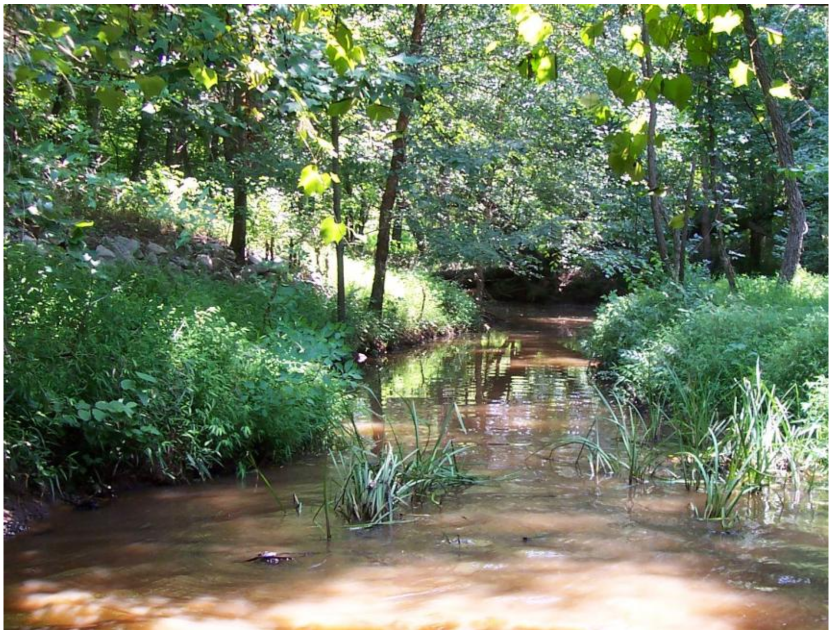
Water Quality Integrated Analysis Report for the Wake-Johnston Collaborative Local Watershed Plan



NC Division of Water Quality

Watershed Assessment Team

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Cover Photo:

Poplar Creek at Knightdale-Eagle Rock Rd., Johnston Co., on 8/04/2009

Contents

I. Executive summary

A benthic macroinvertebrate assessment, and physical and chemical monitoring were conducted in eastern Wake County and western Johnston County in 2009-2010. The results from these efforts will be used to develop a local watershed plan (LWP) being coordinated by Wake County and the NC Ecosystem Enhancement Program.

Eleven sites were assessed. The benthic macroinvertebrate assessment was coordinated by NC State University (NCSU) with assistance from the NC Division of Water Quality (NCDWQ). Bioclassifications were assigned by NCSU to nine of the eleven sites. Two sites, Poplar Cr. at Smithfield Rd., and Buffalo Cr. at Poole Rd. received "Fair" bioclassifications. Others received "Good" or "Good-Fair" bioclassifications. Low flow was one of the stressors noted in a report on the benthos macroinvertebrates written by NCSU. Downstream reaches of both Poplar and Marks Creek were less degraded than the upstream reaches suggesting that stressors were affecting the benthic community in upstream segments of these streams.

Habitat scores were poor in many of watersheds within the LWP area. Habitat total scores ranged from 48 (Poplar Cr. at Smithfield Rd.) to 80 (Rocky Branch and the Little River). Total scores were greater than 70 at only three sites and less than 60 at five sites. There was no obvious relationship between either habitat total scores or any of the habitat submetrics and bioclassifications.

Nutrients were high at some sites, and could be a stressor. High nitrite+nitrate concentrations were measured from the monitoring station along Beddingfield Cr. These concentrations (1.20 to 4.80 mg/L) were greater than those recorded from other regional monitoring stations outside the LWP area for the same period (Oct. 2009 – June 2010). Additionally, high ammonia nitrogen concentrations were measured from Buffalo Cr. at Mitchell Mill Rd., but these are comparable to the results from some regional monitoring stations. A few low dissolved oxygen concentrations (<4.0 mg/L) were noted and were likely due to very warm temperatures. Twenty-one pH values were below 6.0 SU, but nine were recorded during a storm event, and nine others may have been due to a malfunctioning meter. Additional follow-up activities are necessary to identify the sources of the high nutrients and potential compensatory mitigation sites.

II. Introduction

A. Study objectives

This report discusses the results of two water quality investigations at 11 sites in the Wake-Johnston County area during 2009-2010. These investigations include:

1. A biological assessment using benthic macroinvertebrates, the results of which can address whether or not the streams are supporting aquatic life. This investigation was conducted jointly by North Carolina State University (NCSU) and the NC Division of Water Quality (NCDWQ).

2. Physical, chemical and microbiological monitoring. Monitoring was done cooperatively between the Wake County - Environmental Services - Watershed Management Program[1] and the NCDWQ Watershed Assessment Team (WAT)[2]. Methods as to how these investigations were conducted are discussed in Section III – Methods. Monitoring results may:

    a. further aid in the interpretation of the benthic macroinvertebrate results,
    b. help characterize the condition of a stream and identify specific water quality stressors,
    c. determine compliance with water-quality standards,
    d. determine whether follow-up activities are necessary to identify the sources of stressors,
    e. document changes in water quality over time[3].

These efforts were initiated to assist in the development of a local watershed plan (LWP) being coordinated by the NC Ecosystem Enhancement Program (NCEEP) and Wake and Johnston counties[4]. The primary intent of these water quality investigations was to identify potential stressors contributing to the degradation of water quality, habitat and hydrological functions throughout the planning area based on the results of collected data and best professional judgment. The goals of a LWP include the development of a comprehensive watershed management and restoration strategy and a project atlas identifying specific locations and projects within the planning area that, if implemented, would ameliorate water quality, habitat and/or hydrology within the watershed.

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[1] http://www.wakegov.com/water/watershed/default.htm
[2] http://portal.ncdenr.org/web/wq/swp/ws/pdu/wat/
[3] Although monitoring programs can document changes in water quality over time, this report summarizes monitoring data collected during 10 months, thus cannot be used to identify long-term temporal patterns.
[4] For a summary see: http://www.nceep.net/services/lwps/Wake_Johnson_collaborative/pdf/Wake-Johnston%20LWP%2020090910.pdf

B. Watershed Planning and Key Objectives

The Wake-Johnston collaborative local watershed plan must meet two broad objectives. First, the plan must comprise an approach to protect water quality and quantity that focuses on a whole watershed. This is a departure from the traditional approach of managing individual wastewater discharges and/or land use activities, and is necessary due to the nature of polluted runoff, which may be a large contributor to water pollution. This approach likely meets the needs of watershed planning efforts by Wake and Johnston counties.

Secondly the watershed plan must meet the needs of the NCEEP since the NCEEP is a partner in this planning process. The NCEEP uses watershed planning to identify the best locations to implement stream, wetland and riparian buffer restoration. The planning process considers where mitigation is needed and how mitigation efforts might contribute to the improvement of water and habitat quality in the state. Watershed planning, as conducted by the NCEEP, requires GIS data analysis, stakeholder involvement, water quality and habitat monitoring and consideration of local land uses and ordinances. It is a multidimensional process which considers science, policy and partnership.

How the NCEEP meets mitigation needs is, in part, specified in federal regulations by the Department of the Army, Corps of Engineers (33 CFR Parts 325 and 332) and the Environmental Protection Agency (40 CFR Part 230) Selection. This joint rule (Compensatory Mitigation for Losses of Aquatic Resources; Final Rule), published on April 10, 2008 states: "*the ultimate goal of a watershed approach is to maintain and improve the quality and quantity of aquatic resources within watersheds through strategic selection of compensatory mitigation sites*." (COE §332.3 (6)(c) and EPA §230.93 (6) (c). Watershed monitoring helps but may not sufficiently address this key objective. Monitoring data is useful for determining the condition of a watershed, but may not necessarily identify specific sources of water quality stressors. This may be achieved with follow-up activities.

C. Selection and Location of Monitoring Sites

LWP Monitoring Sites

Sites in which the physical and chemical parameters were collected and measured, coincided with the same sites the benthic macroinvertebrate were sampled (Table 1, Figure 1) with the exception of the Little River Site (Map Code 11, Table 1). The Little River site was moved downstream from the original benthos sampling station approximately 0.25 mi. to the NC 97 bridge to facilitate collection of water samples during monthly monitoring. Some of these locations also coincided with locations in other monitoring programs, including the ongoing Wake County monitoring program and a CH2M Hill study conducted in 2001 (CH2M Hill 2002).

Table 1. Locations of the LWP monitoring stations.

Map Code[1]	Road Name	County	Decimal Degrees Latitude	Longitude
1	Beddingfield Cr. at Shotwell Rd. (SR-1553)	Johnston	35.6948	-78.4799
2	Poplar Cr. at Smithfield Rd. (SR-2233)	Wake	35.7724	-78.4742
3	Poplar Cr. at Bethelhem Rd. (SR-2049)	Wake	35.7307	-78.4754
4	Marks Cr. at Eagle Rock Rd. (SR-2501)	Wake	35.7876	-78.4377
5	Marks Cr. at Prichard Rd. (SR-1714)	Johnston	35.7058	-78.4305
6	Buffalo Cr .at Mitchell Mill Rd. (SR-2224)	Wake	35.8878	-78.4373
7	Buffalo Cr .at Poole Rd. (SR-1007)	Wake	35.7760	-78.3837
8	Hominy Cr. at Buck Rd. (SR-2329)	Wake	35.8651	-78.3914
9	Rocky Br. at Riley Hill Rd. (SR-2320)	Wake	35.8445	-78.3763
10	Snipe Cr .at Taylors Mill Rd. (SR-1723)	Johnston	35.7775	-78.2801
11	Little R. at NC 231	Johnston	35.7347	-78.2826

[1] Figure 1. depicts the locations of the monitoring sites within the LWP area.

The benthic macroinvertebrate sampling attempted to select sites that coincided with other monitoring programs such as Wake County monitoring programs or the CH2M Hill investigation in 2001. Additional information on the selection and location of the monitoring sites is provided in the NCSU (2009) report (Appendix A).

Regional Monitoring Sites

To facilitate interpreting monitoring results from the LWP area, results from 29 monitoring sites (Table 2, Figure 2) within a 40 mile radius of the LWP were obtained. No Neuse River sites were selected, since watershed areas for these river sites are much greater than the watershed areas for the LWP sites. References and Benchmark section provides additional information.

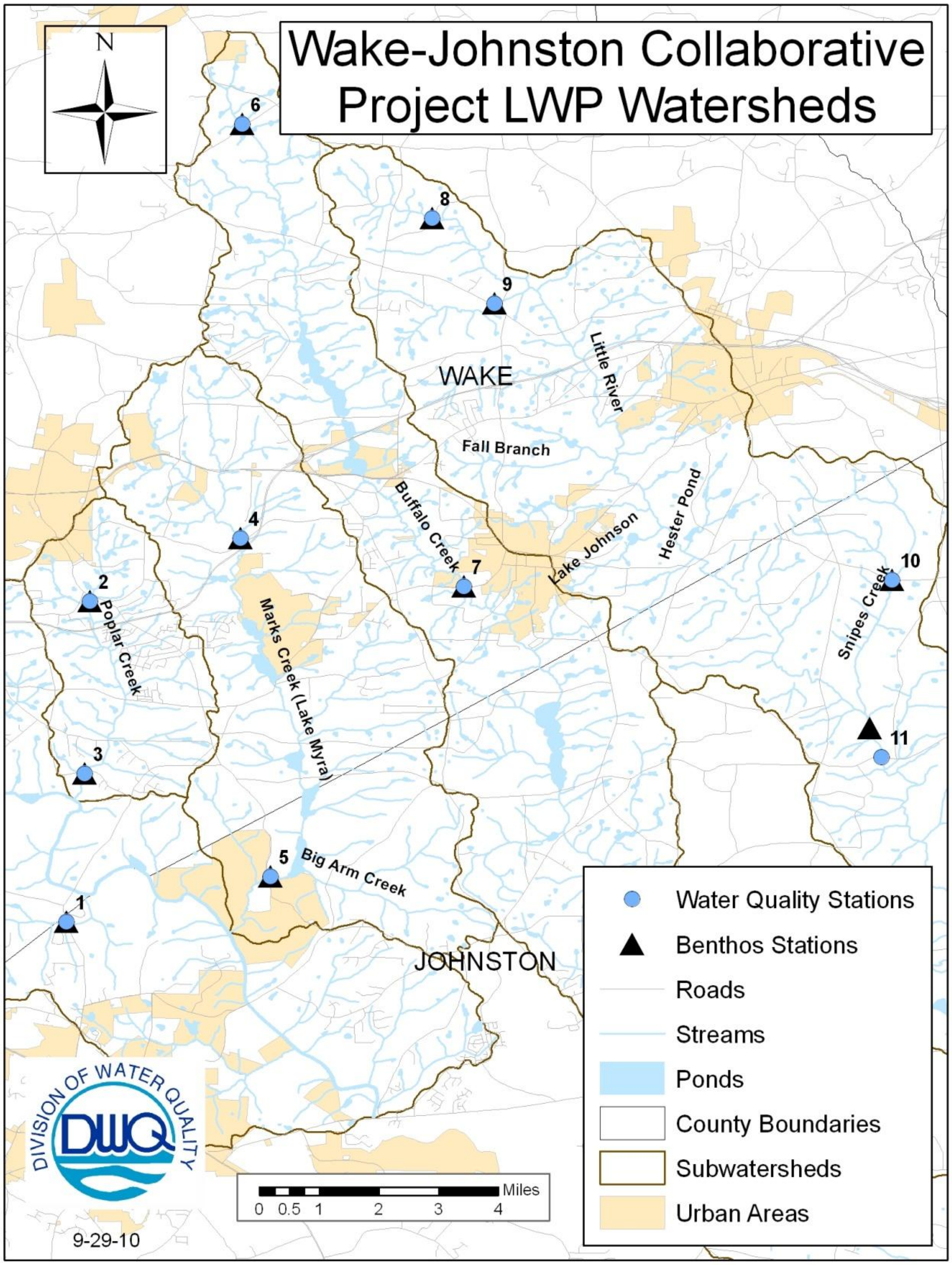


Figure 1. Locations of water quality and benthic macroinvertebrate monitoring stations. Numbers correspond to the map codes in Table 1.

Table 2. Locations of the regional monitoring stations. See foot notes for more information.

Station ID[1]	Map Code[2]	Location	Begin[3]	End[3]	Latitude	Longitude	County
J2230000	C1	Smith Cr. at SR 2045 Burlington Mill Rd near Wake Forest	Dec-94	Jun-10	35.9182	-78.5348	Wake
J2850000	A1	Crabtree Cr. at SR 1795 near Umstead State Park	Jul-73	Apr-10	35.8377	-78.7808	Wake
J3000000	A2	Crabtree Cr. at SR1649 near Raleigh	Sep-76	Apr-10	35.8455	-78.7244	Wake
J3210000	C2	Crabtree Cr. at Lassiter Mill Dam at Raleigh	Dec-94	Jun-10	35.8272	-78.6508	Wake
J3251000	A3	Crabtree Cr. at SR 2000 at Old Wake Forest Rd.	Mar-99	Apr-10	35.8158	-78.6257	Wake
J3300000	A4	Pigeon House Br. at Dortch St., Raleigh	Dec-83	Apr-10	35.7939	-78.6426	Wake
J3970000	C3	Walnut Cr. at SR 2551 Barwell Rd near Raleigh	Dec-94	Jun-10	35.7493	-78.5345	Wake
J4080000	C4	Poplar Cr. at SR 2049 Bethlehem Rd near Knightdale	Dec-94	Jun-10	35.7309	-78.4776	Wake
J4414000	C5	Swift Cr. at SR 1152 Holly Springs Rd near Macedonia	Dec-94	Jun-10	35.7187	-78.7527	Wake
J4510000	A5	Swift Cr. at NC 42 near Clayton	Jan-85	Apr-10	35.6131	-78.5486	Johnston
J4590000	C6	Swift Cr. at NC 210 near Smithfield	Dec-94	Jun-10	35.5186	-78.3819	Johnston
J4619000	C7	Middle Cr. at Lufkin Road near Apex	Feb-07	Jun-10	35.7131	-78.8381	Wake
J4690000	C8	Middle Cr. at SR 1152 Holly Springs Rd near Holly Springs	Feb-96	Jun-10	35.6609	-78.8042	Wake
J4868000	C9	Middle Cr. at SR 1375 Lake Wheeler Rd near Banks	Jul-05	Jun-10	35.6356	-78.7279	Wake
J4980000	C10	Middle Cr. at SR 1006 Old Stage Road near Willow Springs	Dec-94	Jun-10	35.6091	-78.6866	Wake
J5000000	A6	Middle Cr. at NC 50 near Clayton	Jan-81	Apr-10	35.5689	-78.5923	Johnston
J5010000	C11	Middle Cr. at NC 210 near Smithfield	Dec-94	Jun-10	35.5075	-78.4013	Johnston
J5170000	C12	Black Cr. at SR 1162 near Four Oaks	Dec-04	Jun-10	35.4693	-78.4568	Johnston
J5390000	C13	Hannah Cr. at SR 1158 Allens Crossroads Dr near Benson	Feb-04	Jun-10	35.3868	78.5110	Johnston

Station ID[1]	Map Code[2]	Location	Begin[3]	End[3]	Latitude	Longitude	County
J5390800	C14	Hannah Cr. at SR 1227 Ivey Rd near Benson	Feb-04	Jun-10	35.4025	-78.4952	Johnston
J5410000	C15	Mill Cr. at SR 1200 Richardson Bridge Rd near Cox Mill	Jun-09	Jun-10	35.3420	-78.2162	Johnston
J5500000	C16	Falling Cr. at SR 1219 Old Grantham Rd near Bentonville	Aug-09	Jun-10	35.3224	-78.1282	Wayne
J5620000	C17	Little R. at SR 2333 Smithfield Rd near Zebulon	Dec-94	Jun-10	35.8577	-78.3665	Wake
J6410000	C18	Little Cr. at NC 97 at Zebulon	Jun-96	Jun-10	35.8279	-78.3025	Wake
J6450000	C19	Little Cr. at NC 39 at Zebulon	Jun-96	Jun-10	35.8125	-78.2681	Wake
J6500000	C20	Moccasin Cr. at SR 1131 Antioc Church Rd near Conner	Dec-94	Jun-10	35.7301	-78.1895	Wilson
J6680000	C21	Turkey Cr. at SR 1101 Claude Lewis Rd near Middlesex	Apr-99	Jun-10	35.7519	-78.1597	Nash
02087580	G1	Swift Creek at SR 1152 near Apex NC	Oct-89	Sep-09			Wake

[1] Station IDs beginning with "J" are STORET station codes. Water quality data from these sites can be downloaded from the EPA STORET database. The station ID of 02087580 is a US Geological Survey (USGS) monitoring station. Stations are ordered from top to down by the STORET number, which generally corresponds to an upstream to downstream ordering.

[2] The letter prefixes (A, C and G) refer to: A=NCDWQ Ambient Monitoring System, C=Lower Neuse River Basin – a NPDES coalition monitoring system and G=USGS monitoring station.

[3] "”Begin" and "End" are the beginning and ending dates (month-year) of the data used in this report (Appendix E).

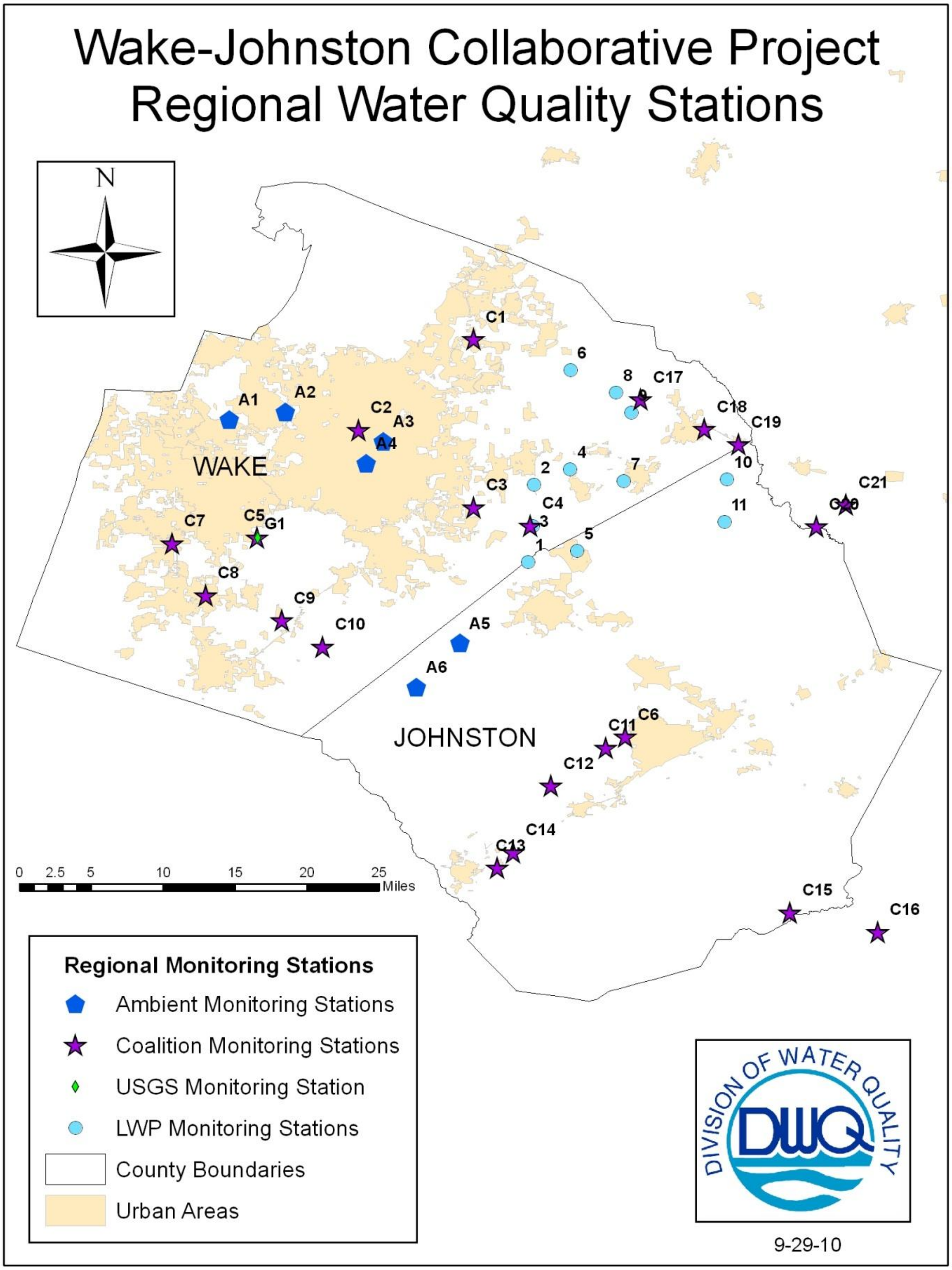


Figure 2. Locations of the regional monitoring stations.

D. Overview of Watershed Conditions

The NCEEP fact sheet on the Wake-Johnston Collaborative Local Watershed Plan identifies five project watersheds:

1. Beddingfield Creek & adjacent portions of the Neuse River,
2. Poplar Creek,
3. upper Marks Creek,
4. upper Buffalo Creek, and
5. a portion of the Little River.

Within these watersheds lie portions of several municipalities including Clayton, Knightdale, Wendell (entirely within), and Zebulon. Residential and commercial development continues to expand from these centers. Much of Buffalo Creek and a segment of the Neuse are designated as impaired waters by the NC Division of Water Quality due to poor biological communities. In addition, an overview of watershed conditions for each monitoring station is provided in Appendix B.

E. References and Benchmarks

Assessment and monitoring results collected within a LWP planning area can be compared to two different suites of numbers. The first set of numbers represents "evaluation levels", water-quality standards and action levels. The second set of numbers represents monitoring results from monitoring stations outside the LWP planning area.

The distinction among a water quality standard, action level and evaluation level is as follows:

Evaluation Levels

Evaluation level– Refers to the applicable numeric or narrative waterquality standard or action level as used in the NCDWQ Ambient Monitoring System Station Summaries[5]. This term does not imply whether water-quality standards or action levels are being met. Additional information is provided in Section IV – Results.

Water-quality standard[6] – Water-quality standards are state regulations or rules that protect lakes, rivers, streams and other surface water bodies from pollution. Standard specify beneficial use designations (classifications), numeric levels and narrative statements (water-quality criteria) protective of the use designations, and procedures for applying the water-quality criteria to wastewater dischargers and other sources of

[5] For example see the column designated "EL" (for Evaluation Level) here: http://www.esb.enr.state.nc.us/documents/CapeFearRiverBasinStationSummaries2004-2008.pdf
[6] For more information see: http://portal.ncdenr.org/web/wq/ps/csu/swstandards

pollution. The NCDWQ has policies in place that determine whether water-quality standards are being met.

Water quality action level - The concentration of a contaminant which, if exceeded, triggers treatment or other requirements which a water system must follow.

Regional Monitoring Data

Not all parameters have specific numeric criteria, such as standards, that can be used to aid in the interpretation of data. Specific conductance and nutrients are examples. To aid in the interpretation of these parameters, monitoring data within a watershed can be compared to results measured outside the watershed. Twenty-eight monitoring stations were selected (Table 2, Figure 2). All but two of the regional (nearby) monitoring stations are with a 25 mile radius of the LWP area. All are within a 40 mile radius. No Neuse river monitoring stations were chosen as comparative sites since the watershed areas of these stations greatly exceed those of the LWP.

III. Methods

A. Chemical and Microbiological

Field measurements included water temperature, dissolved oxygen, dissolved oxygen saturation, specific conductance and pH. All measurements were made *in situ* in a representative point of the channel that was well-mixed and flowing, generally at or near the thalweg with handheld meters. In most cases meters from Wake County were used. When NCDWQ meters were used meter calibrations and measurements were performed in accordance with the NCDWQ Standard Operating Procedures (SOP; NCDWQ, 2006b).

All chemical and microbiological samples were collected in plastic bottles specific for the type of parameter being measured. Parameters selected for sampling included:

1. Nutrients: nitrite + nitrate nitrogen, ammonia nitrogen, total Kjeldahl nitrogen and total phosphorus
2. Residues: total suspended solids
3. Turbidity
4. Metals: arsenic, cadmium, chromium, copper, lead, nickel, and zinc
5. Fecal coliform bacteria.

All samples were collected as grab samples by direct fill of sample bottles by immersion. Samples were taken during base flow conditions (defined as >48 hours since the last measurable rain event) or during storm events. A detailed list of parameters, Practical Quantitation Limits (PQL)[7], water-quality standards and action levels is provided in Appendix C

See the section on quality control/quality assurance below for information regarding quality control.

B. Benthic Macroinvertebrates and Habitat

Biological monitoring and habitat assessments were conducted at 11 sites during August 2009 by NCSU, Wake County, and WAT staff. Sampling, identification, and interpretation of results for benthic macroinvertebrate communities were performed in accordance with NCDWQ Biological Assessment Unit (BAU) Standard Operating Procedures (SOP) for Benthic Macroinvertebrates (NCDWQ 2006a). Habitat assessments were conducted at each site using the BAU form for the Piedmont/Mountains included in the benthic macroinvertebrate SOP (NCDWQ 2006a). The NCSU (2009) report regarding the benthos collection (Appendix A) provides a summary of sampling methods, habitat assessments and bioclassifications.

C. Flow

The US Geological Survey (USGS) initiated stream flow measurements along the Little River in October 2008 near Zebulon. This is the only USGS flow monitoring station in the LWP area. Flow data were downloaded from the USGS National Water Information System web interface for this monitoring station (USGS 02088383) and graphed using SigmaPlot (version 11.0) scientific graphing software. The data were graphed twice, once using a $\log_{10}$ scaling so that the lower flows could be easily discerned, and once using linear scaling, so the peak plows could be easily viewed.

[7] The Practical Quantitation Limit (PQL) is defined and proposed as "the lowest level achievable among laboratories within specified limits during routine laboratory operation." The PQL is about three to five times the calculated Method Detection Limit (MDL) and represents a practical and routinely achievable detection limit with a relatively good certainty that any reported value is reliable." For a list of laboratory PQLs go to: http://portal.ncdenr.org/web/wq/lab/staffinfo/techassist#Practical_Quantitation_Limits

D. Quality Assurance/Quality Control

1. Physical and Chemical Monitoring

The NCDWQ Intensive Survey Unit's standard operating procedure (SOP; NCDWQ 2006b) was followed whenever NCDWQ field meters were used for the measurement of dissolved oxygen, dissolved oxygen saturation, water temperature, specific conductance and pH. The NCDWQ 2006 SOP, in addition to the NCDWQ Laboratory Section's Sample Submission Procedures[8] and Submission Guidance Document[9] were followed for all sample collections submitted to the Laboratory Section.

2. Benthic Macroinvertebrates

The NCDWQ standard operating procedure (SOP, NCDWQ 2006a) was followed for the collection of benthic macroinvertebrates and habitat data.

E. Data Analysis and Statistics

1. Physical and Chemical Monitoring

Field monitoring data collected by Wake County and the NCDWQ-WAT and chemical results provided by the Laboratory Section were entered by hand into a Microsoft Excel (Microsoft Office 2007) spreadsheet. Data were checked for accuracy using a combination of manual checking and by tabulation and graphing using JMP (version 8.0.1). A copy of these data is available on the NCDWQ-WAT website[10].

Monitoring data from the NCDWQ Ambient Monitoring System program, the NCDWQ Coalition program and the US Geological Service (USGS) were compiled into one JMP dataset. Since the data structures among these programs vary, various concatenations and table joins were necessary to produce one dataset in which the data could be graphed. Best professional experience was used to determine whether or not the various concatenations and table joins produced expected resulting data tables.

Data were graphed and summarized using JMP statistical software. No statistical comparisons (e.g. comparison of sample means among monitoring stations) were made using any of the data. Only one linear regression was performed on the relationship between total suspended solids and turbidity. See the discussion on turbidity beginning on page 28/

[8] http://portal.ncdenr.org/web/wq/lab/staffinfo/samplesubmit
[9] http://portal.ncdenr.org/c/document_library/get_file?uuid=92a278e5-f75a-4e42-9be5-282ac0216b2a&groupId=38364
[10] http://portal.ncdenr.org/web/wq/swp/ws/pdu/wat/projects

Special symbols and colors were assigned to results on graphs to distinguish results taken during baseflow and stormflow conditions for those data collected by Wake County and NCDWQ-WAT in the LWP area. A blue plus symbol (+) represents a result collected during baseflow conditions, whereas a red asterisk (✱) represents a result collected during stormflow conditions. A black square (▪) denotes a result that was below the PQL (akin to the "detection limit") of the Laboratory Section. No special marker or color distinctions were assigned to the results of any of the regional stations, since baseflow and stormflow designations were not part of those databases. In addition, horizontal red lines on some of the graphs represent the evaluation level (water quality standard or action level) for that parameter. For example, graphs for dissolved oxygen will show a horizontal red line at 4.0 mg/L. Results below 4.0 mg/L are those violating the water quality standard for dissolved oxygen. See page 72 for an example of a graph for dissolved oxygen with a horizontal red line at 4.0 mg/L

This concept is true for all water quality parameters with a water quality standard or action level, except for fecal coliform bacteria. Results for fecal coliform bacteria greater than 400 cfu/100 ml should not be interpreted as violating the water quality standard. This is because the standard is applicable to five consecutive samples, taken within a 30 day period. The chemical sampling in the LWP planning area was not completed at this frequency. Additionally, it is common practice to sample fecal coliform bacteria and not submit the samples to the Laboratory Section within 6 hours of sample collection (the required holding time). Results collected under these conditions are still useful indicators of fecal coliform pollution, however the results cannot be used to determine if the water quality standard is being met.

The water quality standard for fecal coliform bacteria (15A NCAC 02B .0211) (3)(e) is:

> *Organisms of the coliform group: fecal coliforms shall not exceed a geometric mean of 200/100ml (MF count) based upon at least five consecutive samples examined during any 30 day period, nor exceed 400/100ml in more than 20 percent of the samples examined during such period. 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. All coliform concentrations are to be analyzed using the membrane filter technique unless high turbidity or other adverse conditions necessitate the tube dilution method; in case of controversy over results, the MPN 5-tube dilution technique shall be used as the reference method;*

2. Benthic Macroinvertebrates

Benthic macroinvertebrate taxa are identified to the lowest taxonomic level possible and are enumerated on a scale of 1 (rare) to 10 (abundant).

Additionally each taxon has been assigned a tolerance value that indicates the taxon's tolerance to pollution. Based on this information an NC Biotic Index (NCBI) is calculated:

Where TVi is the tolerance value of the i^{th} taxon, s represents the total number of taxa in the sample, Ni is the relative abundance of the i^{th} taxon and Nt is the total abundance of all taxa in the sample. Biotic indices can range from 0 to 10, with the lower scores indicating a sample with more polluting intolerant taxa and better water quality.

Various metrics are calculated from the sample data, and one of five bioclassifications may be assigned to a sample site: Poor, Fair, Good-Fair, Good, or Excellent. These bioclassifications have regulatory significance since stream segments with either a Poor or Fair bioclassification may be placed on the state's impaired streams list. At this time, only bioclassifications assigned by NCDWQ are used in use-support decisions.

The NCSU report assigned bioclassifications to the samples collected as part of this study. Although these bioclassifications were assigned in accordance with NCDWQ methods (NCDWQ 2006a and 2009) they were never reviewed by the NCDWQ Biological Assessment Unit.

The term "rare" taxon is used within the NCSU report to indicate uncommon or unique taxa. The term "rare" as used within the NCSU report can be misleading to many readers, since the term "rare" is often used elsewhere in the context of "rare and endangered species." None of the benthic macroinvertebrate taxa sampled as part of the benthic macroinvertebrate assessment within the LWP area are officially endangered or threatened.

IV. Results

This section provides a short summary of all the field and chemical parameters that were assessed during the monitoring of the eleven sites. All parameters are described, and the water quality standard or action level is provided when applicable. Results that deviate from NC water-quality standards or depict spatial patterns or are otherwise prominent are noted. Graphs and summary tables of all the monitoring data are provided in Appendix D.

Within this section results from five water quality parameters (specific conductance, ammonia nitrogen, nitrite+nitrate nitrogen, phosphorus and fecal coliform bacteria) monitored within the LWP area were compared to the results from nearby streams for reasons described in the References and Benchmarks section. Only results that were measured during the same time period in which the LWP monitoring occurred (October 2009 to June 2010) were included in the graphs.

Numeric water-quality standards and practical quantitation levels (PQLs) are shown in Appendix C.

A. Field Data

Field meter data (water temperature, dissolved oxygen concentration, percent oxygen saturation, pH, and specific conductance) are routinely measured whenever water samples are collected. These parameters are easily and cost-effectively measured using multi-probe field meters. Field data were available for all water quality sampling dates except in a few cases in which equipment malfunction occurred.

1. Water Temperature

Water temperature is always recorded but very rarely used to diagnose water quality problems. There is a water quality standard for temperature 15A NCAC 02B .0211 (3) (j):

> *Temperature: not to exceed 2.8 degrees C (5.04 degrees F) above the natural water temperature, and in no case to exceed 29 degrees C (84.2 degrees F) for mountain and upper piedmont waters and 32 degrees C (89.6 degrees F) for lower piedmont and coastal plain Waters; the temperature for trout waters shall not be increased by more than 0.5 degrees C (0.9 degrees F) due to the discharge of heated liquids, but in no case to exceed 20 degrees C (68 degrees F).*

Results ranged from 1.1 to 28 ^{o}C and reflected the normal seasonal differences that occur in streams.

2. Dissolved Oxygen

Dissolved oxygen is a very important parameter since oxygen is necessary to support aquatic life. There is a water quality standard for dissolved oxygen 15A NCAC 02B .0211 (3) (b):

> *Dissolved oxygen: not less than 6.0 mg/l for trout waters; for non-trout waters, not less than a daily average of 5.0 mg/l with a minimum instantaneous value of not less than 4.0 mg/l; swamp waters, lake coves or backwaters, and lake bottom waters may have lower values if caused by natural conditions*.

Dissolved oxygen concentrations throughout the LWP area almost consistently were above the 4.0 mg/L North Carolina standard for instantaneous readings. Oxygen concentrations fell below 4.0 mg/L in Buffalo Cr. at Mitchell Mill Rd. once each in December 2009 and June 2010 and once in Hominy Cr. in May 2010.

3. Dissolved Oxygen Saturation

Dissolved oxygen saturation[11] is always recorded, since this parameter is routinely provided by field meters. High results (results near or exceeding 100%) may indicate photosynthetic activity by aquatic plants. Although there is no water quality standard for dissolved oxygen saturation, there is a water quality standard for dissolved gases (15A NCAC 02B .0211 (3) (d): "*Gases, total dissolved: not greater than 110 percent of saturation*." Results are typically more useful when used in conjunction with dissolved oxygen and pH, since photosynthesis can results in diurnal patterns in the concentrations of these parameters. These patterns cannot be determined from monthly monitoring during daylight hours, but can be discerned using dataloggers programmed to take measurements on a frequent interval (e.g. every 15 minutes).

The smallest range of values are from Site 1 – Beddingfield Cr at Shotwell Rd. and Site 3 – Poplar Cr. at Bethlehem Rd. Only two results exceed 110%, and both of these are from Site 2 – Poplar Cr. at Smithfield Rd.

[11] This website provides a good description of dissolved oxygen saturation: http://www.ysi.com/media/pdfs/T602-Environmental-Dissolved-Oxygen-Values-Above-100-percent-Air-Saturation.pdf

4. pH

The acidity or basic nature of a solution is expressed as the pH. It is an important and useful water quality parameter, since aquatic life are adapted to certain ranges of pH. Additionally when pH decreases, many insoluble substances become more soluble and thus available for absorption. The toxicity of many compounds varies with pH. The NC water quality standard for pH is (15A NCAC 02B .0211 (3) (g)):

> *pH: shall be normal for the waters in the area, which generally shall range between 6.0 and 9.0 except that swamp waters may have a pH as low as 4.3 if it is the result of natural conditions.*

Approximately 20% (21 of 106) of the pH readings taken at the monitoring stations were below the North Carolina water quality standard of 6.0 S.U. These included 12 measurements taken during baseflow and all nine taken during the stormflow event on December 3, 2009. A lowering of pH during storm events has been previously observed in the piedmont of NC (Harned, D.A., 1988).

Of the 12 pH results taken during baseflow that were below 6.0 S.U. nine of these occurred on December 1, 2009. These results were measured by WAT staff using a NCDWQ pH meter. A review of the meter calibration log sheets showed that the meter calibrations on December 1 met quality assurance procedures, but various notes of the use of that meter on other days indicated an electrode error occurred.

5. Specific Conductance

Specific conductance is a measure of the capacity of water to conduct electricity and thus is a very convenient way to estimate the total dissolved ionic species in solution. Higher values may indicate higher concentrations of pollutants. There is no water quality standard for specific conductance.

Specific conductance ranged from 9 to 156 µS/cm in the LWP area (Figure 3). The highest median specific conductance values occurred in Poplar Cr. at Bethlehem Rd., Beddingfield Cr., and Marks Cr. at Prichard Rd.   Maximum specific conductances also occurred at these three sites (Appendix C), all of which are downstream from WWTPs. Figure 4 shows that specific conductance readings at the LWP monitoring stations were within the lower range of readings from regional monitoring sites.

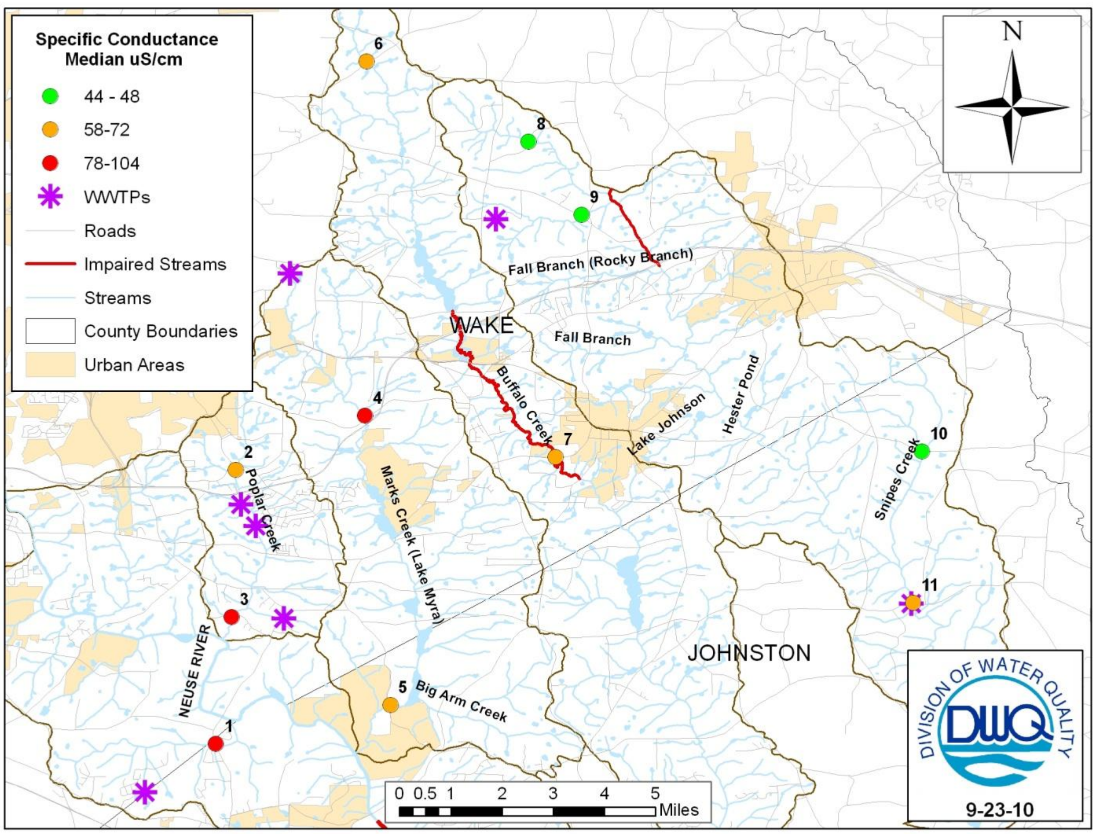


Figure 3. Median specific conductance readings within the LWP area. Numbers adjacent to the stations correspond to the map codes in Table 1.

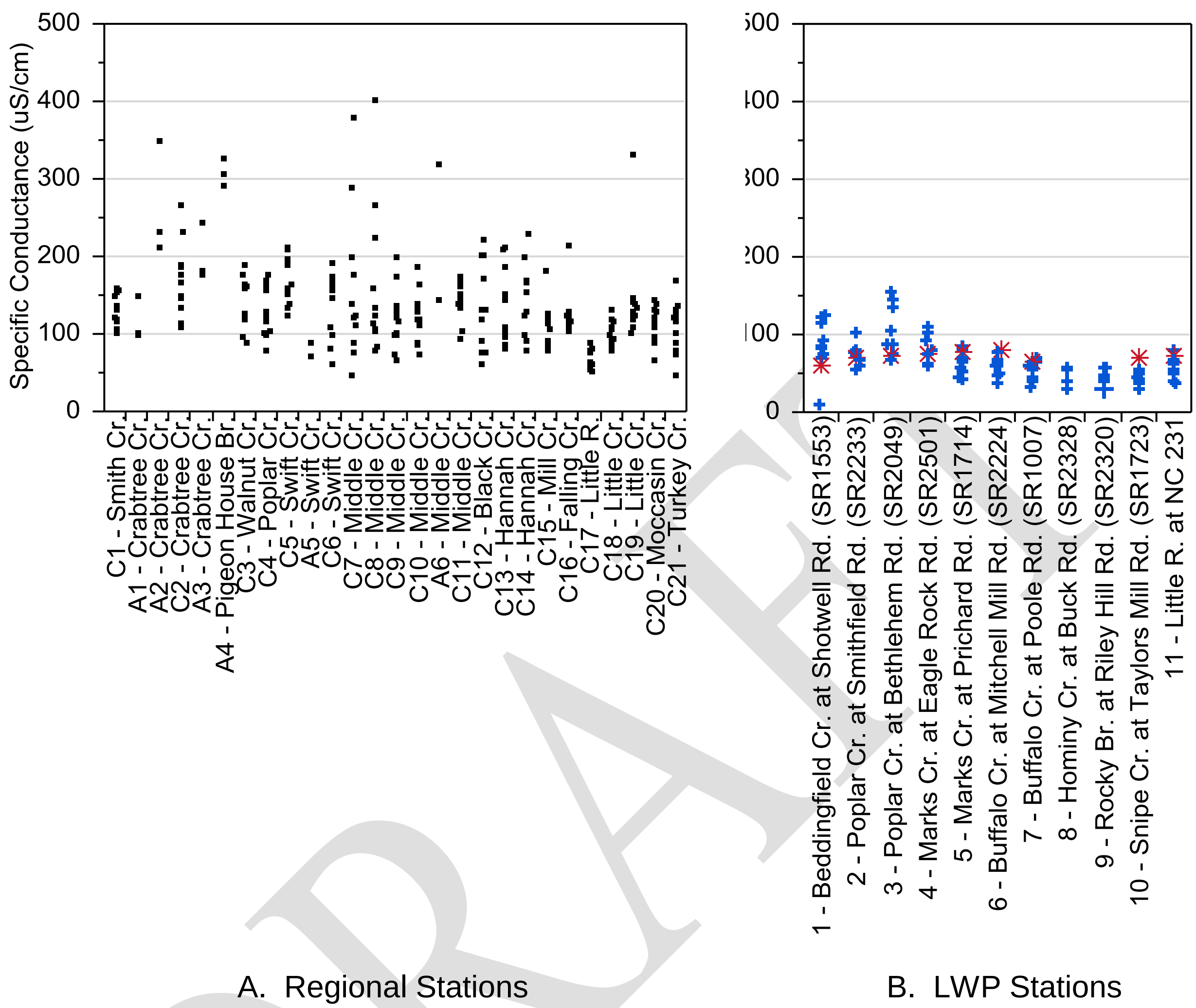


Figure 4. Comparison of results for specific conductance between LWP and regional streams.

A. *Region Streams: X-axis labels for the regional stations represent the map code (see Figure 2) and the stream name. Results are depicted by small black squares. No special symbols are used for baseflow and stormflow results.*

B. *LWP Station: X-axis labels for the LWP stations represent the map code (see Figure 1) for the sampling station location. Blue (+) symbols indicate results taken during baseflow conditions, and red asterisks(*) denote results taken during the falling limb of a storm event.*

B. Chemical and Microbiological

This section describes the results of parameters that are provided by the NCDWQ Laboratory Section through various physical and chemical analyses. These parameters are best grouped as:

1. Nutrients (ammonia nitrogen, nitrite+nitrate nitrogen, total Kjeldahl nitrogen and total phosphorus)
2. Residues (total suspended solids - TSS)
3. Turbidity
4. Metals
5. Microbiological (fecal coliform bacteria)

1. Nutrients

a) Total Kjeldahl Nitrogen

Total Kjeldahl Nitrogen (TKN) is the sum of organic nitrogen and ammonia in a body of water. In addition, total nitrogen is calculated by adding the concentrations of TKN to the concentrations of nitrite+nitrate nitrogen. High measurements of TKN typically result from sewage and manure discharges to water bodies and may reflect high concentrations of ammonia nitrogen.

The graph of TKN (page 76) shows a wide range in concentrations at most monitoring sites. The graph does not readily depict any one or group of sites with results clearly different than the others. The largest average (mean) and median concentrations were found at: Site 3 – Poplar Cr. at Bethlehem Rd., Site 6 – Buffalo Cr. at Mitchell Mill Rd., Site 7 – Buffalo Cr. at Poole Rd., and Site 8 – Hominy Cr. at Buck Rd. This parallels the pattern found for ammonia nitrogen (page 77).

This page is intentionally blank so that the maps and graph for ammonia nitrogen, nitrite+nitrate nitrogen, and total phosphorus are on facing pages.

b) Ammonia Nitrogen

Ammonia nitrogen, under certain conditions, can be toxic to aquatic organisms and deplete oxygen during the conversion of ammonia to nitrite and nitrate.

Ammonia nitrogen concentrations observed within the LWP area generally were low and many were at or below the PQL of 0.02 mg/L (Figure 6B). The highest median concentrations occurred at Site 6 – Buffalo Cr. at Mitchell Mill Rd. and Site 3 – Poplar Cr. at Bethlehem Rd. (Figure 5). The maximum concentrations observed were 0.28 and 0.19 mg/L, respectively, in Buffalo Cr. at Mitchell Mill Rd. and Hominy Cr. (Appendix D, page 77). The higher values all occurred during baseflow. The results for the LWP area were well within the range of data from regional monitoring stations (Figure 6).

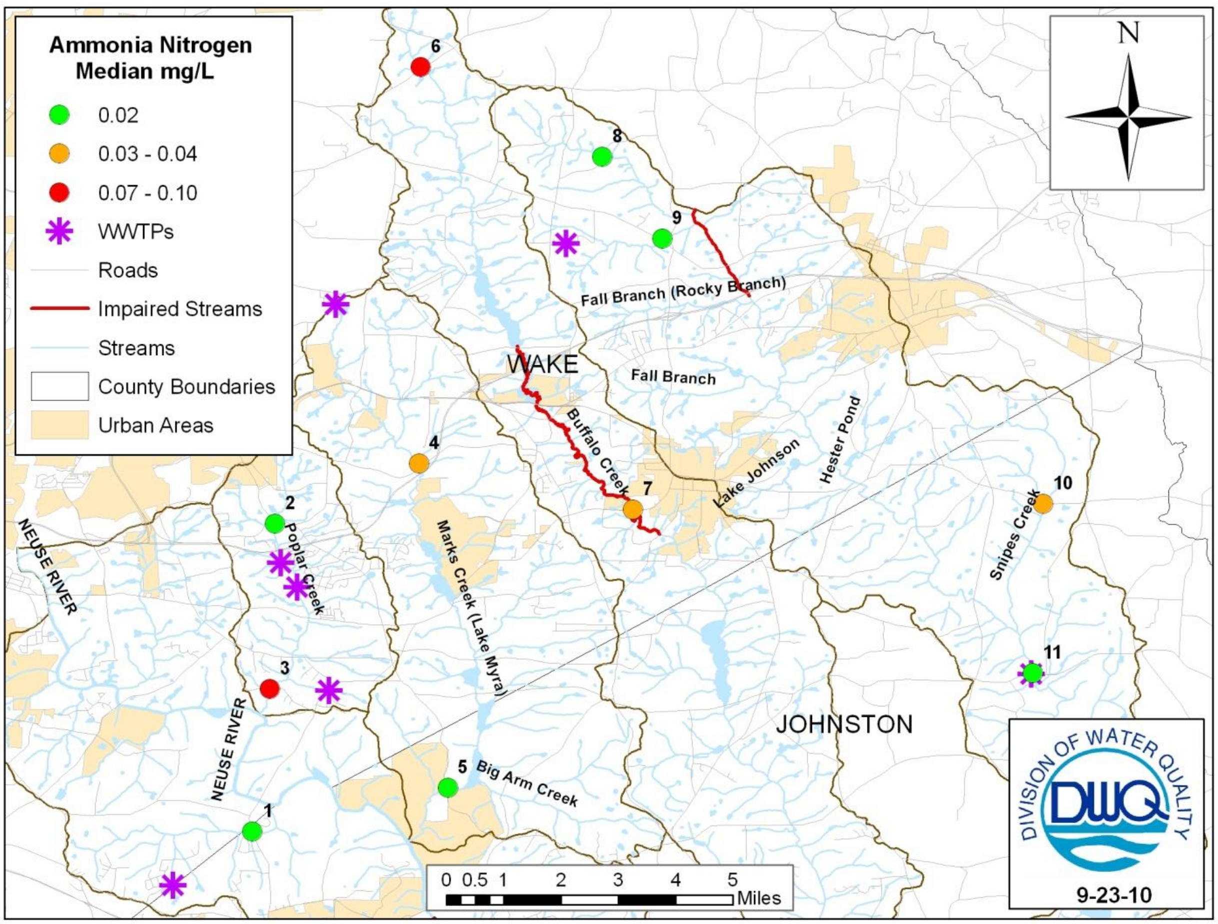
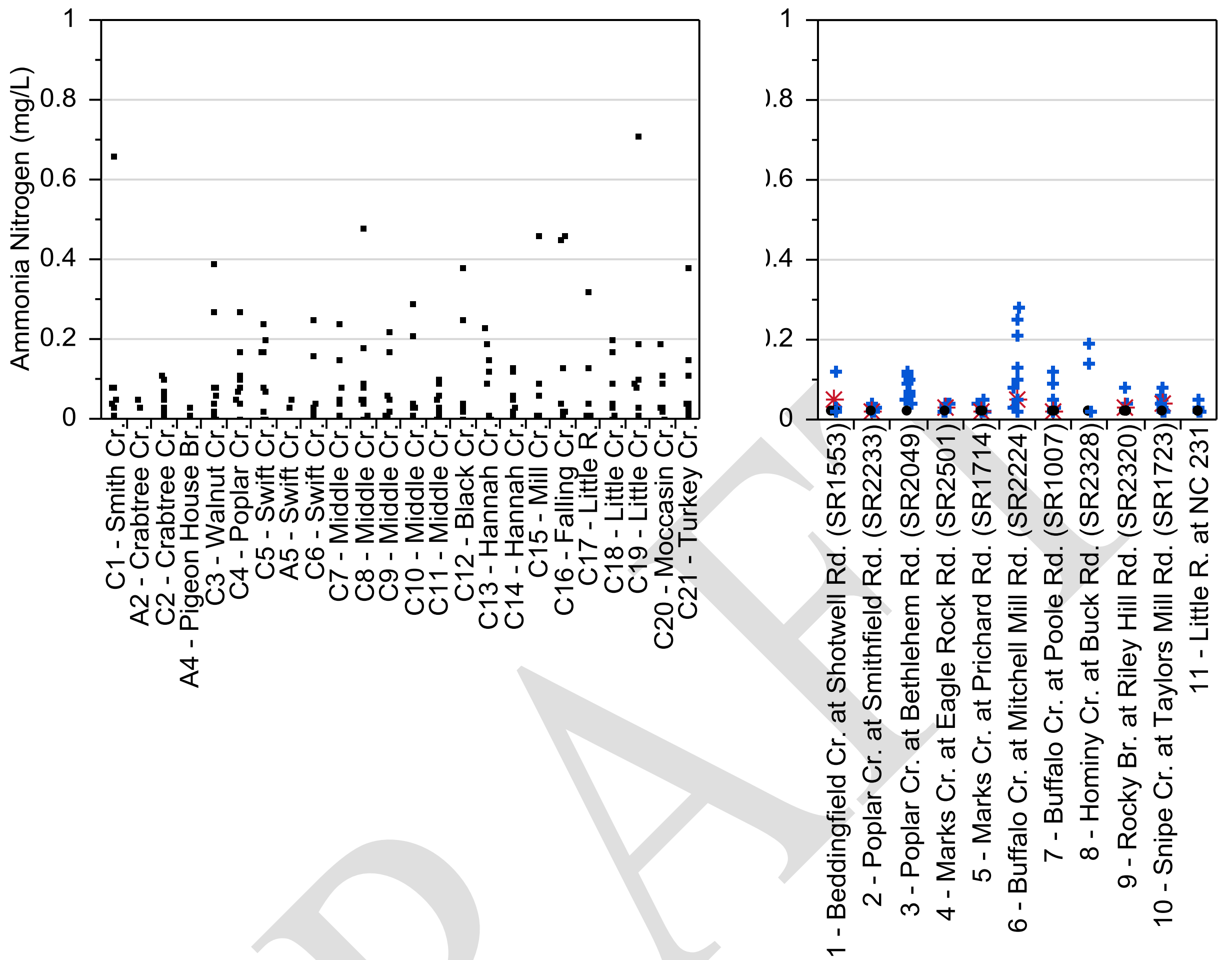


Figure 5. Median ammonia nitrogen concentrations within the LWP area. Numbers adjacent to the stations correspond to the map codes in Table 1.



A. Regional Stations B. LWP Stations

Figure 6. Comparison of results for ammonia nitrogen between LWP and regional streams.

A. Region Streams: X-axis labels for the regional stations represent the map code (see Figure 2) and the stream name. Results are depicted by small black squares. No special symbols are used for baseflow and stormflow results, and results less than any PQLs.

B. LWP Station: X-axis labels for the LWP stations represent the map code (see Figure 1) and the sampling station location. Blue (+) symbols indicate results taken during baseflow conditions, and red asterisks(*) denote results taken during the falling limb of a storm event. Black dots indicate results less than the NDWQ Laboratory Section PQL (0.02 mg/L).

c) *Nitrite+Nitrate Nitrogen*

Among the nutrients there is only one NC water quality standard and that is for nitrate nitrogen (10 mg/L) for bodies of water classified as water supplies. Concentrations of nitrate exceeding 10 mg/L can cause methemoglobinemia (blue baby syndrome) in infants.

Median concentrations of nitrite + nitrate nitrogen (hereafter called NOx) ranged from 0.04 mg/L in Site 7 – Buffalo Cr. at Poole Rd. to 1.70 mg/L at Site 3 – Poplar Cr. at Bethlehem Rd. and 3.3 mg/L at Site 1 – Beddingfield Cr. (Figure 7). The maximum NOx concentrations were 2.80 and 4.80 mg/L, respectively, at these same two sampling sites (Appendix D, page 78). Both are located downstream from WWTPs. The NOx concentrations at Site 1 – Beddingfield Cr. were substantially higher than most concentrations measured in the regional monitoring sites outside the LWP area (Figure 8). Reasons for this pattern need to be investigated.

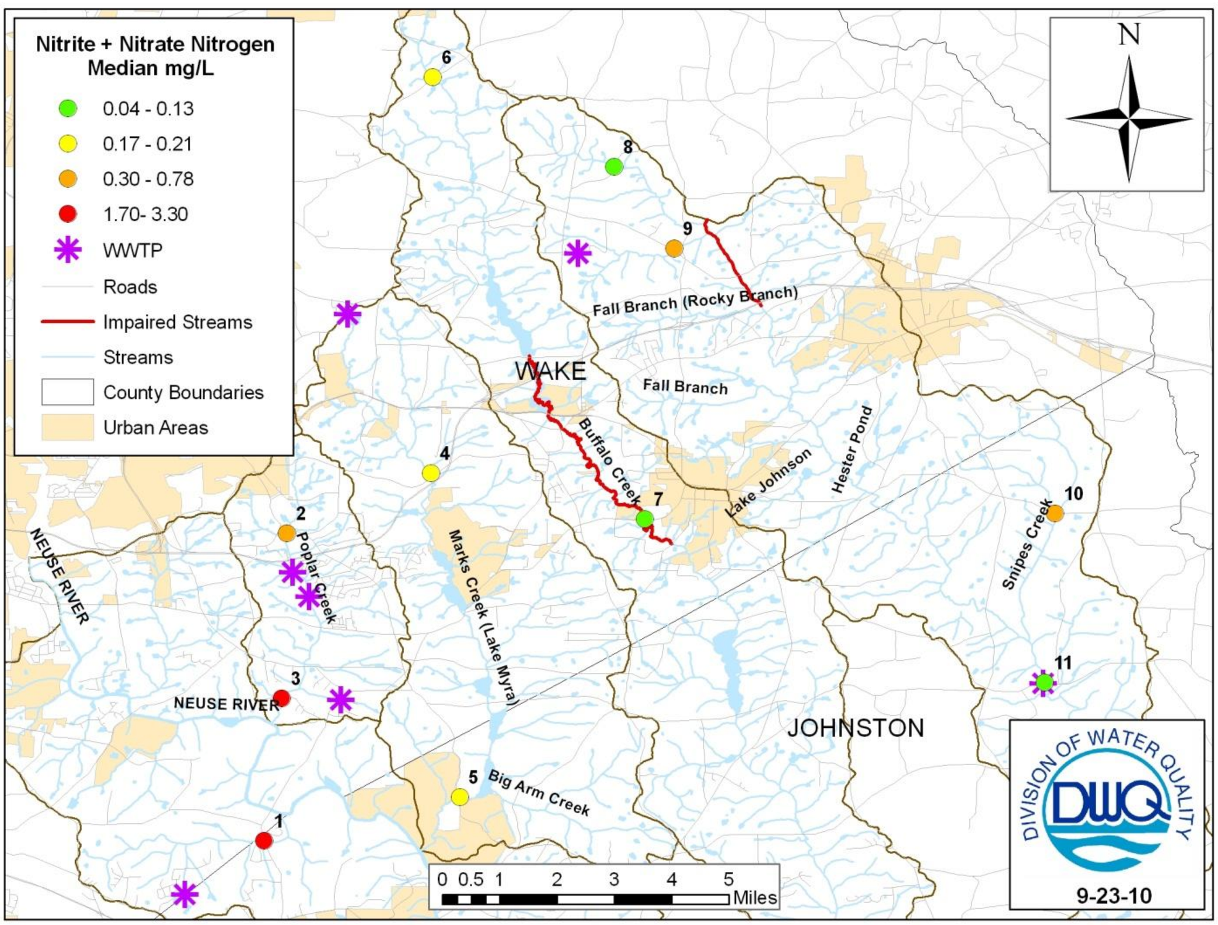
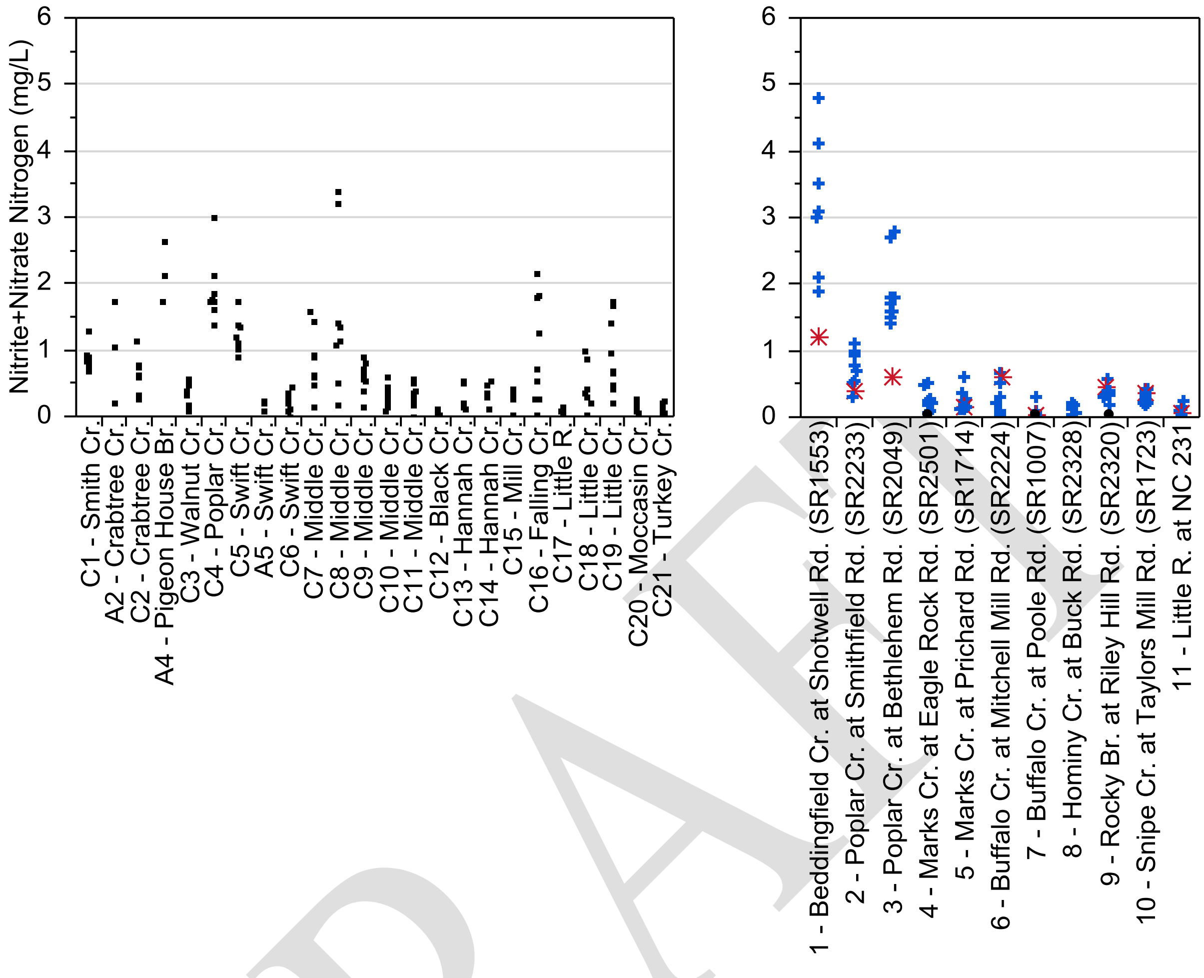


Figure 7. Median nitrite + nitrate nitrogen concentrations within the LWP area. Numbers adjacent to the stations correspond to the map codes in Table 1.



A. Regional Stations

B. LWP Stations

Figure 8. Comparison of results for nitrite+nitrate nitrogen between LWP and regional streams.

A. Region Streams: X-axis labels for the regional stations represent the map code (see Figure 2) and the stream name. Results are depicted by small black squares. No special symbols are used for baseflow and stormflow results, and results less than any PQLs.

B. LWP Station: X-axis labels for the LWP stations represent the map code (see Figure 1) and the sampling station location. Blue (+) symbols indicate results taken during baseflow conditions, and red asterisks(*) denote results taken during the falling limb of a storm event. Black dots indicate results less than the detection level.

d) Phosphorus

Nutrients can limit or promote the growth of algae and aquatic plants. Median phosphorus concentrations ranged from 0.05 to 0.15 mg/L (Figure 9). Out of a total of 108 results for phosphorus, only one was below the PQL of 0.2 mg/L. The largest result (0.7 mg/L) occurred at Site 1 – Beddingfield Cr. at Shotwell Rd. during baseflow. The next two largest results occurred during the December 3, 2009 storm event and were at Site 1 (0.26 mg/L) and Site 3 -- Poplar Cr. at Bethlehem Rd. (0.25 mg/L). Site 6 -- Buffalo Cr. at Mitchell Mill Rd. has the largest median value for total phosphorus (1.0 mg/L). The LWP monitoring results appear low when compared to those from the regional monitoring stations (Figure 10) but many of the regional monitoring stations are downstream of wastewater treatment facilities.

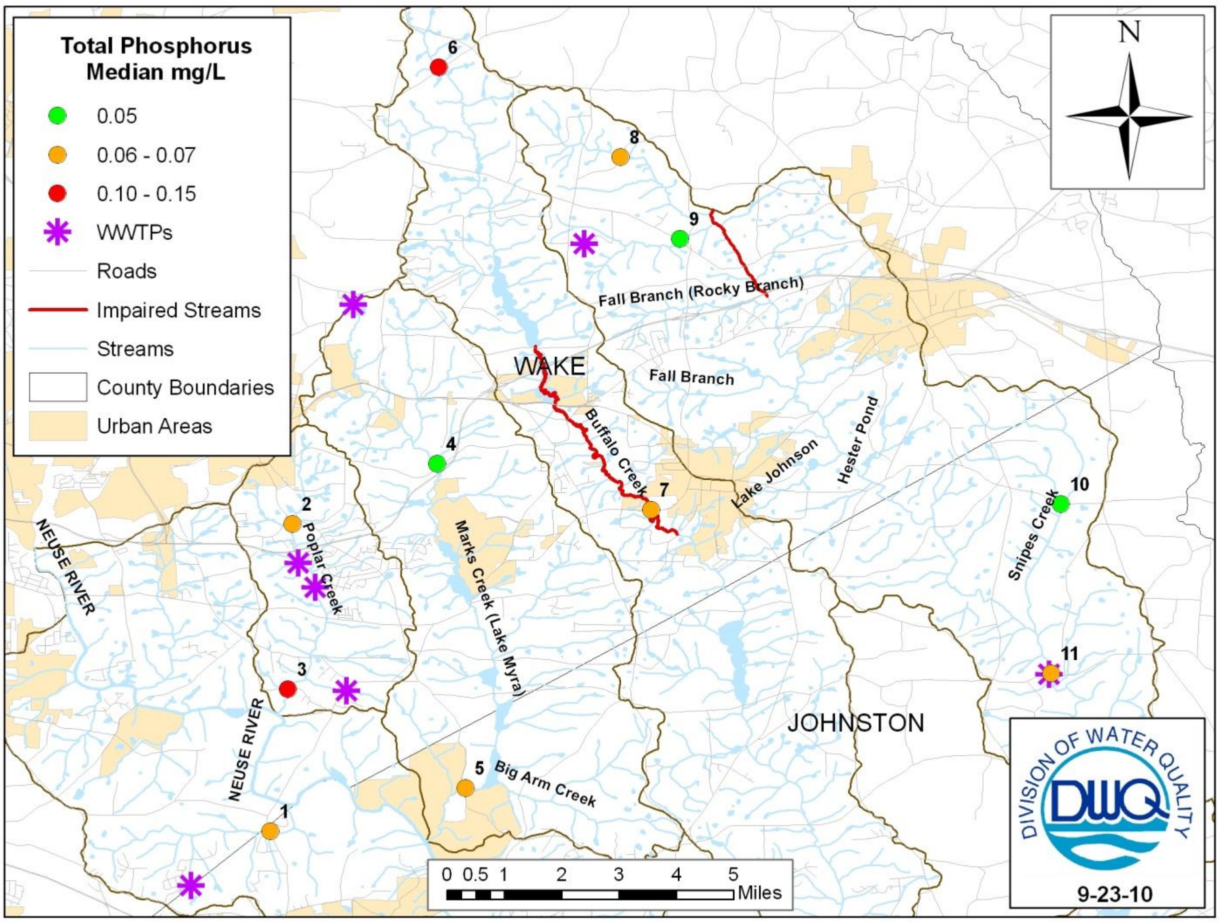
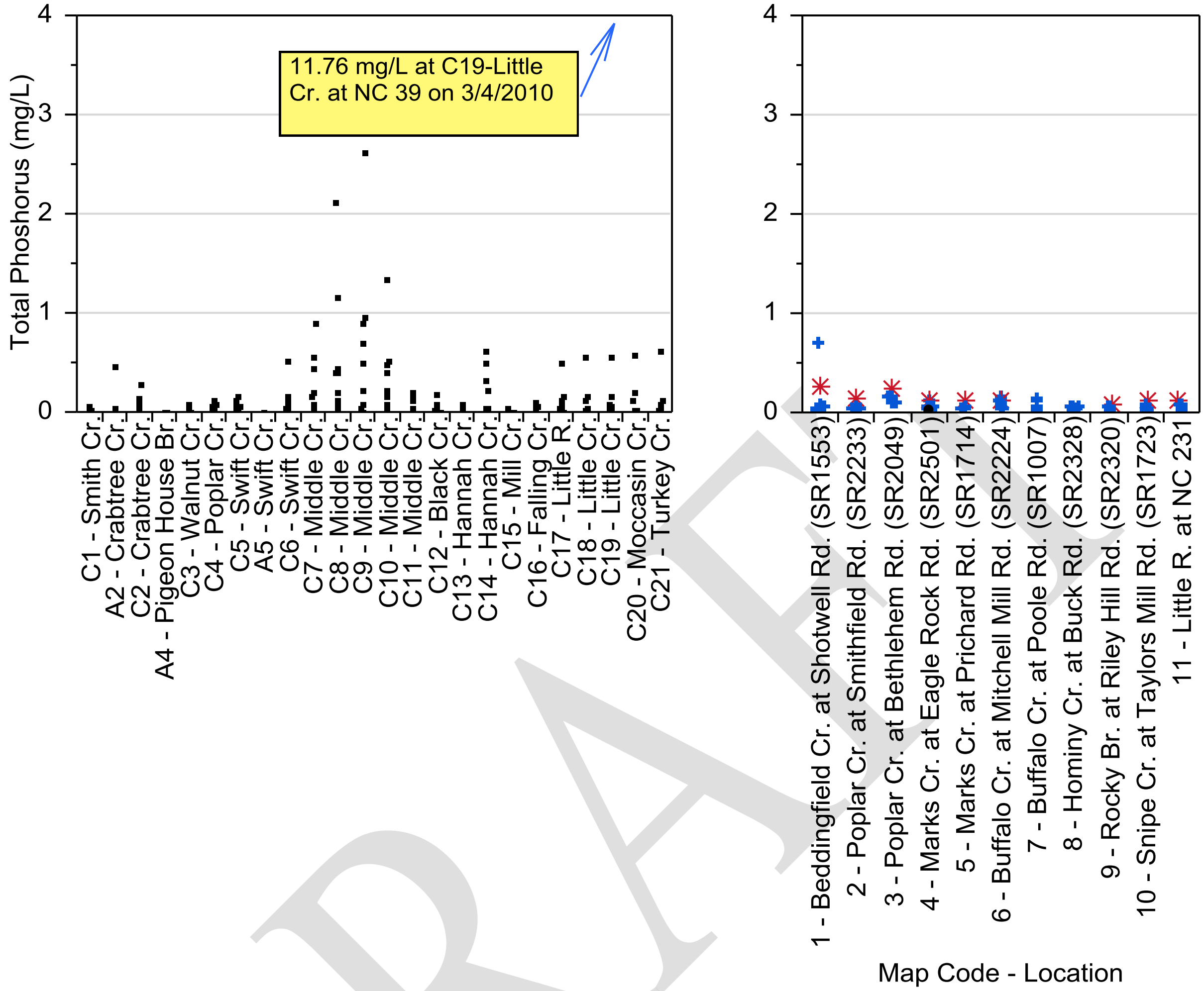


Figure 9. Median total phosphorus concentrations within the LWP area. Numbers adjacent to the stations correspond to the map codes in Table 1.



A. Regional Stations

B. LWP Stations

Figure 10. Comparison of results for total phosphorus between LWP and regional streams.

A. *Region Streams: X-axis labels for the regional stations represent the map code (see Figure 2) and the stream name. Results are depicted by small black squares. No special symbols are used for baseflow and stormflow results, or results less than any PQLs.*

B. *LWP Station: X-axis labels for the LWP stations represent the map code (see Figure 1) and the sampling station location. Blue (+) symbols indicate results taken during baseflow conditions, and red asterisks(*) denote results taken during the falling limb of a storm event. Black dots indicate results less than the detection level.*

2. Total Suspended Solids

Total Suspended Solids (TSS) is comprised of organic and mineral particles that are transported in the water column. TSS is closely linked to land erosion and to erosion of stream banks and channels. High TSS concentrations can affect aquatic life. There is no NC water quality standard for TSS in surface waters.

The three largest concentrations of TSS occurred at: Site 1 – Beddingfield Cr. at Shotwell Rd. (93 mg/L), Site 2 – Poplar Cr, at Smithfield Rd. (66 mg/L), and Site 3 – Poplar Cr. at Bethlehem Rd.(134 mg/L), all in the western portion of the LWP planning area. The higher results at these three stations represented stormflow. Overall most results were low with the 90th percentile being 21.5 mg/L and the 75th percentile being 11.0 mg/L. The lowest PQL is 6.2 mg/L. See page 80 for the summary graph and table for TSS. A figure on page 86 shows the range of results for TSS (1 to > many over 100 mg/L and 1 > 1000 mg/L) found among the regional monitoring stations.

3. Turbidity

Turbidity is a measure of cloudiness in water. Turbidity can be caused by soil erosion, waste discharge, urban runoff, algal growth and organisms that can stir up sediments such as fish. The NC water quality standard for turbidity varies depending on the water quality classification of a body of water. However, for all monitoring stations in the LWP area a standard of 50 NTU applies. See page 81 for the summary graph and table for turbidity. Among all the LWP monitoring stations the 90th percentile was 17.6 NTU, and the 75th percentile was 8.4 NTU. A figure on page 86 shows the range of results for TSS (1 to many over 100 mg/L and 1 > 1000 mg/L) found among the regional monitoring stations.

Results during stormflow were the largest, and only a total of two results among all monitoring stations exceeded the water quality standard of 50 NTU. See page 81 for the summary graphs and tables. There was a significant relationship between turbidity and TSS (Figure 11).

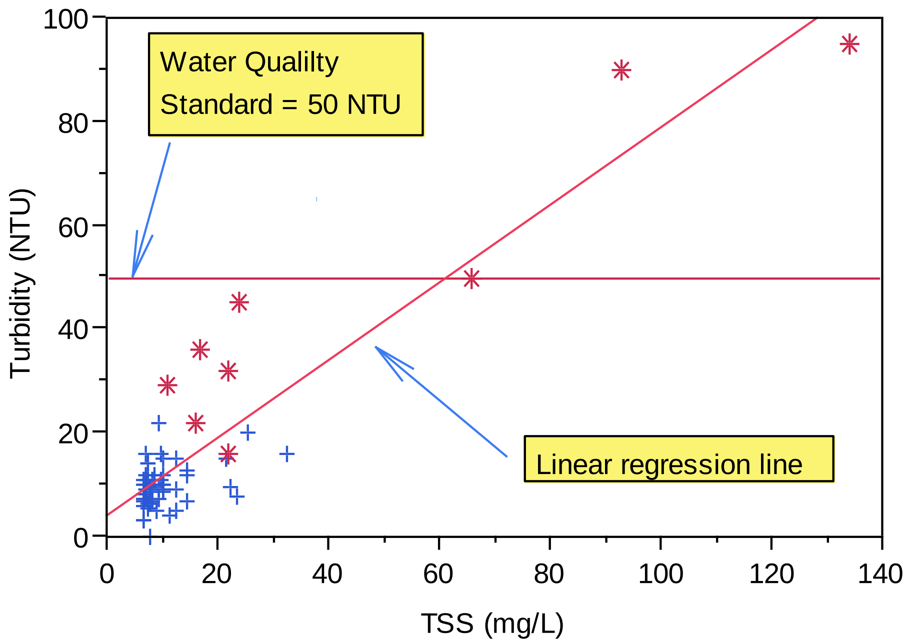


Figure 11. Relationship between TSS and turbidity. Turbidity = 3.9 + 0.75*TSS; R-Squared = 0.83, p < 0.0001. TSS values less than the PQL were not used in this linear regression.

4. Metals

Metals sampled included arsenic, cadmium, chromium, copper, lead, nickel and zinc. Metals can be toxic to aquatic life or in the case of copper and zinc both an essential micronutrient for life in low concentrations and in high concentrations. The applicable NC water-quality standards (or action levels) are as follows (see 15A NCAC 02B .0211 through 15A NCAC 02B .0219):

a. Arsenic: Water-quality standards of 50 µg/L for freshwater aquatic life and 10 µg/L for water supplies
b. Cadmium: Water quality standard of 2.0 µg/L
c. Chromium: Water quality standard of 50 µg/L
d. Copper: Action level of 7.0 µg/L
e. Lead: Water quality standard of 25 µg/L
f. Nickel: Water quality standard of 88 µg/L for freshwater aquatic life and 25 µg/L for water supplies
g. Zinc: Action level of 50 µg/L

All results for cadmium, chromium, lead and nickel were less than the laboratory PQL. Only one result for arsenic (2.1 µg/L) was above the laboratory PQL of 2.0 µg/L, but well below the standard of 50 µg/L. Most of the results for copper and zinc above the laboratory PQLs represented stormflow results. One exception to this patter was found at Site 3 – Poplar Cr at Bethlehem Rd, in which two baseflow results were slightly above the 2 µg/L PQL for copper. All results for copper and zinc were below the action levels for these metals. A graph of the LWP monitoring results for copper and zinc is found on page 83, and a graph of the monitoring results from regional monitoring stations is found on page 87.

5. Fecal Coliform Bacteria

Fecal coliform bacteria counts were relatively low throughout the LWP area during baseflow monitoring. The highest median values occurred in Poplar Cr. at Bethlehem Rd., Beddingfield Cr., and Rocky Br. all of which are sited a short distance downstream of WWTPs (Figure 12). Counts exceeded the 400 cfu/100 ml evaluation levels during baseflow on one occasion each in Buffalo Cr. at Mitchell Mill Rd., Rocky Branch, and Snipes Creek (Figure 13b). Both the lowest median and lowest maximum counts occurred at Hominy Cr.; this site is located downstream from a swamp impounded by a beaver dam. The highest individual counts occurred at all sites during monitoring of a single stormflow event during the falling limb of the hydrograph on December 3, 2009. During this storm event all counts exceeded the 400 cfu/100 ml evaluation level except Buffalo Cr. at Mitchell Mill Rd., which was just slightly below the 400 cfu evaluation level. A comparison with data from regional monitoring stations over the same time period (Figure 13) shows that fecal coliform bacteria counts within the LWP area fall within the same range as data from nearby sites outside of the LWP area. Additional details of the data are presented in Appendix D.

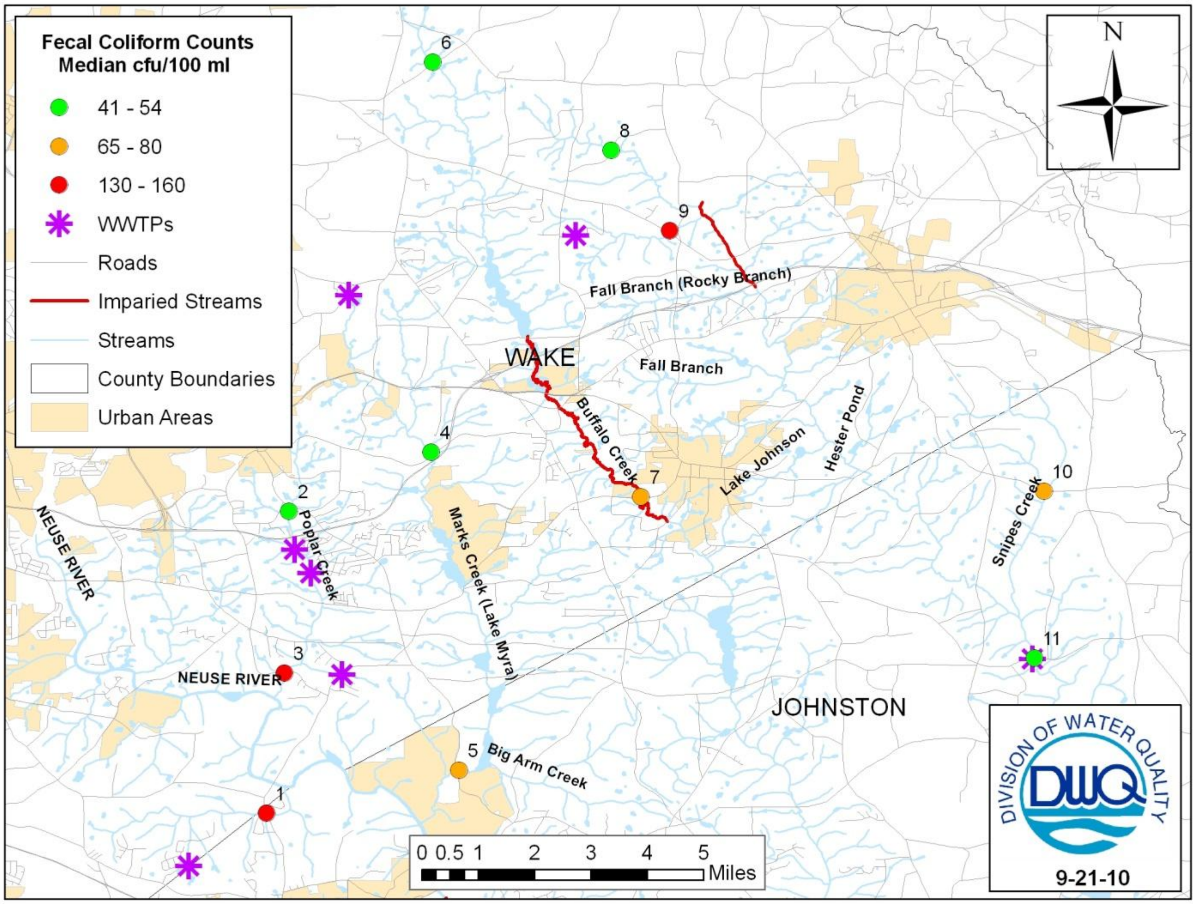
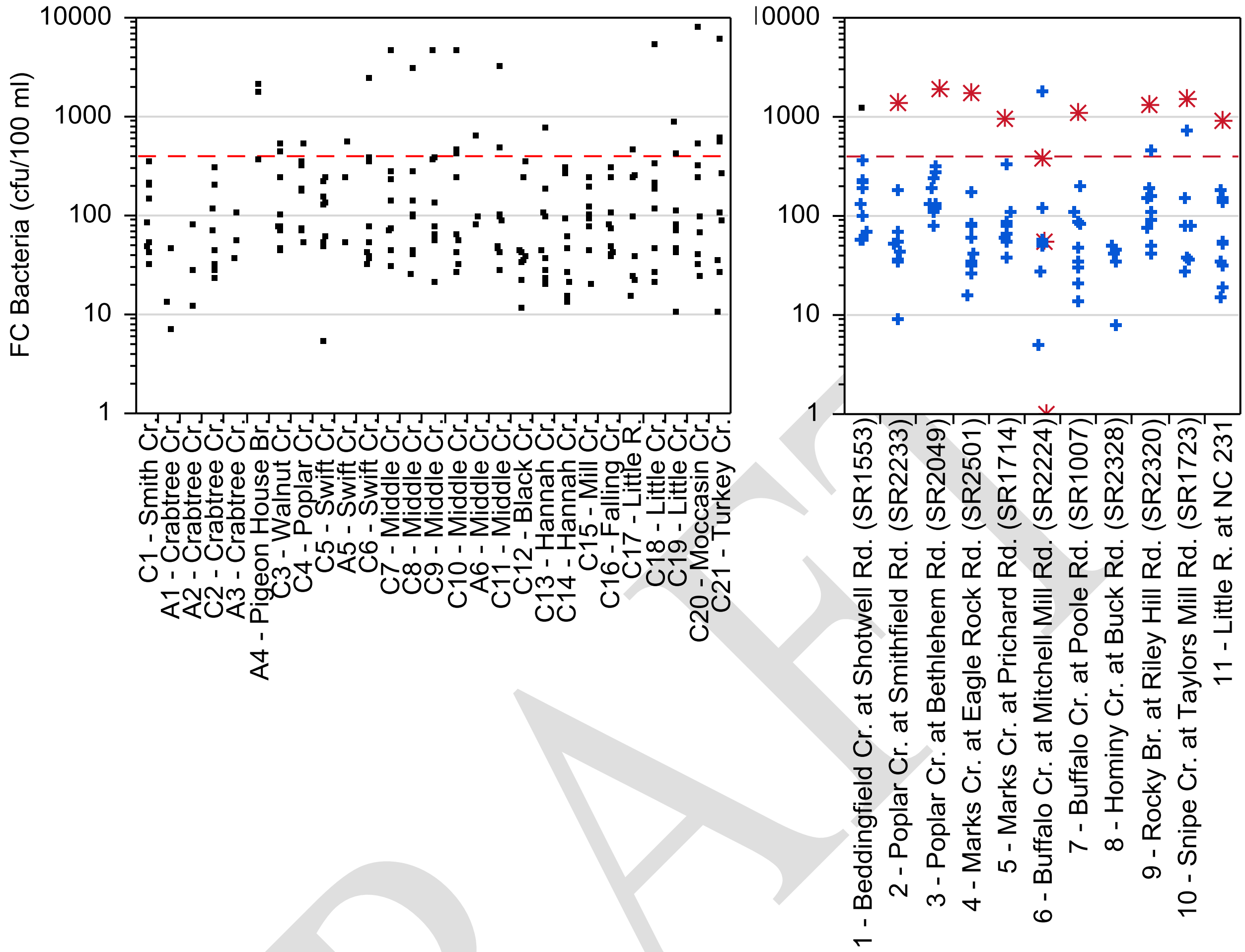


Figure 12. Median fecal coliform bacteria counts within the LWP area. Numbers adjacent to the stations correspond to the map codes in Table 1.



A. Regional Stations B. LWP Stations

Figure 13. Comparison of results for fecal coliform bacteria between LWP and regional streams. Note the y-axis is a $\log_{10}$ scale. The red dashed horizontal line is the 400 cfu/100 ml evaluation level.

A. Region Streams: X-axis labels for the regional stations represent the map code (see Figure 2) and the stream name. Results are depicted by small black squares. No special symbols are used for baseflow and stormflow results, and results less than detection levels.

B. LWP Station: X-axis labels for the LWP stations represent the map code (see Figure 1) and the sampling station location. Blue (+) symbols indicate results taken during baseflow conditions, and red asterisks(*) denote results taken during the falling limb of a storm event.

C. Benthic Macroinvertebrates and Habitat

Benthic Macroinvertebrates

Periodic monitoring of water chemistry does not give a complete picture of conditions that affect the integrity of the biological communities living in the streams. Water quality may fluctuate considerably among sampling periods, and critical events that impact aquatic life may be missed. Long-term changes in water quality also may be missed with the relatively short-term monitoring programs that occur in most watersheds. The biological community (benthic invertebrates and fish) effectively integrates the impacts of all conditions within the stream over time and provides a tool to separate effects of water chemistry from habitat. More diversity and numbers of intolerant species usually indicate better water and habitat quality. Important metrics derived from biological sampling include the total number of taxa (i.e. all species present), the number of EPT taxa (i.e. taxa representing mayflies, stoneflies and caddisflies), and a biotic index. North Carolina's biotic index (NCBI) is based on tolerance values (i.e. tolerance to pollution) of individual taxa on a scale of 0 – 10 with higher numbers reflecting more tolerant taxa and polluted conditions. From these metrics one of five Bioclassifications can be assigned: Poor, Fair, Good-Fair, Good, and Excellent.

Benthic macroinvertebrate communities were depressed in many of the watersheds within the LWP area (Table 3). Only four stations were assigned bioclassification of either Good-Fair or Good by NCSU. The review of existing data (NCDWQ 2010) summarized the finding of the 2009 benthic macroinvertebrate assessments (NCSU 2009) as follows:

- Beddingfield Creek at Shotwell Road (partially within the Clemmons State Forest) was the only location rated Good. Many of the unique taxa were identified in this location.
- The benthic community in the downstream location in Poplar Creek at Bethlehem Road had some intolerant taxa in common with the Beddingfield Creek location. Unique taxa were identified in both locations.
- Downstream reaches of both Poplar and Marks Creek were less degraded than the upstream reaches suggesting that stressors were affecting the benthic community in upstream segments of these streams.
- Dominant taxa in the downstream location in Buffalo Creek at Poole Road were mostly pollution tolerant taxa which suggested upstream pollution sources. No uncommon or unique taxa were identified.

- Habitat conditions in the form of numerous midstream sediment bars in Snipe Creek may be partially responsible for the degraded benthic community surveyed in this location. Unique taxa were identified in this location.

- The benthic community in Rocky Branch was degraded (Fair) but consisted of unique and uncommon taxa not found in other LWP locations. Habitat conditions were scored as one of the highest (80).

Table 3. Summary of benthic macroinvertebrate and total habitat data for Wake-Johnston LWP area (from NCDWQ 2010).

Map Code	Location	EPT Taxa Richness	NCBI	Bio-classification
1	Beddingfield Creek at Shotwell Rd., SR 1553	18	5.2	Good
2	Poplar Creek at Smithfield Rd., SR 2233	9	6.2	Fair
3	Poplar Creek at Bethlehem Rd., SR 2049	11	5.8	Good-Fair
4	Marks Creek at Eagle Rock Rd., SR 2501	7	6.9	Fair
5	Marks Creek at Prichard Rd., SR 1714	15	5.5	Good-Fair
6	Buffalo Creek at Mitchell Mill Rd., SR 2224	3	7.1	N/A
7	Buffalo Creek at Poole Rd., SR 1007	9	6.7	Fair
8	Hominy Creek at Buck Rd., SR 2329	4	7.1	N/A
9	Rocky (Fall) Branch at Riley Hill Rd. SR 2320	9	6.5	Fair
10	Snipes Creek at Taylors Mill Rd., SR 1723	5	6.6	Fair
11	Little River above NC 231	14	6.0	Good-Fair

<u>Habitat</u>

Habitat assessments also are conducted routinely in association with biological community assessments to evaluate the quality of in-stream habitat and conditions in the riparian zone that may impact aquatic life. Habitat assessments indicate if a variety of substrate types are present, the condition of stream banks and quality of riffles and pools, as well as provide a brief assessment of conditions in the riparian zone. Aquatic habitat assessments coupled with chemical and physical monitoring can help ascertain reasons for the condition of fish and aquatic insect communities (USEPA, 1999). If the habitat present is capable of supporting and maintaining a diversity of aquatic life, and the diversity of aquatic communities is depressed compared with reference conditions, then other water quality stressors may be responsible for the lack of diversity. Habitat conditions also provide evidence of altered flow regimes or hydrology due to increases in impervious surfaces in a watershed, deforestation or other perturbations such as hurricanes. The assessment qualitatively evaluates reach scale (100 - 200 meters) conditions of existing habitat structure (riffles, pools, leaf packs, root mats, sticks and logs, bottom substrate) along with those that have the potential to degrade habitat and water quality such as the condition of riparian vegetation and stream bank stability (i.e. increased sedimentation).

Habitat scores were poor in many of watersheds within the LWP area (Table 4). Habitat total scores ranged from 48 (Poplar Cr. at Smithfield Rd.) to 80 (Rocky Br. and Little R.). Total scores were greater than 70 at only three sites and less than 60 at five sites. There was no obvious relationship between either habitat total scores or any of the habitat submetrics and bioclassifications (Table 3).

Table 4. Aquatic habitat data collected during benthic macroinvertebrate assessments in 2009. Heading refer to the various habitat submetrics and the numbers in parenthesis are the submetric scores. (From NCDWQ 2010)

Map Code	Location	Channel Modification (5)	Instream Habitat (20)	Bottom Substrate (15)	Pool variety(10)	Riffle Habitat (16)	Bank Stability and Vegetation (14)	Light Penetration (10)	Riparian Vegetation Zone Width (10)	Total Score (100)
1	Beddingfield Creek at Shotwell Rd., SR 1553	4	12	6	4	7	9	10	6	58
2	Poplar Creek at Smithfield Rd., SR 2233	4	11	3	0	0	10	10	10	48
3	Poplar Creek at Bethlehem Rd., SR 2049	4	9	3	4	6	12	10	10	58
4	Marks Creek at Eagle Rock Rd., SR 2501	2	8	8	8	7	10	10	10	63
5	Marks Creek at Prichard Rd., SR 1714	4	8	3	4	3	11	7	9	52
6	Buffalo Creek at Mitchell Mill Rd., SR 2224	5	16	3	10	7	14	10	10	75
7	Buffalo Creek at Poole Rd., SR 1007,	4	16	3	6	7	8	10	8	62
8	Hominy Creek at Buck Rd., SR 2329	4	15	1	6	3	14	8	8	59
9	Rocky (Fall) Branch at Riley Hill Rd. SR 2320	5	16	3	6	16	14	10	10	80
10	Snipes Creek at Taylors Mill Rd., SR 1723	4	16	8	8	12	8	10	10	76
11	Little River above NC 231	5	16	8	10	7	14	10	10	80

D. Flow

Flow in the Little River since October 2008 is shown in Figure 14. The figure depicts the ranges of flow since the USGS initiated this gage in October 2008, and the range in flow conditions in the LWP watershed during the physical and chemical sample dates.

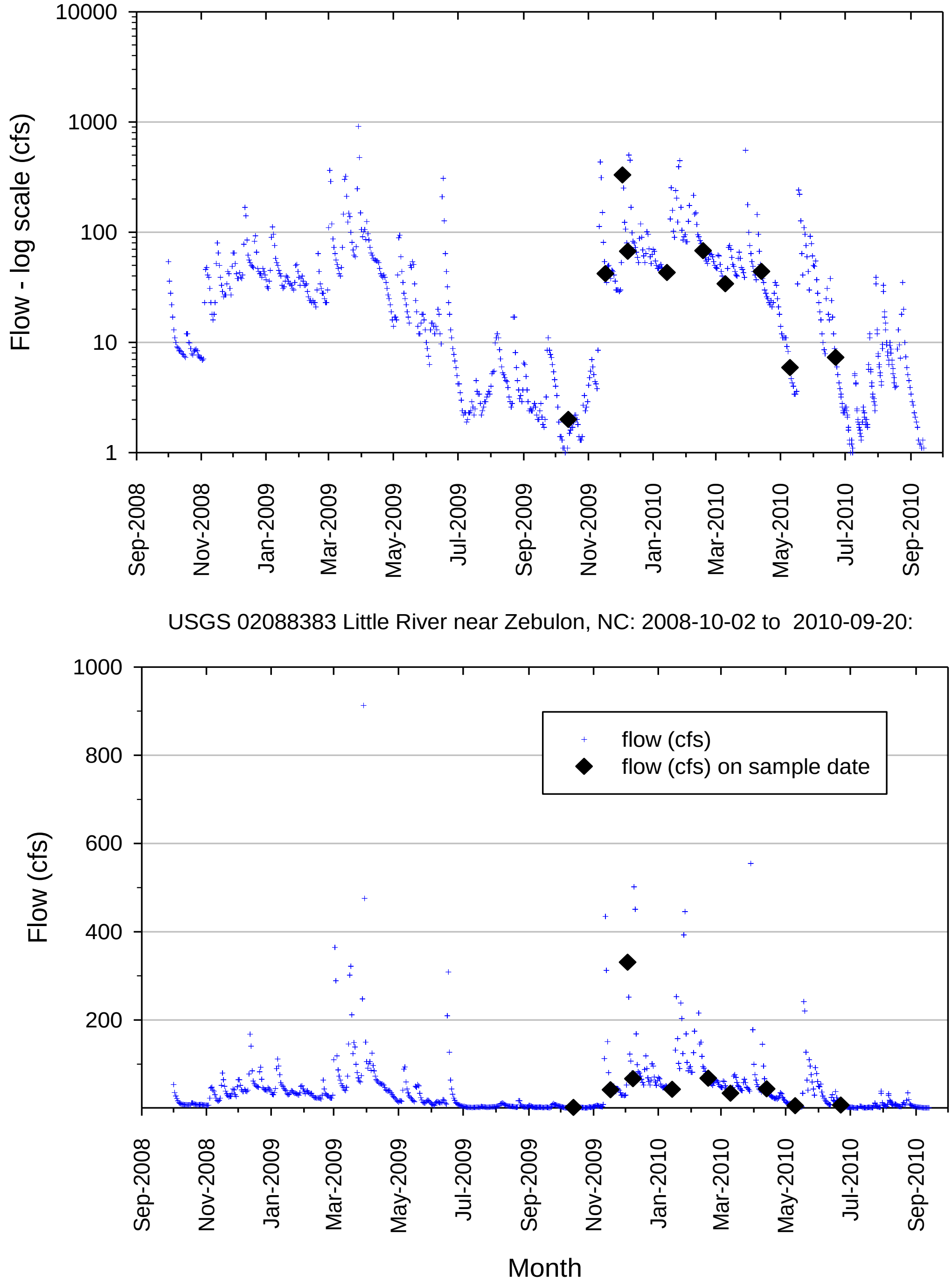


Figure 14. Flow at the USGS Little River monitoring station.

V. Discussion

The field and laboratory chemistry data suggested a possible relationship between both elevated nutrient concentrations and specific conductance values and the locations of the monitoring stations relative to the WWTPs in the LWP watersheds. A brief follow-up investigation in June 2010 in which water samples and field measurements were taken above and below the locations of the WWTPs in Beddingfield Cr. and Poplar Cr. showed elevated specific conductance,nitrite + nitrate concentrations, and total phosphorus concentrations downstream from the WWTPs. The low flow during most of the monitoring period also would suggest limited runoff. The NOx concentrations below the WWTP on Beddingfield Cr. may be sufficient to account for much or all of the elevated NOx observed downstream at the LWP sampling station at Shotwell Rd., with little or no contribution due to runoff from the Raleigh wastewater spray fields. This observation is based on only one sample, however, and will require additional sampling to either confirm this relationship or to indicate other sources of contamination.

Fecal coliform bacteria were not assessed during the follow-up monitoring. However, the LWP monitoring stations on Beddingfield Cr. and on Poplar Cr. at Bethlehem Rd. both are downstream from WWTPs, and the Beddingfield Cr. station also runs adjacent to the City of Raleigh wastewater treatment spray fields. The median fecal coliform counts at these two locations were higher than those at the other LWP monitoring stations. This suggests a possible link between fecal coliform counts and proximity to wastewater effluent and/or runoff from spray fields. Counts were not exceptionally high in any baseflow samples, and only nine months of monitoring were conducted. Further monitoring may be warranted to determine the sources of fecal coliform bacteria in these locations.

Benthic communities throughout the LWP area most likely were stressed by low flow/dissolved oxygen problems compounded by drought, instream impoundments, beaver ponds and limited benthic access to aquatic habitats. As noted in the benthic monitoring report (NCSU 2009), the assessment team had difficulties finding appropriate monitoring locations due to zero or low flow conditions. Two locations (Buffalo Creek at Mitchell Mill Road and Hominy Creek at Buck Road) were not rated due to swamp-like conditions with dissolved oxygen below 2.0 mg/L. Many substantial segments of the Little River were described as longitudinal wetlands. A similar problem locating sites with adequate flow conditions was encountered earlier by the CH2M Hill team in 2001 (CH2M Hill 2002).

VI. Conclusions

- Field data and laboratory analyses generally did not suggest any unusual water quality problems within the LWP area.
- Data for most parameters measured fell well within the ranges of data from regional monitoring sites.
- The few instances of low dissolved oxygen and numerous instances of low pH most likely were related to low flow conditions.
- Specific conductance was higher at sites downstream from WWTPs and generally reflected low flow conditions in which wastewater effluent may have been the dominant contributor to stream flow.
- Nutrients, particularly nitrite + nitrate nitrogen and phosphorus were elevated downstream from WWTPs in comparison with sites above the WWTPs or stations on streams not directly impacted by wastewater.
- A brief follow-up study to localize the sources of nutrient enrichment suggested a direct relationship between nutrient concentrations (nitrite + nitrate nitrogen and phosphorus) and the proximity of the sampling stations to WWTPs. Further assessment will be needed to confirm this hypothesis.
- The follow-up study also suggested that the elevated specific conductance and nutrients at the Beddingfield Cr. monitoring site may be coming primarily from the WWTP rather than from the adjacent City of Raleigh wasterwater spray fields, since there was only limited rainfall and, presumably, limited runoff during most of the monitoring period. This needs to be examined further.
- Fecal coliform bacteria counts were not high anywhere in the LWP area. Counts exceeded a 400 cfu screening value only during stormflow and in two samples collected during baseflow.
- Metals do not appear to be a current concern within the LWP area.
- The quality of benthic communities appears to be related largely to stress resulting from low flow and low dissolved oxygen compounded by drought, instream impoundments and limited benthic access to aquatic habitats. The elevated specific conductances and nutrients below the WWTPs suggest that pollutants from wastewater also may be a factor.

- Continued urbanization of the LWP watersheds can be expected to cause further degradation of water quality, stream channels, and habitat for aquatic life.

VII. Recommendations

- Continue follow-up monitoring and assessment activities to pinpoint the sources of elevated specific conductance and nutrients in the LWP watersheds including but not necessarily limited to Beddingfield Cr., Poplar Cr., and the headwaters of Buffalo Cr. above Mitchell Mill Rd. This follow-up monitoring should include stream walks and use both field meters and field chemistry kits to determine locations of possible sources of contamination such as leaking sewers, illicit discharges and failing septic systems.

- Conduct periodic monitoring of nutrients at the LWP stations to address future changes in water quality as the result of urbanization.

- Repeat benthic macroinvertebrate and habitat assessments at locations sampled in 2009 and consider additional sites as warranted by follow-up assessments. The benthic results should be verified by the NCDWQ BAU.

- Locate sites for implementation of BMPs and other remediation activites based on the results of the follow-up monitoring activities recommended above.

VIII. Literature Cited

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