.6%). The North River, which in turn is fed by Run Swamp Canal and Indiantown Creek, forms the watershed for the western part of the county (Currituck SWCD, personal communication). Currently there are no DWR ambient monitoring stations or benthic macroinvertebrate sites in this watershed. However, water quality monitoring is being conducted by the Currituck Soil and Water Conservation District in the North River (see Chapter 8 for more information about citizen science water quality data collection). Significant Natural Heritage Areas in the North River are characterized by vast, high quality Tidal Freshwater Marshes and Cypress-Gum Swamps, as well as nonriverine wetland communities of Swamp Forest and Atlantic White Cedar. However, only a small fraction of the area is protected. The protection (29,508 acres or ~33% of the land) on the North River is greater on the downstream end (Currituck SWCD, personal communication). Low density residential and agriculture are primary land uses on the upstream of the North River and there is more extensive "V" ditching of agriculture fields on Camden side (Currituck SWCD, personal communication). Between 2012 and 2015, a total of $29,982 dollars were used to fund Best Management Practices by the State Cost Share Programs in the North River watershed (Table 3-12). Practices included cover crops, crop residue management, and land smoothing.

Table 3-12 Best Management Practices Funded by State Cost Share Programs in the North River (HUC: 0301020510) (June 2012 – June 2015)

Best Management Practice	Unit Type	6/1/2012 - 6/30/2015		
		Units Implemented	# of Contracts	Cost Share
Cover Crops	ACRE	91.35	1	$3,654
Crop Residue Management	ACRE	1545.2	6	$23,178
Land Smoothing	ACRE	21	1	$3,150
Grand Total		**1657.55**	**8**	**$29,982**

3.12 Northwest River (HUC: 0301020511)

The Northwest River watershed drains approximately 108 square miles of land area in northern Currituck county (Figure 3-1). This watershed is primarily composed of wetlands (45.7%), agriculture (38.7%) with a small percentage of forested land (6.5%). There are no DWR ambient monitoring stations and one benthic macroinvertebrate site. The benthic macroinvertebrate site (MB11) is located on an unnamed tributary of Cowells Creek. The site was only sampled once in 2005 and received a moderate rating, no ongoing sampling has occurred at this site. Water quality monitoring is being conducted by the Currituck Soil and Water Conservation District in Tulls bay Near Olmstead Lane (see Chapter 8 for more information about citizen science water quality data collection). Between 2012 and 2020, a total of $127,089 dollars were used to fund Best Management Practices by the State Cost Share Programs in the Northwest River watershed (Table 3-13).

Table 3-13 Best Management Practices Funded by State Cost Share Programs in the 3.12 Northwest River (HUC: 0301020511) (June 2012 - June 2020)

Best Management Practice	Unit Type	6/1/2012 - 6/30/2015			7/1/2015 - 6/30/2020		
		Units Implemented	# of Contracts	Cost Share	Units Implemented	# of Contracts	Cost Share
Crop Residue Management	ACRE	1616.4	5	$24,246			
Land Smoothing	ACRE	213.8533	4	$29,967	464.15	3	$64,451
Non-Field Farm Road Repair	EACH				1	1	$6,523
Water Control Structure	EACH				1	1	$1,902
Grand Total			**9**	**$54,213**		**5**	**$72,876**

The Moyock Regional Wastewater Treatment Plant (WQ0035706) has maintained a SOC with the EMC since 2019. The SOC (S17-005 Ad. I) stipulates “The currently permitted wastewater treatment system is no capable of consistently meeting effluent limits in the current permit due to numerous equipment failures, construction issues, and the strength of the influent wastewater being greater than what was estimated when the system was designed.” (NC EMC, 2019). During the 2013 to 2020-time frame, this facility developed an extensive history of permit effluent limit exceedances (i.e. BOD, Ammonia, Total Nitrogen, Phosphorus, and Total Suspended Solids). They are currently moving forward to replace the existing plant with a new system to meet compliance. Nonetheless, there is potential concern groundwater and surface water could be impacted. “The 2L groundwater standard for Ammonia has been exceeded in monitoring wells at the facility in March 2014, July 2014, March 2015, March 2016, July 2016, November 2016, March 2017, November 2017, November 2018, April 2019, and July 2019. In January 2016, November 2017, July 2018, October 2018, January 2019, March 2019, and April 2019 the 2L groundwater standard for Ammonia was exceeded in the sample from the groundwater lowing system around the infiltration basin.” (NCDEQ, 2020).

The Carolina Village WWTP (WQ0004696) entered into a Special Order by Consent in 2018 (S18-002), but the SOC has since expired. During the 2015 through 2020-time frame, this facility has not been capable of meeting effluent limits and have yet modify the WWTP to upgrade the treatment and disposal system (NCDEQ, 2020).

The Eagle Creek WWTP (WQ0014306) and the associated collection system (WQCS00290) have experienced multiple system failures in 2020 which impacted a substantial number of individual householders for several days. Additionally, two monitoring wells have consistently show elevated concentrations of total ammonia nitrogen above the State's groundwater standard of 1.5 mg/L. This facility has also document compliance issues related to operations and maintenance.

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