Survey of Surface Water Quality Associated With Hurricane Matthew, October 2016

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North Carolina Department of Environmental Quality

Division of Water Resources

Water Sciences Section

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Executive Summary

During October 2016, in the aftermath of Hurricane Matthew, the N.C. Division of Water Resources (DWR) conducted water quality monitoring to assess the storm's impacts. Due to the enormous amount of rainfall that occurred across the Upper Coastal Plain and Sandhills regions of the state, flood conditions developed creating wastewater treatment facility flooding, and large areas of municipal flooding. After conditions became safe for travel, DWR staff began conducting site visits to evaluate various situations related to floodwaters and storm damage within days of the storm's passage. Based on various information reported to DWR from the public and staff sources, a strategy was developed for evaluation of surface waters. This effort involved seven river basins across eastern North Carolina. Results of water quality monitoring were compared to baseline conditions and previous hurricane monitoring. The following results were noted.

- Flood Conditions

  Peak river stages were very similar to Hurricane Floyd in the Tar-Pamlico and Neuse and higher in the Cape Fear and Lumber Rivers.
- Area Evaluated

  7 Rivers (Chowan, Roanoke, Tar-Pamlico, Neuse, New, Cape Fear, Lumber), 24 counties, 30 sites.
- Monitoring Summary

  6918 individual chemical analyses, and 544 individual physical measurements were collected as part of two phases. Phase 1 effort was completed Nov. 2, 2016. Phase 2 effort was completed Jan. 30, 2017.
- Short term effects, within four weeks of storm event

  Elevated fecal coliform bacteria concentrations, total kjeldahl nitrogen (TKN) and biochemical oxygen demand (BOD) concentrations above baseline ambient monitoring data, while dissolved oxygen and pH values were overall lower than baseline conditions.
- Long term effect, four months after storm

  Overall nitrate/nitrite (NOx) and fecal coliform bacteria concentrations were found above normal when compared to both initial conditions and historic data. Dissolved oxygen (DO), pH and most other parameters returned to normal conditions by January 2017.
- Historic Storm Comparison, Floyd September 1999

  After Matthew, TKN, NOx, total nitrogen, turbidity, and DO had higher observed concentrations at most sites when compared to Floyd, but ammonia and BOD were less concentrated overall at most sites when compared to post-Floyd concentrations.
- Chemical Pollutants

  There were very minor incidences of semi-volatile, and volatile organic compounds. Monitoring was discontinued after Phase 1 due to lack of detections.
- Coal Ash Sampling

  Physical and chemical samples collected near the H.F. Lee facility in Goldsboro, targeting 25 coal ash specific elements, indicated no effect on water quality in relation to storm flooding.

Introduction

This document provides a summary review of water quality characteristics related to the passing of Hurricane Matthew along the coastline of North Carolina during October 2016. In the aftermath of Matthew, the N.C. Division of Water Resources (DWR) conducted water quality monitoring across affected areas to assess the effects of the storm. Due to the enormous amount of rainfall that occurred across the Upper Coastal Plain and Sandhills regions of the state, flood conditions developed and caused waste lagoon inundation, wastewater treatment facility flooding and shutdowns, and large areas of municipal flooding. Initial environmental monitoring priorities were based on accessibility and emergency needs.

DWR staff began conducting site visits to evaluate various situations related to floodwaters and storm damage after conditions became safe for travel and the storm had passed. Based on information reported to DWR from the public and staff sources, a strategy was developed for evaluation of surface waters. To evaluate waters affected that were in the path of the storm and downstream areas, current information and historical storm monitoring efforts were considered. Monitoring sites selected for post-storm evaluation were chosen based on long-term Ambient Monitoring System (AMS) station locations and information being reported by Department of Environmental Quality regional office staff. Conditions at these selected sites were evaluated using historical chemical and physical water monitoring parameters, as well as additional analyses used to identify problems associated with wastewater treatment facilities, livestock operations, fuel spills and subsequent pollutant loading to rivers and estuaries. Sites selected provide comparative data from past storms similar in magnitude, as well as long-term normal flow conditions. River basins in this effort include the following: Tar-Pamlico, Neuse, Cape Fear, Lumber, Roanoke, Chowan and White Oak.

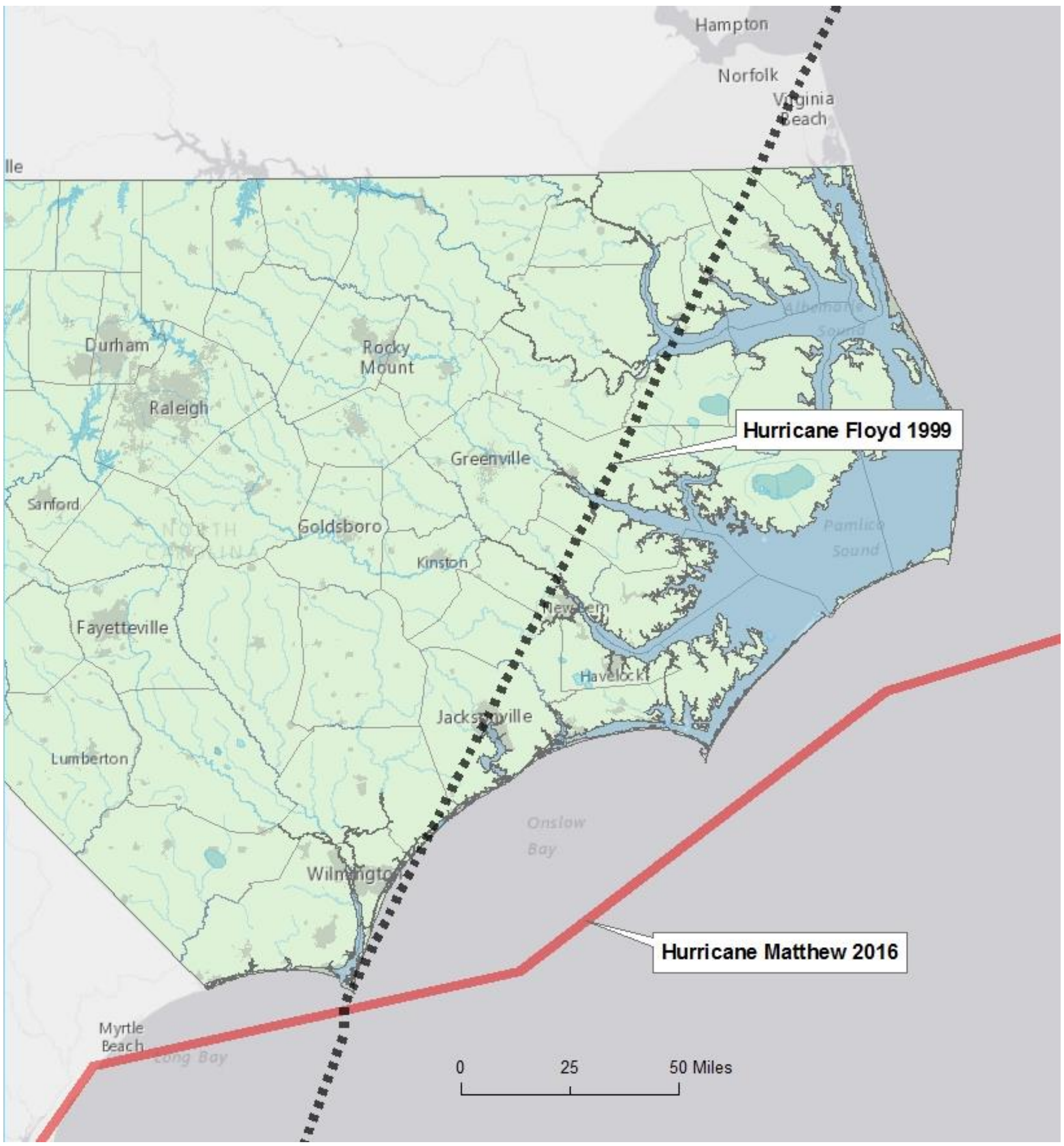
Based on site accessibility, sampling activities progressed in a west-to-east fashion as floodwaters receded. Water quality conditions were monitored in two stages, Phase 1 and Phase 2. Phase 1 monitoring efforts took place within three weeks of the storm event. Phase 2 was conducted from mid-November through January 2017.

After reviewing the data collected, and comparing that to precipitation amounts, river levels and known areas of flooding, the overall impacts of Hurricane Matthew on surface water quality were initially minimal and temporary, and the long-term effects appear to be similar to previous storms and long term historical conditions. While many eastern North Carolina areas were inundated by floodwaters and incidents of spills, breaches or waste facility shutdowns were reported, the amount of water discharged into the river basins resulted in a diluting effect, which primarily resulted in lower than normal concentrations of various pollutants.

Hurricane Matthew

Tropical storms and hurricanes are an annual threat to North Carolina in terms of wind damage and flooding. On October 8-9 of 2016, Hurricane Matthew passed along the state's coast as a category 1 storm. Its track began in the southern Caribbean Sea. Crossing Haiti, eastern Cuba and the Bahama Islands, it travelled north skirting Florida's east coast, then moved along the South Carolina and North Carolina coastlines. Its course turned northeast as it moved past Cape Hatteras and out into the Atlantic Ocean. As Hurricane Matthew passed the North Carolina coast, near record amounts of rainfall fell across eastern and central parts of the state. The storm affected the Piedmont and coastal regions through flooding and inundation from torrential rains. Storm surge produced by Matthew ranged from 2.5 feet to 7 feet above sea level (USGS, 2017). To provide a comparative event for assessment, Hurricane Floyd was referenced. Hurricane Floyd occurred Sept. 14-17, 1999 (Figure 1).

***Figure 1**. Matthew Track and Floyd Track*

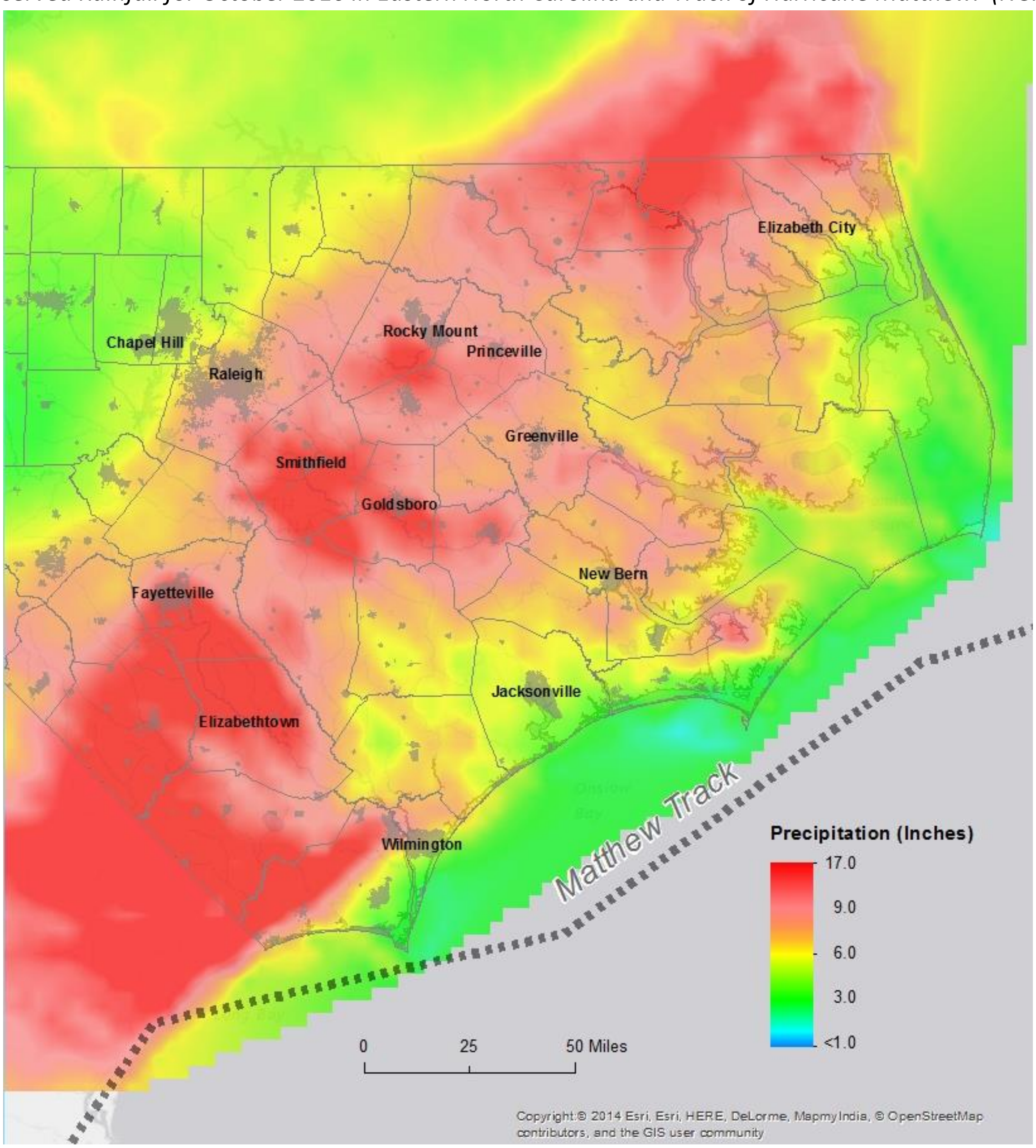


Rainfall

Hurricane Matthew produced rainfall totals reaching historic records along a 120-mile-wide band running southwest to northeast in the outer Piedmont and coastal plain of North Carolina. Rainfall amounts ranged from 3-8 inches across the storm's path in the east, with maximum amounts close to 17 inches over a 24-hour period (Figure 2). Rainfall banding from the storm created significant areas of heavy precipitation in the southeast corner of the state from Fayetteville to Elizabethtown, in the central coastal plain to the west of Goldsboro and in areas to the west of Elizabeth City. The amount of rainfall that fell during Matthew on October 8-9, 2016 represents 5-8 inches, or 200-400 percent more than normal for the entire month of October (NOAA 2017). After Hurricane Matthew passed, very little precipitation occurred in eastern North Carolina through the remainder of October.

Rainfall associated with Hurricane Matthew impacted seven river basins in eastern North Carolina. Two of the watersheds, the White Oak and Lumber, experienced storm associated rainfalls across the entirety of their basins in North Carolina. The remaining rivers had storm associated rain across large portions of their respective watersheds. Due to the large amount of precipitation that occurred within a 24-hour period, all the major rivers across the eastern part of the state began to peak within 48 hours in areas impacted by the storm (Figures 5,6; USGS 2016).

***Figure 2**. Observed Rainfall for October 2016 in Eastern North Carolina and Track of Hurricane Matthew. (NOAA 2017)*



Flooding

STAGE

The objective of examining stream gage associated with Hurricane Matthew was to understand the time progression of flooding from northwest to southeast/east, the duration of flooding versus location, the relation of water levels during water quality monitoring, and to compare with 1999 flood stages associated with Hurricane Floyd. Precipitation amounts from the storm differed across eastern North Carolina in terms of total amounts. The smaller river basins, White Oak and Lumber, experienced differing severity of flooding based on rainfall received despite both being entirely located within the storm's path. Larger river basins in the path of Matthew experienced flooding similar in scale to Hurricane Floyd that occurred in 1999. On larger rivers, stage height above flood stage in upstream reaches was shorter in duration than areas downstream. Much of the headwater areas of these river systems were outside of the main area of precipitation associated with Matthew. Areas that were affected by prolonged flooding, such as Tarboro, Kinston, Goldsboro and Boardman, were located farther downstream where much of the rain that fell across the respective basins had collected into the river's main stem. See figures 3 and 4 below for flood condition reference. The associated drainage from middle-basin areas such as Contentnea Creek and the Black River prolonged flood conditions in lower basin areas when combined with post-storm flows from upper-basin areas. USGS gaging stations located along main stems for the respective river basins indicate that post-Matthew river stages exhibited peaks that ranged 1–17 days after the storm passed (Figures 5&6, USGS, 2016). The New River at Gum Branch in the White Oak basin experienced peak stage almost immediately after the storm. Other areas along the coastal plain experienced peak stage 2–7 days afterwards, and prolonged flood stage conditions for up to two weeks (Table 1).

Figure 3. *Neuse River in Kinston, N.C. 10/15/2016, U.S.70 & U.S. 258 Intersection*
Image courtesey DWR staff Sarah Toppen, Allen Clark

Figure 4. *Tar River in Tarboro, Princeville, N.C. 10/13/2017, N.C. 33 & U.S. 258 Intersection*
Image courtesey NOAA NGS Imagery Services

Table 1. *National Weather Service Flood Stage, Peak Stage During Hurricane Matthew, and Peak Stage During Hurricane Floyd at USGS Stream Gage Locations in Eastern Portions of North Carolina River Basins.*

				Hurricane Matthew (2016)			Hurricane Floyd (1999)		
River Basin	**USGS station number**	**Station name**	**NWS flood stage (ft)**	**peak stage (daily mean ft)**	**peak stage date**	**duration above flood stage**	**peak stage (daily mean ft)**	**peak stage date**	**duration above flood stage**
Roanoke	2081000	Scotland Neck	28	26.89	22-Oct-2016	2 days	30.88	17-Sep-1999	2 days
	2081054	Williamston	12	11.46	25-Oct-2016	0 days	10.08	18-Sep-1999	0 days
Tar	2082585	Rocky Mount	21	28.14	10-Oct-2016	5 days	31.02	17-Sep-1999	7 days
	2083500	Tarboro	19	36.17	13-Oct-2016	10 days	40.16	21-Sep-1999	28 days
Neuse	2084000	Greenville	13	22.23	11-Oct-2016	3 days*	29.66	21-Sep-1999	20 days ***
	2089000	Goldsboro	18	29.63	12-Oct-2016	10 days	28.78	20-Sep-1999	25 days
	2089500	Kinston	14	28.22	14-Oct-2016	14 days	27.57	23-Sep-1999	37 days **
	2091814	Fort Barnwell	13	20.43	15-Oct-2016	13 days	-	-	-
White Oak	2093000	Gum Branch	14	18.59	9-Oct-2016	2 days	-	-	-
Cape Fear	2104000	Fayetteville	35	57.3	10-Oct-2016	5 days	37.66	17-Sep-1999	1 day
	2105500	Tarheel	42	36.07	10-Oct-2016	0 days	20.48	18-Sep-1999	0 days
	2105769	Lock #1 near Kelly	24	-	-	-	-	-	-
Lumber	2133500	Hoffman	8	8.53	9-Oct-2016	1 day	5.74	18-Sep-1999	0 days
	2133624	Maxton	-	15.21	11-Oct-2016	-	10.95	20-Sep-1999	-
	2134500	Boardman	-	14.31	11-Oct-2016	-	10.62	19-Sep-1999	-

* gage damaged after day 3
** days counted until stage increase from next hurricane, Irene (Oct 17-18 1999)
*** the record truncated while above flood stage   - flood stage at Maxton and Boardman (Lumber River) not available, no official flood stage height.

Figure 5. *River Stage Data from Oct. 6 – 26, 2016 During Hurricane Matthew at USGS Stream Gage Locations in Eastern Portions of Roanoke, Tar and Neuse River Basins*

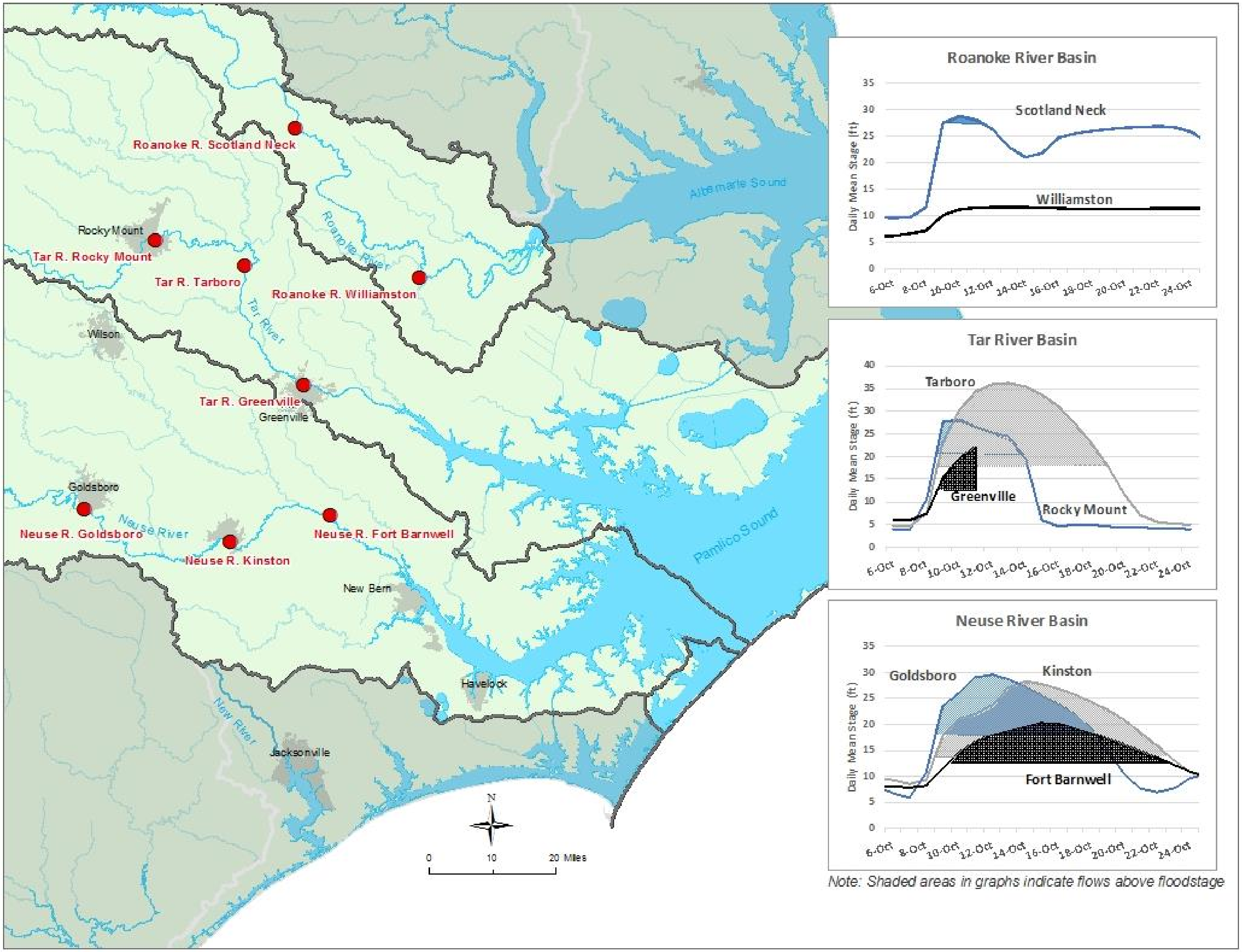
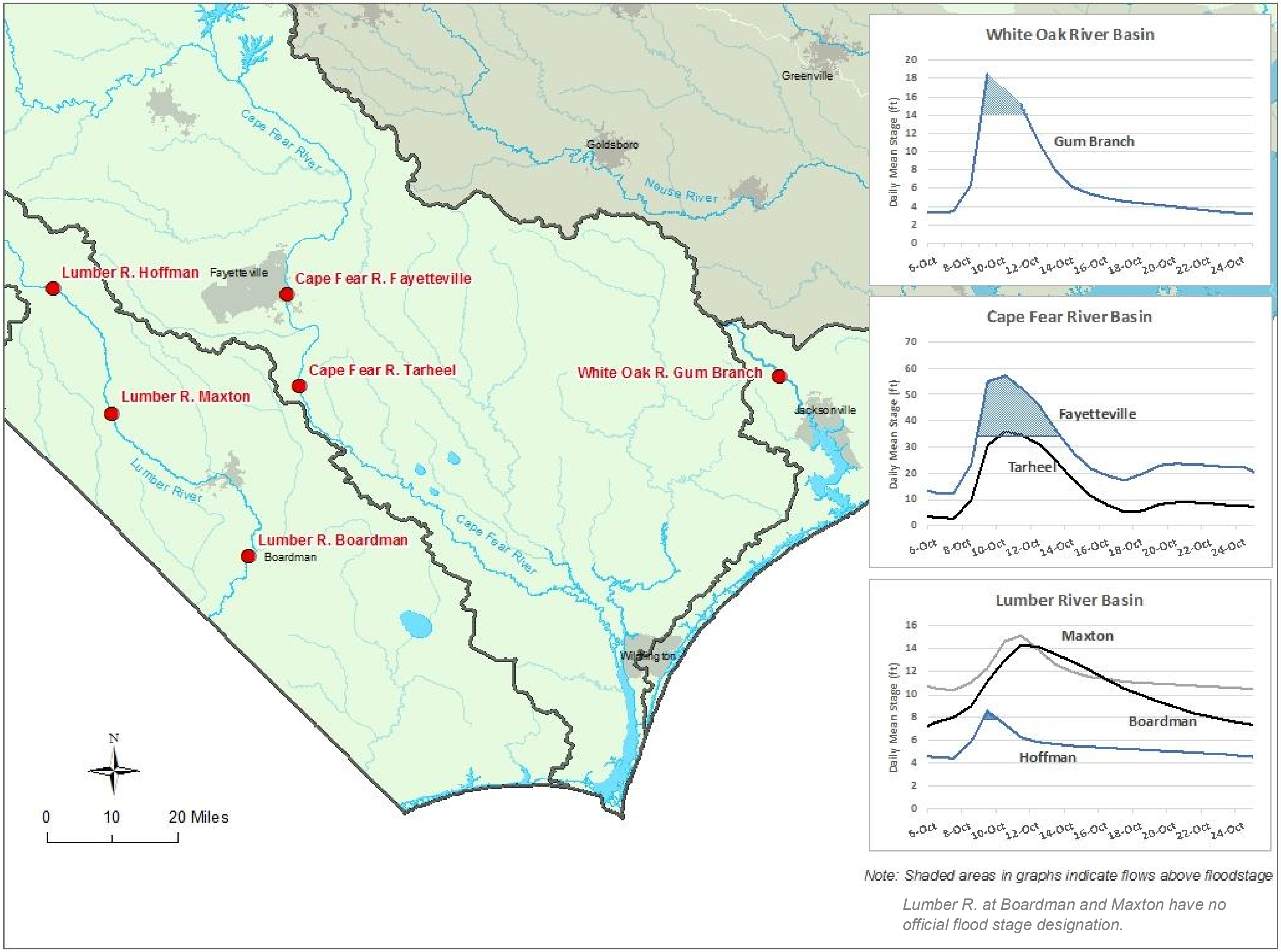


Figure 6. *River Stage Data from Oct. 6 – 26, 2016 During Hurricane Matthew at USGS Stream Gage Locations in Eastern Portions of White Oak, Cape Fear and Lumber River Basins*



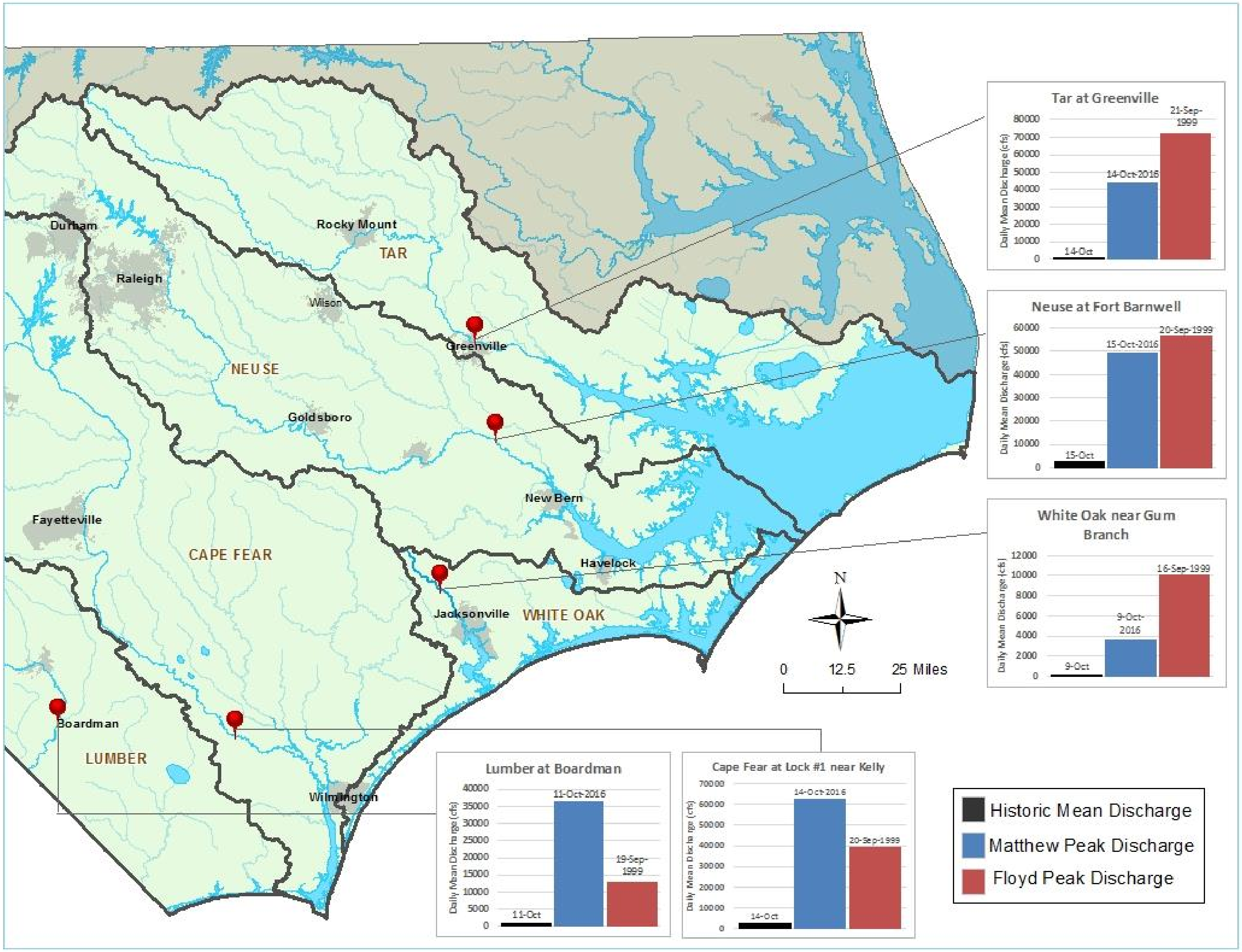
DISCHARGE

The objective of examining river discharge associated with Hurricane Matthew was to understand the quantity of accumulated rainfall moving through the system, as well as to compare with Hurricane Floyd (1999) discharge figures. Sites used to investigate the nature of discharge during Hurricane Matthew were chosen using the following criteria in no specific order: dilution factor, watershed representation, rainfall area, absence of tidal influence, land use in the region, number of flooded municipalities in the region and availability of USGS stream discharge data. Discharge volumes for river basins impacted by Hurricane Matthew are provided for evaluation of normal versus flood condition (Table 2). These discharge values allow for a snapshot of the various constituent loads being transported downstream during the storm event. Daily mean discharge values for downstream points in the Tar-Pamlico, Neuse and White Oak basins were less than values observed during Hurricane Floyd (USGS 2017), while discharges in the Cape Fear and Lumber river basins were higher than those observed after Floyd (Figure 7). These differences in discharge records are indicative of the distinct geographic precipitation amounts, duration of rainfall during Matthew and Floyd, and the amount of groundwater present in the affected areas prior to both storms.

Table 2. *Historic Mean Discharge, Peak Discharge During Hurricane Matthew and Peak Discharge During Hurricane Floyd at Five USGS Stream Gage Locations in Eastern Portions of North Carolina River Basins*

				Hurricane Matthew (2016)				Hurricane Floyd (1999)	
River Basin	**USGS station number**	**Station name**	**Drainage area (mi²)**	**Peak discharge daily mean (cfs)**	**Peak Discharge Date**	**Historic Mean Discharge at Peak Date (cfs)**	**Duration of Historic average data**	**Peak Discharge daily mean (cfs)**	**Peak Discharge date**
Tar	2082585	Rocky Mount	925	-	-	-	-	-	-
	2083500	Tarboro	2183	-	-	-	-	-	-
	2084000	Greenville	2660	44300	14-Oct-2016	880	18 years	72300	21-Sep-1999
Neuse	2089000	Goldsboro	2399	-	-	-	-	-	-
	2089500	Kinston	2692	-	-	-	-	-	-
	2091814	Fort Barnwell	3900	49300	15-Oct-2016	2780	19 years	57000	20-Sep-1999
White Oak	2093000	Gum Branch	94	3620	9-Oct-2016	169	52 years	10100	16-Sep-1999
Cape Fear	2104000	Fayetteville	4395	-	-	-	-	-	-
	2105500	Tarheel	4852	-	-	-	-	-	-
	2105769	Lock #1 near Kelly	5255	63000	14-Oct-2016	2730	34 years	39600	20-Sep-1999
Lumber	2133500	Hoffman	183	-	-	-	-	-	-
	2133624	Maxton	365	-	-	-	-	-	-
	2134500	Boardman	1228	36600	11-Oct-2016	1020	87 years	13000	19-Sep-1999

Figure 7. *Historic Mean Discharge, Peak Discharge During Hurricane Matthew and Peak Discharge During Hurricane Floyd at Five USGS Stream Gage Locations in Eastern Portions of North Carolina River Basins*



Water Quality Conditions

Water Quality Sampling Design and Analysis Methodology

Post-Hurricane Matthew monitoring occurred in two phases using a subset of DWR's Ambient Monitoring System (AMS) locations across the eastern half of North Carolina (Figure 8). Phase 1 monitoring provided data to evaluate conditions immediately after unsafe flood conditions subsided and was comprised of two rounds of sample collections. Round 1 sampling took place Oct. 19–26, 2016 and Round 2 sampling occurred approximately two weeks following (Oct. 31–Nov. 3, 2016). Phase 2 monitoring was intended to capture water quality conditions under 'normal' flow, (i.e., upon waters returning below flood stage), with Round 1 sampling occurring approximately one month after the initial hurricane response from Nov. 15–28, 2016; Round 2 approximately two months post-Hurricane Matthew (Dec. 1–28, 2016); and Round 3 over month three post-hurricane (Jan. 4 - 31, 2017).

The overall purpose of physical and chemical water quality data collection was to evaluate the effect of flood-related impacts such as spills, untreated waste and large scale wetland inundation, as well as gather data on the amount of time needed for conditions to return to normal.

During site visits, field crews recorded physical water quality conditions, site conditions, general flow, river stage, weather and other pertinent information relevant to water quality conditions. Chemical and physical parameters evaluated in this effort are outlined in Table 3. Sample collection information for all sites can be referenced in Table 4, along with site specific information. All procedures, safety considerations and field operations followed the *Hurricane Response Standard Operating Plan* (Water Sciences, 2016). Field crews were dispatched from DWR's Water Sciences Section in Raleigh, while AMS staff from the Raleigh and Wilmington Regional Offices collected samples in their respective territories.

Post-Hurricane Matthew monitoring data was parsed by parameter type and compared alongside historic medians from the last AMS assessment period (2010-2014) and AMS data associated with Hurricane Floyd (collected approximately two weeks after landfall in September-October, 1999) for the 30 sites when and where available.

Table 3. *Water Quality Parameters Collected by NCDWR During Hurricane Matthew Response Monitoring*

Chemical		**Physical**
Fecal Coliform (co/100ml)	Pesticide/Herbicide	Temperature (°C)
BOD5 (mg/L)	Volatile Organics	Conductivity (µs/cm)
Total Suspended Solids (mg/L)	Semi-Volatile Organics	pH (unit)
Chloride (mg/L)	Total Organic Carbon (mg/L)	Dissolved Oxygen (mg/L)
Turbidity (NTU)	TPH Gasoline and Diesel Range	
Nutrients (mg/L)	Metals (µg/L)	

Figure 8. *NC DWR Hurricane Matthew Response Monitoring Sites*

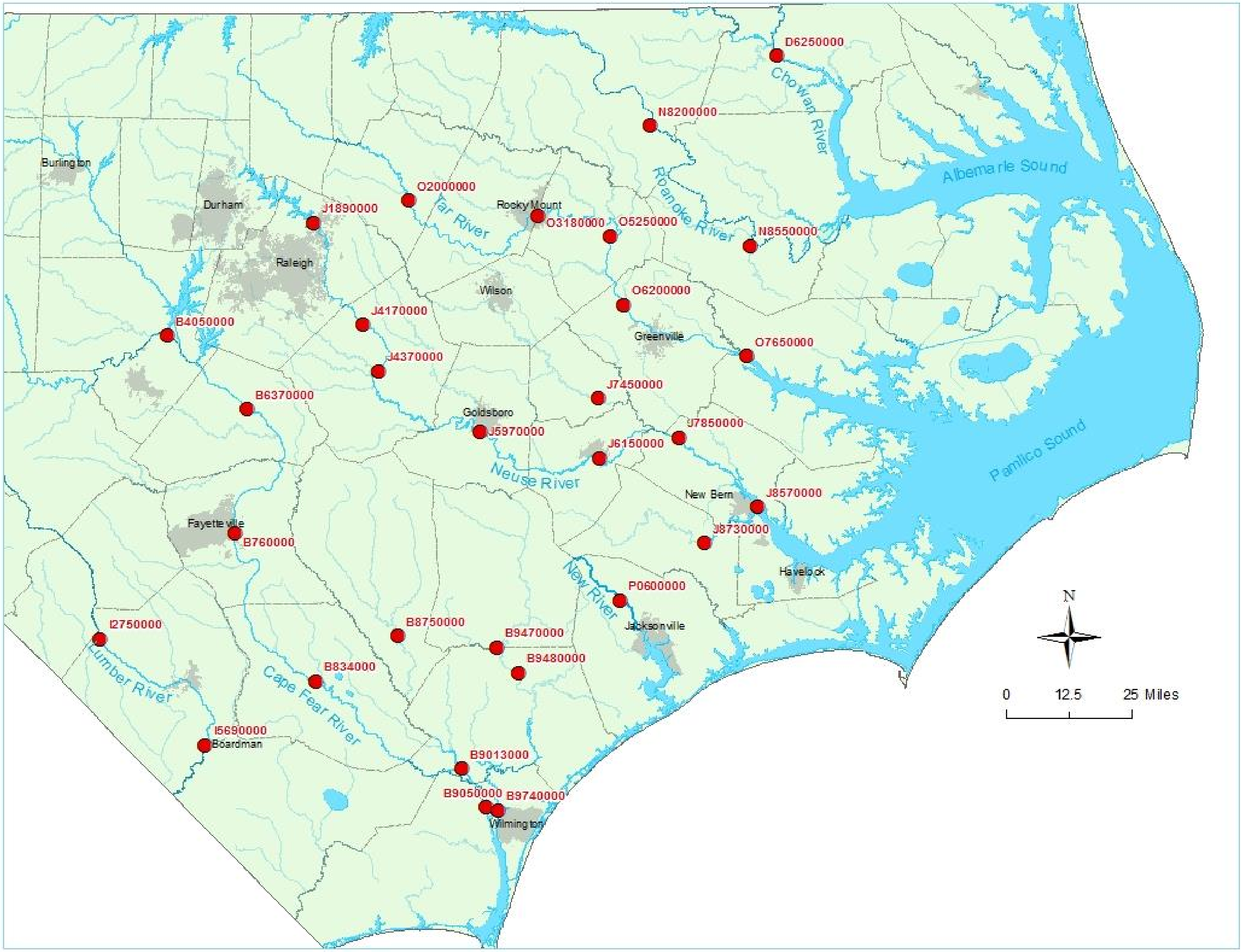


Table 4. *Hurricane Matthew Response Monitoring Site Information and Sampled Chemical Parameters Over Both Sampling Phases*

Site Information			Analysis									
Basin	AMS Site Number	Location Description	Fecal Coliform BOD,TSS, Chloride, Turbidity, Nutrients		Pesticides, Herbicides, Semi-Volatiles (SVOC), Volatiles (VOC), TPH-gas, TPH-diesel		TOC		Metals Total/Dissolved		Latitude	Longitude
			Phase 1	Phase 2	Phase 1	Phase 2	Phase 1	Phase 2	Phase 1	Phase 2		
Chowan	D6250000	CHOWAN RIV AT US 13 AT WINTON	x	x							36.4026	-76.9343
Roanoke	N8200000	ROANOKE RIV AT US 258 NR SCOTLAND NECK	x	x							36.2093	-77.3839
	N8550000	ROANOKE RIV AT US 13 AND US 17 AT WILLIAMSTON	x	x	x		x	x			35.8599	-77.0401
Tar	O2000000	TAR RIV AT SR 1001 NR BUNN	x	x							36.0023	-78.2433
	O3180000	TAR RIV AT NC 97 AT ROCKY MOUNT	x	x	x						35.9544	-77.7874
	O5250000	TAR RIV AT NC 33 AND US 64 BUS AT TARBORO	x	x	x		x	x			35.8935	-77.5323
	O6200000	TAR RIV AT NC 222 NR FALKLAND	x	x							35.6962	-77.4895
	O7650000	PAMLICO RIV AT US 17 AT WASHINGTON	x		x		x				35.5432	-77.0615
Neuse	J1890000	NEUSE RIV AT SR 2000 NR FALLS	x	x							35.9408	-78.5801
	J4170000	NEUSE RIV AT NC 42 NR CLAYTON	x	x							35.6473	-78.4057
	J4370000	NEUSE RIV AT US 70 BUS AT SMITHFIELD	x	x							35.5128	-78.3499
	J5970000	NEUSE RIV AT SR 1915 NR GOLDSBORO	x	x	x						35.3371	-77.9973
	J6150000	NEUSE RIV AT NC 11 AT KINSTON	x	x	x		x				35.2588	-77.5835
	J7450000	CONTENTNEA CRK AT NC 123 AT HOOKERTON	x	x							35.4286	-77.5826
	J7850000	NEUSE RIV AT SR 1470 NR FORT BARNWELL	x	x							35.3139	-77.303
	J8570000	NEUSE RIV .5 MI UPS UNION POINT AT NEW BERN	x	x	x		x	x			35.1097	-77.0317
	Lee1A	Lee Plant Upstream near Goldsboro							x		35.0099	-77.2189
	Lee2A	Lee Plant Downstream near Goldsboro							x		35.6534	-79.0673
	J8730000	TRENT RIV AT US 17 AT POLLOCKSVILLE	x	x							35.4068	-77.219

Table 4 Continued. *Hurricane Matthew Response Monitoring Site Information and Sampled Chemical Parameters Over Both Sampling Phases*

Site Information			Analysis									
Basin	**AMS Site Number**	**Location Description**	**Fecal coliform BOD,TSS, Chloride, Turbidity, Nutrients**		**Pesticides, Herbicides, Semi-Volatiles (SVOC), Volatiles (VOC), TPH-gas, TPH-diesel**		**TOC**		**Metals Total/Dissolved**		**Latitude**	**Longitude**
			Phase 1	Phase 2	Phase 1	Phase 2	Phase 1	Phase 2	Phase 1	Phase 2		
White Oak	P0600000	NEW RIV AT SR 1314 NR GUM BRANCH	x	x	x		x	x			34.849	-77.5196
Cape Fear	B4050000	HAW RIV BELOW JORDAN DAM NR MONCURE	x	x							35.6176	-79.0912
	B6370000	CAPE FEAR RIV AT US 401 AT LILLINGTON	x	x							35.4065	-78.8135
	B7600000	CAPE FEAR RIV AT NC 24 AT FAYETTEVILLE	x	x	x						35.0499	-78.8575
	B8340000	CAPE FEAR RIV AT LOCK 2 NR ELIZABETHTOWN	x		x		x	x			34.6264	-78.5768
	B8750000	BLACK RIV AT NC 411 NR TOMAHAWK	x	x			x	x			34.7544	-78.2891
	B9013000	BLACK RIV AT RACCOON ISLAND NR HUGGINS	x								34.372	-78.0721
	B9050000	CAPE FEAR RIV AT NAVASSA	x	x	x		x				34.2612	-77.9891
	B9470000	ROCKFISH CRK AT I 40 AT WALLACE	x	x							34.7191	-77.9462
	B9480000	NORTHEAST CAPE FEAR RIV AT SR 1318 NR WATHA	x	x	x		x	x			34.6459	-77.8725
	B9740000	NORTHEAST CAPE FEAR RIV AT NC 133 AT WILMINGTON	x	x	x		x				34.2518	-77.951
Lumber	I2750000	LUMBER RIV AT SR 1303 NR MAXTON	x	x							34.747	-79.3246
	I5690000	LUMBER RIV AT US 74 AT BOARDMAN	x	x	x		x	x			34.443	-78.9596

Water Quality Results Overview

For the first round monitoring effort, physical and chemical samples were collected across 24 counties, seven river basins (Cape Fear, Neuse, Lumber, White Oak, Tar-Pamlico, Roanoke and Chowan), and 30 monitoring sites, resulting in 6918 individual chemical analyses and 544 individual physical measurements collected. The Phase 1 effort was completed Nov. 2, 2016 and the Phase 2 effort was completed Jan. 30, 2017.

Phase 1 Summary

Immediate post-storm results from Phase 1/Round 1 indicated elevations of fecal coliform bacteria, total Kjeldahl nitrogen (TKN) and biochemical oxygen demand (BOD) concentrations above baseline ambient monitoring data, while dissolved oxygen and pH values were overall lower than baseline conditions. Phase 1/Round 2 results showed an overall slight increase in nitrate/nitrite (NOx) concentrations across the 30 sites sampled, while most other constituent concentrations such as BOD decreased to values close to baseline. Physical conditions such as dissolved oxygen and pH increased towards their typical baseline values.

Phase 2 Summary

Results from Phase 2 efforts are discussed as average values from three sample collection rounds occurring from mid-November 2016 through the end of January 2017. Water chemistry constituents that exhibited increased concentrations during the Phase 2 monitoring timeframe include NOx and fecal coliform bacteria, when compared to both Phase 1 conditions and ambient data. During this time, two ammonia samples and one NOx sample surpassed the maximum value observed for their particular sites, which occurred during ambient monitoring data collection from 2010-2014. Dissolved oxygen (DO) concentrations returned to conditions that were similar to ambient monitoring results during Phase 2 (Figure 9).

Historic Storm Comparison, Hurricane Floyd vs Matthew

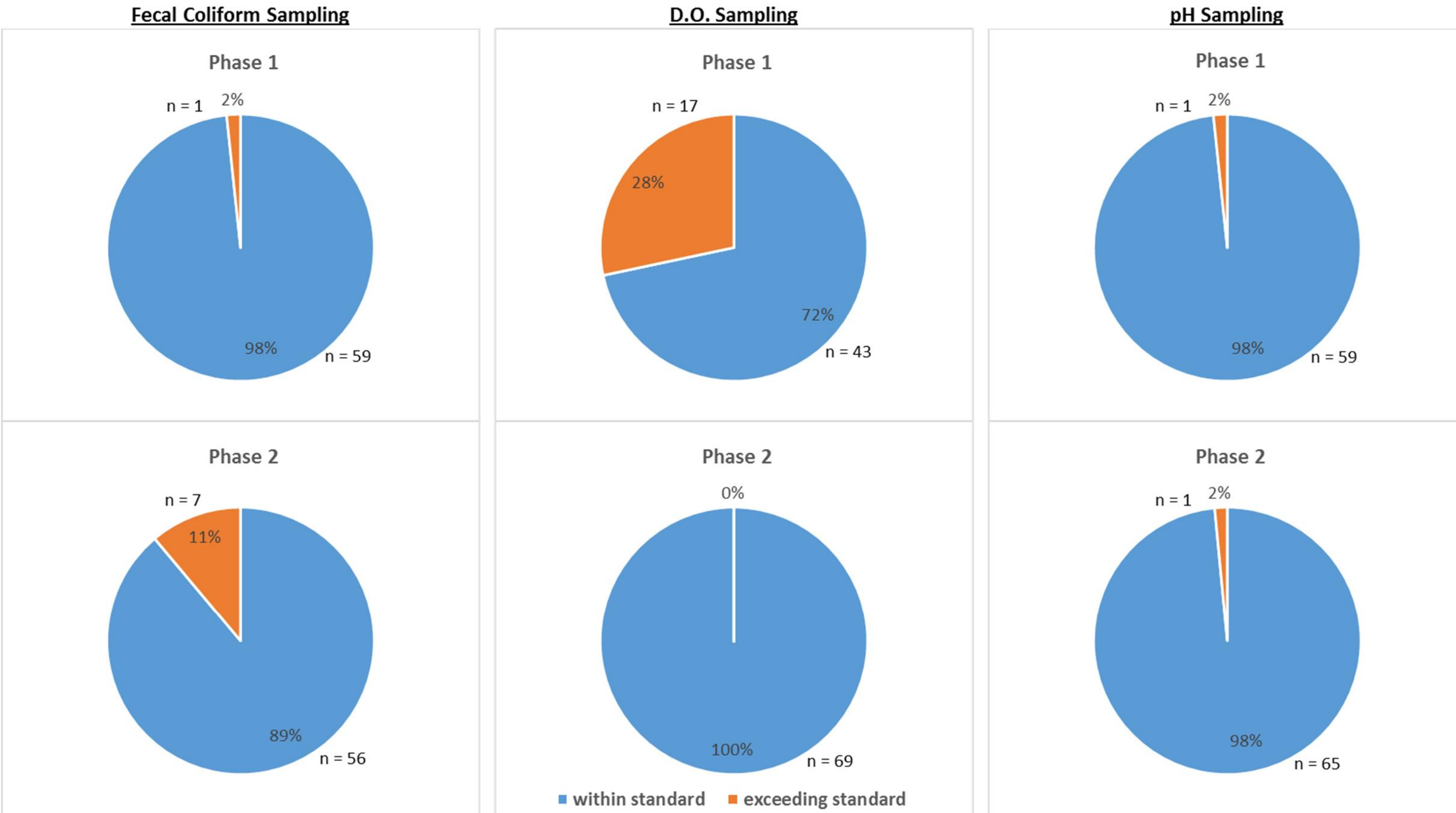
Similarities exist between many of the parameters evaluated in both events due in large part to the river stage and discharge similarities between the two storms. There are distinct differences in several parameters that could be attributed to factors other than storm path and rainfall amounts. After Matthew, TKN, NOx, total nitrogen, turbidity and DO had higher observed concentrations at most sites when compared to Floyd, but ammonia was less concentrated overall at most sites when compared to post-Floyd concentrations. Concentrations for BOD after Matthew were also lower than observed post Floyd. Comparisons for Floyd-related data were based on a time frame equivalent to Phase 1 of the Hurricane Matthew monitoring effort. DWR's Hurricane Floyd monitoring occurred within one month of the storm's passing.

Effects on Water Quality Standards

With the immense amount of water that passed through eastern North Carolina's river basins, water chemistry rapidly changed as rainfall became the dominant constituent of the water traveling from streams to rivers and eastward. As headwater areas, swamps, ponds and lakes were filled with, and subsequently drained of, rainfall from Matthew, the resultant flush of slow moving waters and associated organic materials created conditions that exceeded some water quality standards. During Phase 1, DO concentrations were observed below standard during 28% of sampling events, while pH values and fecal coliform bacteria exceeded standard at 2% of locations sampled. Phase 2 results showed an increased percentage of sampling events where fecal coliform bacteria exceeded standard (11%), while DO exceedances dropped to 0% and pH remained at 2% sampling events observed below state standard (Figure 9).

Various water quality information is presented graphically for selected sites for each river basin in Figures 10-21. Note that these graphs do not include all sampling sites visited during post-storm monitoring. To view data for all sites, refer to Appendices I, II and III.

Figure 9. *Number and Percentage of Sampling Events Above Standard During Phase 1 and Phase 2 of Hurricane Matthew Monitoring*



Nutrients

Certain Phase 1 and 2 nutrient concentrations exhibited differences when compared to historical median values. Values observed for NOx and TKN trend slightly inverse of each other from Phase 1 to 2. Concentrations for NOx generally increased from Phase 1 through Phase 2, while TKN decreased its concentration at most sites from Phase 1 to 2. Concentrations for both nutrient parameters were generally above those observed during Floyd (Figures 10 and 11).

Ammonia and total phosphorous concentrations exhibited less variability over Phase 1 and 2 than other nutrient parameters. Ammonia concentrations in both monitoring phases after Matthew were less than those observed after Floyd. Elevated ammonia levels appeared at site J1890000 in Phase 1 below Falls Lake, likely as a result of hypolimnetic (bottom water) entrainment from Falls Lake releases (J Curtis 2016). See Figures 13 and 14.

Results for TKN after Hurricane Floyd were generally higher than historic ambient concentrations, but exhibited a decrease in concentration from Phase 1 to Phase 2. This is likely associated with the large amount flooding that carried decaying organic material from floodplains, overflows from wastewater systems and animal wastes and into river channels. These materials are a source of organic nitrogen which makes up TKN along with ammonia. Site B9470000 exhibited elevated levels of NOx, total nitrogen (TN), and total phosphorous (TP) during Phase 1 Round 2 monitoring when compared to Phase 1 Round 1, and historic values. Phase 1 Round 1 values for BOD are also elevated at this site when compared to Phase 1 Round 2 concentrations (Figures 10-15).

Figure 10. *Nitrate / Nitrite (NOx) Results*

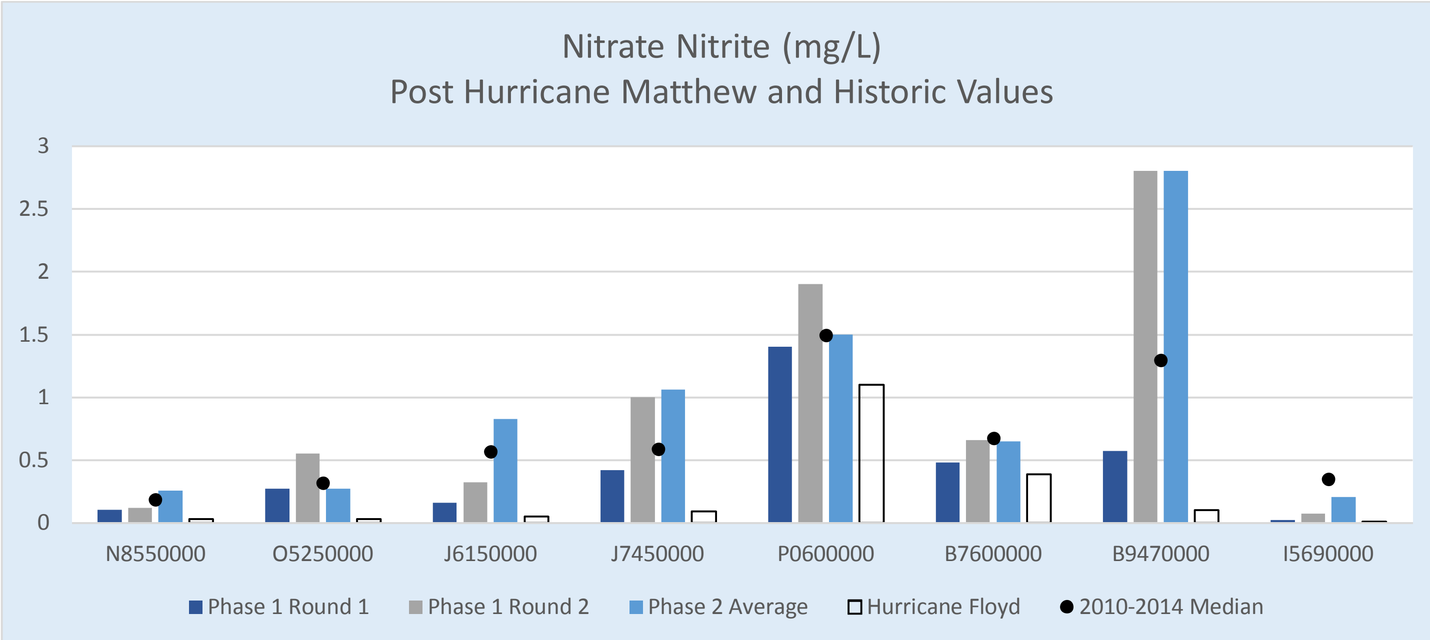


Figure 11. *Total Kjeldahl Nitrogen (TKN) Results*

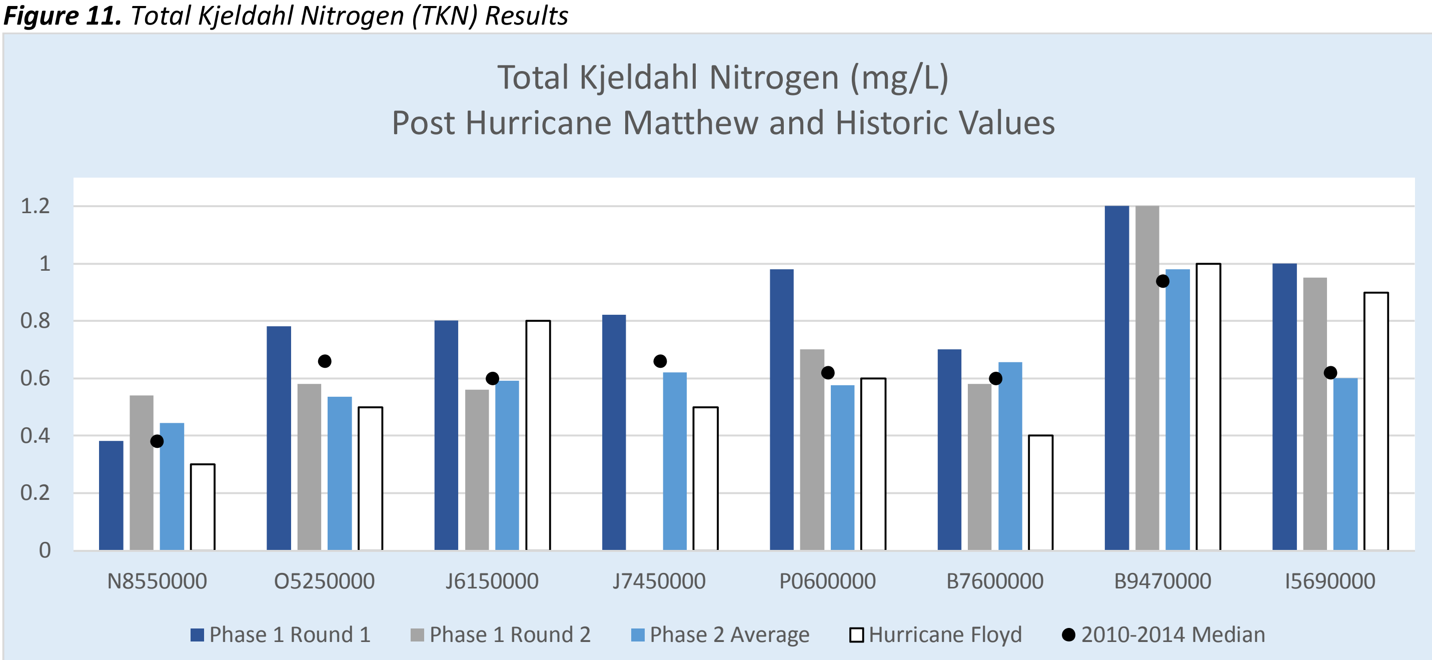


Figure 12. Total Nitrogen (TN) Results

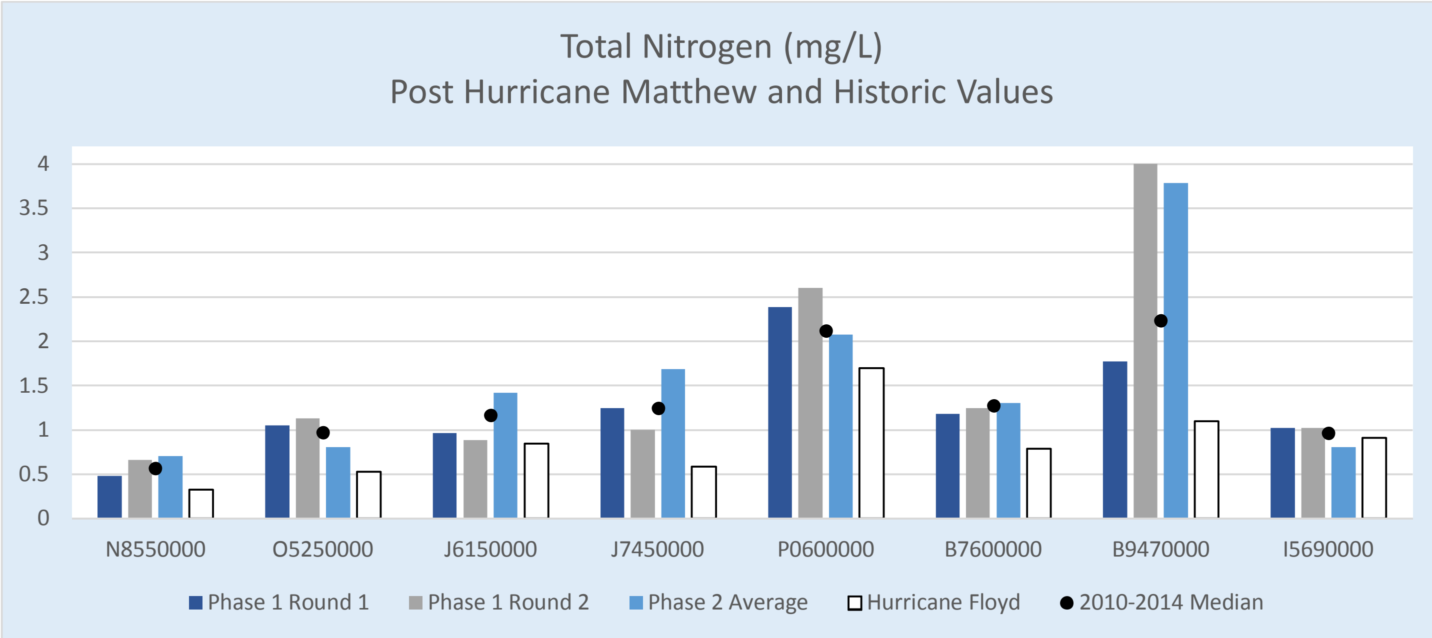


Figure 13. Ammonia (NH3) Results

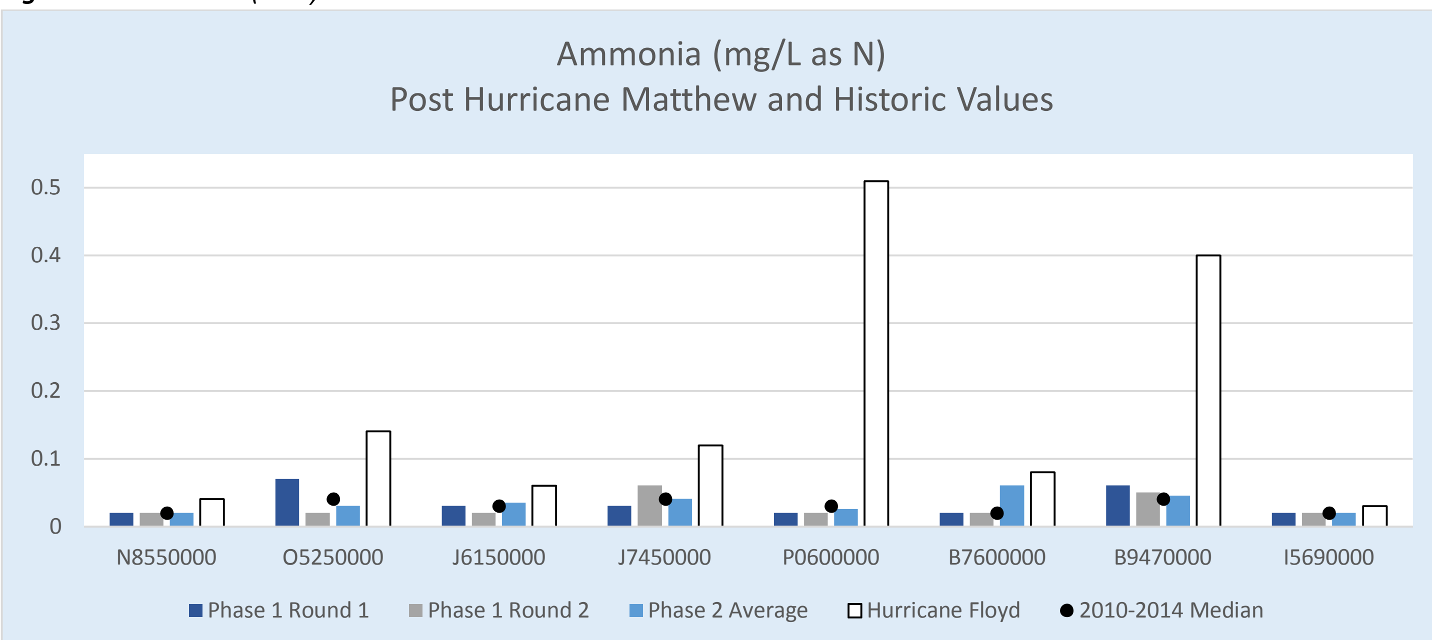


***Figure 14**. Total Phosphorous (TP) Results*

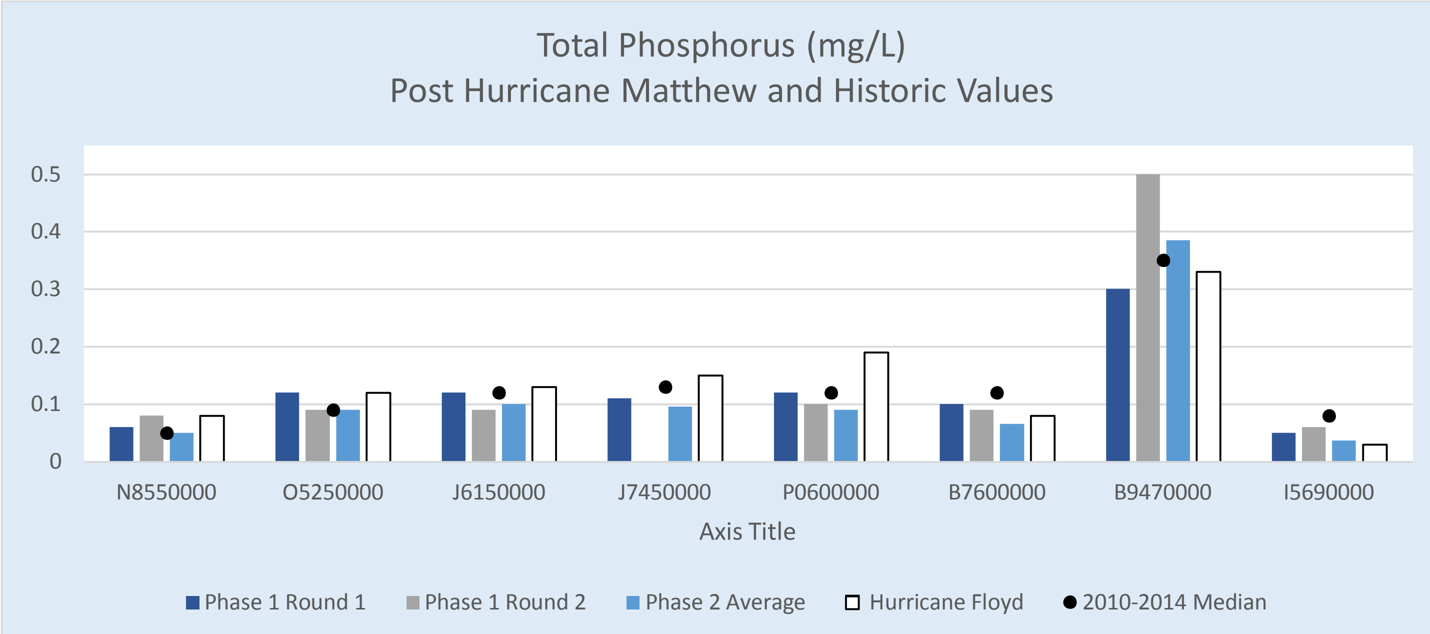
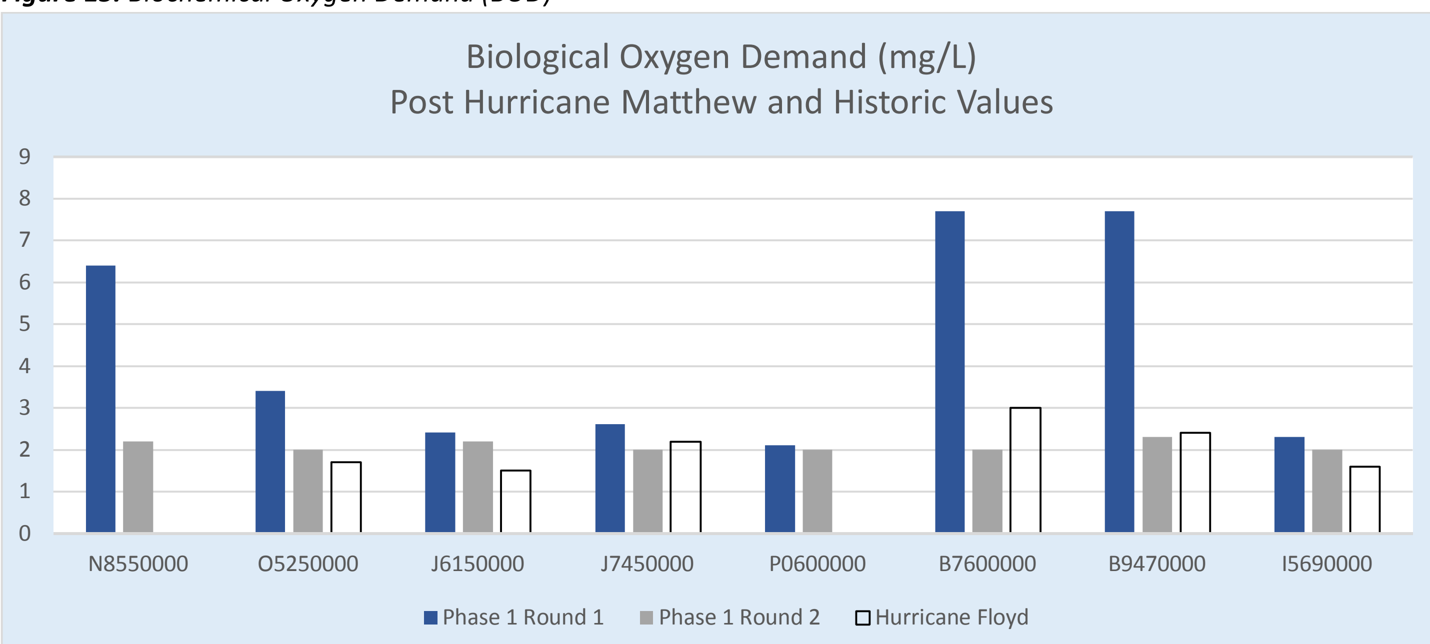


***Figure 15.** Biochemical Oxygen Demand (BOD)*



Bacteria

Overall fecal coliform bacterial concentrations immediately after Hurricane Matthew were below the state surface water standard with minor elevated levels. Elevated concentrations from sites such as J4170000 were likely due to reduced river flow from post-storm management of Falls of the Neuse Reservoir and resultant higher percentage of waste flow from treated wastewater and stormwater. Most sites exhibited a decrease in concentration from Phase 1/Round 1 to Phases 1/Round 2 samples, which were collected two weeks later (Figure 16).

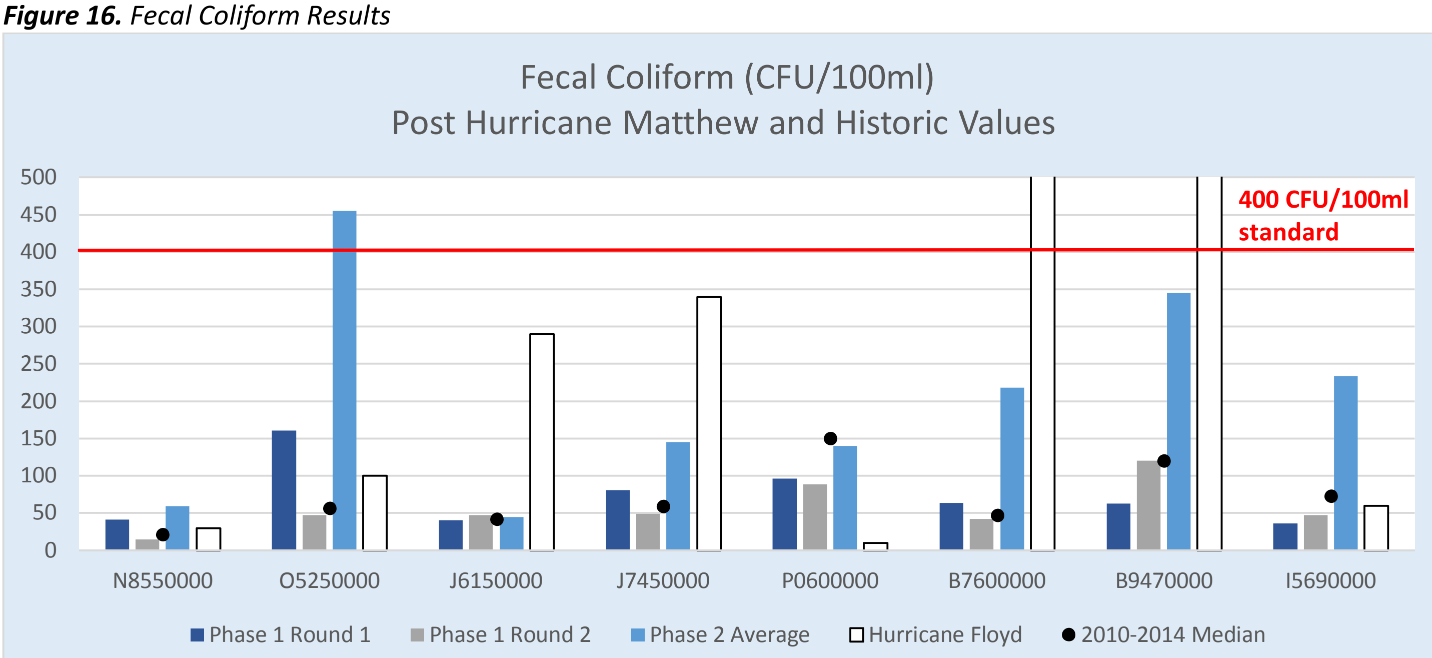
There was an upward trend in fecal coliform values during Phase 2 sampling, from November 2016 through January 2017 (Table 5). While some of these observations were above the historic average median value, concentrations during Phase 2 were not greater than AMS maximum values for the respective sites. Concentrations at many sites were notably lower during all phases when compared to observations made after Hurricane Floyd.

It should be noted that DWR recognizes within its water quality standards that, "Violations of the fecal coliform standard are expected during rainfall events and, in some cases, this violation is expected to be caused by uncontrollable nonpoint source pollution." Elevated concentrations of fecal coliform bacteria are not abnormal during high runoff and flooding events such as hurricanes.

Table 5. Average Fecal Coliform values (CFU/100mL) During Each Round of Hurricane Matthew Monitoring Phase 2 for Sites Sampled and Corresponding Monthly Average AMS Historical Medians Over Years 2008-2014

	Round 1 / November	Round 2 / December	Round 3 / January
Hurricane Matthew Phase 2	66	196	195
Historical AMS Data	60	100	60

Figure 16. *Fecal Coliform Results*



Solids

Overall low concentrations of total suspended solids observed during post-storm monitoring are similar to historical values except for site B7600000 at Fayetteville. Elevated results from the Cape Fear River in Fayetteville were likely due to increased flow from the B. Everett Jordan Reservoir as water releases were being increased (Figure 17). Turbidity values in Phase 1/Round 1 depicted the flushing effect of large amounts of rainfall at most sites. Phase 1/Round 2 concentrations reflect normal or lower than normal results as floodwaters receded (Figure 18).

Figure 17. *Total Suspended Solids Results*

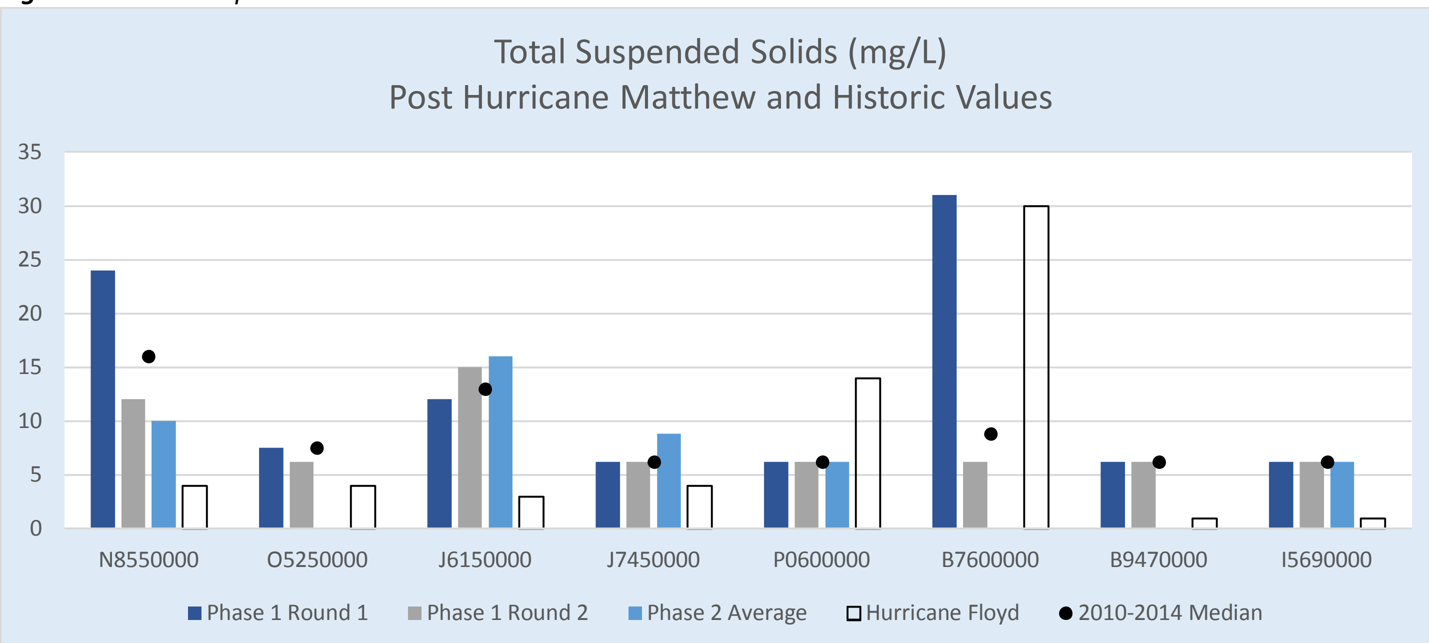
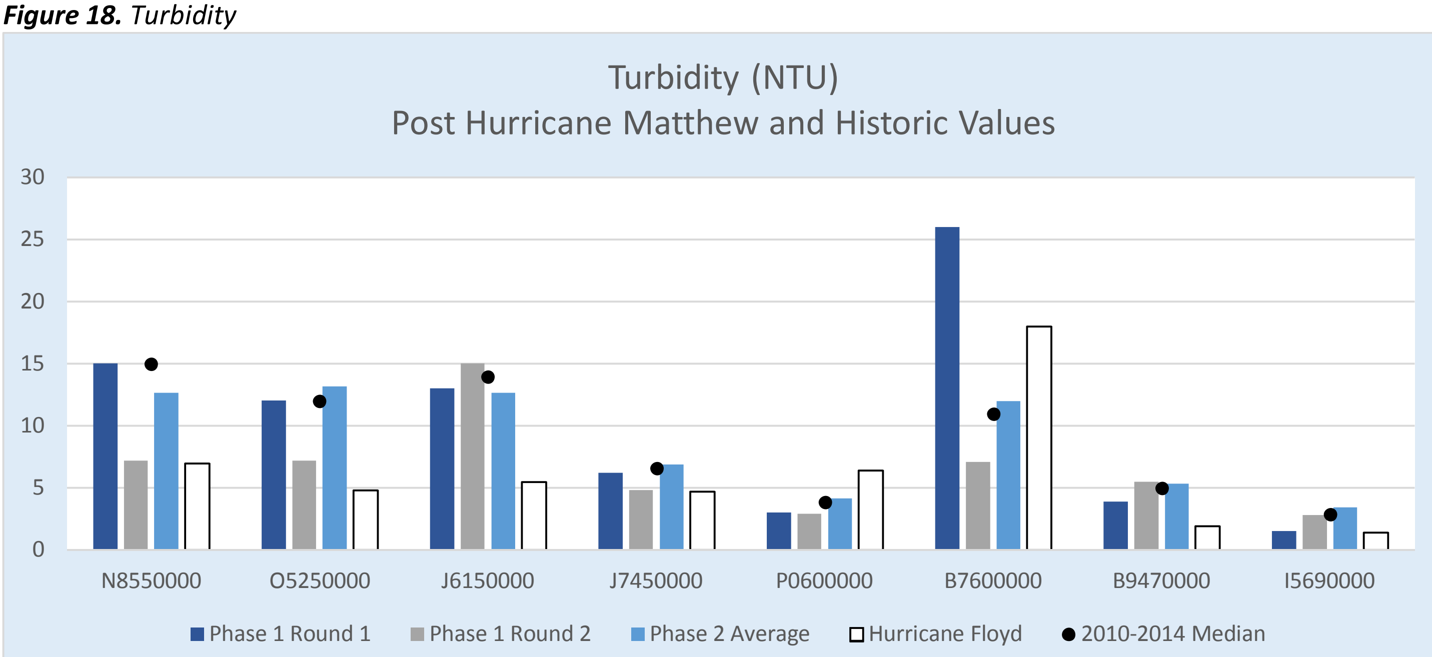


Figure 18. *Turbidity*



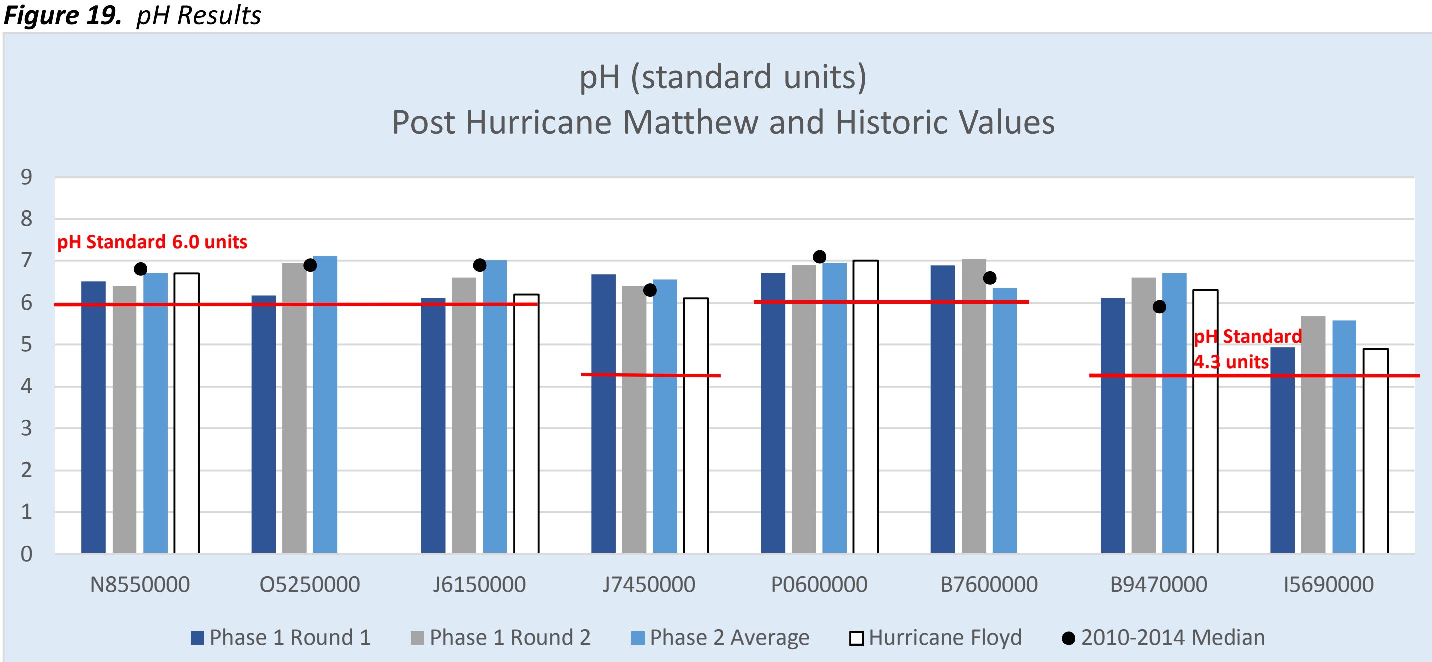
Physical Conditions

Many site locations experienced low pH values, especially those east of U.S. I-95, due to flushing of swamp waters which have naturally low pH characteristics. This resulted in several exceedances of water quality standards for pH (Figure 19). These results are similar to conditions measured after Floyd as well. At most monitoring locations, pH conditions returned to normal as stream flows subsided.

Conductivity observations were lower than historic conditions at most sites due to the dilution effect from the immense amount of rainfall associated with Hurricane Matthew (Figure 20). When post-Matthew conductivity values were compared to Floyd observances, the differences in river discharges between the two storms were evident. Discharges in the Cape Fear and Lumber rivers were higher during Matthew than during Floyd. This was reflected in lower conductivity concentrations, while the Neuse River exhibited correspondingly higher conductivity values during Matthew due to lower discharges than those experienced during Floyd.

Low DO concentrations were recorded east of U.S. I-95 and south of U.S.-Hwy. 64 during Phase 1/Round 1 monitoring (Figure 21). Many of these were below the state standard. Low dissolved oxygen is typical of heavy rainfall flushing events. When flood waters enter the floodplains of rivers and streams, the water in those areas that naturally have very little dissolved oxygen is carried into the main channels. The overall immediate effect is a drop in oxygen levels in the water column. Large amounts of organic material that is washed from floodplains into rivers can also result in low oxygen conditions as it decomposes. Concentrations for DO rose back above the state standard during Phase 2 at all locations after floodwaters had receded.

Figure 19. *pH Results*



**Water quality standards based on classification, class C waters are 6.0-9.0s.u., swamp waters may be as low as 4.3 s.u.*

Figure 20. *Conductivity Results*

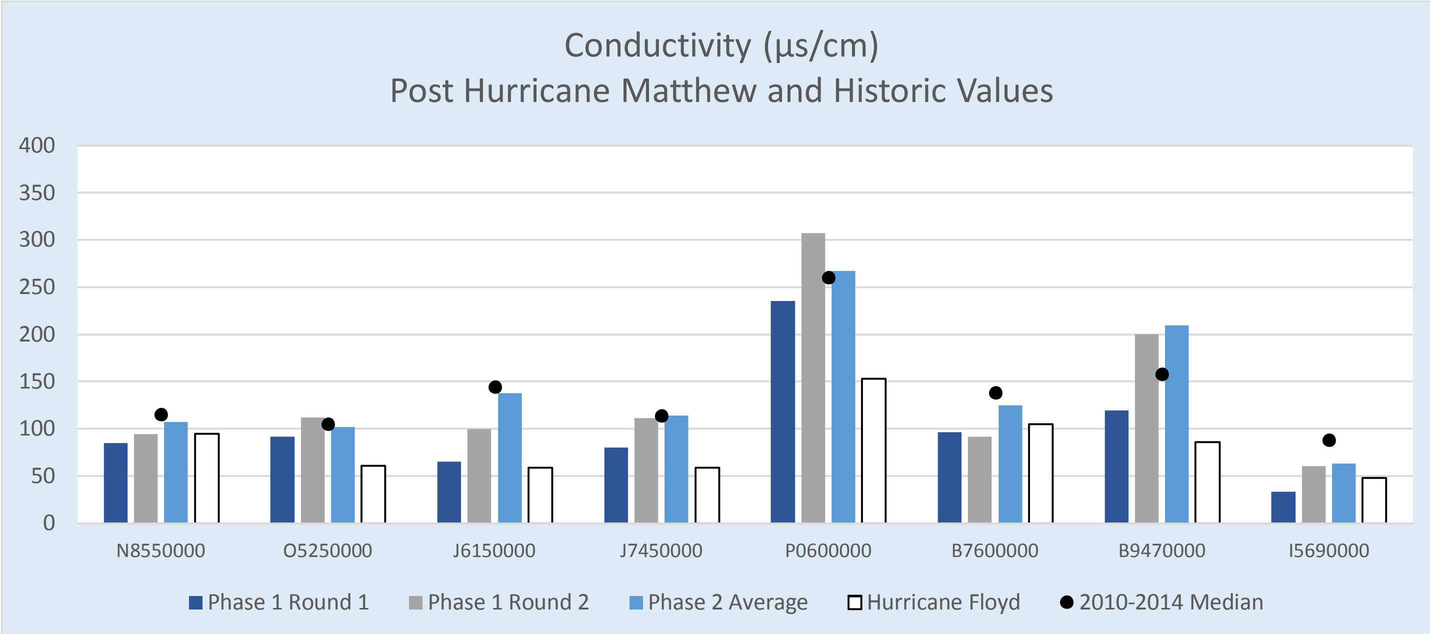
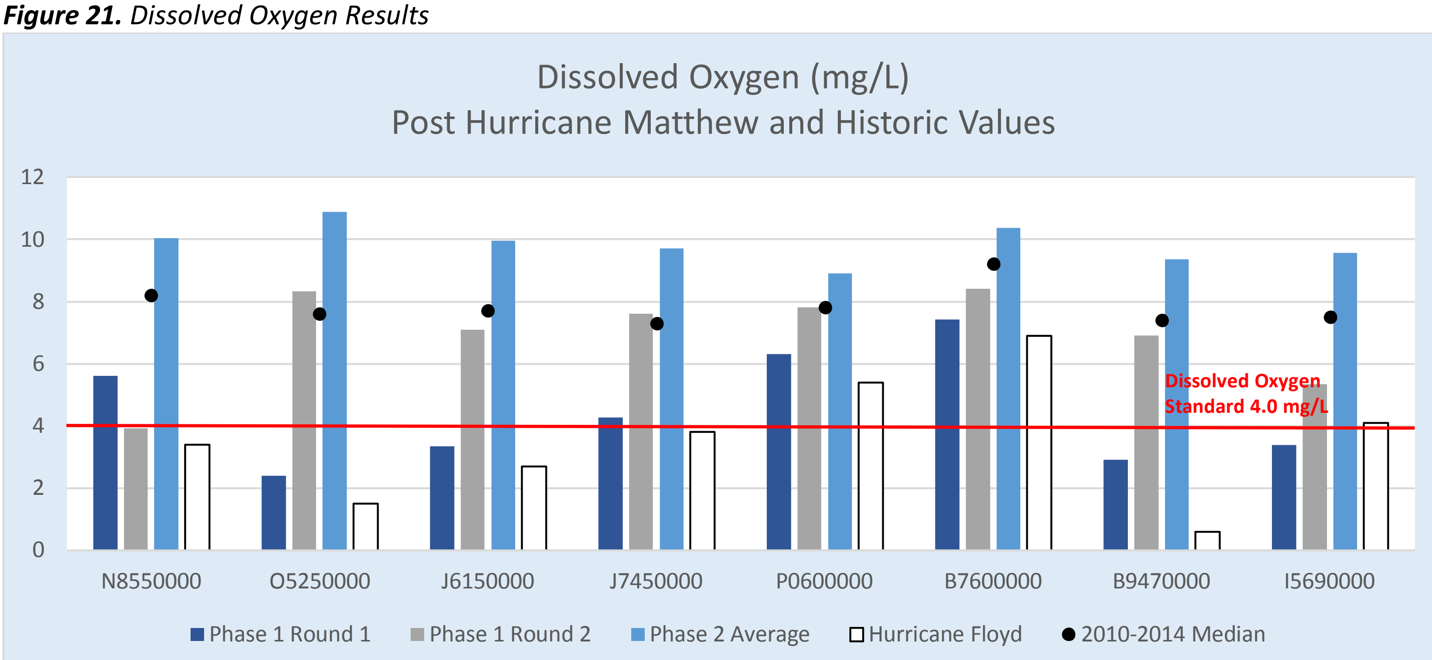


Figure 21. *Dissolved Oxygen Results*



Pesticides, Herbicide, Gas, Volatile and Semi-Volatile Organics

Visual graphical results for these compounds are not provided, and there is very little background information related to ambient concentrations for these in North Carolina surface waters for comparison. Overall, there were very few detections of volatile or semi-volatile compounds observed across the area monitored (Table 6). One semi-volatile compound was observed at site N8550000 near Williamston and one semi-volatile compound was observed at O3180000 in Rocky Mount. One volatile organic compound was detected at site P0600000. This represents a very small percentage of detections that may be found in a large set of potential compounds. Refer to Appendix IV for a full list of analytes included within each analysis for these various groups.

Table 6. *Herbicide, Pesticide, Volatile, and Semi-Volatile Compound Results as Liquid µg/L from Phase 1 Sampling*

Location Description	Phase 1 Sampling		Acid Herbicides	P based Pesticides	Cl based Pesticides	N based Pesticides	Volatile Organics	Semi-Volatile Organics
	Round 1	Round 2						
ROANOKE R. @ WILLIAMSTON	X	X	ND	ND	ND	ND	ND	Bis(2-ethylhexyl)phthalate, 72
TAR R. @ ROCKY MOUNT	X		ND	ND	ND	ND	ND	Bis(2-ethylhexyl)phthalate, 46
TAR R. @ TARBORO	X		ND	ND	ND	ND	ND	ND
PAMLICO R. @ WASHINGTON	X	X	ND	ND	ND	ND	ND	ND
NEUSE R. @ GOLDSBORO	X		ND	ND	ND	ND	ND	ND
NEUSE R. @ KINSTON	X	X	ND	ND	ND	ND	ND	ND
NEUSE R. @ NEW BERN	X	X	ND	ND	ND	ND	ND	ND
NEW R. @ GUM BRANCH	X	X	ND	ND	ND	ND	Chloroform, 0.53	ND
CAPE FEAR R. @ FAYETTEVILLE	X		ND	ND	ND	ND	ND	ND
CAPE FEAR R. @ ELIZABETHTOWN	X	X	ND	ND	ND	ND	ND	ND
CAPE FEAR R. @ NAVASSA	X		ND	ND	ND	ND	ND	ND
NORTHEAST CAPE FEAR R. @ WATHA	X		ND	ND	ND	ND	ND	ND
NE CAPE FEAR R. @ WILMINGTON	X		ND	ND	ND	ND	ND	ND
LUMBER R. @ BOARDMAN	X	X	ND	ND	ND	ND	ND	ND

**Entries of ND signify all analyte results were non-detects. Gas and diesel are included in semi-volatile category*

Ion Chromatography: Fluoride, Chloride, Bromide, Sulfate

Water samples from all 30 hurricane Matthew sampling locations were tested for Fluoride, Chloride, Bromide and Sulfate during both rounds of Phase 1. Data can be found in Appendix I.

All analyzed water samples for fluoride during Round 1 (n = 30) and Round 2 (n = 30) were below the detection level of 0.4 mg/L. Of 60 results, only three were above the detection level of 0.4 mg/L for bromide: 0.48 mg/L in the Pamlico River at Washington (O7650000), 4.3 mg/L in the Cape Fear River at Navassa (B9050000) and 10 mg/L in the Northeast Cape Fear River at Wilmington (B9740000). The three samples were collected in early November 2016, during Round 2. Water collected at those three locations also had elevated chloride values during the Round 2 sampling events: 100 mg/L at O7650000, 840 mg/L at B9470000 and 2600 mg/L at B974000. The other 27 chloride results were below 21 mg/L. Similarly, sulfate values were relatively stable between rounds 1 and 2 as well as among sample sites, ranging from below the detection level of 2 mg/L to as high as 26 mg/L, again with the exception of sites B9050000 and B9740000 during Round 2 of sampling. Those values were 120 and 370 mg/L, respectively.

Metals

Total and dissolved metals samples were collected in the vicinity of the H.F. Lee Power Plant located on the Neuse River in Goldsboro. Sample collection was conducted based on floodwater interaction with the facility's existing and non-active coal ash basins. Sites for this specific collection effort were located upstream and downstream of the facility and the areas where floodwaters affected the coal ash basins. Sample results from physical water quality conditions and 25 coal ash specific target elements indicated no effect on water quality during two separate sampling events. See Appendix 3 for sample results.

Summary

The Division of Water Resources conducted monitoring to identify the short- and long-term effects of Hurricane Matthew on eastern North Carolina. The data collected during the various phases of monitoring provide a time-lapse view of changing conditions as river levels rose and subsided in response to the amount of rain that fell in their respective watersheds. Short-term flushing identified during Phase 1/Round 1 monitoring tended to have a diluting effect on most of the areas affected and parameters evaluated. Conversely, Phase 1/Round 2 monitoring exhibited increased bacterial and NOx concentrations comparatively. Some sites located farther upstream in the Neuse and Tar-Pamlico basins exhibited elevated bacterial concentrations in part due to the flood control management of Falls of the Neuse and B. Everett Jordan reservoirs by the U.S. Army Corps of Engineers. Long-term monitoring results exhibited conditions that were similar to regular monitoring concentrations for physical and most chemical constituents. Fecal coliform bacterial average Phase 2 concentrations were elevated relative to historical and Phase 1 concentrations at nine of the 30 sample sites. The relationship between overall elevated TKN in Phase 1 and elevated NOx in downstream portions of watersheds during Phase 2 likely indicates a response to the input of various organic nutrients into rivers and subsequent nitrification of TKN. Little to no pesticides, herbicides, gas, diesel, volatile or semi-volatile organic compounds were found in surface waters after the storm.

Increased streamflow and flooding that ensued after the storm's massive rainfall created multiple incidences of inundation that released wastewater, stored fuel and other pollutants into surface waters. A number of unconfirmed reports of fish kills were received from areas along the Neuse and Tar-Pamlico rivers in the wake of Hurricane Matthew, although DWR was unable to verify specific details of these events. During the monitoring timeframe, October 2016 – January 2017, no algal blooms or other water quality incidents resulting from nutrient loading were reported to DWR. While flooding created major widespread damage to property and infrastructure, results from extensive sampling in eastern North Carolina indicate the impact of these pollutants to surface waters appears to have been transient, lasting several weeks as water levels returned to normal and water temperatures dropped.

This report may serve as a template and reference document for future tropical storm or hurricane water quality evaluations. The use of existing DWR AMS sites and data is critical to the evaluation of site specific and watershed effects of storms as they pass over North Carolina.

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Appendix I: Phase 1 Results of Hurricane Matthew Monitoring: Round 1 (Oct. 19-26, 2016) and Round 2 (Oct. 31- Nov. 3, 2016)

Location Description	Nox (mg/L as N)			TKN (mg/L as N)			NH3 (mg/L as N)			Total P (mg/L as P)			TOC (mg/L)	
	Round 1	Round 2	2005-10 Median	Round 1	Round 2	2005-10 Median	Round 1	Round 2	2005-10 Median	Round 1	Round 2	2005-10 Median	Round 1	Round 2
CHOWAN R. @ WINTON	0.06	0.08	NA	0.78	0.74	NA	ND	0.06	NA	0.07	0.08	NA	NA	NA
ROANOKE R. @ SCOTLAND NECK	0.16	0.3	0.14	0.36	0.45	0.34	ND	0.02	0.02	0.04	0.05	0.04	NA	NA
ROANOKE R. @ WILLIAMSTON	0.1	0.12	0.19	0.38	0.54	0.38	ND	0.02	0.02	0.06	0.08	0.05	6.4	8.6
TAR R. @ BUNN	0.19	0.14	0.17	0.36	0.35	0.68	ND	ND	0.07	0.06	0.05	0.06	NA	NA
TAR R. @ ROCKY MOUNT	0.29	0.27	NA	0.64	0.49	NA	0.05	0.04	NA	0.07	0.04	NA	NA	8.2
TAR R. @ TARBORO	0.27	0.55	0.32	0.78	0.58	0.66	0.07	0.02	0.04	0.12	0.09	0.09	14	NA
TAR R. @ FALKLAND	0.2	0.61	0.09	0.82	0.61	0.56	0.04	0.03	0.02	0.12	0.09	0.09	NA	NA
PAMLICO R. @ WASHINGTON	0.11	0.63	0.38	0.88	0.65	0.69	0.03	0.11	0.02	0.14	0.11	0.11	18	11
NEUSE R. @ FALLS	0.14	0.06	0.02	1	0.66	0.63	0.43	0.1	0.07	0.05	0.04	0.03	NA	NA
NEUSE R. @ CLAYTON	0.78	0.29	0.44	0.57	0.66	0.71	0.02	0.04	0.08	0.12	0.11	0.16	NA	NA
NEUSE R. @ SMITHFIELD	0.63	0.25	0.46	0.5	0.62	0.56	0.02	0.02	0.02	0.16	0.12	0.22	NA	NA
NEUSE R. @ GOLDSBORO	0.29	0.21	0.48	0.89	0.6	0.59	0.05	0.03	0.04	0.13	0.09	0.14	NA	NA
NEUSE R. @ KINSTON	0.16	0.32	0.57	0.8	0.56	0.6	0.03	0.02	0.03	0.12	0.09	0.12	14	8.1
CONTENTNEA CR. @ HOOKERTON	0.42	1	0.59	0.82	NA	0.66	0.03	0.06	0.04	0.11	NA	0.13	NA	NA
NEUSE R. @ FORT BARNWELL	0.54	0.37	0.54	0.67	0.58	0.64	0.07	0.04	0.04	0.14	0.1	0.13	NA	NA
NEUSE R. @ NEW BERN	0.1	0.4	0.59	0.81	0.67	NA	ND	0.07	0.02	0.15	0.1	NA	17	10
TRENT R. @ POLLOCKSVILLE	0.16	0.68	0.59	0.96	0.71	0.6	0.02	0.05	0.02	0.18	0.13	0.12	NA	NA
NEW R. @ GUM BRANCH	1.4	1.9	1.5	0.98	0.7	0.62	0.02	ND	0.03	0.12	0.1	0.12	20	12
HAW R. @ MONCURE	0.5	0.51	NA	0.73	0.67	NA	0.05	0.12	NA	0.07	0.05	NA	NA	NA
CAPE FEAR R. @ LILLINGTON	0.5	0.62	0.56	0.67	0.62	0.66	0.02	ND	0.02	0.1	0.06	0.09	NA	7.8
CAPE FEAR R. @ FAYETTEVILLE	0.48	0.66	0.68	0.7	0.58	0.6	0.02	ND	0.02	0.1	0.09	0.12	NA	NA
CAPE FEAR R. @ ELIZABETHTOWN	0.47	0.82	NA	0.83	0.68	NA	0.04	0.04	NA	0.12	0.13	NA	10	11
BLACK R. @ TOMAHAWK	0.32	0.87	0.85	0.89	0.8	0.74	0.02	0.02	0.03	0.12	0.12	0.08	19	13
BLACK R. @ HUGGINS	0.09	0.22	0.35	0.8	0.83	0.78	ND	0.04	0.04	0.08	0.1	0.16	NA	NA
CAPE FEAR R. @ NAVASSA	0.12	0.23	0.42	0.82	0.81	0.44	0.02	0.07	0.02	0.1	0.09	0.09	21	18
ROCKFISH CR. @ WALLACE	0.57	2.8	1.3	1.2	1.2	0.94	0.06	0.05	0.04	0.3	0.5	0.35	NA	NA
NORTHEAST CAPE FEAR R. @ WATHA	0.11	0.42	0.48	1	0.77	0.77	0.02	0.04	0.04	0.19	0.18	0.16	24	16
NE CAPE FEAR R. @ WILMINGTON	0.12	0.2	0.45	0.82	0.77	0.64	ND	0.08	0.06	0.11	0.08	0.09	NA	17
LUMBER R. @ MAXTON	0.04	0.23	0.63	0.53	0.52	0.5	ND	ND	0.02	0.03	0.05	0.09	NA	NA
LUMBER R. @ BOARDMAN	ND	0.07	0.35	1	0.95	0.62	ND	0.02	0.02	0.05	0.06	0.08	29	24

Exceeds NC standard

* ND result was a not detected above reported practical quantitation limit, NA signifies result not available

Appendix I continued: Phase 1 Results of Hurricane Matthew Monitoring: Round 1 (Oct. 19-26, 2016) and Round 2 (Oct. 31- Nov. 3, 2016)

Location Description	BOD5 (mg/L)		Fecal Coliform (CFU/100ml)			Suspended Residue (mg/L)			Turbidity (NTU)		
	Round 1	Round 2	Round 1	Round 2	2005-10 Median	Round 1	Round 2	2005-10 Median	Round 1	Round 2	2005-10 Median
CHOWAN R. @ WINTON	2.3	ND	27	8	8	ND	ND	6.2	10	9.6	5.9
ROANOKE R. @ SCOTLAND NECK	2.4	ND	45	16	37	14	13	13.5	8	16	10
ROANOKE R. @ WILLIAMSTON	6.4	2.2	41	14	21	24	12	16	15	7.2	15
TAR R. @ BUNN	2.3	ND	99	45	80	ND	ND	9.4	11	9.3	14
TAR R. @ ROCKY MOUNT	2.3	ND	36	48	42	ND	ND	6.7	13	4.2	8.6
TAR R. @ TARBORO	3.4	ND	160	47	56	7.5	ND	7.5	12	7.2	12
TAR R. @ FALKLAND	2.7	ND	250	36	49	ND	12	7.5	8.2	5.8	8
PAMLICO R. @ WASHINGTON	2.8	ND	100	43	24	ND	ND	6.2	9.5	3	7.4
NEUSE R. @ FALLS	2.2	3	60	4	4	7.5	12	6.2	21	7.3	4.4
NEUSE R. @ CLAYTON	ND	2.6	500	35	86	ND	18	10	14	15	13
NEUSE R. @ SMITHFIELD	ND	2.5	140	54	135	9	26	14.5	17	17	16.5
NEUSE R. @ GOLDSBORO	3.8	ND	160	41	60	15	24	13.5	16	19	14.5
NEUSE R. @ KINSTON	2.4	2.2	40	47	42	12	15	13	13	15	14
CONTENTNEA CR. @ HOOKERTON	2.6	ND	80	49	59	ND	ND	6.2	6.2	4.8	6.6
NEUSE R. @ FORT BARNWELL	ND	2	41	54	49	15	10	7.8	16	12	11
NEUSE R. @ NEW BERN	2	ND	34	3	29	ND	ND	6.2	6.8	5.3	6.1
TRENT R. @ POLLOCKSVILLE	5	ND	52	120	NA	ND	ND	NA	2.7	2.8	NA
NEW R. @ GUM BRANCH	2.1	ND	96	88	150	ND	ND	6.2	3	2.9	3.9
HAW R. @ MONCURE	5.8	3.1	23	11	6	8.2	NA	6.9	13	11	7.1
CAPE FEAR R. @ LILLINGTON	7.3	ND	81	22	52	28	12	8	24	3.9	9.6
CAPE FEAR R. @ FAYETTEVILLE	7.7	2	63	42	47	31	ND	8.8	26	7.1	11
CAPE FEAR R. @ ELIZABETHTOWN	4.8	ND	140	44	NA	21	10	NA	21	9.2	11
BLACK R. @ TOMAHAWK	3.5	ND	52	88	96	ND	ND	6.2	2.3	3.4	3.9
BLACK R. @ HUGGINS	2.4	ND	9	14	19.4	ND	6.2	6.2	4.5	4	4.5
CAPE FEAR R. @ NAVASSA	2.4	ND	45	28	32	7.5	6.4	12	14	6.2	13
ROCKFISH CR. @ WALLACE	7.7	2.3	62	120	120	ND	ND	6.2	3.9	5.5	5
NORTHEAST CAPE FEAR R. @ WATHA	2.3	ND	41	30	42	ND	ND	6.2	3.1	4.5	4.8
NE CAPE FEAR R. @ WILMINGTON	2.4	ND	54	29	28	12	11.9	10	14	5.3	8.2
LUMBER R. @ MAXTON	3	ND	76	59	66	ND	ND	6.2	2	2.3	3.3
LUMBER R. @ BOARDMAN	2.3	ND	36	47	73	ND	ND	6.2	1.5	2.8	2.9
	[shaded]	Exceeds NC standard	* ND result was a not detected above reported practical quantitation limit, NA signifies result not available								

Shaded cell (Exceeds NC standard): NEUSE R. @ CLAYTON, Fecal Coliform Round 1 (500).

**Instantaneous standard of 400cfu/100ml applied to fecal coliform results*

Appendix I continued: Phase 1 Results of Hurricane Matthew Monitoring: Round 1 (Oct. 19-26, 2016) and Round 2 (Oct. 31- Nov. 3, 2016)

	Temperature (⁰C)			Conductivity (umhos/cm)			D.O. (mg/L)			pH (S.U.)		
Location Description	Round 1	Round 2	2005-10 Median	Round 1	Round 2	2005-10 Median	Round 1	Round 2	2005-10 Median	Round 1	Round 2	2005-10 Median
CHOWAN R. @ WINTON	19.9	18.7	18.7	64	84	89	5.3	3.2	6	6.1	6.2	6.4
ROANOKE R. @ SCOTLAND NECK	23.2	19.6	15.8	89	111	119	8	8.2	9.2	7	7.2	7.2
ROANOKE R. @ WILLIAMSTON	21.2	17.9	17.4	84.8	94.2	115	5.6	3.9	8.2	6.5	6.4	6.8
TAR R. @ BUNN	19.5	15.6	20	95.3	112.1	116	7.3	8.9	6.9	7	7.1	7
TAR R. @ ROCKY MOUNT	20.9	17.8	18.1	72	89.5	94	6.6	8.4	9.2	6.9	7.2	7.1
TAR R. @ TARBORO	19.8	16.5	19.9	91.1	111.9	105	2.4	8.3	7.6	6.1	6.9	6.9
TAR R. @ FALKLAND	19	16.6	17.8	91.1	11.9	110	2.4	8.3	8.4	6.1	6.6	6.8
PAMLICO R. @ WASHINGTON	19.7	17.9	19.9	63.1	481.8	194	2.7	6	8.1	6.3	6.4	7
NEUSE R. @ FALLS	20.8	19.2	18.2	77	80.6	96	8.2	10.3	8.6	7	7.0	7.2
NEUSE R. @ CLAYTON	20.4	18.6	20.4	194.3	102.2	177	7.6	8.8	7.6	7.2	7.1	7.1
NEUSE R. @ SMITHFIELD	21.2	18.6	17.2	183.3	116	150	7.1	8.6	8.1	7.1	7.1	7.2
NEUSE R. @ GOLDSBORO	19.6	18	17.3	86.9	99.2	134	3.2	8.0	7.9	6.2	6.9	6.9
NEUSE R. @ KINSTON	20.28	18.1	20.6	65	99.3	144	3.3	7.1	7.7	6.1	6.6	6.9
CONTENTNEA CR. @ HOOKERTON	20.59	17.2	18.6	80	110.9	114	4.3	7.6	7.3	6.6	6.4	6.3
NEUSE R. @ FORT BARNWELL	17	18	20.5	117	104.3	138	6.2	6.9	7.3	6.5	6.6	6.8
NEUSE R. @ NEW BERN	18.2	17.8	20.6	87	123	2652	4	6.9	8	6.3	6.5	7.1
TRENT R. @ POLLOCKSVILLE	19.97	17.8	19.7	96	187	182	2.5	4.9	5.6	6.0	6.8	6.9
NEW R. @ GUM BRANCH	20.3	16.8	17.3	235	307	260	6.3	7.8	7.8	6.7	6.9	7.1
HAW R. @ MONCURE	20.3	19.1	21.4	105	147.2	172	8.9	5.1	8.2	6.9	7.3	7.2
CAPE FEAR R. @ LILLINGTON	20.1	17.52	21.4	108.2	132	164	7.9	9.1	7.4	6.9	7.3	6.9
CAPE FEAR R. @ FAYETTEVILLE	20.1	18.25	14.7	95.8	91	138	7.4	8.4	9.2	6.8	7.0	6.9
CAPE FEAR R. @ ELIZABETHTOWN	20.41	18.5	14.7	79	93.7	141	7.5	7.8	8.8	6.7	6.6	6.5
BLACK R. @ TOMAHAWK	20.8	17.9	12.6	81	115	124	4.7	7.6	8.8	5.8	6.4	6.6
BLACK R. @ HUGGINS	19.8	18.2	19.4	36	83	104	3.2	4.3	5.1	4.8	5.6	6.2
CAPE FEAR R. @ NAVASSA	20	19.7	20	44	3377	281	3.2	3.2	5.8	5.2	6.5	6.8
ROCKFISH CR. @ WALLACE	20.7	17.7	17	119	200	158	2.9	6.9	7.4	6.1	6.6	6.6
NORTHEAST CAPE FEAR R. @ WATHA	20.4	18.2	17.7	80	147	152	3	7	7.2	5.7	6.4	6.3
NE CAPE FEAR R. @ WILMINGTON	20	20.5	20	48	8576	10521	3.1	4.9	6.1	5.2	6.8	6.9
LUMBER R. @ MAXTON	19.97	16.68	14.9	29	39.2	44	5.8	7.2	7.5	5.4	5.8	5.9
LUMBER R. @ BOARDMAN	20.94	17.5	13.3	33	60.1	88	3.4	5.3	7.5	4.9	5.7	5.9
	(shaded)	Exceeds NC standard										

**Water quality standards are based on classification, DO for class C waters are 4.0mg/L, salt SC waters are 5.0mg/L, and for pH, class C waters are 6.0-9.0s.u., swamp waters may be as low as 4.3s.u.*

Appendix I continued: Phase 1 Results of Hurricane Matthew Monitoring: Round 1 (Oct. 19-26, 2016) and Round 2 (Oct. 31- Nov. 3, 2016)

	Fluoride (mg/L)		Chloride (mg/L)		Bromide (mg/L)		Sulfate (mg/L)	
Location Description	Round 1	Round 2	Round 1	Round 2	Round 1	Round 2	Round 1	Round 2
CHOWAN R. @ WINTON	ND	ND	5.1	7.2	ND	ND	5.9	7.2
ROANOKE R. @ SCOTLAND NECK	ND	ND	6.5	8	ND	ND	5.2	12
ROANOKE R. @ WILLIAMSTON	ND	ND	6.5	6.7	ND	ND	5.3	5.7
TAR R. @ BUNN	ND	ND	7	9.1	ND	ND	5	4.2
TAR R. @ ROCKY MOUNT	ND	ND	4.4	6.2	ND	ND	5.5	6.1
TAR R. @ TARBORO	ND	ND	5.4	8	ND	ND	7.7	10
TAR R. @ FALKLAND	ND	ND	8.4	9.3	ND	ND	7.9	10
PAMLICO R. @ WASHINGTON	ND	ND	4.5	100	ND	0.48	6	25
NEUSE R. @ FALLS	ND	ND	5.4	5.6	ND	ND	3.4	4.7
NEUSE R. @ CLAYTON	ND	ND	20	9.7	ND	ND	17	8.2
NEUSE R. @ SMITHFIELD	ND	ND	20	9.7	ND	ND	16	8.2
NEUSE R. @ GOLDSBORO	ND	ND	7.8	8.5	ND	ND	7.1	6.2
NEUSE R. @ KINSTON	ND	ND	5.7	9	ND	ND	5.9	7.5
CONTENTNEA CR. @ HOOKERTON	ND	ND	7.9	12	ND	ND	8.1	11
NEUSE R. @ FORT BARNWELL	ND	ND	12	9.8	ND	ND	10	7.9
NEUSE R. @ NEW BERN	ND	ND	7.2	12	ND	ND	8	10
TRENT R. @ POLLOCKSVILLE	ND	ND	6.2	8.9	ND	ND	6.4	11
NEW R. @ GUM BRANCH	ND	ND	9.5	10	ND	ND	22	26
HAW R. @ MONCURE	ND	ND	9.4	14	ND	ND	8.3	12
CAPE FEAR R. @ LILLINGTON	ND	ND	9.6	13	ND	ND	8.5	11
CAPE FEAR R. @ FAYETTEVILLE	ND	ND	8.5	9.6	ND	ND	7.7	8.3
CAPE FEAR R. @ ELIZABETHTOWN	ND	ND	7.2	9.4	ND	ND	7.2	9.6
BLACK R. @ TOMAHAWK	ND	ND	9.4	15	ND	ND	6.7	7.5
BLACK R. @ HUGGINS	ND	ND	3.4	12	ND	ND	3	6.3
CAPE FEAR R. @ NAVASSA	ND	ND	4.3	840	ND	4.3	4	120
ROCKFISH CR. @ WALLACE	ND	ND	11	21	ND	ND	7.4	8.6
NORTHEAST CAPE FEAR R. @ WATHA	ND	ND	8.4	20	ND	ND	6.1	6
NE CAPE FEAR R. @ WILMINGTON	ND	ND	5.2	2600	ND	10	4.1	370
LUMBER R. @ MAXTON	ND	ND	4.7	6	ND	ND	2.2	ND
LUMBER R. @ BOARDMAN	ND	ND	3.9	9.5	ND	ND	2.2	2.3

Exceeds NC standard   * ND result was not detected above reported practical quantitation limit

Appendix II: Phase 2 Results of Hurricane Matthew Monitoring: Round 1 (Nov. 15-28, 2016), Round 2 (Dec. 1-28, 2016) and Round 3 (Jan. 4-31, 2017)

	Nox (mg/L as N)				TKN (mg/L as N)				NH3 (mg/L as N)				Total P (mg/L as P)			
Location Description	Round 1	Round 2	Round 3	2005-10 Median	Round 1	Round 2	Round 3	2005-10 Median	Round 1	Round 2	Round 3	2005-10 Median	Round 1	Round 2	Round 3	2005-10 Median
CHOWAN R. @ WINTON	0.18	NA	0.24	NA	0.6	NA	0.49	NA	0.06	NA	0.05	NA	0.07	NA	0.09	NA
ROANOKE R. @ SCOTLAND NECK	NA	0.13	0.18	0.14	NA	0.44	0.44	0.34	NA	0.02	0.05	0.02	NA	0.06	0.06	0.04
ROANOKE R. @ WILLIAMSTON	0.25	0.28	0.24	0.19	0.4	0.45	0.48	0.38	ND	0.02	0.02	0.02	0.06	0.05	0.04	0.05
TAR R. @ BUNN	NA	NA	NA	0.17	NA	NA	NA	0.68	NA	NA	NA	0.07	NA	NA	NA	0.06
TAR R. @ ROCKY MOUNT	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
TAR R. @ TARBORO	NA	0.26	0.28	0.32	NA	0.49	0.58	0.66	NA	0.03	0.03	0.04	NA	0.08	0.1	0.09
TAR R. @ FALKLAND	0.51	0.38	0.43	0.09	0.51	0.55	0.4	0.56	0.02	ND	0.02	0.02	0.08	0.08	0.05	0.09
PAMLICO R. @ WASHINGTON	NA	0.36	0.56	0.38	NA	0.47	0.55	0.69	NA	0.03	0.04	0.02	NA	0.09	0.06	0.11
NEUSE R. @ FALLS	NA	0.18	0.22	0.02	NA	0.59	0.66	0.63	NA	0.16	0.12	0.07	NA	0.02	0.02	0.03
NEUSE R. @ CLAYTON	NA	NA	NA	0.44	NA	NA	NA	0.71	NA	NA	NA	0.08	NA	NA	NA	0.16
NEUSE R. @ SMITHFIELD	NA	0.56	0.32	0.46	NA	0.56	0.71	0.56	NA	0.02	0.02	0.02	NA	0.2	0.14	0.22
NEUSE R. @ GOLDSBORO	NA	0.54	0.47	0.48	NA	0.51	0.61	0.59	NA	0.04	ND	0.04	NA	0.11	0.13	0.14
NEUSE R. @ KINSTON	0.85	NA	0.8	0.57	0.64	NA	0.54	0.6	0.04	NA	0.03	0.03	0.12	NA	0.08	0.12
CONTENTNEA CR. @ HOOKERTON	1.1	NA	1.02	0.59	0.62	NA	0.62	0.66	0.04	NA	0.04	0.04	0.11	NA	0.08	0.13
NEUSE R. @ FORT BARNWELL	0.89	NA	0.82	0.54	0.62	NA	0.74	0.64	0.04	NA	0.03	0.04	0.11	NA	0.07	0.13
NEUSE R. @ NEW BERN	0.78	0.63	0.67	0.59	0.6	0.63	0.51	NA	0.05	0.06	0.02	0.02	0.11	0.1	0.07	NA
TRENT R. @ POLLOCKSVILLE	0.81	NA	0.77	0.59	0.39	NA	0.54	0.6	0.02	NA	0.03	0.02	0.11	NA	0.07	0.12
NEW R. @ GUM BRANCH	1.6	1.4	NA	1.5	0.56	0.59	NA	0.62	0.02	0.03	NA	0.03	0.08	0.1	NA	0.12
HAW R. @ MONCURE	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
CAPE FEAR R. @ LILLINGTON	0.53	0.69	0.76	0.56	0.52	0.59	1.5	0.66	ND	0.02	0.34	0.02	0.04	0.04	0.23	0.09
CAPE FEAR R. @ FAYETTEVILLE	NA	0.69	0.6	0.68	NA	0.52	0.79	0.6	NA	ND	0.1	0.02	NA	0.04	0.09	0.12
CAPE FEAR R. @ ELIZABETHTOWN	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
BLACK R. @ TOMAHAWK	1.2	1.2	1.3	0.85	0.64	0.63	0.69	0.74	0.03	0.05	0.08	0.03	0.1	0.08	0.1	0.08
BLACK R. @ HUGGINS	NA	NA	0.46	0.35	NA	NA	0.66	0.78	NA	NA	0.02	0.04	NA	NA	0.06	0.16
CAPE FEAR R. @ NAVASSA	NA	NA	NA	0.42	NA	NA	NA	0.44	NA	NA	NA	0.02	NA	NA	NA	0.09
ROCKFISH CR. @ WALLACE	4	1.6	NA	1.3	1.1	0.86	NA	0.94	ND	0.07	NA	0.04	0.48	0.29	NA	0.35
NORTHEAST CAPE FEAR R. @ WATHA	0.73	0.6	0.9	0.48	0.66	0.65	0.89	0.77	ND	0.03	0.05	0.04	0.12	0.1	0.11	0.16
NE CAPE FEAR R. @ WILMINGTON	0.3	NA	0.51	0.45	0.64	NA	0.63	0.64	0.13	NA	0.07	0.06	0.07	NA	0.07	0.09
LUMBER R. @ MAXTON	0.42	0.4	0.34	0.63	0.38	0.39	0.54	0.5	ND	ND	ND	0.02	0.04	0.05	0.03	0.09
LUMBER R. @ BOARDMAN	0.18	0.16	0.27	0.35	0.7	0.58	0.52	0.62	0.02	0.02	ND	0.02	0.05	0.04	0.02	0.08

Exceeds NC standard

* ND result was not detected above reported practical quantitation limit, NA signifies result not available

Appendix II continued: Phase 2 Results of Hurricane Matthew Monitoring: Round 1 (Nov. 15-28, 2016), Round 2 (Dec. 1-28, 2016) and Round 3 (Jan. 4-31, 2017)

**Instantaneous standard of 400cfu/100ml applied to fecal coliform class C waters, 50NTU is applied to class C waters for turbidity*

	TOC (mg/L)	BOD5 (mg/L)	Fecal Coliform (CFU/100ml)				Suspended Residue (mg/L)				Turbidity (NTU)			
Location Description	Round 2	Round 2	Round 1	Round 2	Round 3	2005-10 Median	Round 1	Round 2	Round 3	2005-10 Median	Round 1	Round 2	Round 3	2005-10 Median
CHOWAN R. @ WINTON	NA	NA	18	NA	26	8	NA	NA	12	6.2	6.1	NA	6.7	5.9
ROANOKE R. @ SCOTLAND NECK	NA	NA	NA	92	210	37	NA	NA	NA	13.5	NA	19	17	10
ROANOKE R. @ WILLIAMSTON	5.3	ND	25	52	100	21	NA	10	NA	16	17	8.9	12	15
TAR R. @ BUNN	NA	NA	NA	360	66	80	NA	NA	NA	9.4	NA	14	15	14
TAR R. @ ROCKY MOUNT	NA	NA	NA	120	420	42	NA	NA	NA	6.7	NA	5.1	17	8.6
TAR R. @ TARBORO	7.8	2.4	NA	230	680	56	NA	NA	NA	7.5	NA	7.3	19	12
TAR R. @ FALKLAND	NA	NA	33	230	53	49	ND	NA	NA	7.5	4.3	6.3	11	8
PAMLICO R. @ WASHINGTON	8.3	ND	NA	23	43	24	NA	ND	NA	6.2	NA	4.2	6.6	7.4
NEUSE R. @ FALLS	NA	NA	NA	2	3	4	NA	NA	ND	6.2	NA	7.8	6.3	4.4
NEUSE R. @ CLAYTON	NA	NA	NA	580	53	86	NA	NA	19	10	NA	11	14	13
NEUSE R. @ SMITHFIELD	NA	NA	NA	580	78	135	NA	NA	24	14.5	NA	11	15	16.5
NEUSE R. @ GOLDSBORO	NA	NA	NA	130	50	60	NA	NA	24	13.5	NA	11	15	14.5
NEUSE R. @ KINSTON	NA	NA	41	NA	48	42	NA	NA	16	13	9.3	NA	16	14
CONTENTNEA CR. @ HOOKERTON	NA	NA	170	NA	120	59	NA	NA	8.8	6.2	3.9	NA	9.8	6.6
NEUSE R. @ FORT BARNWELL	NA	NA	26	NA	43	49	NA	NA	13	7.8	8.1	NA	12	11
NEUSE R. @ NEW BERN	8.7	2.1	57	100	140	29	NA	ND	NA	6.2	4.8	6.2	7.9	6.1
TRENT R. @ POLLOCKSVILLE	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
NEW R. @ GUM BRANCH	14	ND	120	160	NA	150	NA	ND	NA	6.2	3.4	4.9	NA	3.9
HAW R. @ MONCURE	NA	NA	NA	5	84	6	NA	ND	NA	6.9	NA	5.5	13	7.1
CAPE FEAR R. @ LILLINGTON	NA	NA	42	80	1200	52	ND	NA	NA	8	3.1	2.6	55	9.6
CAPE FEAR R. @ FAYETTEVILLE	NA	NA	NA	35	400	47	NA	NA	NA	8.8	NA	3.9	20	11
CAPE FEAR R. @ ELIZABETHTOWN	6.7	ND	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	11
BLACK R. @ TOMAHAWK	10	ND	88	240	420	96	NA	ND	NA	6.2	4	3.3	10	3.9
BLACK R. @ HUGGINS	NA	NA	NA	NA	47	19.4	NA	NA	12	6.2	NA	NA	4.7	4.5
CAPE FEAR R. @ NAVASSA	NA	NA	88	NA	45	32	NA	NA	8.2	12	8	NA	8.8	13
ROCKFISH CR. @ WALLACE	NA	NA	69	620	NA	120	NA	NA	NA	6.2	2.9	7.8	NA	5
NORTHEAST CAPE FEAR R. @ WATHA	14	ND	37	130	300	42	NA	NA	ND	6.2	3.6	3.4	6	4.8
NE CAPE FEAR R. @ WILMINGTON	NA	NA	44	NA	57	28	NA	NA	14	10	7.5	NA	8.2	8.2
LUMBER R. @ MAXTON	NA	NA	71	61	96	66	NA	NA	ND	6.2	2.2	2	5	3.3
LUMBER R. @ BOARDMAN	13	ND	120	280	300	73	ND	NA	NA	6.2	3.1	3.5	3.7	2.9

(Shaded cell) Exceeds NC standard

* ND result was not detected above reported practical quantitation limit, NA signifies result not available

Appendix II continued: Phase 2 Results of Hurricane Matthew Monitoring: Round 1 (Nov. 15-28, 2016), Round 2 (Dec. 1-28, 2016) and Round 3 (Jan. 4-31, 2017)

Location Description	Temperature (^{0}C)				Conductivity (umhos/cm)				D.O. (mg/L)				pH (S.U.)			
	Round 1	Round 2	Round 3	2005-10 Median	Round 1	Round 2	Round 3	2005-10 Median	Round 1	Round 2	Round 3	2005-10 Median	Round 1	Round 2	Round 3	2005-10 Median
CHOWAN R. @ WINTON	14	NA	10.6	18.7	99	NA	151	89	6.2	NA	9.2	6	6.4	NA	7.7	6.4
ROANOKE R. @ SCOTLAND NECK	NA	12.1	9.6	15.8	NA	103.9	109.8	119	NA	10.83	10.59	9.2	NA	7.33	7.09	7.2
ROANOKE R. @ WILLIAMSTON	14	12.1	9.8	17.4	100.5	114.8	104.9	115	8.9	10	11.2	8.2	6.6	6.8	6.7	6.8
TAR R. @ BUNN	NA	9.2	10.1	20	NA	115.3	112.2	116	NA	14.07	13.45	6.9	NA	7.25	7.03	7
TAR R. @ ROCKY MOUNT	NA	11.1	9.5	18.1	NA	104.6	97.1	94	NA	11.53	11.16	9.2	NA	7.46	7.13	7.1
TAR R. @ TARBORO	NA	10.5	9.8	19.9	NA	108.8	94	105	NA	11	10.76	7.6	NA	7.21	7	6.9
TAR R. @ FALKLAND	13.9	10.7	10	17.8	119	116.5	97.3	110	9.2	10.7	10.3	8.4	7	6.6	6.6	6.8
PAMLICO R. @ WASHINGTON	NA	9.4	11.9	19.9	NA	121	116	194	NA	10.1	9.7	8.1	NA	7.2	6.7	7
NEUSE R. @ FALLS	NA	11.3	7	18.2	NA	80.3	77.6	96	NA	10.57	12.43	8.6	NA	7.29	7.18	7.2
NEUSE R. @ CLAYTON	NA	8.5	7.9	20.4	NA	178.1	111.8	177	NA	10.8	12.05	7.6	NA	7.32	7.18	7.1
NEUSE R. @ SMITHFIELD	NA	8.1	8.1	17.2	NA	175.4	111.1	150	NA	11.17	11.71	8.1	NA	7.4	7.28	7.2
NEUSE R. @ GOLDSBORO	NA	7.4	8	17.3	NA	152.5	112.1	134	NA	12.01	11.49	7.9	NA	7.09	7.12	6.9
NEUSE R. @ KINSTON	11	NA	11.8	20.6	155	NA	120	144	9.8	NA	10.1	7.7	7	NA	7	6.9
CONTENTNEA CR. @ HOOKERTON	10.1	NA	10.9	18.6	123	NA	105	114	9.5	NA	9.9	7.3	6.6	NA	6.5	6.3
NEUSE R. @ FORT BARNWELL	12.2	NA	13	20.5	151	NA	120	138	9.3	NA	9.9	7.3	7.1	NA	7	6.8
NEUSE R. @ NEW BERN	11.1	10.4	13.3	20.6	304	784.9	139	2652	9.9	10	10.3	8	7.2	7.4	7.1	7.1
TRENT R. @ POLLOCKSVILLE	12.1	NA	12.4	19.7	219	NA	150	182	7.1	NA	8.6	5.6	7.2	NA	7	6.9
NEW R. @ GUM BRANCH	12.9	9.8	NA	17.3	312	222	NA	260	8.7	9.1	NA	7.8	6.6	7.3	NA	7.1
HAW R. @ MONCURE	NA	9.7	10.1	21.4	NA	211.9	215.8	172	NA	8.98	12.43	8.2	NA	7.47	7.12	7.2
CAPE FEAR R. @ LILLINGTON	13.9	10.8	9.3	21.4	152.1	176.6	131.8	164	9.93	9.98	10.55	7.4	6.3	6.1	6.1	6.9
CAPE FEAR R. @ FAYETTEVILLE	NA	11	9.8	14.7	NA	124.9	124.5	138	NA	10.9	9.82	9.2	NA	6.2	6.5	6.9
CAPE FEAR R. @ ELIZABETHTOWN	16.7	12.6	10.2	14.7	90.9	117.7	104.3	141	9.66	10.43	10.17	8.8	6.2	6.4	5.9*	6.5
BLACK R. @ TOMAHAWK	12	9.1	13.7	12.6	127.7	124.6	116.7	124	9.99	10.18	8.48	8.8	6.6	6.2	6.1	6.6
BLACK R. @ HUGGINS	NA	NA	13.4	19.4	NA	NA	86	104	NA	NA	7.9	5.1	NA	NA	5.8	6.2
CAPE FEAR R. @ NAVASSA	14.9	NA	12.5	20	11826	NA	1671	281	7.3	NA	8.7	5.8	7.1	NA	6.6	6.8
ROCKFISH CR. @ WALLACE	9.2	10.6	NA	17	259	160	NA	158	9.1	9.6	NA	7.4	6.7	NA	NA	6.6
NORTHEAST CAPE FEAR R. @ WATHA	9.9	8.3	3.4	17.7	170	146	101	152	10	10.4	11.4	7.2	6.5	NA	6.2	6.3
NE CAPE FEAR R. @ WILMINGTON	15.5	10.6	12.4	20	19275	160	10051	10521	7.2	9.6	8.6	6.1	7.3	NA	6.9	6.9
LUMBER R. @ MAXTON	9.2	14	1.7	14.9	37.3	40.2	32.3	44	10.15	8.11	13.08	7.5	5.8	5.7	5.8	5.9
LUMBER R. @ BOARDMAN	12	8.6	4.2	13.3	63.1	65.8	60.1	88	8.49	8.6	11.6	7.5	5.7	5.4	5.6	5.9

(Shaded cell) Exceeds NC standard

* ND result was not detected above reported practical quantitation limit, NA signifies result not available

Appendix III: Results of Hurricane Matthew Monitoring at H.F. Lee Power Plant: Phase 1 Round 1 (Oct. 19-26, 2016)

Physical Conditions

Location Description	Temperature (^{0}C)		Conductivity (umhos/cm)		D.O. (mg/L)		pH (S.U.)	
	Oct 17	Oct 24	Oct 17	Oct 24	Oct 17	Oct 24	Oct 17	Oct 24
Lee Plant Upstream	18.7	19.2	82	97.5	4.6	7.54	6.4	6.9
Lee Plant Downstream	18.7	19.4	72	98.2	3.7	7.45	6.2	6.88

Metals in liquid (µg/L)

Location Description	Al		As		Cd		Cu		Fe		Ni		Zn		Ba		Be		B		Ca		Co	
	Oct 17	Oct 24	Oct 17	Oct 24	Oct 17	Oct 24	Oct 17	Oct 24	Oct 17	Oct 24	Oct 17	Oct 24	Oct 17	Oct 24	Oct 17	Oct 24	Oct 17	Oct 24	Oct 17	Oct 24	Oct 17	Oct 24	Oct 17	Oct 24
Lee Plant Upstream	1400	1800	ND	ND	ND	ND	2.5	2.4	1500	2300	ND	ND	ND	15	43	46	ND	ND	ND	ND	5.1	6.5	ND	ND
Lee Plant Downstream	1400	1900	ND	ND	ND	ND	2.9	2.5	1400	2600	ND	ND	ND	11	40	51	ND	ND	ND	ND	4.8	6.7	ND	ND

Location Description	Hg		K		Mg		Na		Mn		V		Cr		Mo		Pb		Sb		Se		Sr		Tl	
	Oct 17	Oct 24	Oct 17	Oct 24	Oct 17	Oct 24	Oct 17	Oct 24	Oct 17	Oct 24	Oct 17	Oct 24	Oct 17	Oct 24	Oct 17	Oct 24	Oct 17	Oct 24	Oct 17	Oct 24	Oct 17	Oct 24	Oct 17	Oct 24	Oct 17	Oct 24
Lee Plant Upstream	ND	ND	4	3.3	2.1	2.7	7	8.7	83	270	ND	ND	ND	ND	ND	ND	ND	2.1	ND	ND	ND	ND	33	38	ND	ND
Lee Plant Downstream	ND	ND	4.1	3.6	2	2.8	5.4	8.8	72	290	ND	ND	ND	ND	ND	ND	ND	2.3	ND	ND	ND	ND	29	38	ND	ND

Dissolved Metals (µg/L)

Location Description	Al		As		Cd		Cu		Fe		Ni		Zn		Ba		Be		B		Ca		Co	
	Oct 17	Oct 24	Oct 17	Oct 24	Oct 17	Oct 24	Oct 17	Oct 24	Oct 17	Oct 24	Oct 17	Oct 24	Oct 17	Oct 24	Oct 17	Oct 24	Oct 17	Oct 24	Oct 17	Oct 24	Oct 17	Oct 24	Oct 17	Oct 24
Lee Plant Upstream	740	330	ND	ND	ND	ND	2.1	ND	780	690	ND	ND	ND	ND	39	32	ND	ND	ND	NA	5.1	6.4	ND	ND
Lee Plant Downstream	340	340	ND	ND	ND	ND	2.5	ND	390	740	ND	ND	ND	ND	33	34	ND	ND	ND	NA	4.5	6.5	ND	ND

Location Description	Hg		K		Mg		Na		Mn		V		Cr		Mo		Pb		Sb		Se		Sr		Tl	
	Oct 17	Oct 24	Oct 17	Oct 24	Oct 17	Oct 24	Oct 17	Oct 24	Oct 17	Oct 24	Oct 17	Oct 24	Oct 17	Oct 24	Oct 17	Oct 24	Oct 17	Oct 24	Oct 17	Oct 24	Oct 17	Oct 24	Oct 17	Oct 24	Oct 17	Oct 24
Lee Plant Upstream	ND	ND	4	3.1	2	2.5	7.1	8.6	69	140	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	32	38	ND	ND
Lee Plant Downstream	ND	ND	3.9	3.4	1.8	2.6	5.2	8.7	53	140	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	29	38	ND	ND

* ND result was not detected above reported practical quantitation limit, NA signifies result not available

Appendix IV: Phase 1 Hurricane Matthew Monitoring Herbicide, Pesticide, Volatile, and Semi-Volatile Compounds

Acid Herbicide	P Based Pesticide	Cl Based Pesticide		N Based Pesticide
Acifluorfen (Blazer) Bentazon 2,4-D 2,4-DB Dicamba 3,5-Dichlorobenzoic Acid Dichlorprop Dinoseb 4-Nitrophenol (Pest) Pentachlorophenol (PCP) 2,4,5-T 2,4,5-TP (Silvex)	Carbophenothion Chlorpyrifos DEF (Oxidized merphos) Demeton Diazinon Dichlorvos Dimethoate Disulfoton Disulfoton Sulfone Disulfoton Sulfoxide EPN Ethion Ethoprop Fenthion Fensulfothion Mevinphos Monocrotophos Naled Ethyl Parathion Methyl Parathion Phorate Ronnel Sulfotepp Terbufos Malathion	Alachlor Aldrin BHC-Alpha BHC-Beta BHC_Delta BHC-Gamma (Lindane) Chlordane, Technical Chlordane, Alpha Chlordane, Gamma Chlordene Chlorobenzilate DCPA DDD 2,4 DDD 4,4 DDE 2,4 DDE 4,4 DDT 2,4 DDT 4,4 Dieldrin Endosulfan I Endosulfan II Endosulfan Sulfate	Endrin Endrin Aldehyde Endrin Ketone Ethazole Heptachlor Heptachlor epoxide Hexachlorobenzene(Pest) Methoxychlor Mirex Trans Nonachlor Oxychlordane Mixed Permethrin Propachlor Tecnazene Trifluralin Toxaphene Aroclor 1016 Aroclor 1221 Aroclor 1232 Aroclor 1242 Aroclor 1248 Aroclor 1254 Aroclor 1260 Aroclor 1262 Chlorothalonil Chloroneb	Ametryn Atrazine Atraton Bromacil Butachlor Butylate Chlorpropham Cyanazine Cycloate Diphenamid EPTC(Eptam) Hexazinone Metolachlor Molinate Napropamide Norflurazon Pebulate Prometon Prometryn Pronamide Propazine Simetryn Tetrachlorvinphos Tebuthiuron Tricyclazole Vernolate Fenarimol Fluridone Terbacil Triadimefon Methyl Paraoxon Metribuzin Terbutryn

Appendix IV continued: Phase 1 Hurricane Matthew Monitoring Herbicide, Pesticide, Volatile, and Semi-Volatile Compound Analytes as Liquid µg/L

Volatile Organics		Semi-Volatile Organics		
Dichlorodifluoromethane	Tetrachloroethene	Acenaphthene	Dibenzo(a,h)anthracene	Indeno(1,2,3-cd)pyrene
Chloromethane	Chlorobenzene	Acenaphthylene	Dibenzofuran	Isophorone
Vinyl Chloride	Ethylbenzene	Aniline	2,4-Dichlorophenol	2-Methylnaphthalene
Bromomethane	Bromoform	Anthracene	1,2-Dichlorobenzene	2-Methylphenol
Chloroethane	m,p-Xylene	Benzo(a)anthracene	1,3-Dichlorobenzene	4-Methylphenol
Trichlorofluoromethane	Styrene	Benzo(a)pyrene	1,4-Dichlorobenzene	Naphthalene(SV)
1,1-Dichloroethene	1,1,2,2-Tetrachloroethane	Benzo(b)fluoranthene	3,3'-Dichlorobenzidine	2-Nitrophenol-
Methylene Chloride	1,1,1,2-Tetrachloroethane	Benzo(g,h,i)perylene	Diethyl phthalate	4-Nitrophenol
trans-1,2-Dichloroethene	o-Xylene	Benzo(k)fluoranthene	2,4-Dimethylphenol	2-Nitroaniline
Methyl Tert-Butyl Ether	1,2,3-Trichloropropane	Benzoic acid	Dimethyl phthalate	3-Nitroaniline
1,1-Dichloroethane	Isopropylbenzene	Benzyl alcohol	Di-n-butyl phthalate	4-Nitroaniline
cis-1,2-Dichloroethene	Bromobenzene	Bis(2-chloroethoxy)methane	2,4-Dinitrophenol	Nitrobenzene
Bromochloromethane	n-Propylbenzene	Bis(2-chloroethyl)ether	4,6-Dinitro-2-methyl phenol	N-nitrosodi-n-propylamine
Chloroform	2-Chlorotoluene	Bis(2-chloroisopropyl)ether	2,4-Dinitrotoluene	N-nitrosodiphenylamine
2,2-Dichloropropane	4-Chlorotoluene	Bis(2-ethylhexyl)phthalate	2,6-Dinitrotoluene	Pentachlorophenol
1,2-Dichloroethane	1,3,5-Trimethylbenzene	4-Bromophenyl phenyl ether	Di-n-octyl phthalate	Phenanthrene
1,1,1-Trichloroethane	tert-Butylbenzene	Butylbenzyl phthalate	Fluoranthene	Phenol
1,1-Dichloropropene	1,2,4-Trimethylbenzene	2-Chloronaphthalene	Fluorene	Pyrene
Carbon Tetrachloride	sec-Butylbenzene	4-Chloro-3-methyl phenol	Hexachlorobenzene	2,4,5-Trichlorophenol
Benzene	m-Dichlorobenzene (1,3)	4-Chloroaniline	Hexachlorobutadiene(SV)	2,4,6-Trichlorophenol
Dibromomethane	p-Dichlorobenzene (1,4)	2-Chlorophenol	Hexachlorocyclopentadiene	1,2,4-Trichlorobenzene
1,2-Dichloropropane	o-Dichlorobenzene (1,2)	4-Chlorophenyl phenyl ether	Hexachloroethane	TPH Diesel Range Organics
Trichloroethene	p-Isopropyltoluene	Chrysene		
Bromodichloromethane	n-Butylbenzene			
cis-1,3-Dichloropropene	1,2-Dibromo-3-Chloropropane			
trans-1,3-Dichloropropene	1,2,4-Trichlorobenzene			
1,1,2-Trichloroethane	Naphthalene			
Toluene	Hexachlorobutadiene			
1,3-Dichloropropane	1,2,3-Trichlorobenzene			
Dibromochloromethane	TPH-Gas in Liquid			
(EDB)1,2-Dibromoethane				