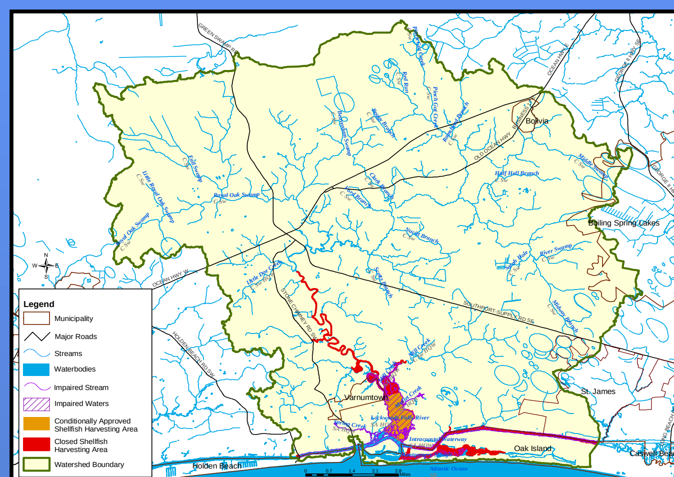
Lockwoods Folly River Local Watershed Plan
Preliminary Findings Report

North Carolina
Ecosystem Enhancement Program

November 2005



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1.0 Introduction

1.1 BACKGROUND AND PURPOSE OF LOCAL WATERSHED PLANNING

The N.C. Ecosystem Enhancement Program (NCEEP) has initiated comprehensive watershed planning efforts in certain high-priority local watersheds in order to meet the following primary objectives:

1) Assessment of historical and current watershed conditions;

2) Identification of the major causes and sources of watershed degradation (including water quality impairment, aquatic habitat degradation, and flooding problems);

3) Involvement of local stakeholder groups in determining major watershed issues and high-priority focus areas;

4) Prediction of future watershed conditions under alternative land use and watershed management scenarios;

5) Development of a consensus-based package of watershed restoration and protection recommendations to be brought before local decision-making bodies, including:

a. identification of stream, wetland, and marsh restoration, enhancement, and preservation opportunities;

b. assisting the N.C. Department of Transportation (NCDOT) in meeting future compensatory mitigation needs for stream, riparian buffer and wetland impacts;

c. identification of non-traditional mitigation projects (e.g., stormwater Best Management Practices (BMPs), urban stormwater retrofits, agricultural practices) for targeted sites or subwatersheds; and

d. identification of a long-term follow-up strategy to assist localities in implementation of the specific watershed protection recommendations developed during the planning process.

The NCEEP has selected the Lumber River Basin cataloging unit 03040207 as a target CU for local watershed planning (LWP) efforts. Initial evaluations of restoration need and opportunity by NCEEP staff have resulted in the decision to focus planning efforts in the 14-digit hydrologic units, or portions thereof, within the Lockwoods Folly River watershed. The Lockwoods Folly River watershed is considered a high-priority area for watershed planning due to two primary factors: (1) documented water quality problems in selected stream segments, including segments listed on the Clean Water Act Section 303(d) list of impaired waters submitted to the U.S. Environmental Protection Agency; and (2) emerging threats to local watershed health which may be attributed to impacts from urban/suburban development, disturbance of wetlands and riparian buffers, agricultural activities, and/or other nonpoint sources.

The NCEEP Local Watershed Planning (LWP) utilizes a watershed assessment that emphasizes lost or impaired (and restorable) functions of key watershed components (streams, riparian buffers, wetlands, and contributing uplands) within the context of an integrated landscape or ecosystem approach. These functions generally fall into three primary categories: water quality, habitat (both aquatic and terrestrial), and hydrology. These three functional areas are the focus of watershed assessment and restoration efforts associated with the LWP process. The NCEEP has funding to implement specific restoration, enhancement and preservation projects that may receive compensatory mitigation credit.

NCEEP is also seeking to work with local governments (and other agencies or non-profit groups) to fund such projects that are not traditional mitigation projects (e.g., stormwater BMPs), under purview of “flexible mitigation” guidelines provided by pertinent regulatory agencies. As part of the development of Local Watershed Plans, the NCEEP and its consultants work with local stakeholder groups to recommend feasible watershed solutions, including assistance in identifying possible funding sources for the recommended solutions.

1.2 MAJOR TASKS CONDUCTED BY THE WATERSHED ASSESSMENT CONSULTANTS

The NCEEP has retained Stantec to conduct a technical assessment of watershed conditions within the LWP study area of the Lockwoods Folly River and to provide other support services in the development of the final LWP for the study area. Stantec’s support services to the NCEEP for this LWP effort began in August of 2005 and were scheduled to be conducted in four phases as follows:

Phase 1 – Initial Watershed Characterization and Restoration Site Search

Phase 2 – Detailed Watershed Assessment including Modeling, Field Work, Sampling, and Stakeholder Involvement

Phase 3 – Identification of Specific Solutions (Targeting of Management)

Phase 4 – Support for Implementation Process

The first phase of these services, which includes this report, is scheduled for completion by November 2005. The major deliverables for Phase 1 of Stantec’s watershed assessment work and the key elements of each are outlined below:

1.1) Compile and review pertinent water quality and GIS data and other relevant assessment information for the LWP effort, beyond that already assembled by NCEEP staff.

1.2) Perform an initial screening to identify potential restoration opportunities within the Lockwoods Folly watershed and use the results of the screening to formulate recommendations for focus areas in subsequent phases of the LWP effort.

1.3) Utilize GIS to delineate LWP subwatersheds according to NCEEP guidelines.

1.4) Review and provide comments on the NC Division of Water Quality's (NCDWQ) review of available water quality data and coordinate with NCDWQ in the development of a water quality monitoring plan for subsequent phases of this LWP.

1.5) Provide support for local advisory group development by attending preliminary meetings with prospective group members in conjunction with NCEEP staff.

1.6) Produce a Preliminary Findings Report detailing the results of all Phase I tasks, outlining the key stressors and issues affecting the watershed, and describing the technical approach for the remaining phases of the local watershed planning process.

1.3 PRELIMINARY FINDINGS REPORT

The purpose of this Preliminary Findings Report is to summarize pertinent and readily available sources of information from previous assessment efforts, as well as local input recruited within the Lockwoods Folly River watershed. Based on that information, the report will identify potential key indicators of overall watershed integrity, including water quality, which could be used in a future detailed assessment phase of the Local Watershed Planning process.

Delineation of subwatersheds within the Lockwoods Folly watershed will be presented in this report, and throughout the report these distinct subwatersheds will be utilized to assess and characterize portions of the LWP study area in terms of the primary threats to watershed functions within them. A variety of preliminary assessment information, including analyses of imperviousness, riparian corridors and wetland condition will be presented. In addition, the most recent information from local planning jurisdictions and natural resource agencies pertinent to the study area will be summarized in this report.

This report will end with recommendations regarding the Phase 2 Detailed Assessment and Phase 3 Targeting of Management portions of the LWP process.

2.0 Physical Attributes

2.1 HYDROLOGY

The Lockwoods Folly River study area is situated in south central Brunswick County and covers approximately 153 square miles (Figure 2-1). Although Lockwoods Folly River is part of the Lumber River Basin, it originates near the Town of Bolivia, flows westerly and then southwesterly, and empties into the Atlantic Ocean through the Lockwoods Folly River Inlet. The barrier islands of Oak Island and Holden Beach protect the river inlet. The Atlantic Intracoastal Waterway (AIWW), constructed in the 1930's, is located landward of the islands connecting to a small estuary formed by the river near the Town of Varnamtown. In addition to the AIWW and the inlet, the Lockwoods Folly River from the ocean to the Highway 211 bridge (~12.5 miles) is maintained for navigation by the US Army Corps of Engineers (Corps).

While it does not drain to the Lumber River, the Lockwoods Folly River watershed is considered to be within the Lumber River Basin, which is composed of four separate river systems. The Lockwoods Folly River is located within the basin's Coastal Area Watershed, which also includes the Shallotte River to the west. The study area, which includes portions draining directly to the AIWW, encompasses five 14-digit hydrologic units: 03040207020010, 03040207020020, 03040207020030, 03040207020040, and 03040207020050. Major tributaries to the Lockwoods Folly River are River Swamp, Royal Oak Swamp, and Mill Creek.

The watershed contains two hydrologic areas as identified by the US Geological Survey (Giese and Mason, 1993): HA2 (sandy soils) and HA1 (clayey soils). Local relief is commonly 1 to 2 feet per mile and the median 7Q10 (the lowest stream flow for seven consecutive days that would be expected to occur once in ten years) approaches zero. Average annual precipitation in Southport, Brunswick County based on 49 years of record is 56.6 inches (Fine and Cunningham, 2001). There are no USGS stream gages located within the watershed. Stream gages in nearby watersheds are at Hood Creek near Leland (USGS 02105900) and Waccamaw River at Freeland (USGS 02109500), located in the northeast and northwest Brunswick County, respectively.

2.2 SUBWATERSHED DELINEATION

The Lockwoods Folly watershed was delineated into 64 LWP subwatersheds ranging from 1.2 to 4.9 square miles using a hydrology modeling extension developed for ArcGIS (ESRI, 2005). A 20-foot digital elevation model (DEM), a raster grid of regularly spaced elevation values derived from recent LIDAR data, was used to develop drainage areas (Brunswick County, 2004). The subwatershed delineation was based initially on a selected number of cells within the DEM that constitute a stream (the threshold was set to 50,000 cells or about 1.9 square miles). Field reconnaissance conducted in an earlier study of a portion of the watershed aided in refining the delineation (NCDOT, 2005). Further aggregation or disaggregation of the resulting subwatersheds was based on land use/land cover and soil characteristics. The size of each subwatershed in square miles is shown in Figure 2-2.

2.3 GEOLOGY AND SOILS

Topography of the study area is mostly characterized by gently undulating to nearly flat plains. Natural subsurface drainage is sluggish except near streams. Elevation ranges from 83 feet down to sea level. The mean elevation for the watershed study area is approximately 36 feet above sea level.

The dominant geologic formation of the Lockwoods Folly River watershed is the tertiary Waccamaw Formation, characterized by fossiliferoas sand with silt and clay. Brunswick County is underlain by more than 1,300 ft of mostly unconsolidated sediments, consisting of surficial deposits, and the Castle Hayne (in the southeastern part of the County), Peedee, Black Creek, Middendorf, and Cape Fear Formations (Fine and Cunningham, 2001).

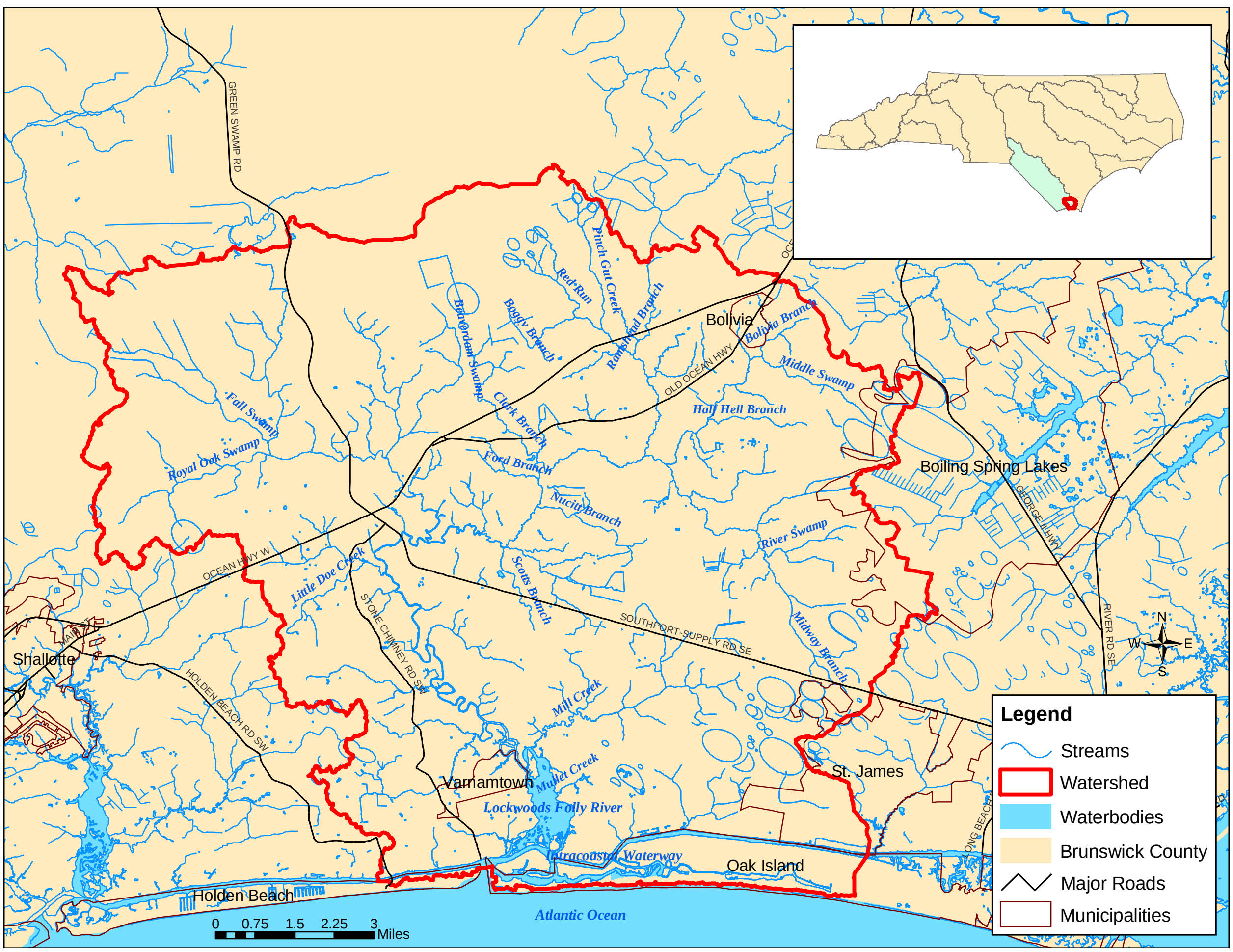

Figure 2-1. Location map for the Lockwoods Folly River watershed.

Figure 2-2. Subwatersheds of the Lockwoods Folly River watershed.

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Most of the watershed is located within the Lower Coastal Plain soil region (Daniels et al., 1999). Upland soils adjacent to the floodplain include well drained and moderately well drained soils (hydrologic soil group A or B) such as the loamy Baymeade (USSCS, 1986). Sandy, excessively drained soils of the Kureb-Wando map units are located within the areas of Varnamtown, Sunset Harbor, and Oak Island. In addition, there are large areas of somewhat poorly to very poorly drained soils such as Leon and Murville, Torhunta, and Croatan, an organic histosol. Map units that are completely hydric soils or contain hydric soils make up about 89% of the soil area.

2.4 LAND COVER AND LAND USE

The most recent land cover data available for the study area is the National Land Cover Database (NLCD) developed by the Multi-Resolution Land Cover Consortium (MLRC). The 1992 NLCD data set represents 1992-1995 land cover derived from Landsat Thematic Mapper 5 satellite data (USGS, 2000). The 2001 NLCD land cover data had not been released for Brunswick County at the writing of this report. Figure 2-3 presents the 1992 NLCD data for the Lockwoods Folly study area. The land cover over the study area was approximately 84% forested or wetlands during that time period. Agriculture and development land covers comprised approximately 9% and 5%, respectively.

While more recent *land cover* data was not available, parcel-based *land use* data provides useful information for understanding the recent development within the study area. Parcel-based land use data for 2004 was obtained from Brunswick County (Figure 2-4).

A comparison of the two data sets was achieved by aggregating to generalized land use/land cover types: developed, agriculture, and forest/wetland. Forested and wetland covers presently represent 75% of the land use within the study area, suggesting a 9% decrease in these cover types over the past decade (Table 2-1). Over the same period, agriculture land use decreased by 3% and developed land use (e.g., residential, commercial, golf courses, etc.) increased by 12%.

Table 2-1. Summary of land use/land cover in the Lockwoods Folly River watershed.

Land Use/Land Cover Type	1992 NLCD Land Cover	2004 Brunswick County Land Use	Percent Change
Developed	5%	17%	12%
Agriculture	9%	6%	-3%
Forest/Wetlands	84%	75%	-9%

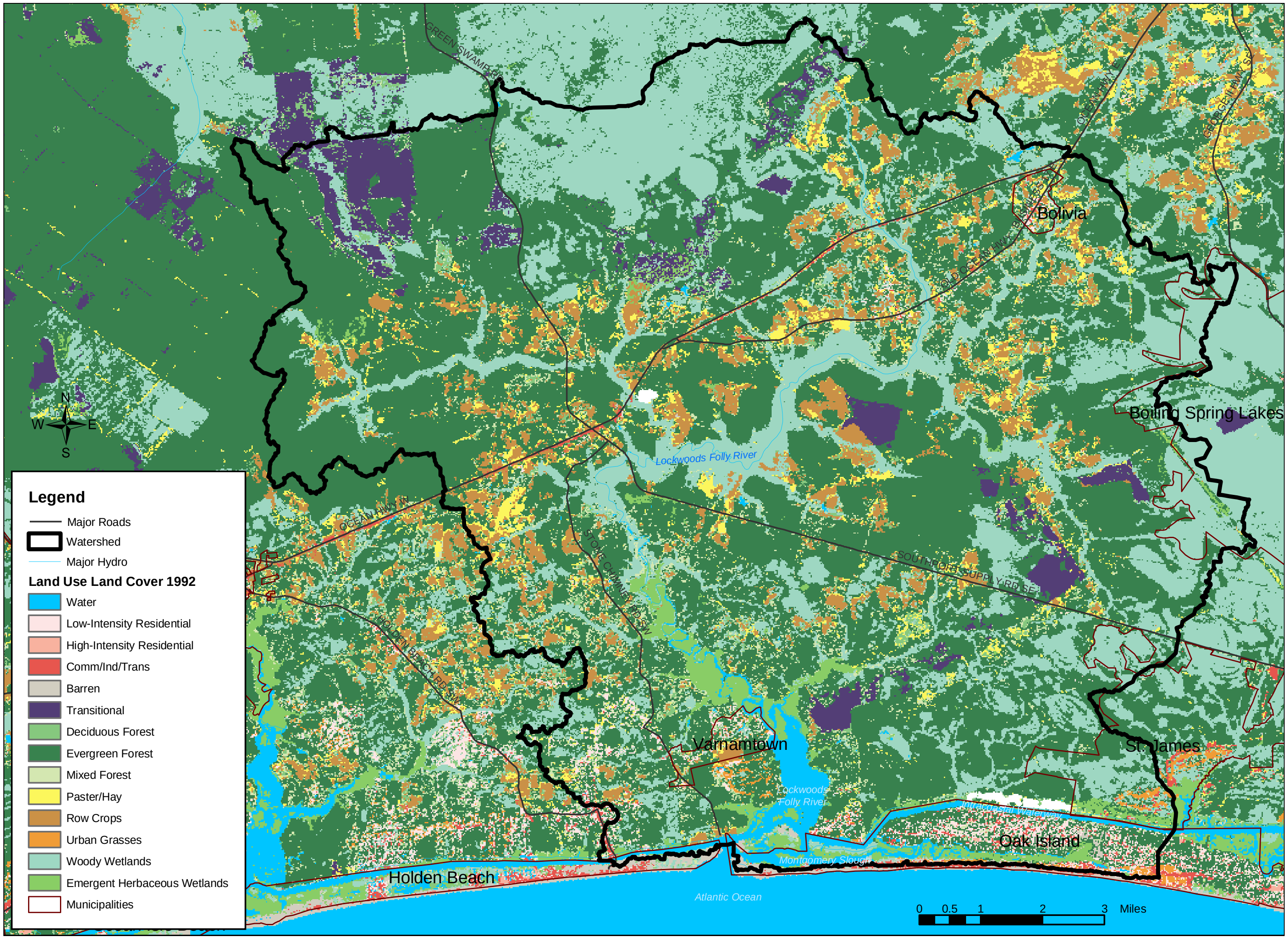

Figure 2-3. 1992 Land cover (NLCD) of the Lockwoods Folly River watershed.

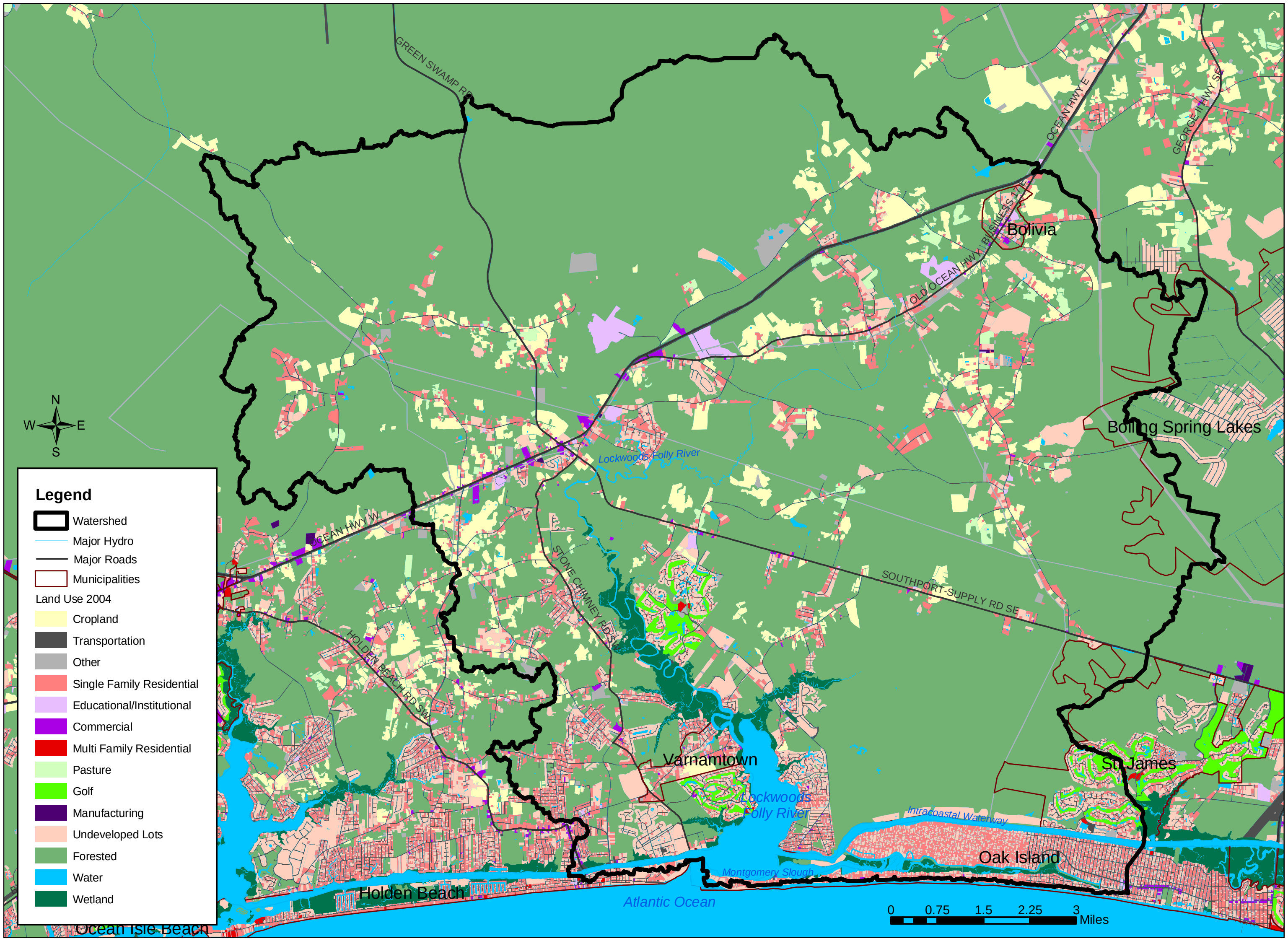

Figure 2-4. 2004 Land use map of the Lockwoods Folly River watershed.

2.5 WETLANDS

Wetlands, the transitional areas between land and water, provide multiple environmental benefits including flood protection, streambank stabilization, habitat, and pollutant filtration (NCDCM, 2003). In North Carolina, wetlands are regulated under the federal Clean Water Act (Sections 404 and 401) and several state statues and regulations covering wetlands, isolated wetlands, and coastal wetlands.

The NC Division of Coastal Management (NCDCM) has developed wetland type mapping in 37 Coastal Plain counties by combining three primary layers of GIS data: the US Fish and Wildlife National Wetlands Inventory (NWI), the county soil surveys, and 30 meter Landsat Thematic Mapper (TM) land cover. Details about the overlay analysis are available in Sutter (1999). While the broad scale NCDCM mapping provides a useful planning tool to aid in wetland protection, it does not substitute for on-site jurisdictional delineations.

Approximately 44% of the study area is covered by wetlands, most of which are flat or depressional wetlands that are isolated or hydrologically disconnected from surface water (Figure 2-5). These include managed pineland, pocosins, pine flats, freshwater marsh, and depressional swamp forest. The largest percentage of wetlands is managed pineland, totaling over a third of the wetland acreage. These are seasonally saturated tracts occurring on hydric soils and are commercially managed for loblolly pine trees (*Pinus taeda*) for production of lumber and pulpwood. After managed pinelands, the dominant wetland types are pocosins, pine flats, and riverine swamp forest. Fewer than five percent of the wetlands are considered coastal wetlands (salt marsh, shrub/scrub, and estuarine forest). Figure 2-5 also presents cutover, drained, and cleared wetlands. The NCDCM definitions for these modifiers are as follows: cleared wetlands are “areas of hydric soils for which satellite imagery indicates a lack of vegetation in both 1988 and 1994. These areas are likely to no longer be wetlands.” Cutover wetlands are “areas for which satellite imagery indicates a lack of vegetation in 1994. These areas are likely to still be wetlands, however, they have been recently cut over. The vegetation in cutover areas may be regenerating naturally, or the area may be in use for silvicultural activities.” Drained wetlands are “any wetland system that is, or has been, partially drained/ditched according to the US Fish & Wildlife Service’s National Wetland Inventory maps” (NCDCM, 2003).

Another mapping product created by NCDCM is the NC Coastal Region Evaluation of Wetland Significance or NC-CREWS data set (Sutter et al., 1999). This product uses a watershed-based GIS wetland functional assessment model to assess the functions of wetlands such as water quality, habitat and hydrology. The assessment is intended to provide users with information about the relative ecological importance of wetlands for use in planning and management.

Briefly, the model consists of four levels: (1) overall functional significance; (2) specific functions and potential risk of wetland loss; (3) subfunctions; and (4) parameters and subparameters evaluated to determine the level and extent of functions. The model evaluates 39 separate characteristics of the wetland and its watershed. NC-CREWS produces 3 possible overall wetland rating scores: exceptional, substantial, or beneficial. Over 98% of the rated wetlands within the Lockwoods Folly watershed are considered exceptional or substantial. About one quarter received the highest functional rating of exceptional (Figure 2-6). While potential risk of wetland loss is not used to determine a wetland's functional significance, it provides an estimation of the relative risk to watershed integrity posed by a specific wetland's loss. More than 91% of all rated enhancement sites within the watershed had a moderate risk of loss and 7% had a high risk of loss.

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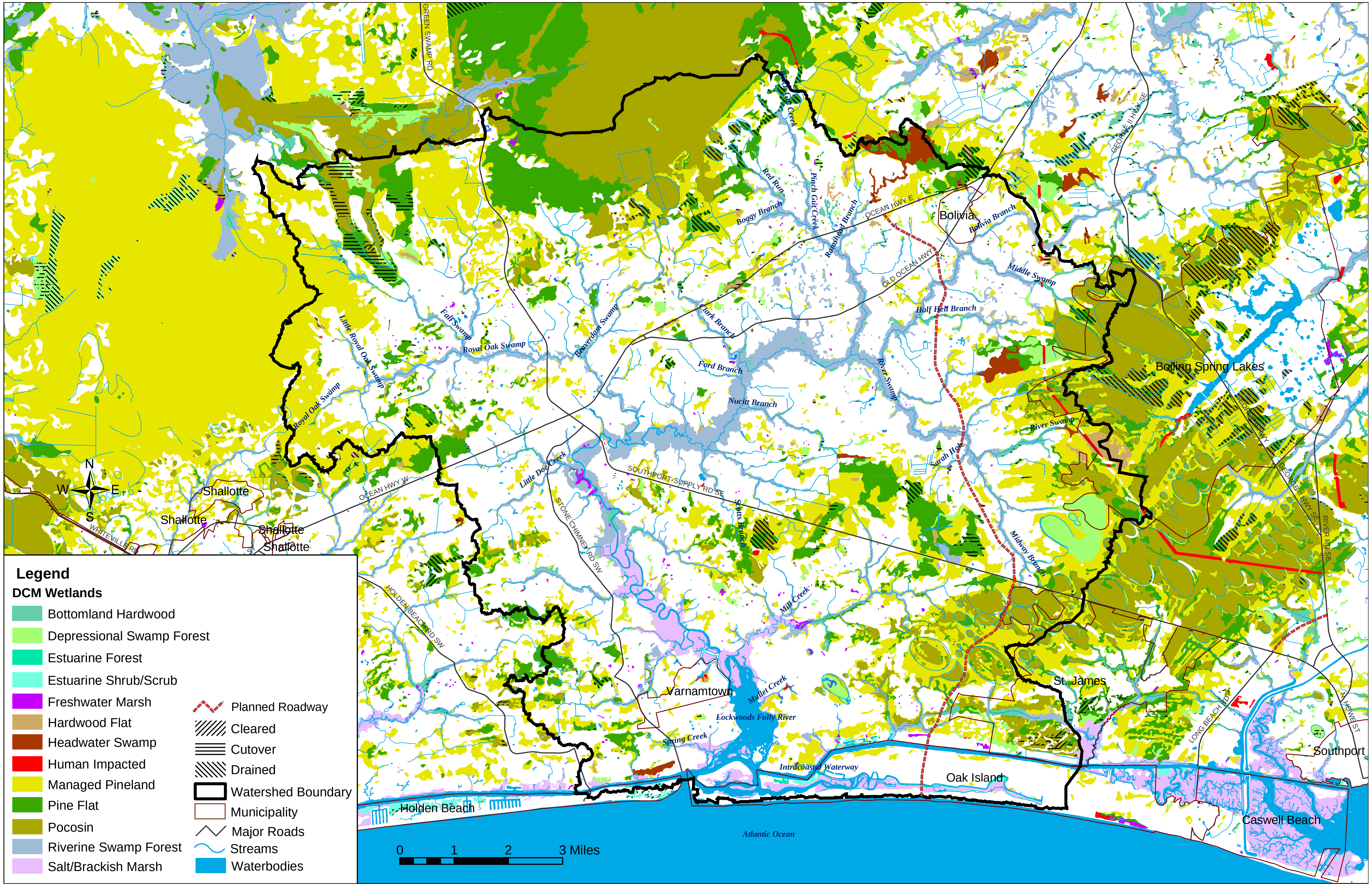

Figure 2-5. NC Division of Coastal Management Wetland Mapping in the Lockwoods Folly River watershed.

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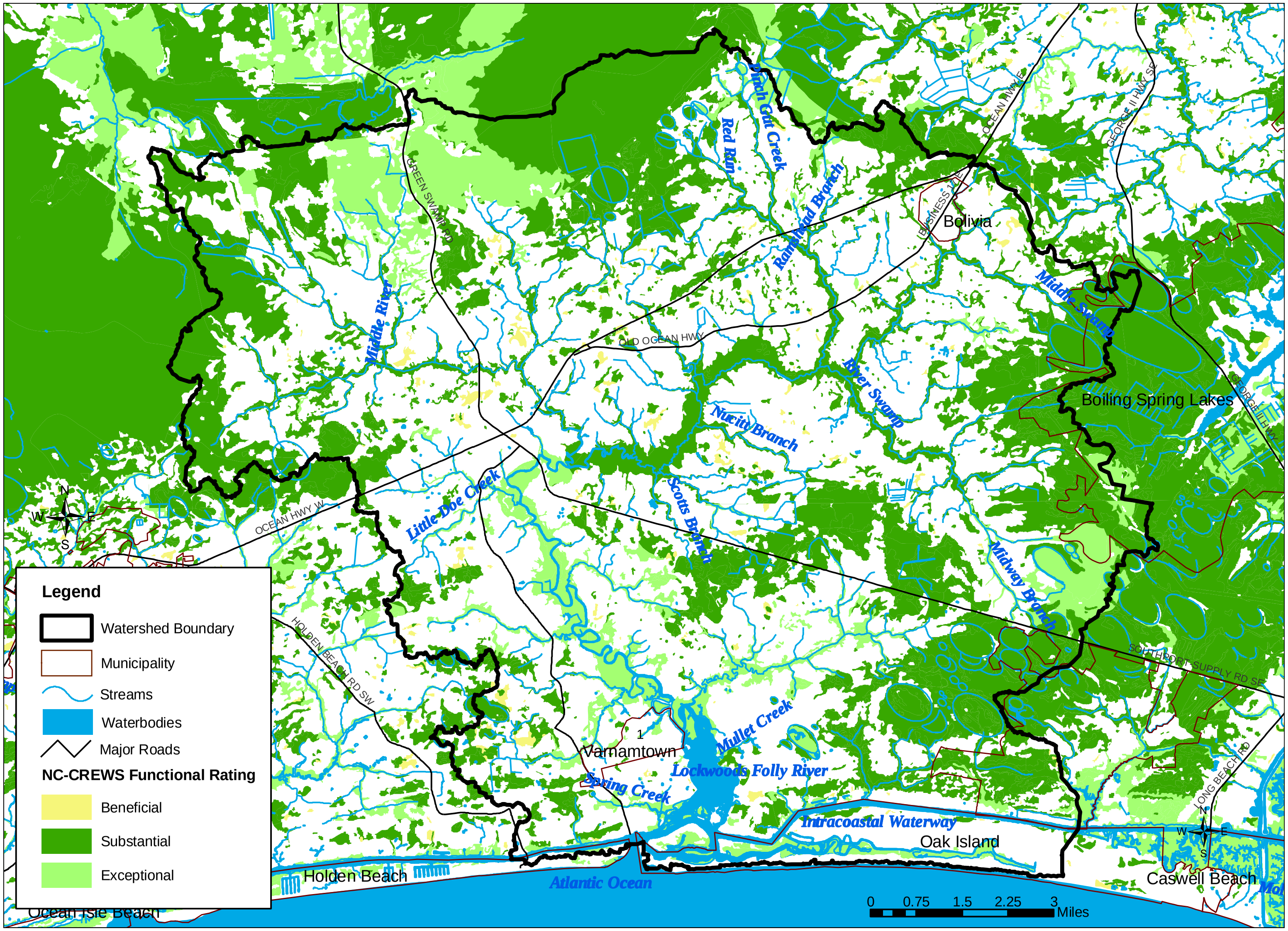

Figure 2-6. NC Division of Coastal Management Wetland Functional Significance for the Lockwoods Folly River watershed.

2.6 DEVELOPMENT TRENDS AND GROWTH MANAGEMENT

2.6.1 Current Development Trends

The entire Lockwoods Folly River watershed lies within Brunswick County, which is one of the fastest growing counties in North Carolina. From 1970 to 2000, the county population grew by over 200%, with an average growth rate of 45% during each decade (standard deviation ± 2.8%). Most of this growth has occurred in the county's beach communities, including Oak Island and St. James.

As shown in Table 2-2, the Town of Oak Island has experienced substantial population growth in recent years, adding roughly 5,744 new residents in the last three decades. Continuous residential growth is also apparent with the recent addition of new housing units in the St. James community (St. James, 2005). As of July 2003, St. James was ranked the sixth fastest growing municipality in North Carolina (NCSDC, 2003) and increased its population by over 100% since the Town's incorporation in 1999.

Table 2-2. Population Trends.

	POPULATION				PERCENT CHANGE		
	1970	1980	1990	2000	1970-	1980-	1990-
Bolivia	185	252	228	148	36.2%	-9.5%	-35.1%
Oak Island [1]	827	2,413	4,550	6,571	191.8%	88.6%	44.4%
St. James [2]	---	---	---	1,610	---	---	131.7%
Varnamtown	---	328	404	481	---	23.2%	19.1%
Brunswick	24,223	35,777	50,985	73,141	47.7%	42.5%	43.5%
North Carolina	5,084,4	5,880,09	6,632,44	8,046,48	15.6%	12.8%	21.3%

SOURCE: NC State Data Center.
NOTES: 1 - Oak Island populations for 1970, 1980, and 1990 were calculated by summing the populations of Long Beach and Yaupon Beach, which were separate municipalities until the two towns merged in 1999.
2 - The actual population of St. James in 2000 was 804 people. Given the Town's rapid growth, the most recent population data (July 2003) is shown in the table. In 1999, at the time of the Town's incorporation, the population was 695 people. The percent change shown for St. James reflects the Town's population increase from 1999 to 2003 and is included to illustrate this substantial growth.

2.6.2 Growth Management Regulations

The following paragraphs detail the growth and stormwater management regulations for the Lockwoods Folly River watershed. As urbanization occurs within a watershed, threats to watershed functions can include: increased stormwater discharges directly to streams; increased overland flow of stormwater; increased pollutant loading in stormwater due to build up and wash off of pollutants, illicit connections, and dumping into storm sewers; increased stream temperature from lack of shading and heated stormwater from ponds and impervious surfaces;

reduced groundwater discharge and stream base flow due to increased imperviousness; and decreased number and diversity of plants and animals due to degraded habitat.

2.6.2.1 Federal and State Regulations

The federal Phase II National Pollutant Discharge Elimination System (NPDES) stormwater program (40 CFR 122), signed into law in December 1999, requires permittees to develop, implement, and enforce stormwater programs to reduce water pollution. In response to the legal issues surrounding Phase II implementation, the NC State Legislature passed Senate Bill 1210 in July of 2004. The Bill provides the Environmental Management Commission (EMC) guidelines for implementing the Phase II program.

The Bill directs the EMC to develop and implement a general permit for Phase II stormwater coverage. The bill provides that the general permit requirements for post-construction stormwater control may be no more stringent than those set out in the temporary rule adopted by the EMC (as modified by the bill). A local government may choose to be covered under the general permit rather than an individual permit.

Both Brunswick County and the Town of Oak Island were required to either apply for a Phase II NPDES permit or certify that they do not own or operate a municipal separate storm sewer system (MS4). NCDWQ has received applications from Brunswick County and Oak Island and the applications are currently being reviewed (Randall, 2005). The permitted storm sewer systems must implement post-construction stormwater requirements within 24 months after receiving the NPDES permit. Municipalities (or other public entities) regulated later under the special State designation process must implement post-construction stormwater requirements within 36 months after receiving an NPDES stormwater permit.

Communities permitted under Phase II NPDES rules are required to develop and implement a comprehensive stormwater management program that includes six minimum management measures: 1) public education and outreach on stormwater impacts; 2) public involvement/participation; 3) illicit discharge detection and elimination; 4) construction site stormwater runoff control; 5) post-construction stormwater management in new development and redevelopment; and, 6) pollution prevention/good housekeeping for municipal operations.

Measures 1, 2, 3, and 6 primarily include non-structural best management practices (BMPs), which focus on stormwater management through source control. Measures 4 and 5 require structural BMPs, such as detention basins, grass swales, and sand filters. Measure 5 is of particular interest, as proper implementation of this measure has the potential to substantially reduce future water quality degradation.

The federal Coastal Zone Management Act of 1972 (CZMA) (16 USC 1451) initiated the creation of the state Coastal Area Management Act of 1974 (CAMA) (15A NCAC 7) to aid in the management and protection of coastal resources. CAMA requires the twenty coastal counties of North Carolina to develop land use plans and update the plans every five years. Brunswick County is currently in the process of updating their 1998 CAMA land use plan. CAMA also established the Coastal Resources Commission (CRC), which is responsible for identifying and regulating Areas of Environmental Concern (AECs). Development within coastal counties is regulated by the CRC and authorized through the NC Division of Coastal Management (NCDCM).

The Lockwoods Folly River watershed is subject to state and federal planning regulations mandated by the federal CZMA and the state CAMA. There are specific water quality rules for coastal counties [15A NCAC 2H .1003(b)]; if a development activity requires a CAMA major permit or a Sedimentation/Erosion Control Plan, then the development is subject to coastal stormwater rules. Although the Lockwoods Folly River watershed contains High Quality Waters (HQWs), development within coastal HQW drainage basins is excluded from the state's HQW stormwater management rules, as they must follow the development rules for coastal counties [15A NCAC 2H .1006(1)]. Because the Lockwoods Folly River watershed contains SA waters (surface tidal salt waters that are used for shellfishing or marketing purposes and all SC and SB uses), the following stormwater rules would apply [15A NCAC 2H .1005(2)]:

Low Density Option

- Built-upon area of 25% or less or single family residences on lots one third of an acre or greater with built-upon area of 25% or less;
- Stormwater runoff transported primarily by vegetated conveyance that does not include a discrete stormwater collection system; and,
- A 30-foot wide vegetative buffer.

High Density Option

- No direct outlet channels or pipes to SA waters [unless permitted in accordance with 15A NCAC 2H .0126];
- Stormwater control systems must be infiltration systems designed in accordance with Rule .1008 to control the runoff generated by 1.5 inches of rainfall; and,
- Runoff in excess of the design volume must flow overland through a vegetative filter designed in accordance with Rule .1008 of this Section with a minimum length of 50 feet measured from mean high water of SA waters.

2.6.2.2 Brunswick County Regulations

In addition to federal and state regulations for development in coastal areas, Brunswick County has also adopted regulations for development.

In anticipation of the Phase II NPDES regulations, Brunswick County adopted the *Stormwater Quality Management and Discharge Control Ordinance* on September 16, 2002. The County submitted a Phase II NPDES permit application to the NC Division of Water Quality in June 2003. The County has stated that it would amend its Ordinance to comply with future Phase II NPDES regulations.

Section 3.1 of the *Brunswick County Stormwater Ordinance* authorizes the County to adopt and impose BMPs for the prevention, control, and reduction of stormwater pollutants. In accordance with Phase II NPDES post-construction stormwater requirements, Section 3.1(b) authorizes the requirement of appropriate BMPs to control the volume, rate, and potential load of stormwater runoff from new development and redevelopment projects. Section 3.1(c) references Brunswick County *Stormwater Management Manual* (Brunswick County, 2002) for BMP design criteria. The Manual specifies the following post-construction requirements for new development and redevelopment:

- No net increase in peak discharge from predevelopment conditions for the 1-year, 24-hour storm;
- No more than a 5% increase in peak discharge from the predevelopment conditions for the 10-year, 24-hour storm;
- A 30-foot riparian buffer on all waterbodies; and,
- The calculation of pre-development and post-development pollutant exports for four indicator constituents: total nitrogen (TN), total phosphorus (TP), total suspended solids (TSS), and fecal coliform.

The *Stormwater Management Manual* also encourages low-impact development (LID) and provides extensive guidance on the technique. The design strategy of LID is to maintain the pre-development hydrologic regime of a site through the use of infiltration and detention and/or lengthening the path water must take to reach a waterbody. LID also focuses on the preservation of riparian buffers, wetlands, and areas with highly permeable soils.

2.6.2.3 Municipal Regulations

The Town of Oak Island has submitted a Phase II NPDES permit application and has implemented a stormwater program in anticipation of Phase II NPDES requirements. The Town has developed the following items: Stormwater Ordinance; Stormwater Management Plan; Stormwater Management Design Manual (adopted the County's manual); Illicit Discharge Detection Ordinance and Program; and, Stormwater Advisory Board. Most of these items mirror the Brunswick County programs.

The Town of St. James has adopted the Brunswick County Stormwater Ordinance and has entered an interlocal agreement with the County for the enforcement of the Ordinance.

2.6.2.4 Other Regulations

The Town of Long Beach [since incorporated with the Town of Yaupon Beach to form the Town of Oak Island] and Brunswick County jointly prepared the *Second Bridge to Oak Island Corridor Land Use and Development Plan* (Town of Long Beach, 1997) with a grant provided by the DCM. This plan was adopted by Long Beach Town Council on January 20, 1998, certified by the CRC on November 20, 1998, and was incorporated by reference into the Brunswick County and Oak Island CAMA land use plans (Harbeck, 1997) (Town of Long Beach, 1998). The objective of the corridor plan is "to complement the construction of a second bridge at the west end of Oak Island and the new highway connecting the bridge to NC 211 on the mainland. The corridor plan provides guidance to local governments and developers as they make decisions about land uses and development in the corridor. The goals of the plan are summarized below:

1. Preserve and enhance natural resources that are fundamental to the community's coastal lifestyle;

2. Encourage land uses and development patterns that ensure a high quality of life for current and future residents and that provide a traditional "small town" atmosphere;

3. Encourage development and improvements along the second bridge corridor that creates a sense of place at the entrance to Oak Island; and,

4. Protect the capacity of the new bridge and highway.

The corridor plan contains specific guidelines for development, which are summarized as follows:

1. Set overall density target at 2.0 dwelling units per acre, with a maximum density of 4.0 dwelling units per acre. This criteria will encourage compact residential development with open space and provide opportunities for walking and biking;

2. Create regional commercial center at the intersection of NC 211 and Midway Road intersection;

3. Encourage small commercial clusters at the access points along the new highway to serve pedestrians and bicyclists from adjacent neighborhoods; and,

4. Encourage streetscape design and a bicycle-friendly transportation system.

In its CAMA land use plan, the Town of Long Beach adopted policies regarding future development within its planning area (Town of Long Beach, 1997). Policy 3.1.2 states that the Town of Oak Island encourages a regional approach towards development along the corridor and that it supports the planning concepts contained in the *Second Bridge to Oak Island Corridor Land Use and Development Plan*. Policy 3.1.3 states that the Town encourages the NCDOT to acquire and preserve significant natural communities.

2.6.3 Future Development Trends

Consistent with current trends, future growth would most likely be concentrated within primary and secondary growth areas. Primary growth areas include the Towns of Oak Island and St. James, and the communities of Sunset Harbor and Sandy Hill. Secondary growth areas include portions of the Town of Varnamtown and unincorporated areas along the Lockwoods Folly River south of highway 211 in Supply (Figure 2.7). In Figure 2-7, impending development consists of undeveloped residential lots taken from the Brunswick County land use coverage. Future development is based on lots zoned for residential or commercial development combined with a future land use scenario developed for the Second Bridge to Oak Island Indirect and Cumulative Impact (ICI) Study (NCDOT, 2005).

The North Carolina Department of Transportation (NCDOT) 2004-2010 Transportation Improvement Program (TIP) includes the construction of a second bridge to Oak Island in Brunswick County, North Carolina (TIP Project No. R-2245). The project would provide a second vehicular access to Oak Island by widening SR 1105 (Middleton Avenue), constructing new bridges over Davis Canal and the Atlantic Intracoastal Waterway (AIWW), and constructing a roadway on a new location from the new high-rise bridge to NC 211 at SR 1500 (Midway Road). The approximate length of the project is 4.5 miles. The project would improve accessibility of the island portion of the project study area and would moderately improve the accessibility of the mainland project study area. The roadway along the mainland would be controlled access, with the exception of two access points.

Development studies conducted by the North Carolina Department of Transportation (NCDOT) as part of the environmental analysis for the proposed Second Bridge to Oak Island found that local planners anticipate full build-out conditions for their respective planning areas by 2025 and concluded that development in the area between NC 211 and Oak Island is anticipated to occur regardless of the second bridge's construction (NCDOT, 2005; Town of Oak Island, 2005; Town of St. James, 2005).

A more moderate average growth rate of 22.4% is projected for the county from 2000 to 2030 (standard deviation $\pm$ 8.0%); however, this rate is much higher than projected growth rates for many other North Carolina counties (USBOC, 2000). Municipal projections were determined by linear extrapolation of current population trends. As shown in Table 2-3, higher amounts of growth are projected for the Towns of Oak Island and St. James.

Table 2-3. Projected Population Growth.

	POPULATION				PERCENT CHANGE		
	2000	2010	2020	2030	2000-	2010-	2020-
Bolivia [1]	148	---	---	---	---	---	---
Oak Island	6,571	8,433	10,370	12,307	28.3%	23.0%	18.7%
St. James [2]	804	3,255	5,634	8,014	304.9%	73.1%	42.2%
Varnamtown	481	558	634	711	16.0%	13.6%	12.1%
Brunswick	73,141	95,961	115,412	133,435	31.2%	20.3%	15.6%
North Carolina	8,046,4	9,441,44	10,943,9	12,467,2	17.3%	15.9%	13.9%

SOURCE: Brunswick County and North Carolina projections are based on USBOC projections. Municipal projections were determined by regression analysis.
NOTES: 1 - Population projections were not calculated for the Town of Bolivia, as the projected trend indicates negative population growth. It is more likely that Bolivia's population will remain near its current population and will not experience substantial growth during the next three decades.
2 - The projected population increases for St. James were calculated by extrapolation of the town's 1999, 2000, and 2003 populations. Growth from 2003 (1,610 residents) to 2010 would be an increase 102.2%.

In the near future, the Town of Oak Island and its extra territorial jurisdiction (ETJ) will be serviced by a regional sewer system that will be able to treat up to 3.3 million gallons per day (MGD). The Towns of Bolivia and St. James will be serviced by the West Brunswick Regional Water Reclamation Facility, which is currently under construction. This facility will have a wastewater treatment capacity of 3.0 MGD. Most areas are scheduled for service by 2010 (Brunswick County, 2005) (HDR, 2005).

Future development is likely to follow current trends and grow as residential golf community/planned unit developments (PUDs). Two new planned unit developments are located along the east side of Lockwoods Folly River just south of highway 211: Winding River Plantation and River Sea Plantation. Commercial development is anticipated along NC 211, SR 1115 (Stone Chimney Road), and SR 1112 (Sunset Harbor Road), intermixed with existing low density residential uses. For the next three decades, minimal development is predicted in Bolivia and other areas in the northern portion of the watershed.

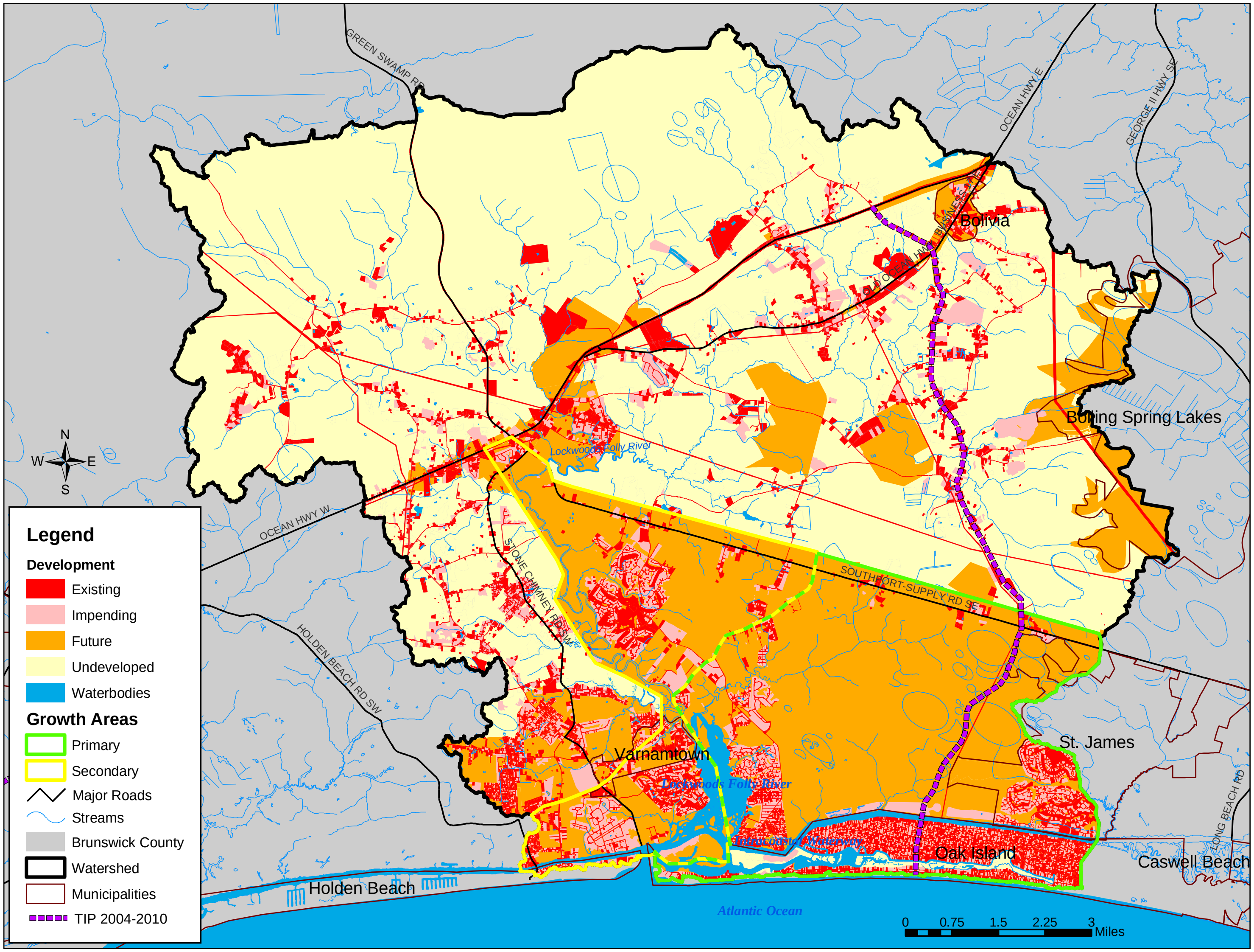

Figure 2-7. Primary and secondary growth areas within the Lockwoods Folly study area.

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3.0 Preliminary Assessment of Watershed Functions

The primary watershed functions considered in this study fall into three basic categories: water quality, hydrology, and habitat. The following subsections summarize the basis for assessment of watershed functions and present the preliminary findings based on the available data.

3.1 STREAM CLASSIFICATION AND USE SUPPORT RATINGS

Rules contained in Section 15A NCAC 02B.0200 of the N.C. Administrative Code describe a classification system by which the N.C. Environmental Management Commission (NCEMC) and the N.C. Division of Water Quality (NCDWQ) assign use classifications to waterbodies. These use classifications stipulate the designated best uses for each waterbody and determine the standards to which water quality is to be protected in order to maintain those uses. For more information on the NCDWQ's use support classifications for surface waters (and associated water quality standards), go to http://h2o.enr.state.nc.us/admin/rules/.

Streams in the upper portions of the Lockwoods Folly LWP study area are classified as Class C-Sw waters (Figure 3-1). Class C-Sw waters are protected for secondary recreation, fishing, wildlife, fish and aquatic life propagation and survival, agriculture and other uses suitable for Class C. Secondary recreation includes wading, boating, and other uses involving human body contact with water where such activities take place in an infrequent, unorganized, or incidental manner. The Class C designation is the minimum standard for all freshwaters in North Carolina. The Swamp (Sw) supplemental classification is intended to recognize those waters that generally have naturally occurring very low velocities, low pH and low dissolved oxygen.

Near the crossing with Highway 211 (Southport-Supply Rd), the Lockwoods Folly River is classified as SC, tidal salt waters protected for secondary recreation. Many of the tributaries in the vicinity remain C-Sw. An additional supplemental classification, High Quality Waters, is also applied to the Lockwoods Folly River and its tributaries at this location. High Quality Waters (HQW) is a designation intended to protect waters with quality higher than state water quality standards. The estuary of the Lockwoods Folly River, the ICWW (Intracoastal Waterway), Spring Creek, Mullet Creek, and portions of Mill Creek are classified as SA, shellfishing waters (HWQ by definition). The Atlantic Ocean is classified as SB, tidal salt waters for primary recreation.

Section 305(b) of the Clean Water Act requires that states periodically evaluate each waterbody, and based on available data, determine whether water quality within the waterbody is adequate to support its designated uses. In North Carolina, use support data for streams in each river basin is evaluated every five years in conjunction with the development of basinwide plans. NCDWQ reports on waterbodies across the state every two years and assigns use support ratings to each indicating whether they are "Supporting," or "Not Supporting" their designated uses, based on updated information from the basin plans.

Section 303(d) of the Clean Water Act requires that states place waters that are rated "Not Supporting" on a list of impaired waters, referred to as the 303(d) List. Section 303(d) also requires that a Total Maximum Daily Load (TMDL) be determined for any waterbody that is impaired by a specific identifiable pollutant or pollutants. The intent of the TMDL is to determine the assimilative capacity of the waterbody, identify sources for the specific pollutant(s), and provide a framework by which the pollutant loads from those sources can be reduced to restore the impaired uses.

Impaired segments within the Lockwoods Folly River watershed are identified in Table 3-1 and in Figure 3-1. All segments are impaired for shellfish harvesting closure due to exceedences of the fecal coliform bacteria standard for SA waters. The standard requires that fecal coliform group not exceed a median MF of 14/100 ml and not more than 10 percent of the samples exceed an MF count of 43/100 ml in areas most probably exposed to fecal contamination during the most unfavorable hydrographic and pollution conditions (15A NCAC 02B .0221). The abbreviation MF stands for the membrane filter procedure for bacteriological analysis. Not included below is the Atlantic Ocean (AU 99-(1)), where large portions are impaired due to fish advisory-mercury.

The 2004 Integrated 305(b) and 303(d) Report is available for download from NCDWQ at http://h2o.enr.state.nc.us/tmdl/General_303d.htm. The 2003 Lumber Basinwide Water Quality Plan is available for download at http://h2o.enr.state.nc.us/basinwide/.

3.2 OVERVIEW OF WATER QUALITY AND BIOLOGICAL MONITORING DATA

The NCDWQ collects a variety of biological, chemical, and physical data throughout the watershed. In addition the NC Division of Environmental Health's (NCDEH) Shellfish Sanitation Section collects data to protect the consuming public from shellfish and crustacea that could cause illness and for the Recreational Beach Monitoring program. Current and historical information on sampling and assessment is available in the Lumber River Basinwide Assessment Report (NCDWQ, 2002) and in the Lockwoods Folly River Basin Water Quality Evaluation Report (NCDEM, 1989). The following summary principally draws from a summary of available data prepared by the NCDWQ (2005) and the most recent Lumber River Basinwide Water Quality Plan (NCDWQ, 2003). The full NCDWQ data summary is presented as Appendix 8.1.

3.2.1 Monitoring Programs and Sampling Locations

The locations of monitoring stations throughout the watershed are listed in Table 3.2 and mapped in Figure 3-2. Station information is presented along with fields indicating the agency or program conducting sampling.

The NCDWQ collects biological (benthic macroinvertebrates and fish), physical/chemical, and bacterial data within the watershed. Benthic macroinvertebrate sampling is conducted on the Lockwoods Folly River (LFR02), located near the center of the watershed, and in Royal Oak Swamp (TR01). Fish sampling has been conducted at two locations: Lockwoods Folly River at

US 17 Business (LFR01) and at TR01. Habitat assessments were conducted in 1996 and 2001 for TR01. Ambient monitoring system (AMS) data including physical, chemical, and bacterial parameters is available for thirteen stations from 1974 to the present. Only five AMS sites are currently active: LFR03, LFR06, LFR11, LFR19, and MS01.

Data on fecal coliform bacteria and other indicator species such as enterococcus are collected by the NCDWQ under the AMS, NCDEH Recreational Beach Monitoring program, and the NCDEH Shellfish Sanitation program. NC water quality standards protecting recreation and shellfishing uses are based on fecal coliform. In contrast, the Recreational Beach program has monitored for fecal coliform, enterococcus, and E. coli. The BEACH Act of 2000 required a switch from fecal coliform to enterococcus for federally identified bathing beaches, and a new standard based on this indicator was enacted in 2004.

Table 3-1. Impaired waterbodies in the Lockwoods Folly River watershed.

<table>
<tr><th>Name</th><th>Assessment Unit Number</th><th>Stream Classification</th><th>Reason for Listing</th><th>Acres</th></tr>
<tr><td>Portions of Lockwoods Folly River</td><td>15-25-1-(16)</td><td rowspan="6">SA HQW</td><td rowspan="6">Shellfish harvesting closure: fecal coliform</td><td>606.2</td></tr>
<tr><td>Mullet Creek</td><td>15-25-1-19</td><td>5.7</td></tr>
<tr><td>Spring Creek</td><td>15-25-1-21</td><td>2.4</td></tr>
<tr><td>Mill Creek</td><td>15-25-1-18-(2)</td><td>2</td></tr>
<tr><td>Portions of the Intracoastal Waterway</td><td>15-25</td><td>~304</td></tr>
<tr><td>Montgomery Slough</td><td>15-25v</td><td>~101.2</td></tr>
</table>

Source: NCDWQ (2003)

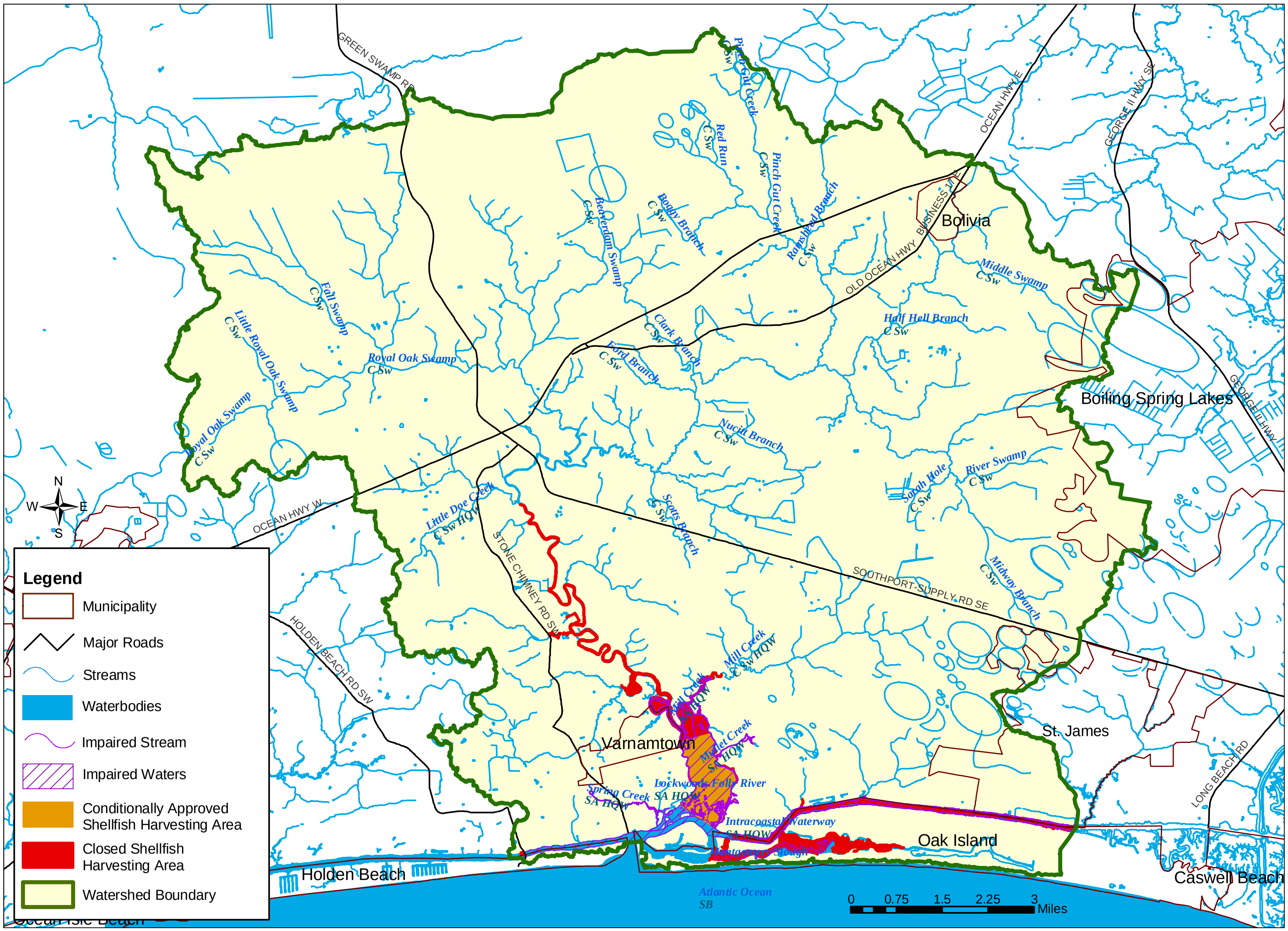

Figure 3-1. Stream classifications and use support in the Lockwoods Folly River watershed.

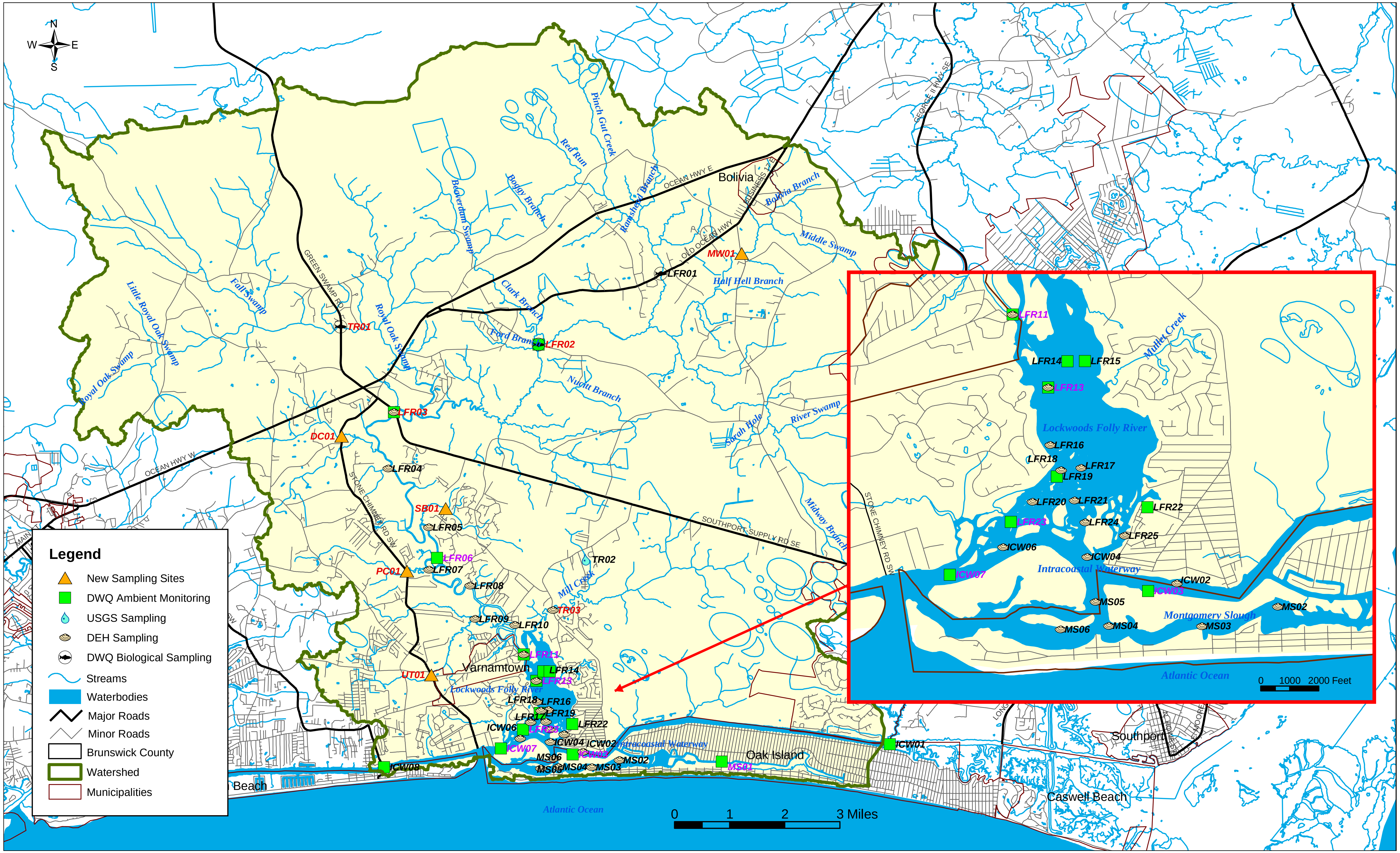

Figure 3-2. Water quality monitoring locations in the Lockwoods Folly River watershed. Proposed phase II monitoring discussed in section 5.3 is identified with red (tributary loading) and purple (trophic status) text.

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Table 3-2. Summary of monitoring stations within the Lockwoods Folly River watershed.

Station Number	Station Description	Latitude	Longitude	Stream Index #	Stream Class	DWQ benthos	DWQ fish comm.	DWQ AMS	DEH Rec. Beach	DEH Shellfish	USGS
LFR01	Lockwoods Folly R at US 17 Business	34.0469	-78.1789	15-25-1-(1)	C Sw		X				
LFR02	Lockwoods Folly R at SR 1501 near Supply/ Shellfish special study station LF10	34.0284	-78.2177	15-25-1-(11)	SC HQW	X	X	X		X	
LFR03 *	Lockwoods Folly R at NC 211 at Supply/ Shellfish special study station LF8	34.0108	-78.2636	15-25-1-(11)	SC HQW			X		X	
LFR04	Shellfish special study station LF7	33.9959	-78.2655	15-25-1-(11)	SC HQW					X	
LFR05	Shellfish special study station LF6	33.9803	-78.2528	15-25-1-(11)	SC HQW					X	
LFR06 *	Lockwoods Folly R near Sandy Hill	33.9722	-78.2503	15-25-1-(11)	SC HQW			X			
LFR07	Shellfish special study station LF5	33.9691	-78.2528	15-25-1-(11)	SC HQW					X	
LFR08	Shellfish special study station LF4	33.9648	-78.2399	15-25-1-(11)	SC HQW					X	
LFR09	Shellfish special study station LF3	33.956	-78.2384	15-25-1-(11)	SC HQW					X	
LFR10	Shellfish special study station LF2	33.9543	-78.2258	15-25-1-(16)	SA HQW					X	
LFR11 *	Lockwoods Folly R at Varnamtown/ Shellfish special study station LF1	33.9465	-78.2232	15-25-1-(16)	SA HQW			X		X	
LFR12	Lockwoods Folly R at CM 10	33.9443	-78.2216	15-25-1-(16)	SA HQW				X		
LFR13	Lockwoods Folly R at CM R8 DNS of Varnamtown (west channel)/ Shellfish station 5A	33.9395	-78.2192	15-25-1-(16)	SA HQW			X		X	
LFR14	Lockwoods Folly R DNS of Varnamtown (center)	33.942	-78.217	15-25-1-(16)	SA HQW			X			

Table 3-2. Continued

Station Number	Station Description	Latitude	Longitude	Stream Index #	Stream Class	DWQ benthos	DWQ fish comm.	DWQ AMS	DEH Rec. Beach	DEH Shellfish	USGS
LFR15	Lockwoods Folly R DNS of Varnamtown (east channel)	33.942	-78.215	15-25-1-(16)	SA HQW			X			
LFR16	Shellfish station 6A	33.934	-78.219	15-25-1-(16)	SA HQW					X	
LFR17	Shellfish station 30A	33.9318	-78.2155	15-25-1-(16)	SA HQW					X	
LFR18	Lockwoods Folly R at CM 5/ Shellfish station 14A	33.9316	-78.2178	15-25-1-(16)	SA HQW				X	X	
LFR19 *	Lockwoods Folly R at CM R6 NW Sunset Harbor (west channel)	33.931	-78.2183	15-25-1-(16)	SA HQW			X			
LFR20	Shellfish station 14B	33.9286	-78.2211	15-25-1-(16)	SA HQW					X	
LFR21	Shellfish station 7A	33.9287	-78.2163	15-25-1-(16)	SA HQW					X	
LFR22	Lockwoods Folly R at NW of Sunset Harbor (east channel)	33.928	-78.208	15-25-1-(16)	SA HQW			X			
LFR23	Lockwoods Folly R at West Channel Islands	33.9267	-78.2236	15-25-1-(16)	SA HQW			X			
LFR24	Shellfish station 7	33.9266	-78.2151	15-25-1-(16)	SA HQW					X	
LFR25	Shellfish station 8	33.9253	-78.2106	15-25-1-(16)	SA HQW					X	
TR01	Royal Oak Swamp at NC 211	34.0335	-78.2803	15-25-1-14	C Sw	X	X				
TR02	Mill Creek near SR 1112 near Long Beach	33.9715	-78.2033	15-25-1-18-	SA HQW						X
TR03	Shellfish special study station LF9	33.9582	-78.2138	15-25-1-18-	SA HQW					X	
ICW01	ICW at CM R16 at Beaverdam Cr near Long Beach	33.92195	-78.1078	15-25	SA HQW			X			

Table 3-2. Continued

Station Number	Station Description	Latitude	Longitude	Stream Index #	Stream Class	DWQ benthos	DWQ fish comm.	DWQ AMS	DEH Rec. Beach	DEH Shellfish	USGS
ICW02	Shellfish station 11	33.9207	-78.2047	15-25	SA HQW					X	
ICW03	ICW at Sunset Harbor	33.92	-78.208	15-25	SA HQW			X			
ICW04	Shellfish station 10	33.9233	-78.2149	15-25	SA HQW					X	
ICW05	Lockwoods Folly R at mouth at ICW CM 41	33.9237	-78.2237	15-25	SA HQW				X		
ICW06	Shellfish station 13	33.9243	-78.2245	15-25	SA HQW					X	
ICW07	ICW at CM R42 west of Lockwood Folly R	33.9217	-78.2306	15-25	SA HQW			X			
ICW08	ICW at NC 130 near Holdens Beach	33.91699	-78.2676	15-25	SA HQW			X			
MS01 *	Montgomery Slough at SR 1105 near Long Beach	33.91777	-78.1609	15-25	SA HQW			X			
MS02	Shellfish station 24	33.9184	-78.1932	15-25	SA HQW			X			
MS03	Shellfish station 24A	33.9166	-78.2019	15-25	SA HQW					X	
MS04	Shellfish station 9	33.9167	-78.2125	15-25	SA HQW			X			
MS05	Shellfish station 9A	33.919	-78.214	15-25	SA HQW					X	
MS06	Shellfish station 16	33.9164	-78.218	15-25	SA HQW				X		

Source: NCDWQ (2005)
* Active AMS station

3.2.2 Biological Monitoring Data

Biological monitoring data within the Lockwoods Folly River watershed is limited by the swamp conditions of many of the streams. Only recently have criteria to evaluate swamp streams been approved. Sampling under these new criteria is scheduled to begin in 2006 for the watershed. In addition, there is no approved index to evaluate estuarine waters and water salinity prevents electroshocking under fish sampling protocols.

Site TR01 on Royal Oak Swamp, which drains a mostly undeveloped, forested area, is used by the NCDWQ as a "least-disturbed" reference site for the ecoregion. While benthos and fish community sampling suggest diverse and healthy communities, this site has not been rated in past years due to its swamp classification. The stream is approximately seven meters wide at NC 211 with an intact riparian area. The substrate consists largely of muck and woody debris (NCDWQ, 2002).

The benthic site located on the Lockwoods Folly River mainstem (LFR02) has received Good-Fair ratings in 1984 and 1996. The site could not be sampled in 2001 due to low flow conditions.

Fish community sampling has been performed at two stations: LFR01 and TR01. The NC Index of Biological Integrity (NCIBI) used by the fish monitoring program is not applicable to the Lumber and other lower coastal river basins, and so there are no ratings for these sites. The raw data from 1992 and 2001 for TR01 show a diverse and healthy community. At LFR01, the number of species was 11 (1992) and 12 (1996), with one tolerant species dominant in number, mosquitofish *(Gambusia holbrooki)*. In contrast, the number of species at TR01 was 19 and 16, including the intolerant ironcolor shiner *(Notropis chalybaues)*.

Habitat assessments were conducted in 1996 and 2001 at TR01. Scores ranged from 83 to 90 out of 100. In 2001, silt levels in the substrate increased by 20 to 25% from the 1996 assessment.

3.2.3 Physical Data

Data collected for dissolved oxygen (DO), pH, and salinity are available for the NCDWQ ambient monitoring sites. Depressed levels of DO (Figure 3-3) and pH are not uncommon in the upper to middle portions of the watershed (LFR02 and LFR03), most likely due to inflow of swamp-like tributaries. There are no other obvious sources that would contribute oxygen-consuming wastes: there is one confined animal operation and one minor NPDES facility discharging wastewater within the watershed.

Salinity values suggest the tidal influence is exerted as far upstream as LFR03 and LFR02. Typically the tidal influence extends to the region between LFR03 and LFR06. At estuarine stations, the median salinity ranges from 28 to 32 parts per thousand (ppt), indicative of a polyhaline (salinity of >18-30 parts per thousand or ppt) to euhaline (salinity of >30ppt) environment.

Exceedences of the turbidity standard (25 NTU) are not common. However, TSS can reach levels of 100 to 200 mg/L intermittently with concentrations greater than 50 mg/L not unusual (Figure 3-4). North Carolina does not have an instream TSS standard. While TSS and turbidity both quantify suspended material in the water column, they do not always track one another. For example, fine clay particles can cause high turbidity via effective light dispersion but not contribute to high TSS. On the other hand, large organic or inorganic particles are often less effective at dispersing light, yet their greater mass results in high TSS.

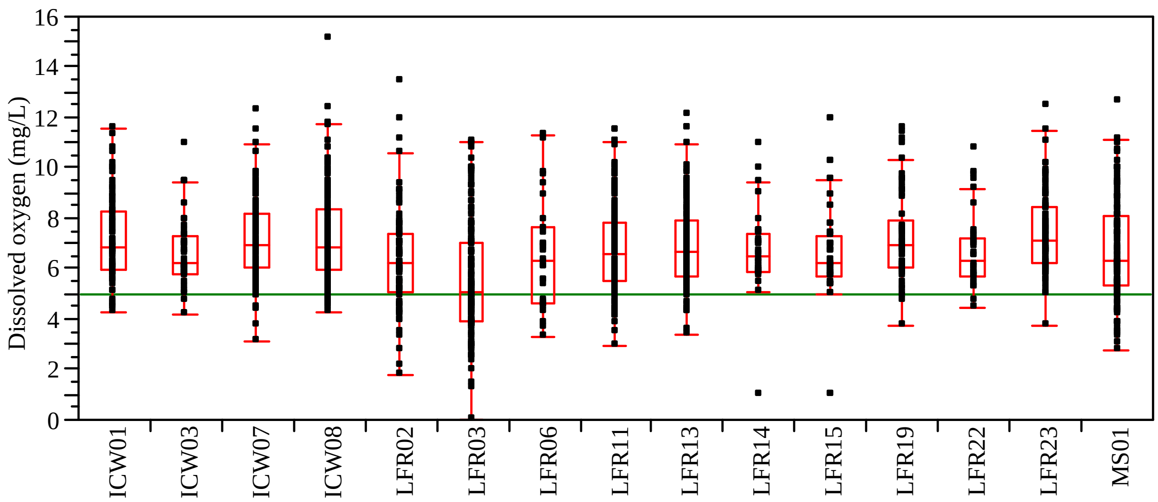


Figure 3-3. Distributions of dissolved oxygen in the Lockwoods Folly River watershed. The green line indicates NC water quality standard for aquatic life in saltwater of 5.0mg/L. Graph from NCDWQ (2005).

NCDWQ's analysis suggests no apparent trends in TSS and turbidity except at MS01, which is situated in the middle of Oak Island. An upward trend is apparent for both parameters at this station. This is not surprising considering the significant development that has occurred on the island in recent years.

Secchi depth, a parameter used to determine the clarity of surface waters, was collected at several stations. Median station values were at moderate levels of 0.9 to 1.1 meters. Values significantly less than one meter commonly correlate with high turbidity and high light attenuation.

3.2.4 Chemical Data

Data for ammonia nitrogen (NH3-N), nitrite and nitrate (NO2-N and NO3-N), total kjeldahl nitrogen (TKN), and total phosphorous (TP) are available up to 2001. No chlorophyll *a* data, an indicator of algal growth, is available. NCDWQ is not collecting nutrient or chlorophyll *a* data in the watershed at the present time.

Median concentrations of TP and total nitrogen (TN), calculated as TKN plus NO2-N and NO3-N, were lower than neighboring Cape Fear Estuary and other South Atlantic estuaries (NOAA, 1996). Values of TP and TN were typically 0.03 to 0.05 mg/L and 0.4 to 0.5 mg/L, respectively. The highest median levels of TP and TKN were found at station MS01 near Oak Island. Given the lack of recent nutrient data, it is difficult to assess trends and evaluate more recent concentrations.

The majority of metals sampled were reported as less than the detection limit. Only aluminum, iron, zinc, and copper were commonly detected. Of those metals, concentrations of copper often exceeded the action level of 3 µg/L at nearly all stations sampled as part of the AMS program. The average exceedance was 15%. The exceedance percentage was greater than 20 at LFR14, LFR15, and ICW08. It should be noted that copper occurs naturally in rocks and soil (NCDA, 2003). Such natural occurrences of copper may contribute to the instream concentration levels seen here. Copper is also found in metal alloys, automobile brakes, electrical wiring, some water pipes, preservatives, and some agricultural fungicides.

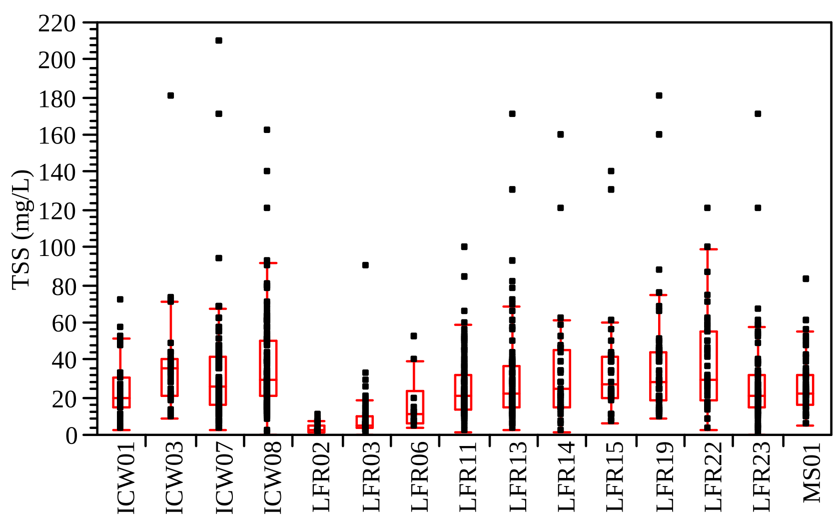


Figure 3-4. Distributions of total suspended solids (TSS) by station in the Lockwoods Folly River watershed.
Graph from NCDWQ (2005).

3.2.5 Bacteriological Data

For more than two decades since the Lockwoods Folly River appeared on NC's 303(d) list of impaired waters, fecal coliform has been a key concern in the watershed. The NCDEH began closing portions of the Lockwoods Folly River and other sectors of the NCDEH area A-3 in the late 1970's. In the larger subbasin that includes the Shallotte River, NCDEH currently has classified 711 acres as conditionally approved-closed and 1,469 acres as prohibited/restricted.

Due to multiple protected uses, a particular waterbody may be subject to more than one water quality standard for microbial pathogens in NC. A summary of the various standards is shown in Table 3-3. Fecal coliform bacteria are used as indicators of possible contamination because they are commonly found in human and animal feces. Although they are generally not harmful themselves, they indicate the possible presence of pathogenic (disease-causing) bacteria, viruses, and protozoans that also live in human and animal digestive systems.

Likely sources of fecal coliform bacteria in the watershed are urban runoff and failing or faulty septic tanks. An intensive investigation of the problem in the late 1980's suggested that septic systems in areas of excessively drained soils were a probable cause of much of the contamination (NCDEM, 1989). These conditions promote transport of septic drainage to waterbodies prior to bacteria die off or binding to the soil. Confined animal operations and non-stormwater NPDES discharges are not prevalent in the study area and as such are not considered large sources of fecal coliform. There is one minor discharger in Bolivia (Brunswick County Schools) and one confined animal operation located approximately 3 miles west of the Bolivia town limits.

Table 3-3. Summary of bacterial pathogen standards in North Carolina.

Waterbody Use	Affected Waters	Indicator	Standard- central tendency	Standard- single sample max
Primary recreation[1]	B, SB, and SA classifications	Fecal coliform	geometric mean <200	<20% of samples >400
Secondary recreation[1]	All stream classifications	Fecal coliform	geometric mean <200	<20% of samples >400
Shellfishing	SA classifications	Fecal coliform	median <14	<10% of samples >43
Bathing beach	Federally designated bathing beaches	Enterococcus	Tier I: geometric mean	Tier I: >104
			Tier II: N/A	Tier II: >276
			Tier III: N/A	Tier III: >5002

1 The standard is based on the results of five samples taken within a thirty-day period.
2 This value must be exceeded in two or more consecutive samples.
All values are in colonies/100mL

A summary of fecal coliform data collected by NCDWQ (Table 3.4) and NCDEH (Table 3.5) demonstrates widespread degradation. While most of the higher levels are found in the estuary and ICWW, NCDEH found elevated levels as far upstream as LFR04. Of the nearly 40 stations where data have been collected by both agencies, 40% of them have experienced elevated levels of fecal coliform bacteria. For stations with multiple years of data, the highest median concentrations were found at LFR11, LFR12, MS01, and MS02.

Table 3-4. Summary of fecal coliform data (cfu/100mL) collected by the NC Division of Water Quality.

Station	Start date	End date	Number of Samples	Median	%>43	Geometric Mean	%>400
ICW01	05/1995	07/2002	81	5	10	5	0
ICW03	07/1989	02/1995	39	1	3	2	0
ICW07	07/1989	07/2002	125	1	7	3	2
ICW08	08/1970	07/2002	191	1	8	4	2
LFR02	06/1973	11/1984	89	N/A	N/A	103	17
LFR03	07/1989	04/2005	160	N/A	N/A	95	9
LFR06	09/2002	04/2005	32	N/A	N/A	90	0
LFR11	07/1989	04/2005	161	20	29	15	1
LFR13	07/1989	07/2002	126	2	19	6	2
LFR14	07/1989	04/1995	32	1	13	4	0
LFR15	07/1989	04/1995	31	1	10	3	0
LFR19	07/1989	04/2005	72	1	8	3	0
LFR22	07/1989	04/1995	42	1	10	2	0
LFR23	07/1989	07/2002	114	1	7	2	1
MS01	05/1995	04/2005	112	39	48	29	2

Source: NCDWQ (2005).

Table 3-5. Summary fecal coliform data (cfu/100mL) collected by the NC Division of Environmental Health, Shellfish Sanitation Section.

Summary station #	Start date	End date	Number of Samples	Median	%>43	Geometric Mean	%>400
ICW02	03/1993	06/2005	74	12.0	16.2	11.0	1.4
ICW04	03/1993	06/2005	74	6.8	8.1	7.5	0.0
ICW06	03/1993	06/2005	74	4.5	9.5	5.8	0.0
LFR12	03/1993	06/2005	74	17.0	31.1	14.7	1.4
LFR15	07/2004	06/2005	10	4.5	10.0	6.6	0.0
LFR17	07/2004	02/2005	6	1.9	0.0	3.0	0.0
LFR18	07/2004	06/2005	10	3.3	0.0	3.8	0.0
LFR20	07/2004	06/2005	10	3.3	0.0	3.9	0.0
LFR21	07/2004	06/2005	10	2.0	0.0	3.2	0.0
LFR24	03/1993	06/2005	74	4.5	9.5	6.2	0.0
LFR25	03/1993	06/2005	74	4.5	9.5	6.5	0.0
MS02	03/1993	06/2005	74	17.0	14.9	16.7	0.0
MS03	07/2004	06/2005	10	12.0	0.0	10.8	0.0
MS04	03/1993	06/2005	74	7.8	13.5	9.6	0.0
MS05	07/2004	06/2005	10	3.0	0.0	3.3	0.0
MS06	03/1993	06/2005	74	4.5	8.1	6.2	0.0
Special study locations							
LFR03	02/2005	08/2005	11	N/A	N/A	143.2	9.1
LFR04	04/2005	08/2005	10	N/A	N/A	194.9	20.0
LFR05	02/2005	08/2005	11	N/A	N/A	126.8	18.2
LFR07	04/2005	08/2005	10	N/A	N/A	96.6	20.0
LFR08	02/2005	08/2005	11	N/A	N/A	96.3	18.2
LFR09	02/2005	08/2005	11	N/A	N/A	99.2	9.1
LFR10	04/2005	08/2005	10	N/A	N/A	71.7	0.0
LFR11	02/2005	08/2005	11	49	72.7	47.4	0.0
TR03	06/2005	08/2005	6	205	100.0	216.7	16.7

Source: NCDWQ (2005).

3.3 ADDITIONAL SCOPING LEVEL ASSESSMENT

One of the programmatic goals of NCEEP is to provide a consistent and streamlined approach to address compensatory mitigation requirements associated with Section 401 and 404 permits issued by NCDWQ and the US Army Corps of Engineers. To meet this goal, NCEEP accepts payments and performs mitigation on behalf of permit applicants such as NCDOT. The LWP is used to focus compensatory mitigation projects in areas with the greatest need for ecological restoration.

Initial evaluations of restoration need and opportunity by NCEEP resulted in a focus in the 14-digit hydrologic units, or portions thereof, within the Lockwoods Folly River watershed. The following discussion presents an initial screening to identify potential restoration opportunities within this watershed and provides a basis to select further focus areas for subsequent phases of the local watershed planning effort.

The initial screening focuses on three lines of evidence: (1) evaluating subwatershed impervious surface levels, (2) identifying streams vulnerable to channel erosion and buffer vegetation disturbance and (3) prioritizing wetland restoration and enhancement sites. Additional assessment was performed to evaluate coastal shoreline restoration. All of these assessments were supplemented with field reconnaissance and a review of high-resolution aerial photography.

3.3.1 Subwatershed Imperviousness

The LWP subwatersheds (Figure 2-2) were ranked based on the percentage of impervious surfaces contained within each. Impervious surface cover (IC), including roads, parking lots, sidewalks, rooftops, and other impermeable surfaces, is a useful indicator for understanding the impacts of development. Increases in the amount of imperviousness in a watershed are associated with increases in the volume and velocity of stormwater and an increase in pollutant loading.

The Center for Watershed Protection's impervious cover model (ICM) indicates that streams are likely to be adversely impacted when impervious cover (IC) within their watershed reaches 10 percent or more, and that the level of degradation becomes significantly more likely and more severe at IC levels of 25 percent or more (Schueler, 1994). The Center reviewed 225 research studies that measured a number of indicators of stream health relative to the amount of IC (Schueler, 2003). The review reaffirmed that IC in the ranges of 10-25 percent imperviousness is a strong predictor of stream degradation, and at levels of 25 percent or more, degradation was almost inevitable. While IC is a more robust and reliable indicator of overall stream quality beyond the 10% IC threshold, several studies cited in Schueler (2003) documented stream degradation at levels of watershed imperviousness below the 10 percent threshold.

The 2001 NLCD Impervious Surface Coverage, which represents 1999-2003 imagery and land cover based on Landsat 7 data (MRLC, 2005) for the study area, was converted to a 30-m grid with cell values ranging from zero (no impervious surfaces) to 100 (complete imperviousness).

The mean ISC within each subwatershed is presented in Figure 3-5. Areas of highest ISC are located in the vicinity of Varnamtown, Oak Island, and St. James. A few of these subwatersheds are approaching or exceeding the 10% threshold in overall impervious cover, and subcatchments within them likely exhibit significantly higher levels.

Since there is no subwatershed that coincides with the Town of Oak Island municipal limits, an analysis of imperviousness within the island portion of the Town of Oak Island was conducted. Excluding consideration of land area covered by waterbodies and wetlands, the recent imperviousness was 19.8%.

3.3.2 Stream Channel Erodibility

Erodibility of riparian soils plays a role in the risk of channel erosion along a given stream segment. The erodibility of soils within the riparian zone of a given stream segment was assessed using an area-weighted average soil erodibility (*k*) factor within the stream buffer polygon.

Polygons were developing surround streams representing a 30-meter buffer on each side of perennial stream segments contained within the 1:24000 hydrography coverage of the study area (NCCGIA, 2001). The 167 stream segment polygons ranged in length from 326 to 4907 meters. The average polygon length was 1760 meters or 1.1 miles.

The *k* factors were obtained from tabular data available from the Natural Resources Conservation Service joined to the SSURGO county level soil coverages (NRCS, 2004). Values were limited to those from the H1 (top layer) horizon. In addition, *k* factors were area-weighted based on the soil components within each soil map unit and area-weighted within individual stream segment polygons.

The results of the soil erodibility analysis indicate a relatively low risk of stream erosion throughout the watershed with most values less than 0.20 (Figure 3-6). In lower portions of the watershed, mostly along the Lockwoods Folly River, values of *k* rise slightly to low to moderate values of 0.21 to 0.27.

3.3.3 Assessment of Disturbed Riparian Vegetation

The next component of the screening process involved an analysis of streams and their vulnerability to degradation as a function of riparian vegetation disturbance using the stream polygons developed in section 3.3.2.

The level of riparian vegetation disturbance was assessed by combining two existing data sets: the 1992 Multi-Resolution Land Characteristics Consortium's National Land Cover Database (NLCD) representing 1992-1995 land cover based on Landsat 5 data (USGS, 2000) and the 2001 NLCD Impervious Surface Coverage. The 2001 NLCD land cover data had not been released for Brunswick County at the time of this analysis.

Combining the older land cover data with the more recent imperviousness data creates a more accurate representation of current land cover for this analysis. The data sets were converted to raster grids and the 30-m grid cells reclassified to indicate the presence or absence of a human altered or disturbed land cover type (impervious surfaces, residential and commercial development, cropland, pasture/hay fields, and transitional cover) within each stream segment polygon. The area within each polygon was then tabulated to calculate the percentage of cells in human-altered land cover types.

An examination of riparian vegetation suggests that there are a number of subwatersheds with elevated levels of buffer disturbance (Figure 3-7). Some of the areas of highest disturbance occurred in the subwatersheds of Doe Creek, Royal Oak Swamp, and the lower Lockwoods Folly River.

3.3.4 Potential Wetland Restoration or Enhancement Sites

Existing data generated by NCDCM were utilized to conduct the initial screening for wetland restoration or enhancement sites. NCDCM data products used for this step include Wetland Functional Significance Maps or NC-CREWS, and Potential Wetland Restoration and Enhancement Site Maps (NCDCM, 2003).

The GIS identification procedure used by NCDCM analyzed several layers of GIS data to identify degraded wetlands (for enhancement) and areas that formerly supported wetlands (for restoration). This existing data provides the foundation for an initial screening of wetland restoration or enhancement sites.

Restoration sites include areas that have been drained and may or may not have been cleared. In addition, areas identified by the National Wetlands Inventory (NWI) as being located in an excavated channel or basin are included in this category. Sites that have been ditched but not cleared, managed pinelands, and areas identified by the NWI as being impounded fall within the enhancement category.

One of the measures contained within the NC-CREWS data set that can be considered is Potential Risk. While the measure is not used to determine a wetland's functional significance, it provides an estimation of the relative risk to watershed integrity posed by a specific wetland's loss. More than 95% of enhancement sites had a moderate to high risk. Therefore, additional screening for risk was not performed.

Based on existing EEP criteria, sites that were less than 5 acres were excluded. Managed pinelands were also excluded except for those identified in the NC-CREWS data set as being drained or partially drained. The exclusion of managed pinelands is based on the assumption that such areas represent lower priority enhancement.

Results of this initial wetland screening are presented in Figure 3-8. Areas in the upper and southeastern portions of the watershed have the most potential for restoration and enhancement in terms of total site area.

3.3.5 Coastal Shoreline Marsh Restoration

Many developed shoreline areas along the lower Lockwoods Folly River and the ICWW have been hardened to prevent erosion with shoreline stabilization structures such as bulkheads. These hardened structures contribute to the loss of marsh areas, potentially impacting species such as penaied shrimp (*Penaeus sp.*), red drum (*Sciaenops ocellatus*), and others. NCEEP has an interest in restoring these areas where feasible and promoting the creation of shoreline marsh.

The North Carolina Coastal Federation (NCCF) has a cost share program to encourage Living Shoreline projects along estuarine coasts. NCCF defines a living shoreline project as “an innovative approach that combines various stabilization methods to control shoreline erosion, while restoring and/or preserving the characteristics of the estuarine marshes and upland buffers.” The shoreline may consist of a low rock wall that absorbs energy with wetland vegetation behind it that serves as a stormwater buffer, reduces erosion, and restores habitat (NCCF, 2005)

Figure 3-9 shows vacant parcels that border coastal waterbodies and estuarine wetlands. This may present opportunity to promote the creation of non-hardened stabilization techniques and restoration or creation of shoreline marsh habitat. Groupings of vacant parcels along the ICWW and on the north side of Oak Island should be evaluated for opportunities through field visits and landowner contact. Vacant parcels were selected and identified to reflect the assumption that once a parcel has been built upon, the likelihood that a landowner will consider the elimination of hardened shoreline structures diminishes. One possible exception to this assumption is if the existing structure is malfunctioning or severely damaged.

3.3.6 Summary of Scoping Level Assessment

In figures 3-5, 3-7, and 3-8, the subwatersheds in the upper quartile of opportunity or risk have been highlighted. Subwatersheds with at least two parameters in the top quartile are summarized in Table 3-6 and mapped in Figure 3-10. The highest concentration of these subwatersheds is located within the middle and lower Lockwoods Folly River. Another notable area is the Doe Creek subwatershed, which contains the NC 211 and US 17 intersection.

The subwatersheds highlighted in Figure 3-10 are likely to represent areas where the greatest numbers of restoration opportunities exist for the NCEEP. However, the existence of such opportunities will have to be verified through onsite investigations of feasibility and determination of landowner interest.

Table 3-6. Lockwoods Folly subwatersheds with the highest opportunity for restoration or enhancement.

Subwatershed	Primary Waterbody	Existing Imperviousness	Buffer Disturbance	Potential Wetland Restoration
LL1	Ut to Lower Lockwoods Folly River	√	√	√
DC1	Doe Creek	√	√	
FS1	Fall Swamp		√	√
IW6	Intracoastal Waterway	√	√	
LL3	Lower Lockwoods Folly River	√	√	
LL4	Lower Lockwoods Folly River	√	√	
LL5	Spring Creek	√	√	
LL6	Lower Lockwoods Folly River	√	√	
ML4	Sandy Branch	√	√	
SB2	Ut to Lockwoods Folly River		√	√
ML6	Middle Lockwoods Folly River	√		√
OI1	Oak Island Beach	√		√

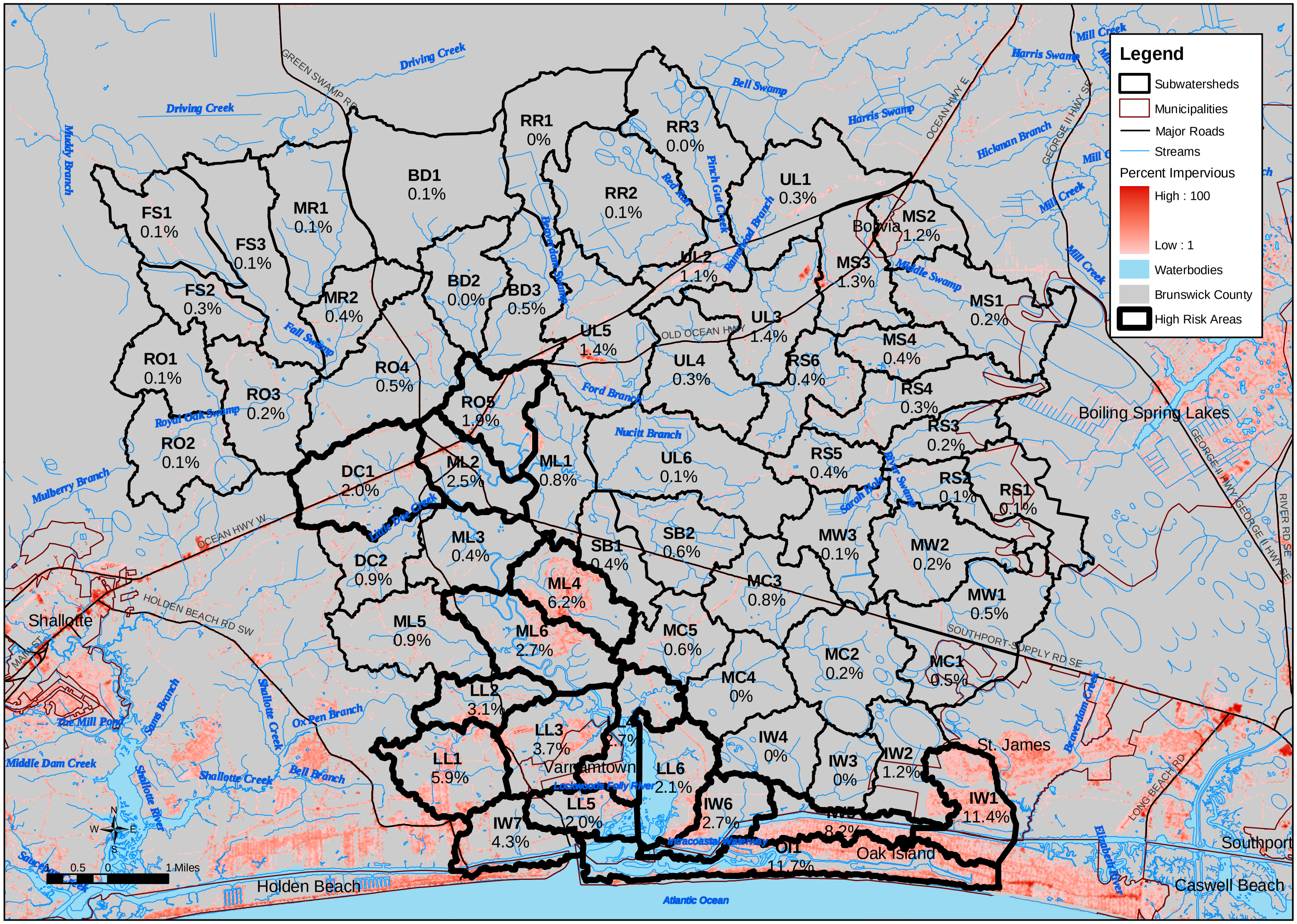


Figure 3-5. Imperviousness within subwatersheds of the Lockwoods Folly River.

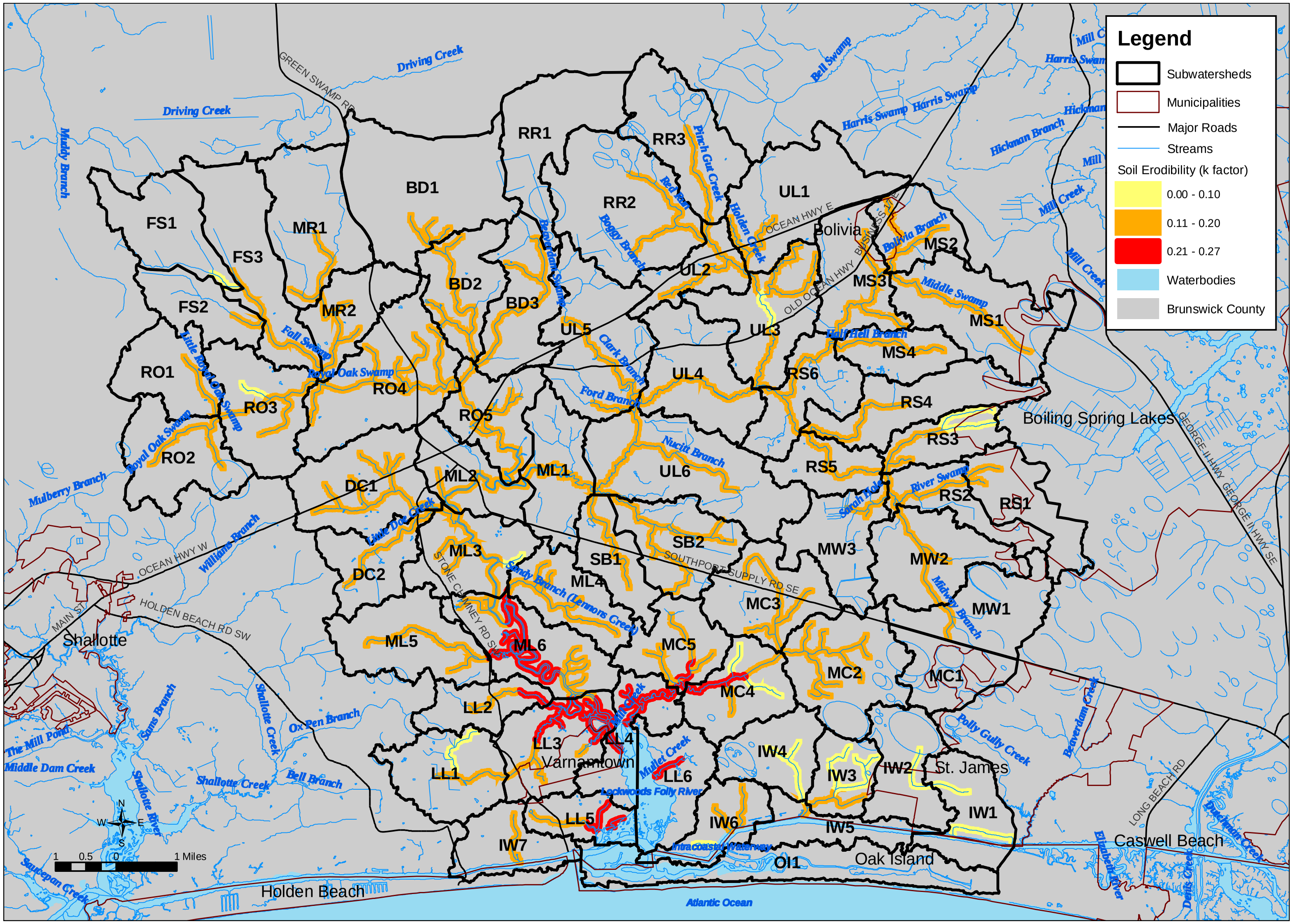


Figure 3-6. Erodibility risk of riparian areas within the Lockwoods Folly River watershed.

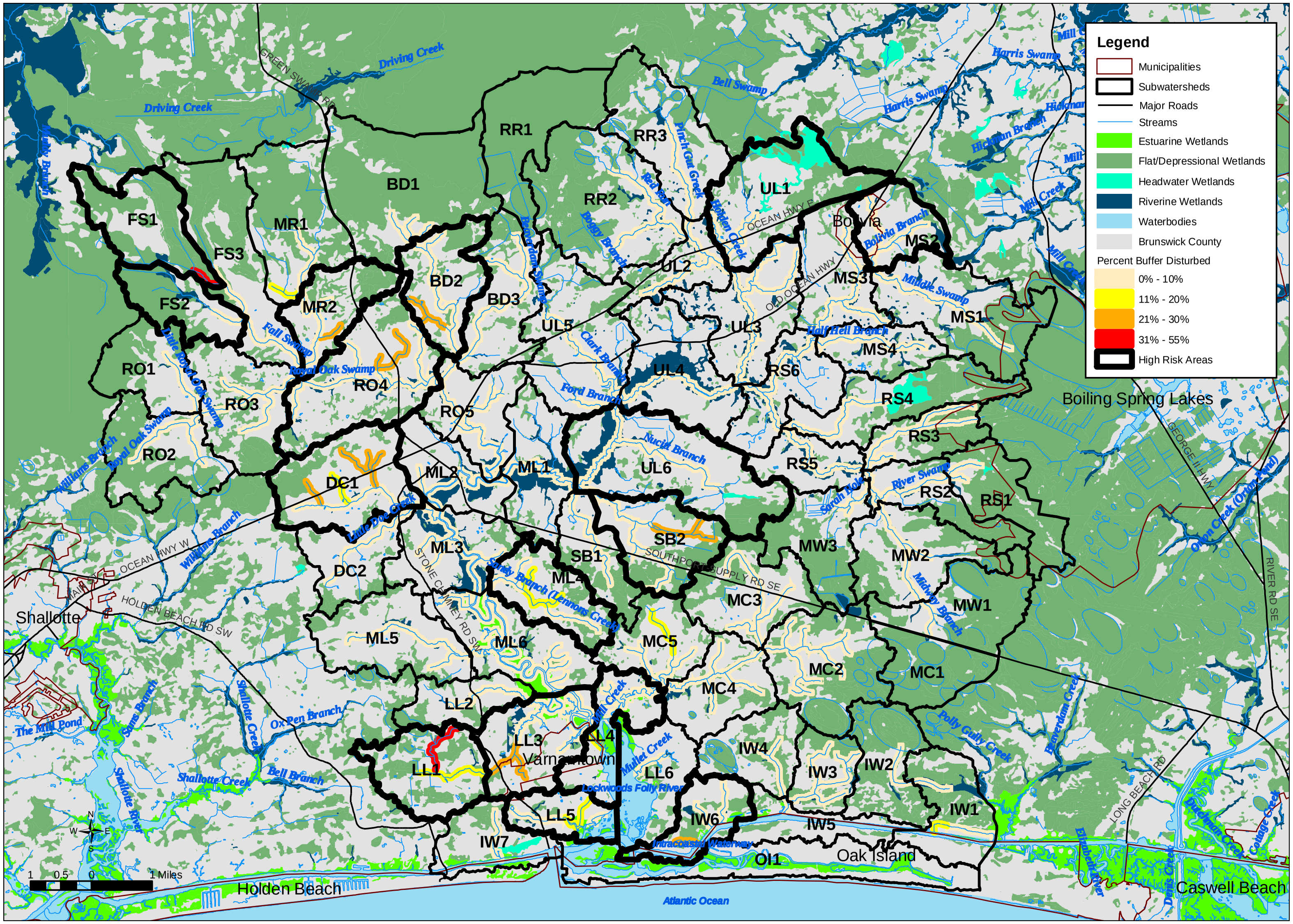


Figure 3-7. Assessment of disturbed riparian vegetation in the Lockwoods Folly River watershed.

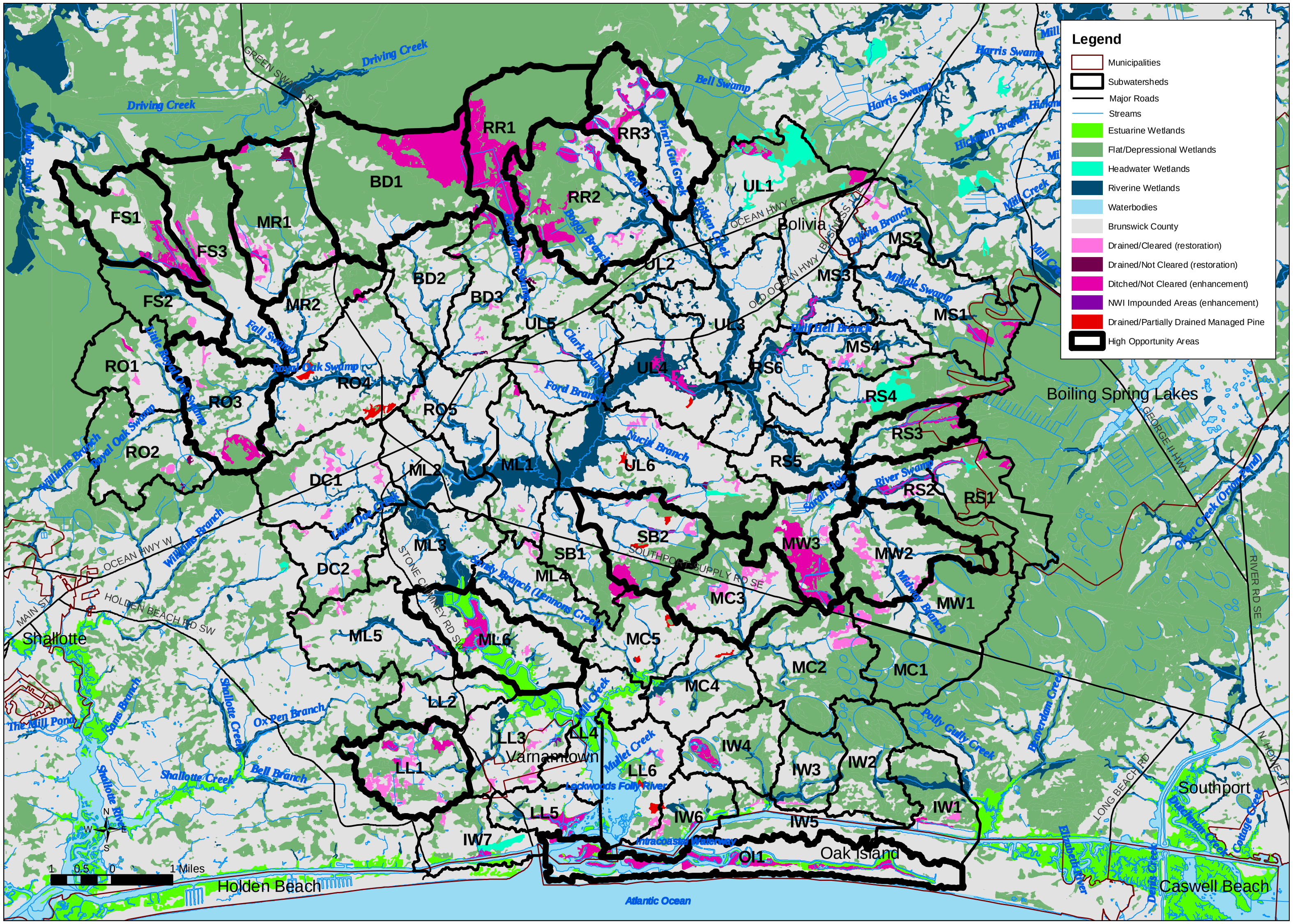


Figure 3-8. Potential wetland restoration and enhancement sites within the Lockwoods Folly River watershed (NC_CREWS).

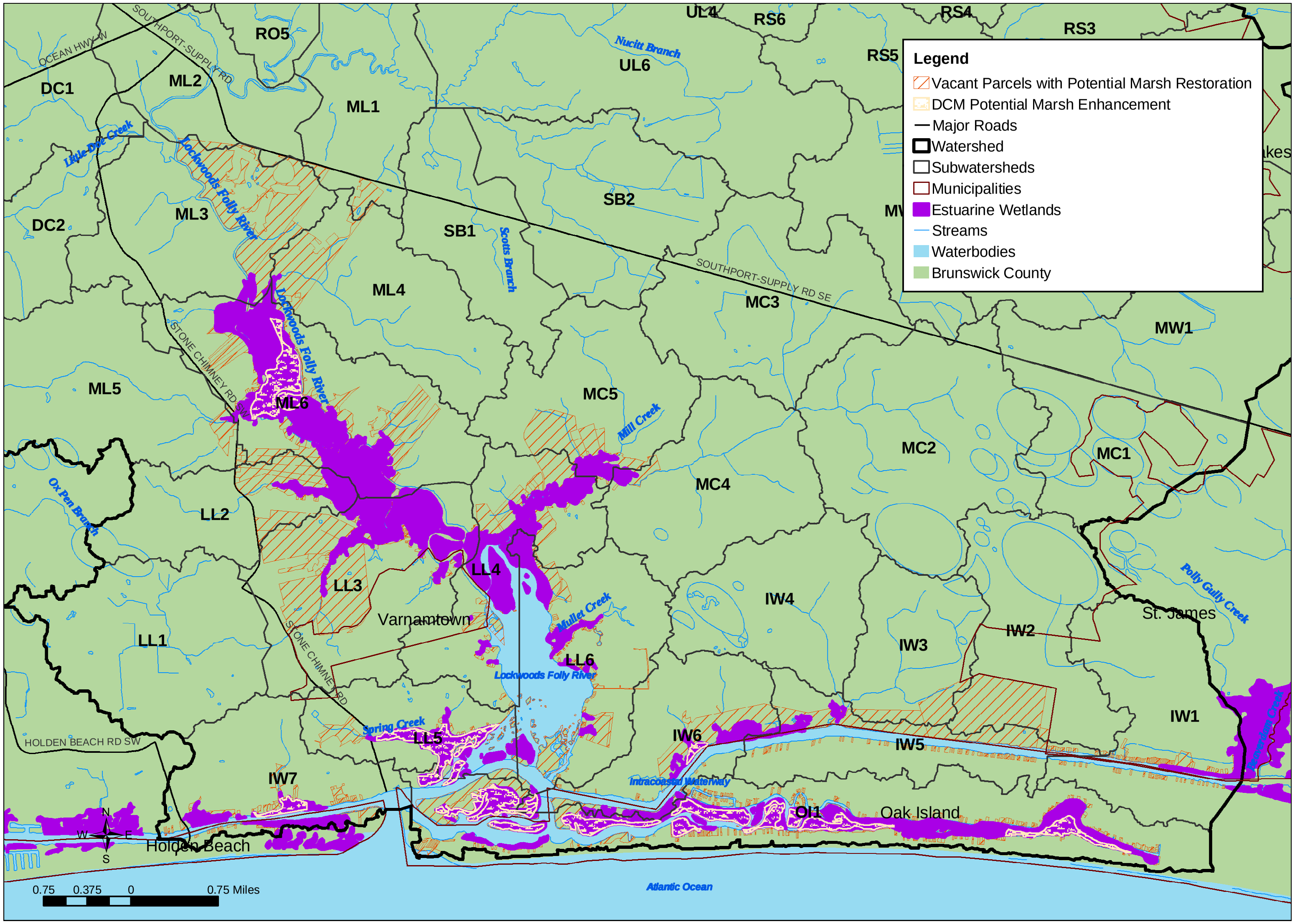


Figure 3-9. Potential coastal shoreline restoration sites within the Lockwoods Folly River watershed.

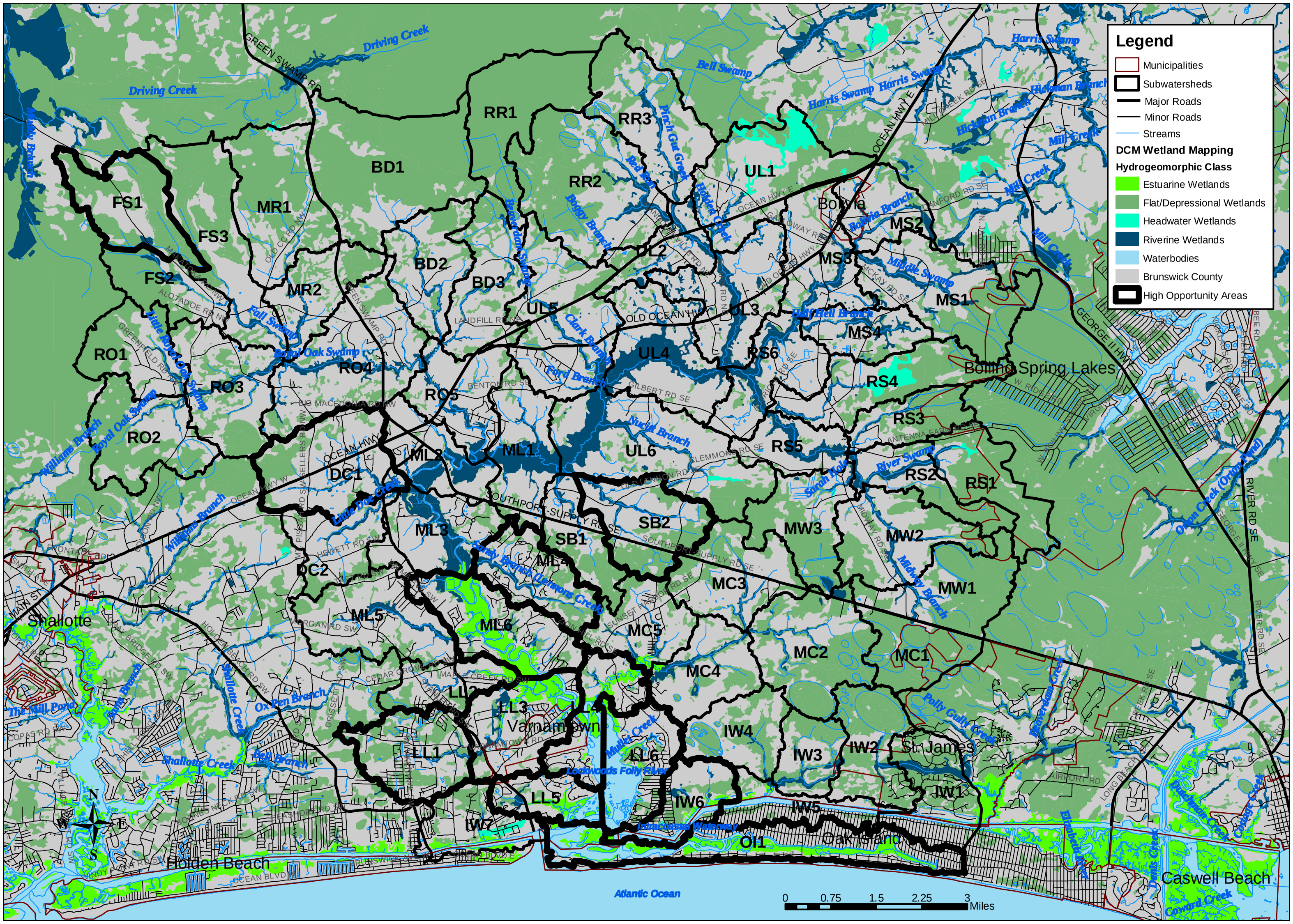


Figure 3-10. High risk or restoration opportunity subwatersheds within the Lockwoods Folly River watershed.

3.3.7 Preliminary Watershed Reconnaissance and Site Assessment

Staff from Stantec and the NCEEP conducted watershed reconnaissance on August 23 and 24, 2005.

Staff toured the Town of St. James, a growing community largely centered around planned developments and golf courses. Development of new residential housing and golf courses is continuing at a fast pace in this newly formed town (Photograph 3-1).

The prior development team connected with St. James was fined $250,000 in the late 1990's for ditching and draining large Carolina Bays in the area. Though the developer was required to block off key sections of the canals as part of the settlement, most of the drainage ditches and canals were not completely back filled (Photograph 3-2; Figure 3-11).

Reconnaissance of shoreline areas in St. James and Oak Island found that while some shoreline areas remain intact with healthy marsh habitat (Photograph 3-3), many of the developed lots bordering the ICWW are hardened with bulkheads or rock riprap (Photograph 3-4). Similarly, many shoreline sites along the Lockwoods Folly River are being developed (Photograph 3-5).

The Town of Oak Island has also experienced a considerable amount of growth in recent years. Reconnaissance indicated continuing development, though a number of vacant lots are still present.

Large areas of wetlands on Oak Island are potentially degraded according the NCDCM Potential Wetland Restoration and Enhancement site maps due to their proximity to channelized navigation canals (Figure 3-8). However, field reconnaissance found no visible signs of widespread disturbance in these areas. Similarly, NCDCM site maps suggest that large areas of pine plantations in the northwest portion of the watershed are degraded. However, many of these tracts may have been classified as degraded due to pine tree harvesting, a temporary loss of cover.

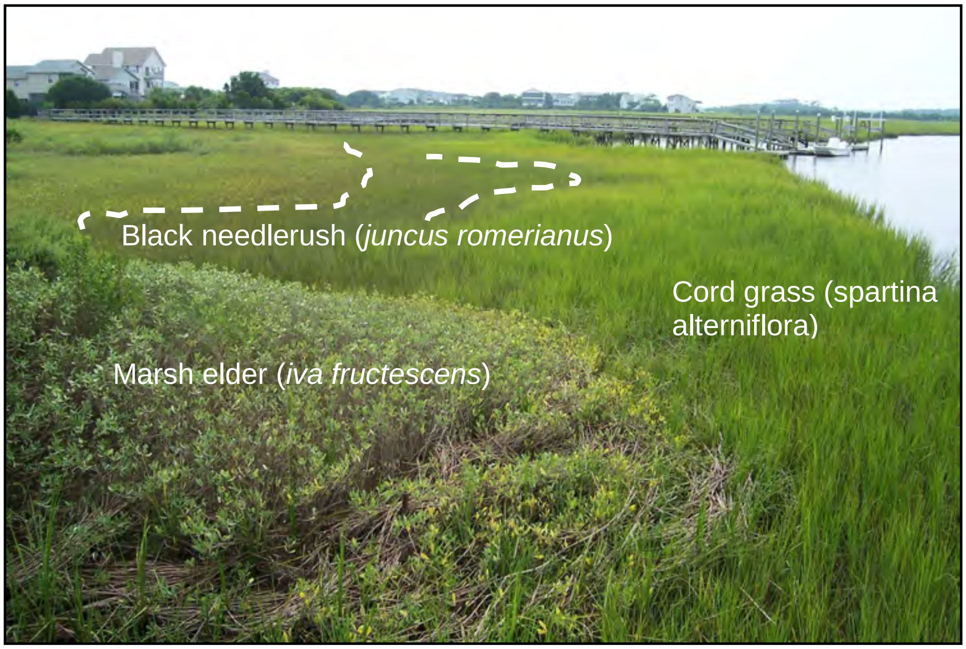
A tour of other mainland portions of the watershed confirmed many of the problem areas indicated by the scoping level analysis using data derived from satellite imagery. Some of these observations are briefly described below:

- Stream channel incision at the outlet of Mullet Creek possibly due to upstream development and an impoundment above Island Drive in the River Run community.
- Stream channel incision and a disturbed riparian buffer along an unnamed tributary in subwatershed LL1 (Sea Shrimp Rd.).
- A wooded wetland site with a freshly cut ditch adjacent to agricultural fields in subwatershed DC1 (Photograph 3-6).
- Buffer disturbance in SB2 adjacent to residential lot and agricultural fields.

- Stormwater pipe discharging into the Lockwoods Folly River (Photograph 3-7).
- Lack of wooded riparian buffer in a residential neighborhood (Photograph 3-8).

Photograph 3-1. Golf course and planned unit development activity in St. James.

Photograph 3-2. Drainage canal in a Carolina Bay near St. James.



Photograph 3-3. Natural shoreline marsh along the ICWW on Oak Island.

Photograph 3-4. Hardened shoreline on the Intracoastal Waterway in St. James.

Photograph 3-5. Development activity along the eastern side of the Lockwoods Folly River.

Photograph 3-6. Ditching of a wooded wetland area in subwatershed DC1.

Photograph 3-7: Stormwater pipe discharging into the Lockwoods Folly River.

Photograph 3-8: Disturbed riparian buffer in a residential neighborhood near Varnamtown.

Figure 3-11. Aerial photography of a Carolina Bay impacted by ditching.

3.4 TERRESTRIAL AND AQUATIC HABITAT QUALITY

The Lockwoods Folly River watershed is located within the Middle Atlantic Coastal Plain level III ecoregion (Griffith et al., 2002) and contains the following level IV ecoregions: Carolina Flatwoods (63h), Carolinian Barrier Islands and Coastal Marshes (63g), and the Nonriverine Swamps and Peatlands (63c).

3.4.1 Significant Natural Heritage Areas

The North Carolina Natural Heritage Program identifies areas that have outstanding conservation value due to the presence rare or endangered species, or the existence of an excellent, intact ecological community. Sites within the study area including those that are protected from development (Figure 3-12) and descriptions from NCNHP (2005) are provided below:

- Big Cypress Bay and Ponds is a regionally significant site comprised of two overlapping Carolina bays and adjacent lime sink depressions. American alligator and anhinga are known from the area, as well as five rare plant species. The site is privately owned

- Boiling Spring Lakes Wetland Complex is a nationally significant, 23,000-acre site that contains an outstanding mosaic of community types in fair to excellent condition over a large contiguous area. The natural communities include most of the known distribution of a rare Wet Pine Flatwoods variant and a rare Pine Savanna variant. There are many Carolina bays overlain on relict dune ridges; these features are known to occur together in only five locations. The Federal and State Endangered red-cockaded woodpecker occurs in longleaf pine communities at this site. Twenty-one rare plant species are known from the area, including the Federal and State Endangered rough-leaf loosestrife, the State Endangered Carolina goldenrod, and the State Threatened savanna indigo-bush. The NC Department of Agriculture's Plant Conservation Program owns a portion of the site.

- Fall Swamp – Middle River Limesink Complex is regionally significant because its sinkholes support good quality Small Depression Pond and Small Depression Pocosin communities. These provide habitat for seven rare plants. This site is privately owned.

- Green Swamp is nationally significant, as this 17,800-acre site contains extensive areas of high quality savanna, flatwoods, and pocosin habitat. The Pine Savanna has a per acre species richness that is among the highest in temperate North America. Twenty-four rare plants and 19 rare animals are known from the site. In addition, Green Swamp is on a large, broad flat terrace at a higher elevation than the surrounding area, and headwaters for streams to the Waccamaw, Cape Fear, and Lockwoods Folly River systems are found here. The rare plants include the Federal and State Endangered rough-leaf loosestrife; the State Endangered golden crest, Carolina grass-of-parnassus, and Carolina goldenrod; and the State Threatened savanna indigo-bush and yellow fringless orchid. The rare animals include the Federal and State Endangered red-cockaded woodpecker; as well as the Cape Fear threetooth, Bachman's sparrow, and Henslow's sparrow. The Nature Conservancy owns the majority of the site.

- Spring Creek Ponds is a state significant site comprised of a flat upland terrace with lime sink depressions. Excellent quality Small Depression Pond natural communities occur in the depressions. The uplands support a mosaic of sandhill and maritime forest, including one of the best known examples of the rare Coastal Fringe Evergreen Forest. This site is privately owned.

- Sunset Harbor/Ash Swamp has state significance. This 300-acre site contains low upland terraces with Coastal Fringe Sandhill community that is intersected by swamp forest. Coastal Fringe Evergreen Forest occurs in moist sands along the edges of the upland terraces. Vernal Pools are found in depressions within the sand hill community. This site is privately owned.

- Lockwoods Folly River Tidal Wetlands is state significant because it contains one of the three known Tidal Freshwater Marsh (Freshwater Variant) natural communities with a cypress-gum canopy. The site provides exceptional scenic value along three miles of the Lockwoods Folly River. American alligators are known from the area, as well as the rare plant drooping bulrush. The site is privately owned. The NC Coastal Land Trust through funding from the Clean Water Management Trust Fund (CWMTF) has acquired a 150-acre tract.

- Juniper Creek Floodplain is a state significant site of mostly interrupted swamp owned by the NC Wildlife Resources Commission and private landowners. It is located on the northwest border of the watershed, adjacent to Green Swamp. Most of the site is not within the study area.

- Sites of local significance are Middle Swamp, Prospect Ridge White Cedar Forest, and Cumbee Pond and Sandhills. All sites are privately held.

3.4.2 Natural Heritage Element Occurrences

The Natural Heritage Element Occurrences GIS coverage identifies occurrences of plants, animals, exemplary or unique natural communities, and important animal assemblages (Figure 3-12). Collectively, these plants, animals, natural communities, and animal assemblages are referred to as "elements of natural diversity" or simply as "elements". Specific occurrences of these elements are referred to as "element occurrences".

The federally listed endangered species within the study area are the Red-cockaded Woodpecker, the West Indian Manatee, and the wetland vascular plant, Rough-leaf Loosestrife. Federally threatened species are the Piping Plover, American Alligator, Bald Eagle, and the terrestrial plant, Seabeach Amaranth.

State listed threatened and endangered species include those that are federally-listed and the following: one invertebrate (Cape Fear Threetooth), three vertebrates (Eastern Coral Snake, Eastern Diamondback Rattlesnake, Carolina Gopher Frog), and four vascular plants (Carolina Grass-of-parnassus, Savanna Indigo-bush, Snowy Orchid, Yellow Fringeless Orchid). Protected areas that contain these elements include the Green Swamp Preserve, a 36-acre, CWMTF acquisition adjacent to the Lockwoods Folly Inlet, and the CWMTF acquisition along the middle Lockwoods Folly River.

Natural community occurrences document a distinct and reoccurring assemblage of populations of plants, animals, bacteria, and fungi naturally associated with each other and their physical environment. Fifteen different communities are located within the study area and are contained within Significant Natural Heritage Areas, as described above.

Taken collectively the NC Natural Heritage Program data illustrate that the Lockwoods Folly River watershed is an extremely valuable collection of rare, regionally, and even nationally important habitats and species.

3.4.3 NC GAP Data

The North Carolina Gap Analysis Project (NCGAP) is the state level representative of the National Gap Analysis Program sponsored by the Biological Resources Division of the United States Geological Survey. The project is derived from the understanding that a species-by-species approach to conservation is not effective because it does not address the continual loss and fragmentation of natural landscapes. Only by protecting regions already rich in habitat, can we adequately protect the animal species that inhabit them.

NCGAP provides maps of land cover; predicted distributions of terrestrial vertebrate species, and vertebrate species and land cover types in areas managed for the long-term maintenance of biodiversity. The development of a spatial database of predicted species distributions throughout the state is ongoing. A summary of NCGAP land cover for the watershed is presented in Table 3.7. Note the discrepancy between the total agriculture land in Table 3-7 (16.6%) and Table 2-1 (9%). This discrepancy most likely rests with differences in analysis of the satellite imagery data. The base satellite imagery is from the same time period in both data sets.

3.4.4 Nursery Areas

Salt marshes and estuaries along the coast serve as nursery grounds for most of North Carolina’s fisheries. North Carolina designates nursery areas to protect these fragile ecosystems. The NC Division of Marine Fisheries (NCDMF) is charged with protection of these designated areas. There are three categories of nursery areas in coastal waters:

<u>Primary Nursery Areas</u> are located in the upper portions of creeks and bays. These areas are usually shallow with soft muddy bottoms and surrounded by marshes and wetlands. Low salinity and the abundance of food in these areas are ideal for young fish and shellfish. To protect juveniles, many commercial fishing activities are prohibited in these waters; including the

use of trawl nets, seine nets, dredges or any mechanical methods used for taking clams or oysters.

Secondary Nursery Areas are located in the lower portions of creeks and bays. As they develop and grow, young fish and shellfish, primarily blue crabs and shrimp, move into these waters. Trawling is not allowed in these areas.

Special Secondary Nursery Areas are located adjacent to Secondary Nursery Areas but closer to the open waters of our sounds and the ocean. The majority of the year when juvenile species are abundant, these waters are closed to trawling.

Fishery nursery areas including important shrimp nurseries (Carpenter, 2005) are located within the study area in the Lockwoods Folly River, Little Doe Creek, Doe Creek, Mill Creek, Pamlico Creek, Davis Creek canal, and several unnamed tributaries (Figure 3-12).

Table 3.7. Summary of NCGAP land cover in the Lockwoods Folly River watershed.

Category	Habitat	Acres	Percent of Total
Agriculture	Agricultural Crop Field	12517	12.8%
Agriculture	Agricultural Pasture/Hay and Natural Herbaceous	3681	3.8%
Barren	Barren; quarries, strip mines, and gravel pits	240	0.2%
Barren	Ocean Beaches	92	0.1%
Barren	Barren; bare rock and sand	16	0.0%
Coastal Plain	Coastal Plain Mixed Bottomland Forests	4248	4.3%
Coastal Plain	Coastal Plain Nonriverine Wet Flat Forests	3475	3.5%
Coastal Plain	Coastal Plain Oak Bottomland Forest	1373	1.4%
Coastal Plain	Coastal Plain Fresh Water Emergent	15	0.0%
Coastal Plain	Coastal Plain Dry to Dry-Mesic Oak Forests	8	0.0%
Forest Coniferous	Coniferous Cultivated Plantation (natural / planted)	18227	18.6%
Forest Coniferous	Xeric Longleaf Pine	11470	11.7%
Forest Coniferous	Mesic Longleaf Pine	6178	6.3%
Forest Deciduous	Successional Deciduous Forests	1564	1.6%
Forest Mixed	Dry Mesic Oak Pine Forests	1862	1.9%
Human Dominated	Residential Urban	1022	1.0%
Human Dominated	Urban High-Intensity Developed and	555	0.6%
Human Dominated	Urban Low-Intensity Developed	32	0.0%
Maritime	Tidal Marsh	2224	2.3%
Maritime	Maritime Forests and Hammocks	1153	1.2%
Maritime	Maritime Grasslands	297	0.3%
Maritime	Maritime Scrubs and Tidal Shrublands	185	0.2%
Maritime	Tidal Swamp Forest	105	0.1%
Piedmont	Coastal Plain Mixed Successional Forest	2858	2.9%
Shrub Coniferous	Coniferous Regeneration	4276	4.4%
Water	Open water	1901	1.9%
Wet Forest	Pocosin Woodlands and Shrublands	16385	16.7%
Wet Forest	Cypress-Gum Floodplain	1247	1.3%
Wet Forest	Seepage and Streamhead	631	0.6%
Wet Forest	Peatland Atlantic White-Cedar Forest	69	0.1%
Wet Forest	Pond-Cypress - Gum Swamps, Savannas and	21	0.0%
Wet Forest	Wet Longleaf or Slash Pine Savanna	5	0.0%

3.4.5 Coastal Habitat Protection Plan

The Lockwoods Folly River has an active commercial fishery for clams, flounder, crabs, and mullet (Carpenter, 2005). The North Carolina Coastal Habitat Protection Plan (CHPP) identifies threats and recommends management actions to protect and restore habitats critical to North Carolina's coastal fishery resources (Street et al., 2005).

The primary focus of the plan is describing habitats for coastal fisheries resources in eastern North Carolina, threats to those habitats, and management actions to address those threats. The CHPP development process identified hundreds of management needs. The members of the three state Commissions selected four general goals, listed below, and a series of recommended actions to reach each goal.

1) Improve effectiveness of existing rules and programs protecting coastal fish habitats

2) Identify, designate, and protect all Strategic Habitat Areas

3) Enhance habitat and protect it from physical impacts

4) Enhance and protect water quality

The CHPP is built around six basic habitats utilized by coastal fishery species: water column, shell bottom, submerged aquatic vegetation (SAV), wetlands, soft bottoms, and hard bottoms.

The plan presents a method for identifying Strategic Habitat Areas (SHAs), areas that contribute disproportionately more to the viability of fishery and forage stocks, and populations of protected species. While some of the areas are known (i.e., PNAs), many are unverified. Location and delineation of these areas is to be addressed in the eleven Management Unit plans following adoption of the CHPP. There are no designated SHAs in North Carolina at this time.

The plan discusses threats contributing to the degradation and loss of wetlands and provides recommendations for protection and enhancement of these habitats. While ditching and draining of wetlands due to new development has accounted for much of the permitted wetland loss in recent years, smaller, site-specific losses from infrastructure and water-dependent development contribute, cumulatively, to large losses as well.

Threats to fish habitat identified below were discussed throughout the plan as they apply to each coastal fish habitat. Broad categories are discussed below.

- Fishery-related dredging: Effects include uprooting vegetation, breaking physical structures, and digging and suspending sediment.

- The cumulative effects of increasing boater access facilities and associated boating activities are a concern due to documented negative impacts from operation of individual boats and access facilities. Some effects include disturbance and removal of sediment, changes in currents, and degradation/loss of wetlands and SAV.

- The increasing modification of natural shorelines to prevent or reduce landward migration of the shoreline (a natural process) is a major concern. These modifications often result in loss of wetlands and shallow water habitats, reduced fish diversity and abundance, and changes in runoff patterns.

- Nonpoint source (NPS) pollution: Some impacts include reduced availability of dissolved oxygen, reduced water clarity, and excessive nutrients that trigger algal blooms. Increases in stormwater can also threaten the salinity regime of estuarine waters by reducing salinity levels. This may result in a reduction in the area of available habitat for shrimp, oysters, and other fisheries.

- Habitat loss: Sources of physical degradation and loss include dredging and draining of wetlands, conversion of habitat to impervious surfaces, installation of dams, culverts, bulkheads, and jetties.

- Shellfish harvest area closures: The increasing closure to harvest of shellfishing waters has been correlated with increasing coastal development and stormwater runoff. The presence of indicator bacteria is strongly correlated with presence of other pollutants and nutrients.

It is likely that SHAs will be identified within the Lockwoods Folly River watershed. Given that many of the threats to fish habitat identified in the CHPP are present and growing in the watershed (e.g., hardened shorelines, nonpoint source pollution, habitat loss, and shellfish area closure), many of the management recommendations identified are appropriate.

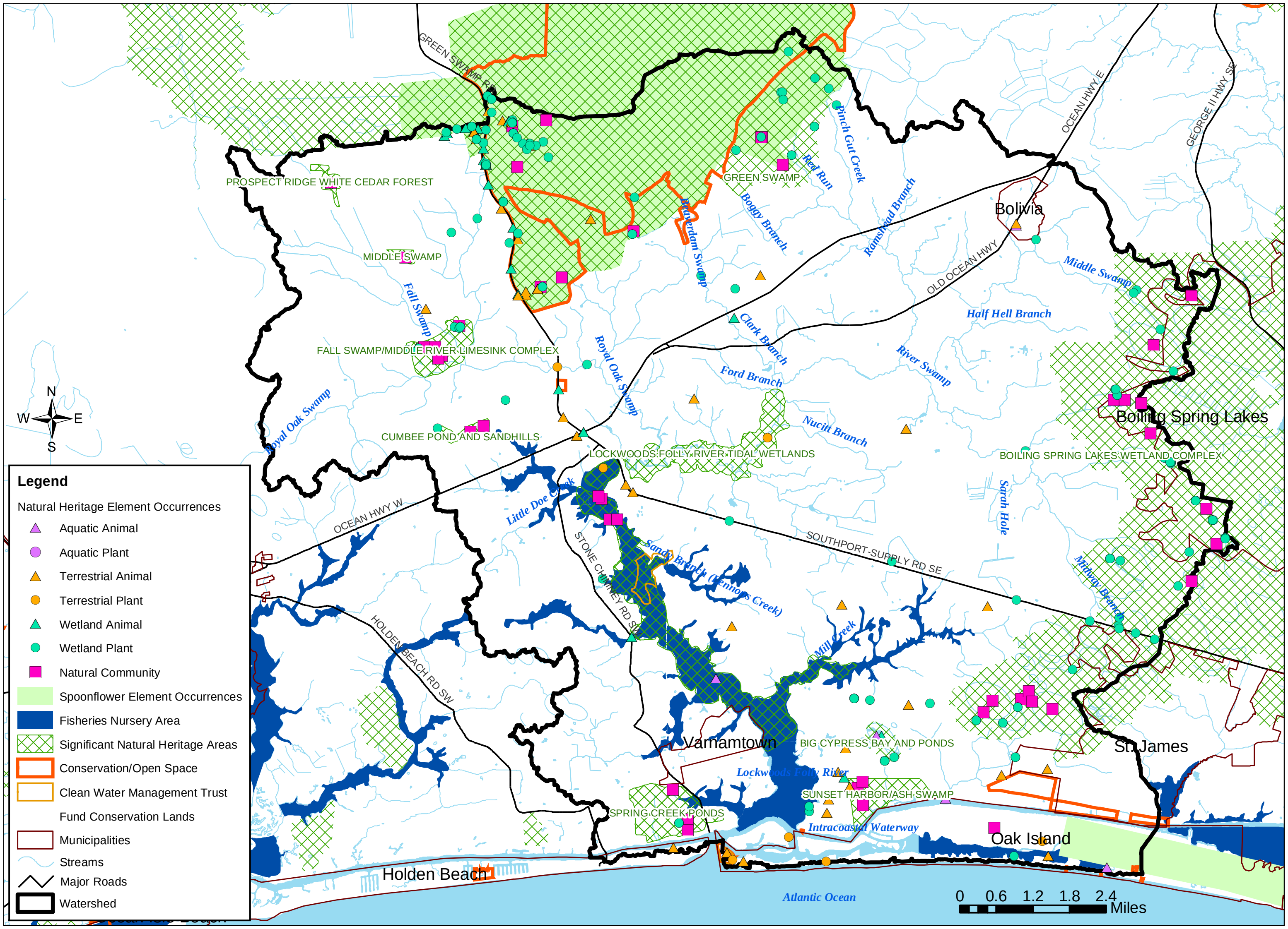


Figure 3-12. Significant terrestrial and aquatic habitat areas within the Lockwoods Folly River watershed.

3.5 LOCAL STUDIES AND PLANNING INITIATIVES

3.5.1 Lockwood Folly River Watershed Protection Demonstration Project

The North Carolina Coastal Federation and Brunswick County received a US Environmental Protection Agency grant for a demonstration project in the Lockwoods Folly River watershed.

The goal of the project is to prepare a watershed-based strategy to maintain and restore water quality in the watershed. The strategy will aim to promote land use practices that are compatible with the water quality and aquatic resources that are part of the natural heritage of Brunswick County. The objective is to demonstrate the use of watershed-based permitting of development through the Phase II NPDES stormwater permit as a tool to protect and restore water quality threatened by stormwater.

The project, which began in the spring of 2005, includes the following components: land suitability analysis, a watershed roundtable, evaluation of existing programs, pollution surveys and additional bacteria monitoring, fiscal impact analysis, outreach/education/training, land acquisition strategy, watershed-based permit, and demonstration of watershed-based management alternatives. The land suitability analysis uses existing GIS data layers such as soils, wetlands, streams, and parcel data to identify areas where the risk of future development could result in high impacts to water quality. In addition to the watershed-based permitting strategy, one of the primary goals of the project is to develop a strategy to acquire important properties within the watershed for protection and restoration of water quality.

The eight-member Watershed Roundtable consists of citizens and local decision-makers selected to represent the various community and economic interests in the watershed. Their objective is to recommend a model watershed strategy to the Brunswick County Board of Commissioners by the fall of 2006 that is consensus-based and consistent with the communities' values and aspirations.

3.5.2 US Army Corps of Engineers

3.5.2.1 Lockwoods Folly Numerical Circulation Study

The flushing rate (or residence time) is defined as the amount of time needed for a parcel of water and associated pollutants to travel through a waterbody. The flushing rate of an estuary is influenced by the water circulation, tidal range, freshwater or riverine input, and wind.

The Corps (1992) conducted a modeling study of water circulation and flushing in the estuary from 1991 to 1992. The primary objective of the study was to determine the impact of the AIWW on tidal flushing in the Lockwoods Folly Inlet area.

The study found that the cumulative flushing rate, determined by the time required for the estuary to be flushed to half of the initial concentration of a conservative tracer, was nearly 2 weeks. Though the model assumed no freshwater inflow, including this factor would likely contribute little to overall flushing considering that the dominant force contributing to circulation is tidal energy and that actual freshwater inflow is relatively low.

Further, the study concluded that a deepened channel around the southern part of Sheep Island and through the Eastern Channel or the removal of the ICWW would not increase overall flushing.

3.5.2.2 Public Participation Process Scoping Report

In 1998 the Wilmington District of the US Army Corps of Engineers (Corps) contracted with the Natural Resources Leadership Institute at North Carolina State University (NCSU) to conduct a public participation scoping study in the Lockwoods Folly River watershed (Addor et al. 1998). The scoping study is a component of the Corps' study of water quality problems in the Lockwoods Folly River. The objectives of the scoping study were to: (1) identify the primary and secondary stakeholders in the watershed; (2) identify and assess stakeholders' issues; (3) identify informational needs; and (4) examine the feasibility of creating a collaborative effort for investigating water quality concerns in the watershed.

Personal interviews of 36 stakeholders from the local area were conducted including community elders, other residents, fisherman, developers, local government officials, forest landowners, farmers, environmental advocates, and other businesses. Central issues of importance identified by respondents were divided into the following groupings: (1) river circulation, (2) growth and development, (3) existing sources of pollution, (4) aquatic resources including shellfish and finfish, (5) general water quality, (6) the Corps, (7) boating, (8) recreation and tourism, (9) beach erosion, (10) conservation and preservation, and (11) other miscellaneous issues.

The study indicates that respondents recognized that a water quality problem exists in the Lockwoods Folly River watershed. Perceptions of water quality, and the causes and solutions to the problems varied by respondent. There was an overall awareness of the need to share information and open up discussion. The NCSU team identified that an opportunity exists to bring the stakeholders together to participate in a collaborative process for determining an action plan for improving water quality in the watershed. However, a collaborative process with Corps and local stakeholders did not materialize.

3.5.2.3 Lockwoods Folly River Watershed/Ecosystem Study

The Corps (2000) developed a project study plan and feasibility cost share agreement for the Lockwoods Folly River Watershed/Ecosystem Study under a resolution adopted by the Committee on Transportation and Infrastructure of the U.S. House of Representatives in 1998. The plan was intended to be used to define and manage the development of a feasibility study for evaluating alternatives to address ecosystem and water quality problems in the Lockwoods Folly River watershed. However, a cost share agreement was never executed due to changes in budgetary priorities.

3.5.2.4 Lower Lockwoods Folly River Restoration Project

Deposition of sediment in the lower Lockwoods Folly River is believed to play a role in alterations of hydrology and aquatic habitat in the lower Lockwoods Folly River. In 2003, the Corps developed a preliminary restoration plan to address these concerns (Corps, 2003). The $1.4 million plan consists of dredging the Galloway Flats and the Eastern Channel to restore tidal circulation and placement of oyster clutches to establish oyster habitat. Although implementation of the project was scheduled for 2009, funding has not been made available to date and it is unclear if it will receive funding in the near future (NCDWR, 2005; Owens, 2005).

3.5.3 North Carolina State University Section 319 Project

In 2002, NCDWQ and the US EPA approved Clean Water Act Section 319 funding for a study in Brunswick County entitled, *Water Quality Impacts of Alternative Build-out Scenarios for Brunswick County*. The principal investigator for the project is James Tomlinson, Assistant Dean for Research, Extension and Engagement at the North Carolina State University College of Design. The ongoing project seeks to provide local decision makers with information regarding the water quality impacts of current development patterns versus alternative patterns such as low impact development (LID). LID is a site design strategy that seeks to maintain the predevelopment hydrologic regime through the use of best management practices and landscape design techniques.

4.0 Primary Threats to Watershed Functions and Detailed Assessment Objectives

The existing and emerging threats to watershed functions within the Lockwoods Folly LWP study area are discussed in the following sections.

From 1970 to 2000, Brunswick County's population grew an average rate of 45% during each decade, nearly three times greater than the state average. Most of this growth occurred in the county's beach communities, including Oak Island and St. James. Growth over the next 25 years is expected to continue at a high rate (Table 2-3). Areas south of highway 211, particularly along the lower Lockwoods Folly River, ICWW, and Atlantic Ocean are undergoing rapid development. Much of the upper portion of the watershed north of state highway 211 (Southport-Supply Rd) is relatively undeveloped.

Despite the differences in development experienced by these two regions of the watershed, they share common threats to watershed functions; only the magnitude of the threat is different. The lower watershed is of greater concern as demonstrated by the concentration of high risk subwatersheds (Figure 3-10).

4.1 THREATS IN URBANIZING AND RURAL SUBWATERSHEDS

Development and urbanization are accompanied by decreases in natural vegetative cover and terrestrial habitat, and increases in impervious surfaces, stormwater runoff, and pollutant loading. The following sections enumerate the stressors currently degrading watershed functions or those having the future potential to degrade watershed functions as a result of the trends in development.

4.1.1 Stressor: Pathogen Loading

Objectives for Detailed Assessment:

- Perform analysis to determine the most likely sources of fecal coliform.
- Assess existing and future fecal coliform loading scenarios to identify areas with the greatest loading potential.
- Identify and prioritize management needs and stormwater BMP retrofit opportunities.

Fecal coliform contamination has been the most important water quality concern in the watershed for more than two decades. Elevated bacteria concentrations are widespread, particularly in the lower half of the watershed (Table 3-4 and Table 3-5). Most of the shellfish waters are closed to harvesting (Figure 3-1). After large amounts of rain, the remainder of the SA waters are closed temporarily.

Improperly functioning septic systems and stormwater runoff are the likely primary causes of current impairment of Lockwoods Folly River but their relative contributions are not known. While pathogen loading has been a persistent problem for many years, future development has the potential to further exacerbate that problem. Increases in stormwater from new development may contribute to higher loads of fecal coliform without proper management. Aside from septic systems, development-related sources of fecal coliform include pets, leaking sewer lines, straight piping, and sewer overflows. Wildlife is often an important source of fecal coliform contamination as well.

4.1.2 Stressor: Stream Channelization and Stream Erosion

Objectives for Detailed Assessment:

- Identify, assess, and prioritize potential stream channel restoration sites.

Existing threats to streams within the watershed are most commonly the result of stream channelization. Throughout the watershed streams have been straightened and networks of drainage ditches created to accommodate agriculture and development. These man-made alterations degrade aquatic habitat and promote destabilization of the stream channel. Channelization also reduces the natural beneficial functions of floodplain wetlands since streamflow tends to be more confined to the channel rather than spreading out across a floodplain during storms.

Increased imperviousness and associated increases in stormwater volume and peak flow also promote stream channel erosion. Though the soil erodibility along stream corridors is relatively low (Figure 3-6), the disturbance of riparian vegetation and increases in stormwater may still present a risk to stream channel stability.

4.1.3 Stressor: Buffer Disturbance and Wetland Loss

Objectives for Detailed Assessment:

- Identify, assess, and prioritize the feasibility of individual wetland restoration sites.
- Identify high quality wetland areas for preservation.
- Identify areas for stream buffer rehabilitation.

Ditching and draining of wetlands in North Carolina has been a restricted activity since the early 1990's. Except for a short period during and after 1998, no new large-scale wetland drainage projects have occurred in the watershed in the past three decades. In 1998, after the Corps lost authority to issue permits for certain wetland ditching activities under a federal court decision, approximately 9,500 acres of wetlands were impacted by ditching in Brunswick County (Street et al., 2005). The next year, the State of North Carolina determined that the ditching activity fell under its authority and began prohibition of the activity and sought legal action of the ditching that had occurred since the federal court ruling. One of the largest cases is summarized in the Appendix.

Due to mostly historical impacts, nearly 20,000 acres (excluding undrained managed pine sites) in the watershed have been identified by the NCDCM as having wetland enhancement or restoration potential (Figure 3-8). Restoration of wetlands will lead to improved watershed function and remove the sites from future development.

While riparian buffer disturbance is not a widespread phenomenon in the watershed (Figure 3-7), areas of disturbance have been identified (e.g. Photograph 3-7). Further identification, assessment, and prioritization of stream reaches in need of a rehabilitated buffer is needed.

4.1.4 Stressor: Loss of Coastal (Shoreline) Marsh

Objectives for Detailed Assessment:

- Identify, assess, and prioritize the feasibility of coastal shoreline restoration sites.

Shoreline stabilization is the modification of the natural shoreline to prevent erosion. Stabilization practices are typically composed of hardened structures (e.g., bulkheads). These structures can accelerate erosion on adjacent properties and contribute to the loss of shallow intertidal bottom habitat and fringe marshes. Studies have documented lower relative abundance and diversity of invertebrates and juvenile fish adjacent to bulkheaded shorelines compared to unaltered marsh habitats (Street et al., 2005). Development adjacent to shorelines is a common and growing feature in the watershed. Existing hardened shorelines should be softened where feasible and new development should be encouraged to use stabilization methods that promote the preservation of marsh habitat such as the “living shorelines” approach promoted by NCCF. Demonstration sites within the watershed will aid this effort.

4.1.5 Future Stressor: Nutrient and Sediment Loading

Objectives for Detailed Assessment:

- Identify subwatersheds with the greatest potential to deliver nutrients and sediment to the lower river and estuary.

- Use this information to target restoration and preservation, and identify management needs to prevent future water quality degradation and functional loss from excess eutrophication.

In addition to fecal coliform, increases in sediment and nutrient loading can be expected to accompany development in the watershed. The process of constructing roads and buildings can contribute large quantities of sediment to streams through erosion of disturbed soils. Stream channel erosion resulting from increased imperviousness and associated stormwater is another source of sediment.

Pollutants may also accumulate on hardened surfaces such as parking lots and roads. The build up and subsequent wash off of these particles during storms contributes sediment, nutrients, and other pollutants to adjacent water bodies. Another important source of nutrients in urbanizing subwatersheds of the Lockwoods Folly is fertilizer from lawns and golf courses. Numerous golf courses and planned unit developments are situated along the lower Lockwoods Folly and ICWW.

Eutrophication of estuaries and coastal waters is common in North Carolina and throughout the Southeast (NOAA, 1996). The estuary formed by the Lockwoods Folly River is vertically mixed and highly irregular in shape with large areas of mud flats and marsh (Evans, 1992). Its shallow depth, low freshwater inflow rates, high salinity, and low tidal range (1.28 m) suggest relatively low flushing rates and a greater sensitivity to nutrient inputs (USEPA, 2001).

While NCDWQ's (2005) analysis of existing data suggests an upward trend in sediment loading near the fast-growing Oak Island, an assessment of the trends in nutrient concentrations is hampered by the lack of nutrient data since 2001. A more complete assessment of the current trophic status of the estuary is further limited by the lack of data on algal response (e.g. chlorophyll *a*). Historical nutrient concentrations from the 1990's were not at levels considered indicative of advanced eutrophication (NOAA, 1996).

Growth in population and development and accompanying nutrients will likely be a source of stress in the next decade. Since residence times in the estuary are much greater than algal doubling rates (½ to 1 ½ per day), the Lockwoods Folly River estuary is susceptible to eutrophication from increased nutrient loading. An understanding of baseline conditions and the future threat is an imperative.

4.1.6 Future Stressor: Loss of Aquatic and Terrestrial Habitat

Objectives for Detailed Assessment:

- Identify areas of high quality terrestrial and aquatic habitat to target management and preservation to prevent functional loss.

Threats to aquatic and terrestrial habitat exist throughout the watershed. As development continues, habitat will continue to be lost or fragmented. Efforts are needed to preserve the highest quality habitats, particularly considering the abundance of significant Natural Heritage Areas, unique natural communities, and important plant and animal assemblages located within the Lockwoods Folly River watershed (see Section 3.4.1 and 3.4.2).

5.0 Recommended Approach to Detailed Assessment

The indicators necessary to measure conditions in the watershed in terms of stressors are presented in the following section. In addition, the assessment tools and methods necessary to evaluate the indicators are discussed.

5.1 NONPOINT SOURCE POLLUTANT LOADING

Watershed Function	Potential Stressor	Indicator	Scale	Assessment Technique
Water Quality Functions	Pathogen Loads	Fecal Coliform Loading Rates	Subwatershed	PLOAD Watershed Model
		Fecal Coliform Concentrations	Watershed	Source Tracking and Tributary Monitoring
	Nutrient Loads	Nitrogen and Phosphorus Loading Rates	Subwatershed	PLOAD Watershed Model
		Nutrient Concentrations and Eutrophic Response	Watershed	Tributary and Estuary Monitoring
	Sediment Loads	Sediment Loading Rates	Subwatershed	PLOAD Watershed Model
		Sediment Concentrations and Turbidity	Watershed	Tributary Monitoring

5.1.1 Water Quality Monitoring

Fecal coliform, nutrient, and sediment loading are indicators of water quality in the Lockwoods Folly River and its estuary. Excess nutrient loading can lead to eutrophication in the estuary. However, collection of eutrophication parameters in recent years is lacking in this system. Therefore, an assessment of the existing trophic status of the lower river and estuary through collection of nutrient (nitrogen and phosphorus), chlorophyll *a*, and algal community data would be beneficial. In addition, an intensive tributary sampling program designed to improve the understanding of sources of fecal coliform and other nonpoint source pollutants in the watershed is needed. Additional details on these monitoring needs are discussed in detail within section 5.4.

5.1.2 Watershed Modeling

Watershed and water quality models provide the ability to evaluate complex environmental processes of source, transport, transformation, and fate of pollutants. Watershed loading or runoff models are aimed at predicting pollutant movement from the land surface to waterbodies. Receiving water models evaluate the response of a waterbody to pollutant loading.

Models are essential in evaluating future conditions and the effects of land use changes and various management alternatives. There is a wide range of watershed modeling frameworks available, from relatively simple annual export coefficients to complex, detailed process simulation models. Selection of an appropriate modeling approach often depends on the project goals and objectives, site-specific environmental characteristics, budget, data availability, the parameters of concern, and the spatial and temporal scales of interest.

The PLOAD modeling framework will be used to develop a watershed loading model to examine sediment, nutrient and pathogen loads from land sources within the Lockwoods Folly watershed (USEPA, 2001). The objective of the approach is to develop a screening tool to plan, restore, and retrofit the watershed. The results of this screening-level modeling analysis will provide the means to target restoration and management efforts to those areas delivering the highest pollutant loads to waterbodies within the study area. The modeling analysis will also allow for evaluation of the relative magnitude of load increases associated with future land use conditions and the potential for pollutant load reductions associated with watershed-scale land use changes and management measures.

The impaired status of the Lockwoods Folly River requires development of a TMDL (Total Maximum Daily Load) under Section 303(d) of the federal Clean Water Act. A TMDL is a calculation of the maximum amount of a pollutant that a waterbody can receive and still meet water quality standards. An additional objective of this modeling analysis is to provide a scoping-level tool to inform future development of a TMDL for fecal coliform in the Lockwoods Folly watershed.

5.1.3 Bacterial Source Tracking

One of the difficulties in assessing fecal coliform impairments is the uncertainty inherent in identifying specific and numerous sources of fecal coliform bacteria. A successful watershed restoration program will depend on an understanding of the sources of contamination. Employing the use of a source tracking methodology to understand the sources of contamination in the Lockwoods Folly River watershed is recommended.

Two types of methods commonly used in tracking the sources of bacterial contamination include biochemical methods and a chemical method of detecting optical brighteners in detergents using fluorometry (USEPA, 2002). Though both have the same goal of identifying sources of fecal pollution, they each accomplish this goal with various degrees of labor and expense.

Bacterial Source Tracking (BST) using the biochemical method called Antibiotic Resistance Analysis (ARA) can be used to assess the contribution of specific bacteria sources (human, domestic animals, wildlife, etc.) to fecal coliform loads in the watershed. In a method that can be characterized as “biochemical fingerprinting”, individual bacterial isolates that have been collected from the subject stream are examined to determine their most likely source using laboratory analysis and statistical methods. This method has frequently been employed in North Carolina to complement TMDL development and watershed planning. While ARA is currently the most widely used BST method throughout the country, other methods are available.

A chemical source-tracking method using fluorometry can be used to determine if fecal bacteria from polluted waters are from human sources or not. Detection of optical brighteners from detergents has been the most widely used chemical method to date. The method is lower in cost compared to BST, but results in less detailed information regarding sources. The method provides qualitative, presence-absence data for human wastes.

For the detailed assessment, it is recommended that the fluorometry method be used to determine the spatial extent and sources of the contamination. The results of the fluorometric approach can be used to design a more detailed assessment using ARA, if such an effort is warranted in the future to support TMDL development.

Eleven sites are recommended for sampling: MW01, DC01, SB01, TR03, MS01, MW01, UT01, PC01, ICWW at the St. James Marina, and two stormwater outfalls along the lower Lockwoods Folly River to be determined (Figure 3.2). Samples for fluorometry should be collected along with fecal coliform samples at least four times per site (two stormflows and two baseflows). Successful implementation of the fluorometry method will depend on the development and execution of effective protocols.

5.2 RIPARIAN CORRIDOR AND WETLAND RESTORATION

Watershed Function	Potential Stressor	Indicator	Scale	Assessment Technique
Hydrologic and Aquatic Habitat Functions	Stream Channelization and Erosion	Imperviousness and Stream Morphology	Subwatershed and Stream Reach	GIS Analysis and Onsite Assessment
	Riparian Buffer Disturbance	Riparian Buffer Condition	Subwatershed and Stream Reach	GIS Analysis and Onsite Assessment
	Wetland Loss	Wetland Function	Subwatershed and Site	GIS Analysis and Onsite Assessment
	Shoreline Erosion and Loss of Shoreline Habitat	Hardening and Modification of Shoreline	Subwatershed and Site	GIS Analysis and Onsite Assessment

Stream channels and associated alterations in the watershed can be divided into rural and urban types. In rural areas, many streams have been ditched and channelized to increase drainage for agriculture. In urban areas, increases in the volume and peak velocity of stormwater due to increased imperviousness can compromise natural stream stability and promote stream channel erosion. Levels of imperviousness provide an indicator of urban-derived stream erosion. Results of an analysis of imperviousness and riparian buffer disturbance by subwatershed were discussed in section 3.3. Further review of aerial photography and onsite assessments will be required to locate and evaluate potential restoration reaches in rural areas of the watershed. Urban and rural sites will be identified, assessed, and prioritized. Based on the analysis in section 3.3.3, at least 20 sites have been identified for onsite assessment.

The East Carolina University Coastal Plain Stream Assessment will be used to assess the identified streams (Reinhardt et al., 2005). This reference based assessment protocol was developed for intermittent and perennial riparian systems in the Coastal Plain. The riparian system condition is evaluated relative to unaltered reaches of the same type. To evaluate condition, approximately 100 yards of channel and riparian zone are assessed using 8-9 indicators of hydrology, biogeochemistry, and habitat functions of the stream channel and the riparian zone: 1) riparian zone cover, 2) near-stream cover, 3) instream woody structure, 4) sediment regime, 5) channel-riparian zone connection, 6) pollution affecting stream, 7) factors affecting riparian zone, 8) habitat quality of riparian zone, 9) stream bank stability (not evaluated on rural low order streams).

Each indicator evaluates more than one function therefore a mean function score can be calculated for each function by adding the scores from specific indicators. A composite function score can be calculated by averaging all of the function scores. Mean function scores and composite function scores will help identify types, locations and prioritization of restoration activities in the watershed.

An initial selection of potential wetland restoration and enhancement sites was discussed in section 3. At least twenty restoration sites have been identified for assessment using the results of the analysis in section 3.3.4, a review of aerial photography, and parcel data. Sites need to be further identified and assessed in the field. This information can be used to prioritize wetland restoration in the watershed.

Potential nontidal wetland restoration sites will be assessed using the Guidance for Rating the Values of Wetlands in North Carolina, Fifth Version Draft, produced by the Division of Water Quality (NCDWQ, 1999). This method evaluates six wetland values: 1) water storage, 2) bank/shoreline stabilization, 3) pollutant removal, 4) low flow augmentation, 5) wildlife habitat, 6) aquatic life. In addition to evaluating existing wetland conditions, potential post-restoration conditions will be evaluated in the same manner. In addition, other indicators gathered from a review of a number of wetland assessment procedures will be evaluated (Bartoldus, 1999).

Tidal wetlands or areas where tidal wetlands could be restored will be visually assessed to determine degree of invasion of exotic species, size of potential restoration area, amount of fill or other obstructions to flow, and condition of adjacent land. Identification of shoreline restoration sites will focus primarily on groups of vacant lots where an alternative to bulkheads can be promoted.

5.3 HABITAT QUALITY AND PRESERVATION

Watershed Function	Potential Value	Indicator	Scale	Assessment Technique
Terrestrial and Aquatic Habitat Functions	Forest Habitat Contiguousness	Forest Cover Disturbance	Subwatershed	GIS Analysis
	High Quality Habitat	Habitat Composition	Subwatershed	GIS Analysis of: GAP, Natural Heritage Inventory, and NCCREWS
	Species and Habitat of Special Concern	Natural Heritage Element Occurrences and Significant Natural Heritage Areas	Subwatershed	GIS Analysis of Natural Heritage Data

The extent of forest cover will be used to target preservation efforts in those subwatersheds or areas with the least disturbed, most contiguous forest habitat within the riparian corridor and throughout each subwatershed. These indicators will be evaluated by calculating the percentage forest vegetative cover within the riparian area and across the entire subwatershed through a GIS analysis of land cover data.

The North Carolina Natural Heritage Program maintains a GIS database of Natural Heritage Element Occurrences that maps documented observations of federal and state level endangered and threatened species, species of concern, and unique or significant natural communities. The Natural Heritage data will be combined with GAP forest cover data to identify and summarize high quality habitats within the watershed. NCEEP and Stantec will consult with representatives of wildlife habitat and natural resource agencies on prioritization of the GAP vegetation data.

Wetlands provide valuable terrestrial and aquatic habitat. In coastal areas, wetlands make up some of the primary remaining large areas of natural habitat (Sutter et al., 1999). Forest wetlands where conversion to farmland was impractical serve as refugia for wetland and upland wildlife. Coastal wetlands provide spawning habitat for fish. The NC-CREWS data set contains ratings for wetlands sites based on the quality of terrestrial wildlife and aquatic life habitat. The data will be evaluated by filtering and selecting the high ranking sites and summarizing the data by subwatershed. Additionally, input from NCCF and the Lockwoods Folly Watershed Roundtable will be used to guide site selection.

All of the data sources discussed above will be utilized in a comprehensive GIS analysis to target the remaining high quality terrestrial habitat areas for preservation efforts.

5.4 ADDITIONAL MONITORING NEEDS

The purpose of this section is to identify additional data needed to complete the detailed assessment and development of a local watershed plan for the study area. The needs described are intended to provide the data to adequately describe water quality conditions, enhance existing databases, and characterize sources of pollutant loading. Additional needs fall into several categories: eutrophication monitoring, tributary pollutant loading, and benthic sampling.

5.4.1 Eutrophication Monitoring

Presently, chlorophyll *a* and nutrient data are not being collected in the watershed. Collection of parameters to characterize the trophic status of the lower river and estuary would be beneficial. In addition to physical parameters including DO, temperature, pH, conductivity, TSS, and turbidity, the following parameters are recommended to characterize trophic status and assess trends:

- Total Kjeldahl Nitrogen
- Ammonia Nitrogen
- Nitrite/Nitrate
- Total Phosphorus
- Orthophosphate
- Chlorophyll *a*
- Secchi Depth

There are currently only two active AMS stations (LFR11 and LFR19) located within the Lockwoods Folly River estuary (Table 3.2 and Figure 3.2). Two additional stations (LFR03 and LFR06) are located upstream of the estuary and south of highway 211 and one is located in Montgomery Slough (MS01). Monitoring of selected parameters should be conducted at three of these stations (LFR06, LFR11, and MS01) monthly from March through October. Four additional sites are recommended for monitoring: LFR13, LFR23, ICW07 and ICW03. Vertical profiles of DO and temperature should be collected at stations downstream of LFR06, as resources permit.

5.4.2 Tributary Pollutant Loading

A monitoring effort to collect fecal coliform, nutrient, and sediment (TSS and turbidity) data from various other watershed locations will supplement existing databases and assist in characterizing pollutant loading and potential sources. Grab samples for fecal coliform should be collected during baseflow and stormflow conditions at the following seven stations: LFR02, LFR03, TR01, TR03, LFR09, and DC01 (Figure 3.2). In addition, automatic samplers should be deployed to collect stormwater samples at a minimum of five sites: SB01, PC01, MW01, UT01, and one site in subwatershed IW1 north of the ICWW to be determined (Figures 3.2 and 2.2). Parameters analyzed with automatic samplers should include fecal coliform, nutrients, and sediment.

5.4.3 Benthic Sampling

Sampling under the new benthic criteria for swamp streams is currently scheduled to begin in 2006 for the watershed. An effort to coincide with the detailed assessment for the Lockwoods Folly River LWP would be beneficial. Biological monitoring data is in short supply in this watershed. Evaluation performed under the new criteria will provide useful information for evaluating aquatic life uses of the swamp streams and insight into associated watershed functions.

6.0 Recommended Approach for Targeting of Management

The Detailed Assessment will culminate in a comprehensive assessment of all watershed indicators to identify subwatersheds having the greatest functional losses and the greatest risk for future degradation of watershed functions.

Areas with the greatest existing functional losses will be targeted for stream and wetland restoration or enhancement, BMP retrofits, and other management efforts. Development of appropriate management and protection measures to prevent future losses of watershed function will be targeted to the areas with the greatest future risk for degradation. Areas with the highest quality habitat and benefits will be targeted for preservation.

Management alternatives identified to address the targeted areas will be described in detail and prioritized. To the extent possible, solutions will address both local and watershed-scale functions. Recommendations necessary to protect and restore watershed functions will be developed to address local planning and development policy.

Potential restoration projects within targeted subwatersheds will be ranked using functional assessment results and a variety of criteria including number of landowners, feasibility, landscape position, stakeholder input, and contribution to overall watershed function.

To the extent possible, watershed management scale recommendations as well as identified site-specific BMP opportunities and restoration projects will be evaluated with the watershed modeling framework developed for the Detailed Assessment. Where applicable, predicted pollutant load reductions will be used in conjunction with conceptual design level estimates of cost to gage the cost effectiveness of recommended projects to inform prioritization and optimize the expenditure of implementation funds.

Whenever possible, opportunities will be identified and highlighted to locate multiple BMP retrofits and restoration projects together in high opportunity subwatersheds to achieve additive watershed functional benefits. The local advisory group including the Watershed Roundtable (see 3.5.1) will play a key role in guiding recommendations for the local watershed planning effort. Project atlases will be developed to illustrate the details and locations of recommended projects.

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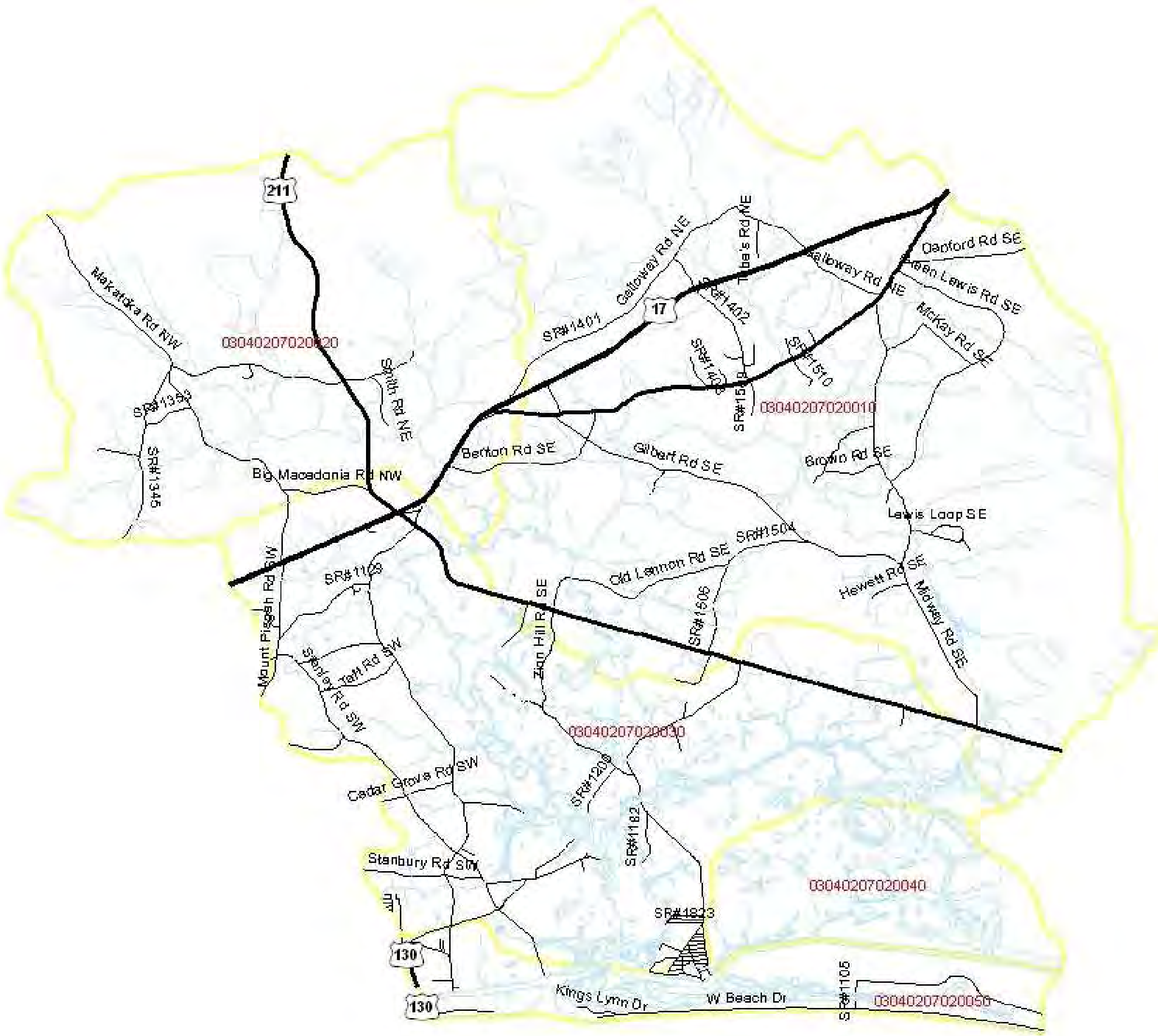
8.0 Appendices

8.1 LOCKWOODS FOLLY RIVER SUMMARY OF AVAILABLE DATA: PREPARED BY THE NC DIVISION OF WATER QUALITY

Lockwoods Folly River: Summary of Available Data

NC Subbasin: 03-07-59 (Lumber 59)
Cataloging Unit: 03040207
Hydrologic Units: -020010, -020020, -020030, -020040, -020050



Lockwoods Folly River 14-digit HUCs for Local Watershed Plan development

Prepared by
NC Division of Water Quality
Watershed Assessment Team
Raleigh, NC
September 13, 2005

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Tables and Figures

Summary

The NC Ecosystems Enhancement Program (EEP) has selected the Lockwoods Folly River watershed for development of a Local Watershed Plan (LWP). In support of this, the DWQ Watershed Assessment Team (WAT) has developed this summary of available water quality data for the region. The watershed is entirely located in Brunswick County, which is undergoing increasing growth and development pressure. The project area includes the subwatersheds of upper Lockwoods Folly R. (HU 03040207020010), Royal Oak Swamp (HU 03040207020020), lower Lockwoods Folly R. (HU 03040207020030), unnamed tributaries (HU 03040207020040), and the ICW (HU 03040207020050).

Historically, the major concern with the Lockwoods Folly River watershed has been fecal coliform. Much of the lower mainstem (HU 020030, in part) as well as the ICW and accompanying sloughs (HU 020050) are designated as class SA waters for protection of shellfishing uses. However, in the period from 1980-1988, the Division of Environmental Health (DEH) shellfishing area A3 underwent closures to this use, in a gradual upstream to downstream progression. This was a response to fecal coliform levels exceeding the NC water quality standard for SA waters of a median of 43 colonies/100mL or >10% of samples exceeding 43 colonies/100mL. Currently this area is listed as “Conditionally Approved Closed”. These closures have resulted in the impairment and consequent 303(d) listing of 913 acres by DWQ.

The potential sources of the fecal coliform are listed in the 303(d) list as urban runoff/storm sewers, septic tanks, and marinas. A previous report prepared in 1989 by the Division of Environmental Management (NC DENR, DEM 1989b) implicated septic systems sited on soils with moderate to severe limitations for septic tanks as a possible coliform source. It has also been suggested that waterbody substrates can harbor fecal coliform, providing a source of “re-infection” of the waterbody whenever bottom sediments are disturbed through natural or human activities.

Biological data are relatively scarce in this watershed, in part due to the swamp characteristics of many of the streams. Until recently, an appropriate set of criteria for evaluating NC swamp streams using benthos data was not available. The recently approved benthos swamp criteria developed by the BAU will definitely be a useful tool to evaluating aquatic life uses in the next basin assessment sampling, scheduled for 2006. Another hindrance to benthos and fish community sampling in this watershed is the presence of salinity. There is not an approved estuarine index for assessing benthos communities, and high specific conductances disallow electroshocking for collection of fish data.

One site on Royal Oak Swamp (HU 020020) is used by the Biological Assessment Unit as a “least-disturbed” reference site for the ecoregion. Benthos and fish community sampling show diverse and seemingly healthy communities, though this site has not been rated in the past. One other sampling site located on the Lockwoods Folly R. mainstem has received Good-Fair ratings based on benthos data, though the most recent data are from 1996.

There is one NPDES discharger in this watershed, Bolivia Elementary School (permit NC0045250), which discharges into Bolivia Branch. Bolivia Br. is a tributary of Middle Swamp, which in turn feeds into the Lockwoods Folly River. The facility is a minor, 100% domestic discharger but has a number of DMR violations over the last 10 years, including several fecal coliform permit limit violations in the spring of 2005.

Available data sources

Sources of data include DWQ Lumber Basinwide Assessment Reports, DWQ Lumber Basin Plans, USGS' National Water Information System (NWIS) website, EPA's STORET database, the DWQ Basinwide Information System (BIMS), and raw data requested directly from individual monitoring programs.

Due to the large number of locations monitored in this watershed by several organizations, the following summary is grouped by monitoring program. To assist the reader in finding the desired data type, a summary of the programs and available data types are shown in Table 1.

Table 1: Monitoring programs included in data summary

Monitoring Program		Effluent	Benthos	Fish community	Field chemistry	Analytical chemistry	Microbiological
NC DENR, Division of Water Quality (DWQ)							
	Benthic Macroinvertebrate[1]		X		X		
	Fish Community[1]			X	X		
	Ambient Monitoring System (AMS)				X	X	X
	NPDES permitting program	X					
NC DENR, Division of Environmental Health (DEH)							
	Recreational Beach Monitoring						X
	Shellfish Sanitation Monitoring						X
U.S. Geological Survey (USGS)					X	X	

[1] *These programs also include habitat assessments in their monitoring regime.*

Station locations

Descriptions of the sites with available data and which programs have monitored at each location are shown in Table 2. Maps of station locations are shown in Figures 1-2. The geolocational information included in the table should be considered draft and not appropriate for publication. Data sources, particularly for Shellfish Sanitation stations, have not been rigorously reviewed or QC'ed at this time. There were a number of inactive Shellfish Sanitation stations that did not have accompanying geolocational information; these have not been included in this summary.

Table 2: Monitoring locations

Summary station number	Station description	HU	latitude (dec. degrees)	longitude (dec. degrees)	NC stream index	NC stream class	DWQ benthos	DWQ fish comm.	DWQ AMS	DEH Rec. Beach	DEH Shellfish	USGS
Mainstem Lockwoods Folly R.												
LFR01	Lockwoods Folly R at US 17 Business	020010	34.0469	-78.1789	15-25-1-(1)	C Sw		X				
LFR02	Lockwoods Folly R at SR 1501 near Supply/ Shellfish special study station LF10	020010	34.0284	-78.2177	15-25-1-(11)	SC HQW	X	X	X		X	
LFR03	Lockwoods Folly R at NC 211 at Supply/ Shellfish special study station LF8	020030	34.0108	-78.2636	15-25-1-(11)	SC HQW			X		X	
LFR04	Shellfish special study station LF7	020030	33.9959	-78.2655	15-25-1-(11)	SC HQW					X	
LFR05	Shellfish special study station LF6	020030	33.9803	-78.2528	15-25-1-(11)	SC HQW					X	
LFR06	Lockwoods Folly R near Sandy Hill	020030	33.9722	-78.2503	15-25-1-(11)	SC HQW			X			
LFR07	Shellfish special study station LF5	020030	33.9691	-78.2528	15-25-1-(11)	SC HQW					X	
LFR08	Shellfish special study station LF4	020030	33.9648	-78.2399	15-25-1-(11)	SC HQW					X	
LFR09	Shellfish special study station LF3	020030	33.956	-78.2384	15-25-1-(11)	SC HQW					X	
LFR10	Shellfish special study station LF2	020030	33.9543	-78.2258	15-25-1-(16)	SA HQW					X	
LFR11	Lockwoods Folly R at Varnamtown/ Shellfish special study station LF1	020030	33.9465	-78.2232	15-25-1-(16)	SA HQW			X		X	
LFR12	Lockwoods Folly R at CM 10	020030	33.9443	-78.2216	15-25-1-(16)	SA HQW				X		
LFR13	Lockwoods Folly R at CM R8 DNS of Varnamtown (west channel)/ Shellfish station 5A	020030	33.9395	-78.2192	15-25-1-(16)	SA HQW			X		X	
LFR14	Lockwoods Folly R DNS of Varnamtown (center)	020030	33.942	-78.217	15-25-1-(16)	SA HQW			X			
LFR15	Lockwoods Folly R DNS of Varnamtown (east channel)	020030	33.942	-78.215	15-25-1-(16)	SA HQW			X			
LFR16	Shellfish station 6A	020030	33.934	-78.219	15-25-1-(16)	SA HQW					X	
LFR17	Shellfish station 30A	020030	33.9318	-78.2155	15-25-1-(16)	SA HQW					X	
LFR18	Lockwoods Folly R at CM 5/ Shellfish station 14A	020030	33.9316	-78.2178	15-25-1-(16)	SA HQW				X	X	
LFR19	Lockwoods Folly R at CM R6 NW Sunset Harbor (west channel)	020030	33.931	-78.2183	15-25-1-(16)	SA HQW			X			
LFR20	Shellfish station 14B	020030	33.9286	-78.2211	15-25-1-(16)	SA HQW					X	
LFR21	Shellfish station 7A	020030	33.9287	-78.2163	15-25-1-(16)	SA HQW					X	
LFR22	Lockwoods Folly R at NW of Sunset Harbor (east channel)	020030	33.928	-78.208	15-25-1-(16)	SA HQW			X			
LFR23	Lockwoods Folly R at West Channel Islands	020030	33.9267	-78.2236	15-25-1-(16)	SA HQW			X			
LFR24	Shellfish station 7	020030	33.9266	-78.2151	15-25-1-(16)	SA HQW					X	
LFR25	Shellfish station 8	020030	33.9253	-78.2106	15-25-1-(16)	SA HQW					X	

Table 2 (continued): Monitoring locations

Summary station number	Station description	HU	latitude (dec. degrees)	longitude (dec. degrees)	NC stream index	NC stream class	DWQ benthos	DWQ fish comm.	DWQ AMS	DEH Rec. Beach	DEH Shellfish	USGS
Lockwoods Folly Tributaries												
TR01	Royal Oak Swamp at SR 1501	020020	34.0335	-78.2803	15-25-1-14	C Sw	X	X				
TR02	Mill Creek near SR 1112 near Long Beach	020030	33.9715	-78.2033	15-25-1-18-(2)	SA HQW						X
TR03	Shellfish special study station LF9	020030	33.9582	-78.2138	15-25-1-18-(2)	SA HQW					X	
Intracoastal Waterway (ICW)												
ICW01	ICW at CM R16 at Beaverdam Cr near Long Beach	020050	33.92195	-78.1078	15-25	SA HQW			X			
ICW02	Shellfish station 11	020050	33.9207	-78.2047	15-25	SA HQW					X	
ICW03	ICW at Sunset Harbor	020050	33.92	-78.208	15-25	SA HQW			X			
ICW04	Shellfish station 10	020050	33.9233	-78.2149	15-25	SA HQW					X	
ICW05	Lockwoods Folly R at mouth at ICW CM 41	020050	33.9237	-78.2237	15-25	SA HQW				X		
ICW06	Shellfish station 13	020050	33.9243	-78.2245	15-25	SA HQW					X	
ICW07	ICW at CM R42 west of Lockwood Folly R	020050	33.9217	-78.2306	15-25	SA HQW			X			
ICW08	ICW at NC 130 near Holdens Beach	020050	33.91699	-78.2676	15-25	SA HQW			X			
Montgomery Slough												
MS01	Montgomery Slough at SR 1105 near Long Beach	020050	33.91777	-78.1609	15-25	SA HQW			X			
MS02	Shellfish station 24	020050	33.9184	-78.1932	15-25	SA HQW					X	
MS03	Shellfish station 24A	020050	33.9166	-78.2019	15-25	SA HQW					X	
MS04	Shellfish station 9	020050	33.9167	-78.2125	15-25	SA HQW					X	
MS05	Shellfish station 9A	020050	33.919	-78.214	15-25	SA HQW					X	
MS06	Shellfish station 16	020050	33.9164	-78.218	15-25	SA HQW					X	

Figure 1: Monitoring stations (1:100K topo)

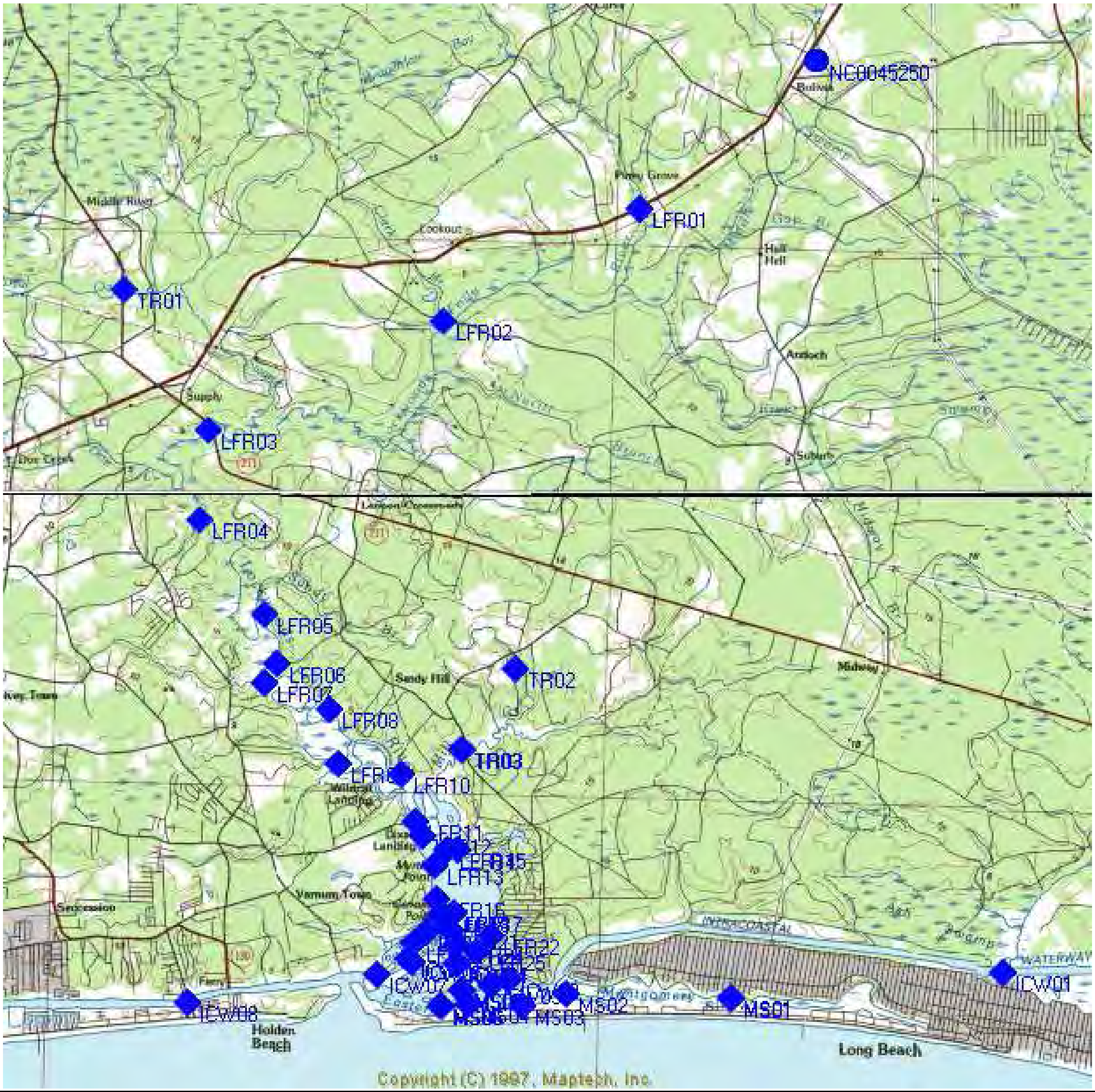
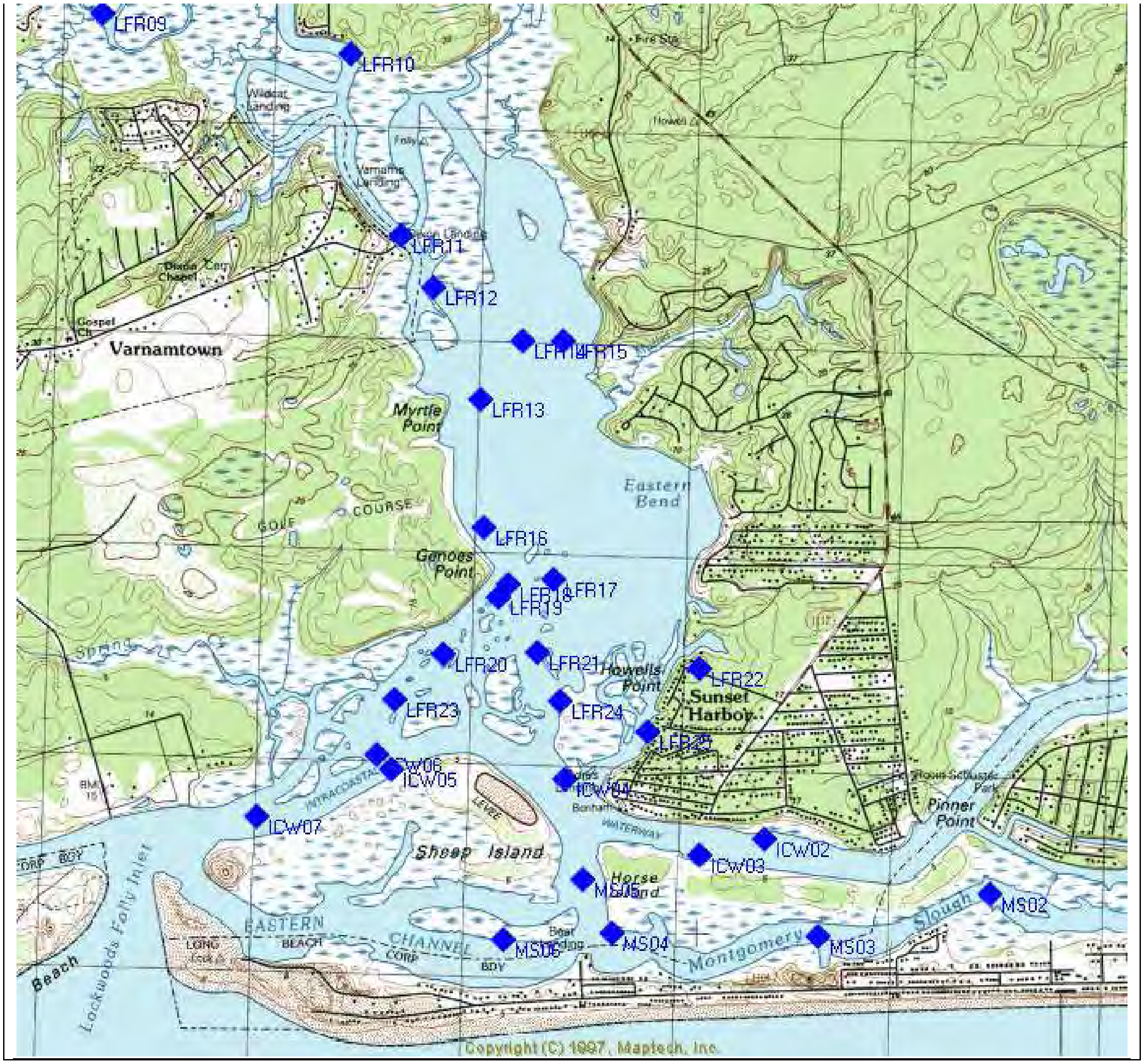


Figure 2: Monitoring station locations, Lower Lockwoods Folly R. detail



DWQ: Benthic macroinvertebrate data

Benthic macroinvertebrate data have been collected by the Environmental Sciences Section's Biological Assessment Unit (BAU) at two locations as part of the regular basinwide sampling. This includes Lockwoods Folly R. at SR 1501 near Supply (LFR02) and Royal Oak Swamp at SR 1501 (TR01). The Royal Oak Sw. is used as a "least-impacted" reference site for the ecoregion.

Finding appropriate benthos monitoring sites in this watershed has historically been challenging. Until recently, the DWQ did not have approved criteria for rating swamp streams. In developing a study plan for this LWP study, it should also be kept in mind that swamp streams will need to be sampled in February-March when there is consistent flow. The presence of salinity throughout much of the watershed also rules out a large number of other locations. At one time, the BAU was working on developing methods and criteria appropriate for estuarine sites. Though that project was discontinued, Larry Eaton, the primary biologist coordinating that investigation is currently a staff member of the DWQ Watershed Assessment Team. If biological data are desired in tidal areas, he will be an excellent technical resource.

Benthos data are reported by the BAU in terms of community diversity (i.e., taxa richness) and a metric termed the NC biotic index (BI), which is based on abundance and sensitivity of each taxon. Each of these measures can also be reported for all taxa, or by using only the so-called EPT taxa. EPT refers to the orders Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies). Taxa in these orders are generally much more sensitive to stressors and better indicators of water quality.

Lockwoods Folly R. (LFR02) was sampled in the summers of 1984 and 1996, receiving a Good-Fair rating in both cases. Due to low flows, this location was not sampled during the last basinwide sampling season in 2001, so more recent data are not available. There was a significant increase in the number of EPT taxa found during the 1996 sampling (14 EPT, 66 total taxa) as compared to the 1984 sampling (6 EPT, 67 total taxa).

The Royal Oak Sw. (TR01) has been sampled five times from 1996-2001. Much of this sampling was to assist with development of the recently approved benthos criteria for swamp streams. Since this is a swamp stream, it has not been rated in the past. It is expected that this

Table 3: Summary of DWQ benthos results

ST: total number of taxa — BI: biotic index based on all taxa
S EPT: number of EPT taxa — EPT BI: biotic index based on EPT taxa only

Station #	Location	Date	ST	EPT S	BI	EPT BI	Bioclass
LFR02	LFR at SR 1501 near Supply	7/8/96	66	14	6.33	5.41	Good-Fair
		7/10/84	67	6	7.79	7.33	Good-Fair
TR01	Royal Oak Sw. at NC 211	7/11/01[1]	--	13	--	5.49	Not rated
		2/5/01	58	18	6.01	4.56	Not rated
		2/18/99	75	21	6.41	5.19	Not rated
		3/3/98	55	18	6.24	4.96	Not rated
		7/8/96[1]	--	15	--	3.45	Not rated

[1] *The BAU does not recommend using summer collections in swamp streams for water quality assessments. See text for more information.*

would allow a rating to be applied to Royal Oak Sw. when sampled in early 2006 as part of the next basin assessment cycle. Due to the naturally high variability of summer conditions of this and similar streams, the BAU recommends that only results from winter sampling be considered for water quality assessments. Of the past sampling events, two occurred in summer (July 1996 and July 2001) and three in winter (March 1998, February 1999, and February 2001). For the winter samples, the EPT abundances were consistently high, with scores of 18, 21, and 18 respectively.

Field parameters are also measured during benthos sampling. Though the small data set disallows analysis, they are provided in Table 4 for reference.

Table 4: Benthos monitoring program field data

Station #	**Location**	**Date**	**Specific conductance** (uS/cm at 25°C)	**DO** (mg/L)	**pH** (SU)	**Temp** (°C)
LFR01	Lockwoods Folly R. at SR 1501	7/8/96	125	4.4		25
TR01	Royal Oak Sw. at NC 211	7/11/01	96	5.4		29
		2/5/01	105	10.0	6.9	8
		7/8/96	141	5.3		26

Additional sampling occurred at Lockwoods Folly R. at NC 211 (LFR03) in 1991 and at one additional location Lockwoods Folly R. at CM 14 (no station number) in 1996 as part of a special study supporting development of an estuarine biotic index. Since this project was never finalized, the results are not included here.

DWQ: Fish community data

Fish community sampling has been performed in two locations in the Lockwoods Folly River basin: Lockwoods Folly R. at US 17 business (LFR01) and Royal Oak Swamp at SR 1501 (TR01). The NC Index of Biological Integrity (NCIBI) used by the Fish Community monitoring program is not applicable to the Lumber and other lower coastal river basins, and so there are no ratings for these sites. When selecting fish community sampling sites in this watershed, another major consideration is salinity. Electroshocking, the method of collection used by DWQ, cannot be conducted when specific conductance exceeds 400-500 uS/cm, which is roughly equivalent to a salinity of 0.2-0.3 ppt.

The Lockwoods Folly R. station (LFR01) was sampled in 1992 and 1996. As with benthos monitoring, low flows prevented sampling at this location in 2001. No interpretive information on the earlier sampling events was included in the 2002 Lumber Basin Assessment Report, but raw data are included in Appendix 1. The number of species found was 11 (1992) and 12 (1996), with *Gambusia holbrooki*, a tolerant species, dominant in terms of number of individuals collected in both cases.

Royal Oak Sw. (TR01) has been sampled in 1992 and 2001. Samples from both years showed diverse and healthy fish communities, and included an intolerant species (ironcolor shiner, *Notropis chalybaeus*). *N. chalybaeus* was actually the most numerous species collected in 2001.

The 1992 sampling had a slightly more diverse community (19 species, as compared to 16 in 2001), but the 2001 sampling resulted in a much higher number of individuals (326, as compared to 210 in 1992). Field data from the 2001 sampling are available and shown in Table 5.

Table 5: Fish community monitoring program field data

Station #	**Location**	**Date**	**Specific conductance** (uS/cm at 25°C)	**DO** (mg/L)	**DO saturation** (%)	**pH** (SU)	**Temp** (°C)
TR01	Royal Oak Sw. at NC 211	5/21/01	171	3.3	39.3	6.8	24.1

DWQ: BAU habitat assessments

Habitat assessments are part of benthos and fish community sampling activities, and are available for the site on Royal Oak Sw at NC 211 (TR01). Available habitat data for each category are shown in Table 6.

In 2001, both benthos and fish community habitat evaluations gave maximum scores to Royal Oak Sw. (TR01) for all categories except instream habitat, bottom substrate, pool variety, and shade (benthos only). Total scores were 83 (fish) and 87 (benthos) out of a possible score of 100. Habitat evaluations from 1996 benthos sampling show similar numbers (total score = 90), though the 2001 assessment had a significant drop in the instream habitat score, which is likely due to overzealous post-hurricane de-snagging. The 1999-2001 benthos results noted an increase in the silt/sand ratio as compared to 1996-1998 samplings. Silt levels were reported as having increased from 10-15% to 30-40% over that time period.

Table 6: Habitat assessment scores for Royal Oak Sw. (TR01) by category

Date (B = benthos, F = fish)	**Channel**	**Instream habitat**	**Substrate**	**Pool variety**	**Stability**	**Bank vegetation**[1]	**Shade**	**Riparian**	**Total**
1996 (B)	15	20	9	4	14	10	8	10	90
2001 (B)	15	16	10	8	20	N/A	8	10	87
2001 (F)	15	15	7	6	20	N/A	10	10	83
Max scores (2001)	15	20	15	10	20	N/A	10	10	100

[1] *Bank vegetation is no longer included as a separate category in current habitat assessment methods.*

Overview of data record

The main focus of this section is data collected by the DWQ Ambient Monitoring System (AMS). AMS physical and chemical data are available for thirteen locations in the Lockwoods Folly watershed, going back as far as 1974. All stations are located on the mainstem of Lockwoods Folly R., the Intracoastal Waterway (ICW), or Montgomery Slough. However, not all stations have been continuously active for this period. A summary of station locations, start/end dates, and total number of results is shown in Table 7. A summary of available data by parameter is shown in Table 8.

The USGS also have physical and chemical data available from a single sampling event on Mill Creek in February 2000. These data are not summarized here, but are included in their entirety in Appendix 2.

This section will look at 26 common parameters of interest, and describe any patterns or trends noted during AMS data explorations. Graphical representations of distributions are presented in some cases to show possible spatial trends. Numerical distributions for many common parameters at each station are shown in Appendix 3. Non-detects are warehoused as "<RL", where RL was the reporting limit at the time of analysis. For these non-detects, the RL was used as the value for analysis.

Table 7: Total number of AMS records by station

Station	Location	N records	Min date	Max date
ICW01	ICW at CM R16 at Beaverdam Cr near Long Beach	1692	05/1995	07/2002
ICW03	ICW at Sunset Harbor	841	07/1989	02/1995
ICW07	ICW at CM R42 west of Lockwood Folly R	2596	07/1989	07/2002
ICW08	ICW at NC 130 near Holdens Beach	3071	08/1970	07/2002
LFR02	Lockwoods Folly R at SR 1501 near Supply/ Shellfish special study station LF10	886	06/1973	11/1984
LFR03	Lockwoods Folly R at NC 211 at Supply/ Shellfish special study station LF8	3044	07/1989	04/2005
LFR06	Lockwoods Folly R near Sandy Hill	380	09/2002	04/2005
LFR11	Lockwoods Folly R at Varnamtown/ Shellfish special study station LF1	3044	07/1989	04/2005
LFR13	Lockwoods Folly R at CM R8 DNS of Varnamtown (west channel)/ Shellfish station 5A	2618	07/1989	07/2002
LFR14	Lockwoods Folly R DNS of Varnamtown (center)	696	07/1989	04/1995
LFR15	Lockwoods Folly R DNS of Varnamtown (east channel)	674	07/1989	04/1995
LFR19	Lockwoods Folly R at CM R6 NW Sunset Harbor (west channel)	1265	07/1989	04/2005
LFR22	Lockwoods Folly R at NW of Sunset Harbor (east channel)	911	07/1989	04/1995
LFR23	Lockwoods Folly R at West Channel Islands	2357	07/1989	07/2002
MS01	Montgomery Slough at SR 1105 near Long Beach	1943	05/1995	04/2005

Table 8: Number of AMS results by parameter

Parameter	*N results*	*Parameter*	*N results*
Algae, floating mat - severity	10	Odor severity (choice list)	13
Alkalinity, Carbonate as CaCO3	209	pH	1279
Alkalinity, Total (total hydroxide + carbonate + bicarbonate)	106	Phosphorus as P	620
Aluminum	340	Phosphorus, orthophosphate as P	330
Ammonia, unionized	403	Precipitation	550
Arsenic	642	Salinity	1148
BOD, Biochemical oxygen demand	93	Secchi disk depth	269
Cadmium	646	Selenium	8
Chemical oxygen demand (COD)	53	Sludge, floating - severity (choice list)	9
Chloride	506	Specific conductance	1257
Chromium	646	Temperature, air	705
Cloud cover	716	Temperature, water	1261
Cobalt	11	Tide stage (choice list)	23
Copper	646	Total Coliform	3
Dissolved oxygen (DO)	1260	Total Organic Carbon (TOC)	8
Dissolved oxygen saturation	477	Total Solids	707
Fecal Coliform	839	Total Suspended Solids (TSS)	118
Fish Kill, severity (choice list)	8	Turbidity	778
Flow, severity (choice list)	785	Turbidity severity (choice list)	591
Hardness, Ca + Mg	524	Water level reference point elevation	7
Iron	346	Wind direction (deg from North)	720
Lead	645	Wind force, Beaufort scale	86
Manganese	24	Wind velocity	634
Mercury	644	Zinc	646
Nickel	640		
Nitrogen, Kjeldahl	618		
Nitrogen, Nitrite (NO2) + Nitrate (NO3) as N	621		
Nitrogen, ammonia (NH3) as NH3	621		

Field measurements

The majority of field data collected by the AMS program have been surface readings (depth = 0.1m). For certain stations, a modified depth profile is collected, with readings taken at the surface, at mid-depth in the water column, and just above the bottom. For this summary, only surface readings have been analyzed. These historic profile data are readily available if required for future modeling projects.

In reviewing time plots of data by station, it appears that most stations were affected by the drought, showing an upward trend in conductivity and salinity, and perhaps a slight upward trend in pH, during the early 2000's. Those stations with a continuous record show a re-adjustment to earlier levels in 2003-2005. Graphs for LFR03 are shown in Figure 3 as a typical example of patterns over time.

Distributions for DO, pH, and salinity for all stations are shown in Figure 4. Violation of the NC water quality standard of 5.0mg/L for salt waters is common (>=25% of measurements) at LFR02, LFR03, and LFR06. At LFR03 (Lockwoods Folly at NC 211), about 50% of DO measurements do not meet the standard. Stations LFR02 and LFR03 also show a large proportion of violations of the pH standard of 6.8 for salt waters.

The distribution for salinity is presented to give an indication of tidal influence in the Lockwoods Folly River. In viewing the graph, it appears that salinity fluctuations occur as far upstream as LFR03. Anecdotal evidence by BAU field staff indicated that salt wedges have been noted as far upstream as station LFR02. However, in reviewing graphs of conductivity and salinity over time, it appears that many of the higher salinities at this location coincided with a severe drought. Under average conditions, the cutoff of tidal influence may more likely lie between LFR03 and LFR06. The salinity level will have a significant effect on the feasibility of benthos and fish community sampling in the watershed.

Figure 3: Salinity, DO, and pH for station LFR03, Lockwoods Folly R at NC 211

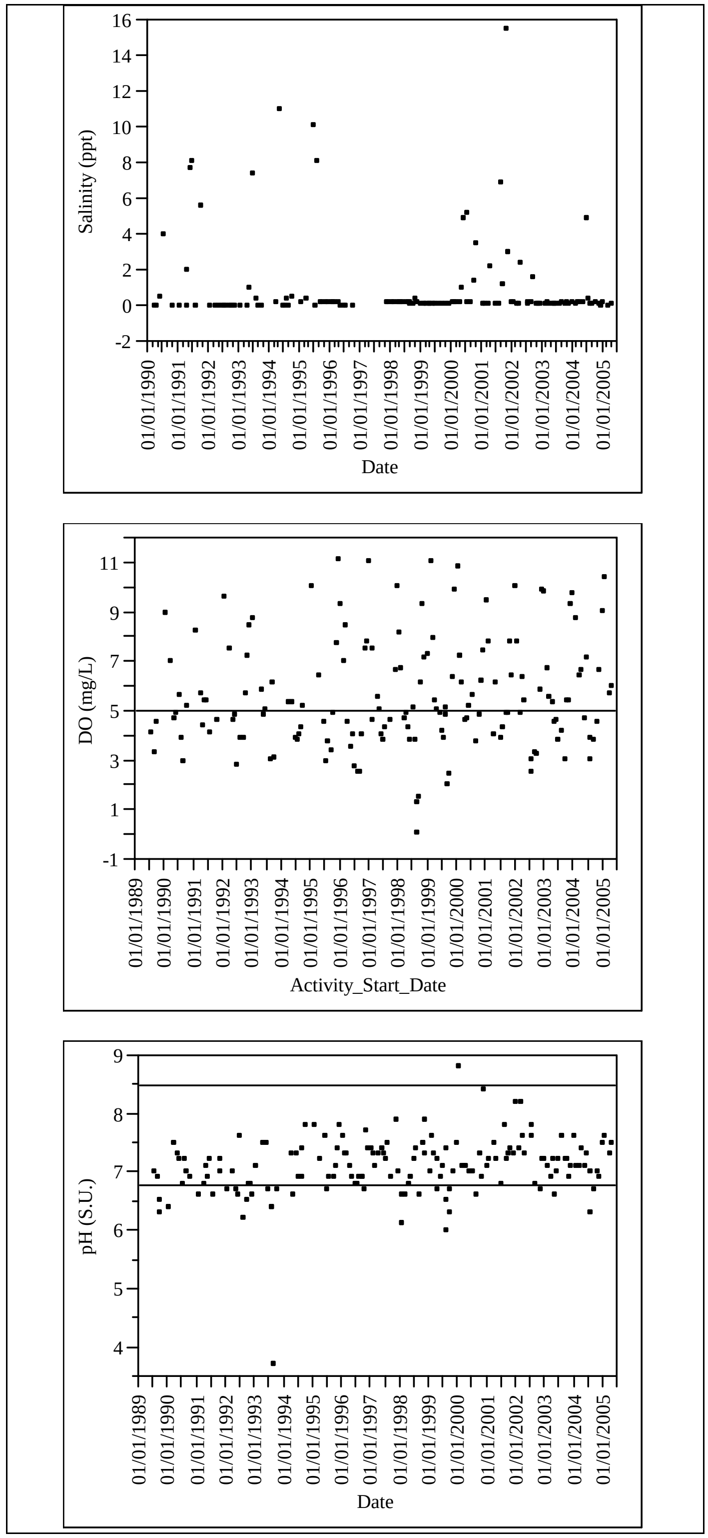
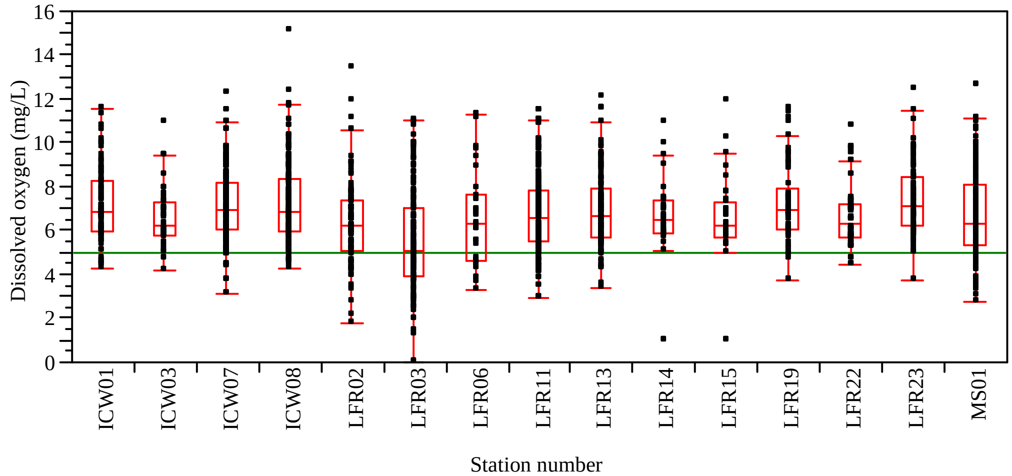
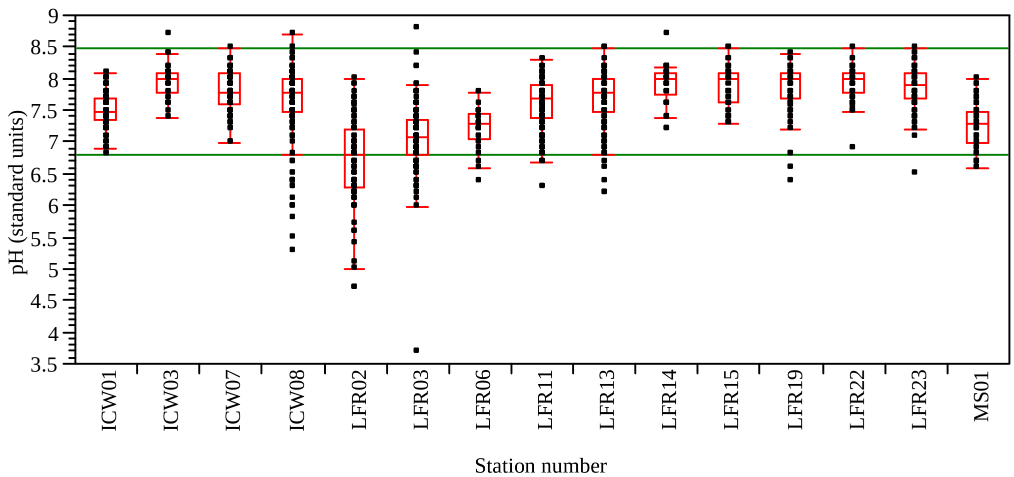


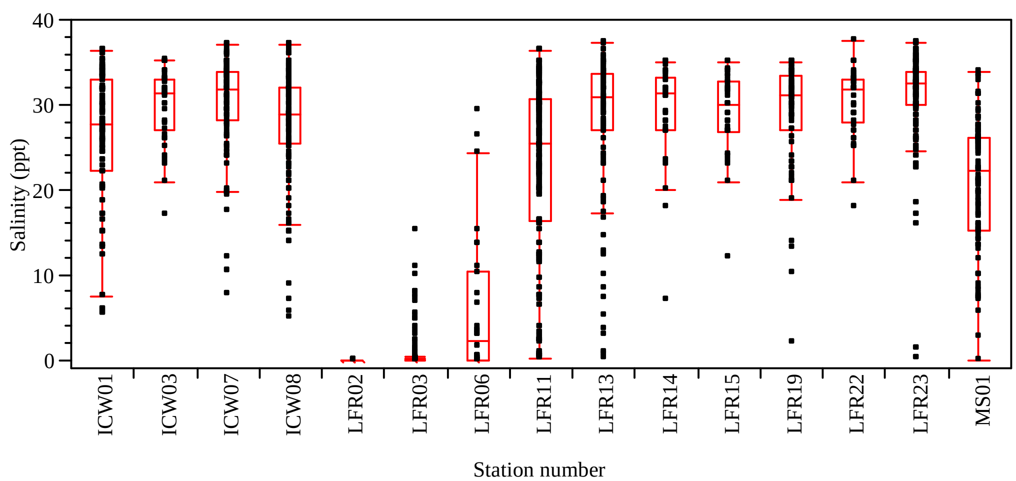
Figure 4: Distributions of selected AMS field measurements by station



DO distributions. Green line indicates NC water quality standard in saltwater of 5.0mg/L.



pH distributions. Green lines indicate upper and lower limits of 6.8 SU and 8.5 SU for the NC water quality standard in saltwater.



Salinity distributions

Nutrients

A sizable data set for ammonia, NO2+NO3, TKN, and Total P is available for fourteen locations. However, the most recently available data for any station is from 2001, with other locations ceasing collection of nutrients in 1995.

Historically the Lockwoods Folly R. has not had issues with phytoplankton, such as blooms, indicating that nutrient enrichment may not be as significant an issue here as in other basins. When graphing nutrients over time, there appears to be a trend of increasing ammonia levels, with a corresponding increase in TKN. However, this increase seems to correspond with the severe drought, and more recent data are not available to determine if NH3 and TKN values returned to former levels, as was seen with field data. Ammonia results from station LFR11 (Lockwoods Folly R at Varnamtown) are shown in Figure 5 as an example of this increase.

Distributions of nutrient data by station are presented in Figure 6. For nitrate+nitrite and total phosphorus distribution graphs, the y-axis scale was shortened in order to get better resolution for the majority of data points. Four possible outliers for nitrate+nitrite and eight possible outliers for total phosphorus do not show up on the graphs; refer to the distribution table in Appendix 3 to obtain these values.

Figure 5: Ammonia nitrogen at station LFR11, Lockwoods Folly R at Varnamtown

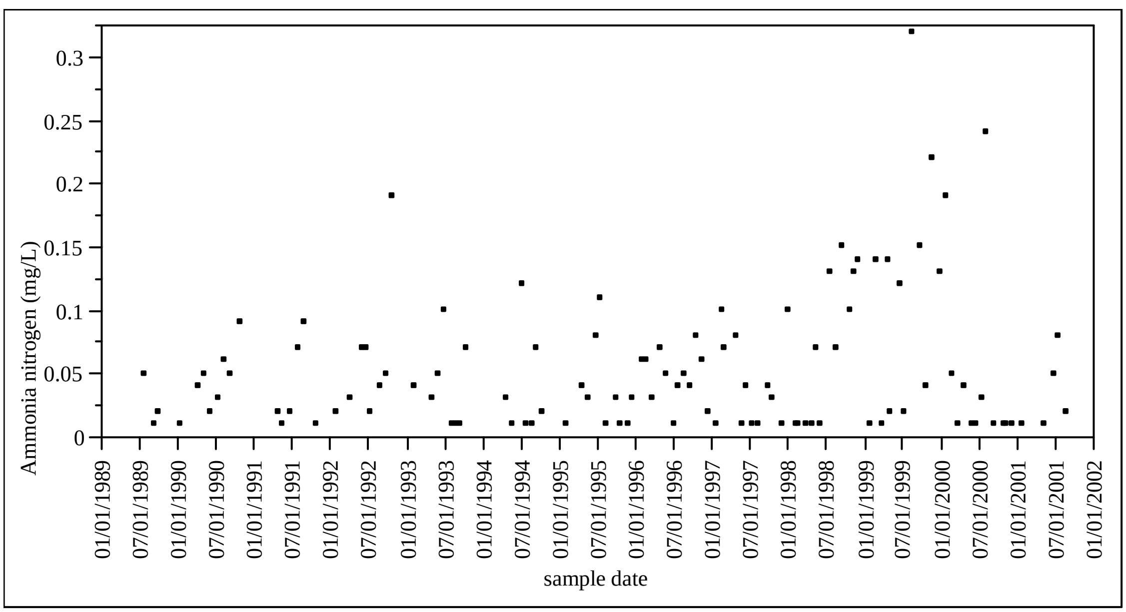
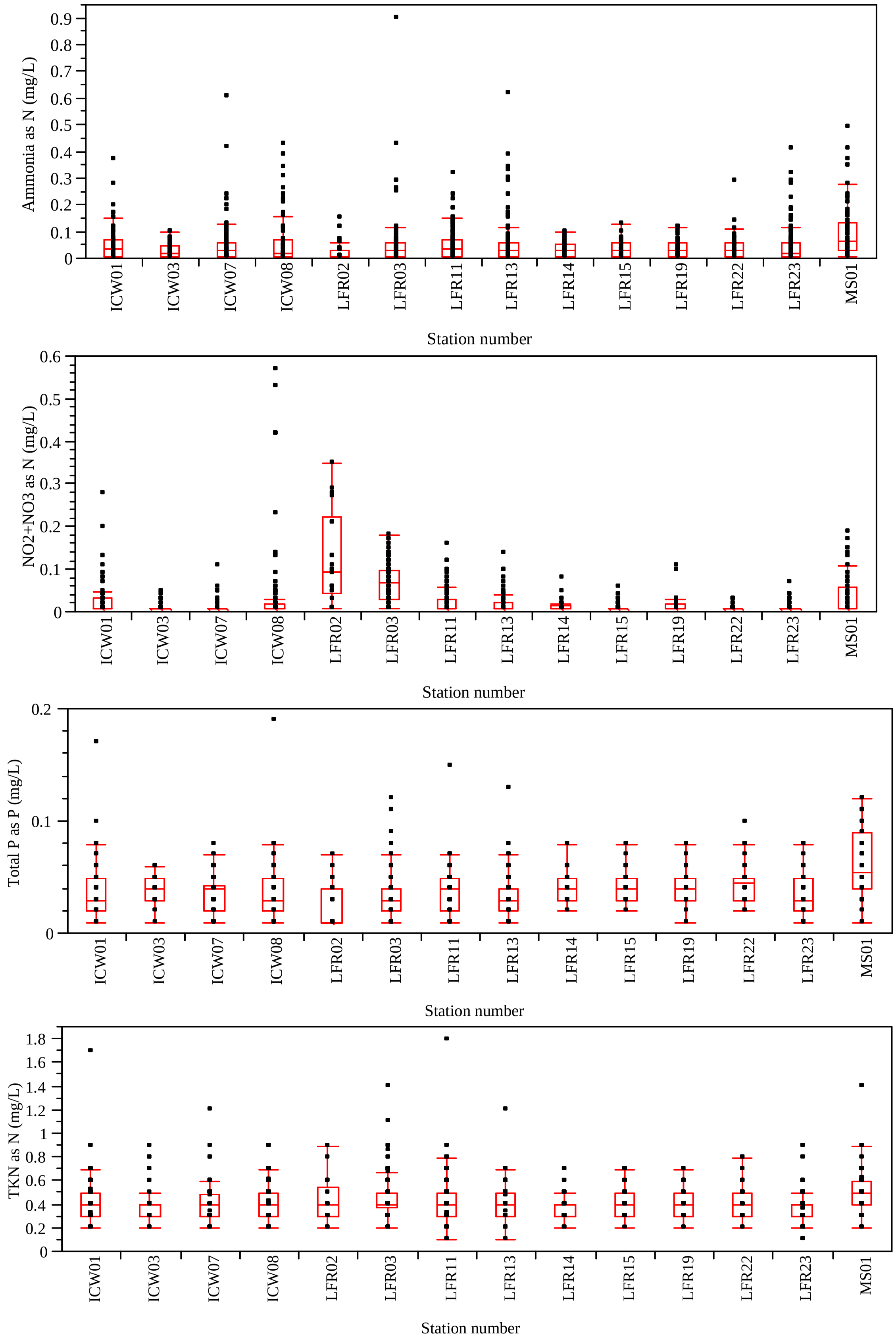


Figure 6: AMS nutrient data distributions



Metals

The majority of metals sampled as part of the AMS program are reported as less than the reporting level (i.e., non-detects). A summary of non-detects for AMS data is shown in Table 9. The only metals with suitable amounts of data suitable for analysis are aluminum, iron, zinc, and copper. Of these, there are corresponding action levels for copper (3 ug/L) and zinc (86 ug/L). A summary of action level exceedences for each station is shown in Table 10.

Table 9: Percent of metals results that are non-detects

Metal	N	N non-detects	% non-detects
Aluminum Al - Total (ug/L)	647	1	0
Iron Fe total (ug/L)	654	25	4
Zinc Zn total (ug/L)	1045	597	57
Copper Cu total (ug/L)	1045	756	72
Lead Pb total (ug/L)	1044	1010	97
Nickel Ni total (ug/L)	1033	1008	98
Cadmium Cd total (ug/L)	1045	1024	98
Chromium Cr total (ug/L)	1043	1030	99
Mercury Hg total (ug/L)	1042	1031	99
Arsenic As total (ug/L)	1035	1029	99

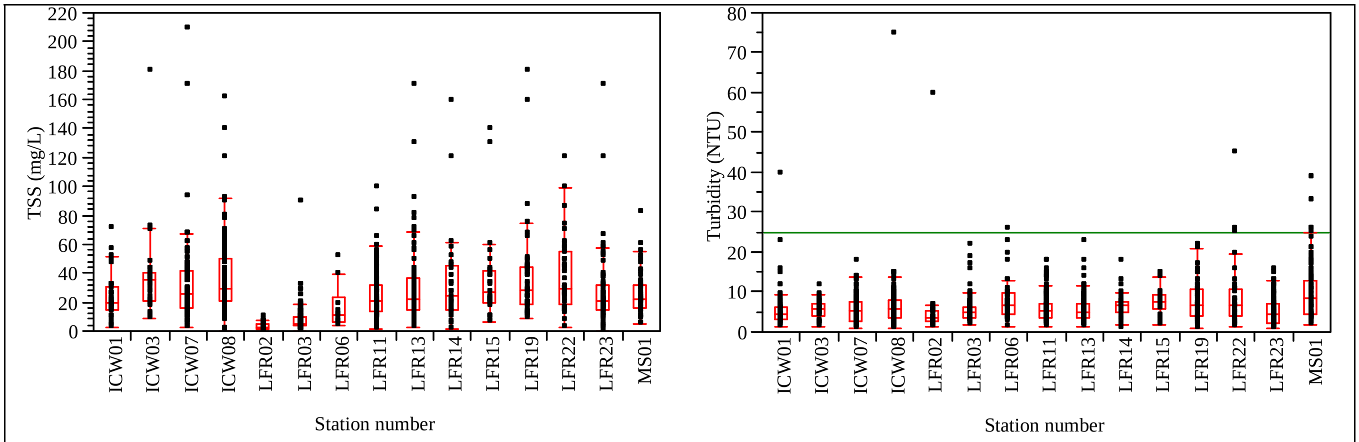
Table 10: NC Action Level Exceedences for Copper and Zinc

Station	% results > Cu AL	% results > Zn AL
LFR02	5	10
LFR03	15	0
LFR06	0	0
LFR11	17	1
LFR13	15	0
LFR14	22	0
LFR15	23	0
LFR19	18	0
LFR22	17	0
LFR23	19	0
ICW01	13	1
ICW03	8	0
ICW07	14	0
ICW08	28	4
MS01	12	1

TSS and Turbidity

Distribution of total suspended solids (TSS) and turbidity are shown in Figure 7. Few exceedences of the turbidity standard of 25 NTU occur. There are no apparent patterns for these parameters that hold true for all stations, within HUCs, or upstream/downstream: some stations show little to no change, some show upward trends, some downward trends. Certain stations on the Lockwoods Folly R. mainstem actually show inverse trends for TSS and turbidity, i.e., turbidity appears to be trending up while TSS is trending down. An example of this from station LFR23 is shown in Figure 8. However, Montgomery Slough, which is situated in the middle of the Long Beach/Oak Island barrier island and has experienced significant growth over the last several decades, shows an expected upward trend for both parameters, as shown in Figure 9.

Figure 7: TSS and Turbidity distributions by station



Green line indicates NC water quality standard of 25 NTU for saltwater.

Figure 8: TSS and Turbidity at Lockwoods Folly R. at West Channel Islands (LFR23)

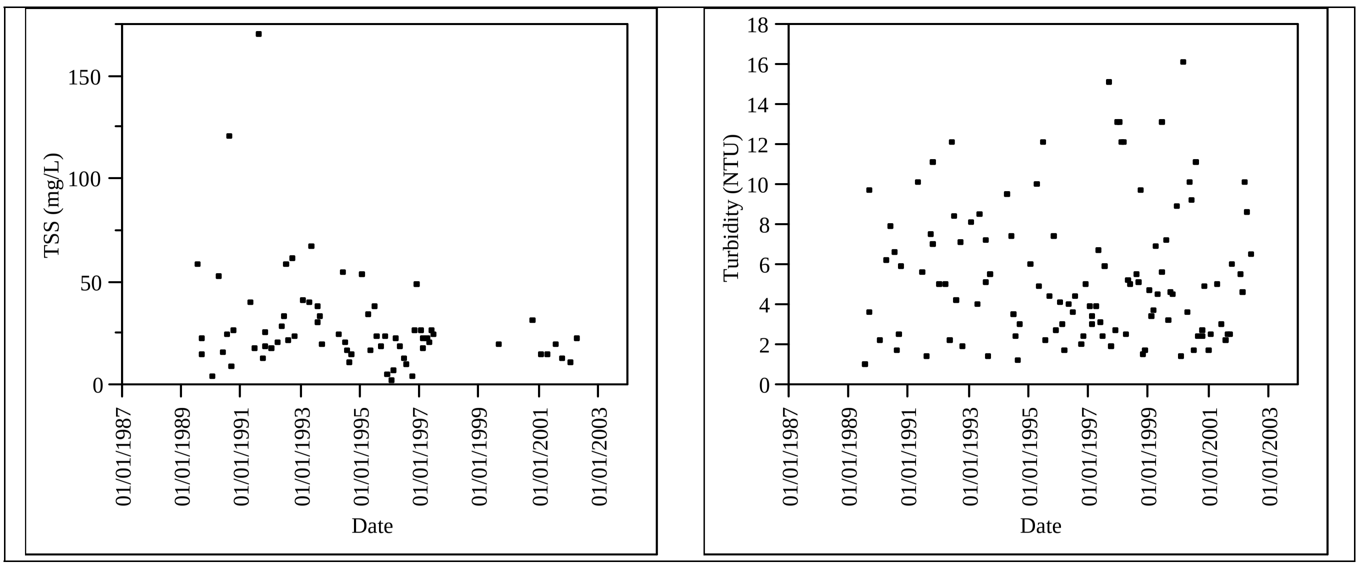
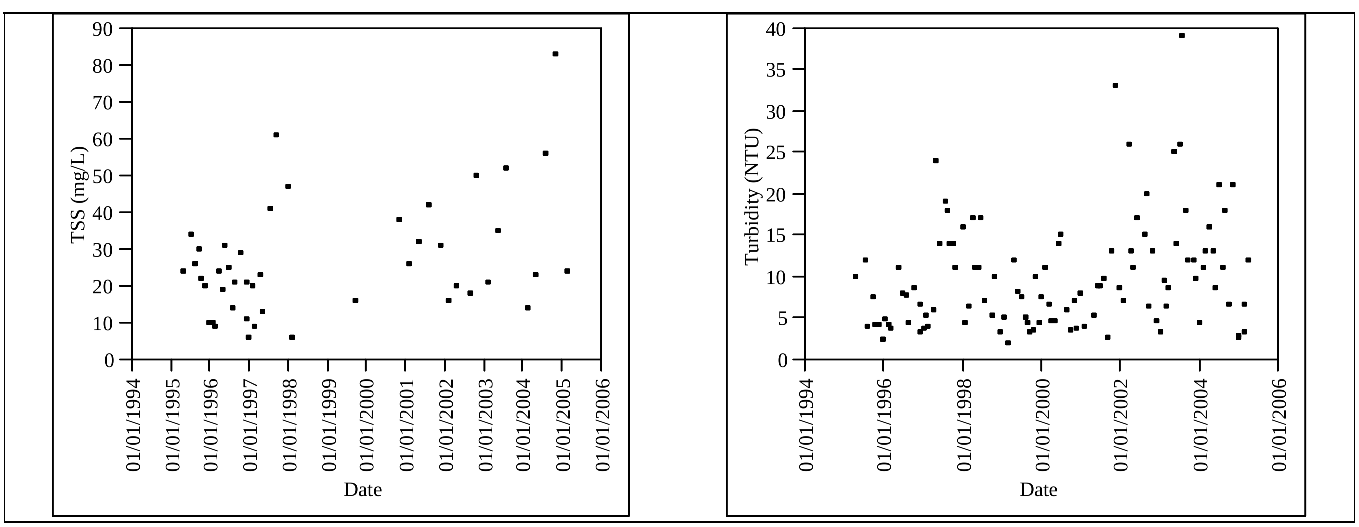


Figure 9: TSS and Turbidity at Montgomery Slough at SR 1105 (MS01)



Fecal coliform and other microbiological pathogen indicators

Data on fecal coliform and other indicator species are collected by the DWQ AMS, DEH Recreational Beach Monitoring program, and the DEH Shellfish Sanitation program. The two major types of pathogen indicator data available are fecal coliform and enterococcus. NC water quality standards protecting for recreation and shellfishing uses are based on fecal coliform, and this has been the primary pathogen monitored by the AMS and Shellfish Sanitation programs. In contrast, the Recreational Beach program has monitored for fecal coliform, enterococcus, and E. coli. Historically, fecal coliform has also been the indicator used for recreational beaches. The BEACH Act of 2000 required a switch to the indicator enterococcus for federally identified bathing beaches, and a new standard based on this indicator was enacted in 2004. Since 2002, enterococcus has been measured exclusively at Recreational Beaches.

Due to multiple protected uses, a particular waterbody may be subject to more than one water quality standard for microbial pathogens in NC. A summary of the various standards is shown in Table 11. (All results for fecal coliform and enterococcus are reported as colonies/100mL.)

Table 11: Summary of bacterial pathogen standards in NC

(All values are in colonies/100mL)

Use	Affected waters	Indicator	Standard- central tendency	Standard- single sample max
Primary recreation[1]	B, SB, and SA classifications	Fecal coliform	geomean <200	<20% of samples >400
Secondary recreation[1]	All stream classifications	Fecal coliform	geomean <200	<20% of samples >400
Shellfishing	SA classifications	Fecal coliform	median <14	<10% of samples >43
Bathing beach	Federally designated bathing beaches	Enterococcus	Tier I: geomean <35[1]	Tier I: >104
			Tier II: N/A	Tier II: >276
			Tier III: N/A	Tier III: >500[2]

[1] The standard is based on the results of five samples taken within a thirty-day period.
[2] This value must be exceeded in two or more consecutive samples.

Summary by program

DWQ- Ambient Monitoring System (AMS)

A summary for each station of available data, measures of central tendency and percent of samples greater than the single sample maximum are shown in Table 12. AMS samples are not taken often enough for definitive decisions of standard exceedences, since standards are based on five samples taken within a thirty-day period. For the purposes of this report, the values specified by the SA and SC water quality standards are used as guidelines or benchmarks to highlight stations that may have ongoing concerns with fecal coliform levels. The results for these stations are shown in bold in Table 12, but should not be interpreted as a definitive indication of use support or standard violations.

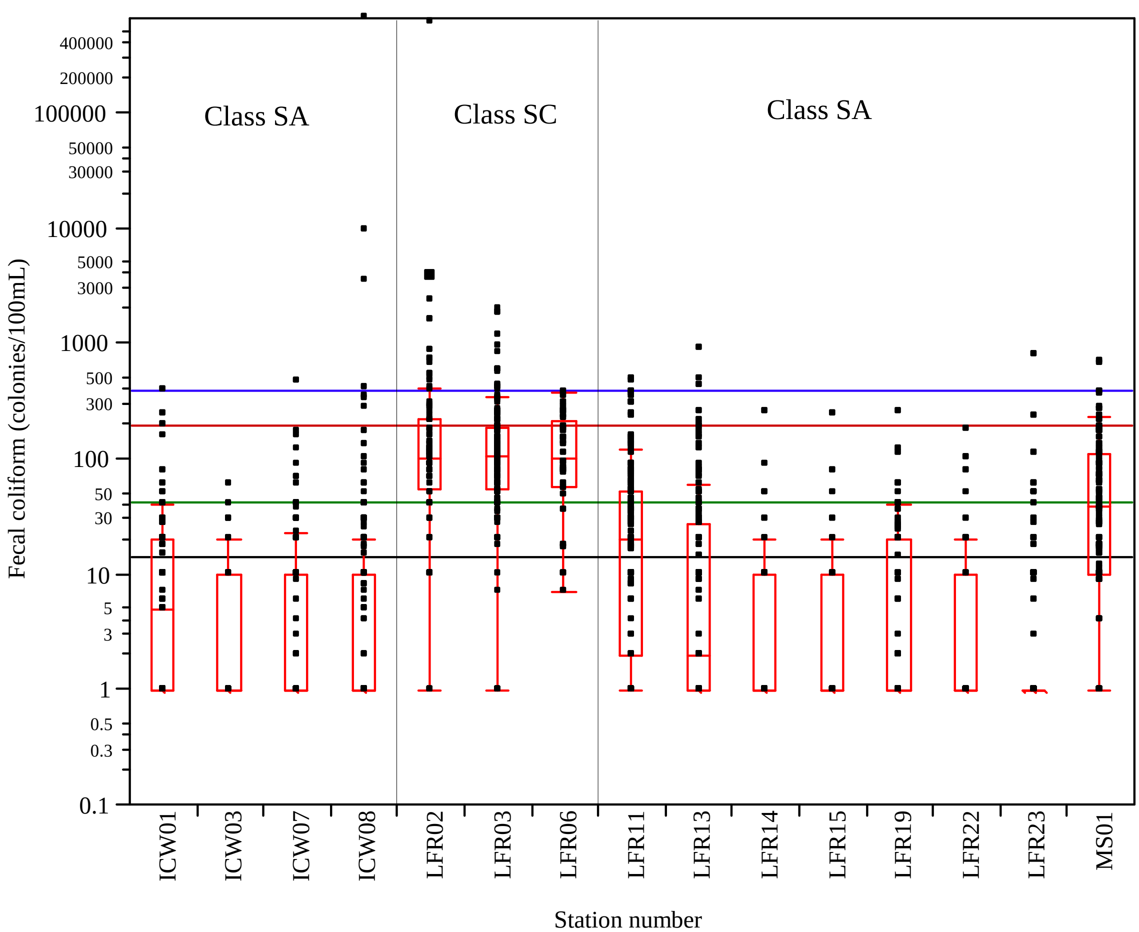
Distributions for all AMS stations are shown in Figure 10. There are several lines shown for reference that correspond to SA and SC water quality standards: black = 14; green = 43; red = 200; blue = 400.

Table 12: AMS Fecal Coliform data summary

Bold numbers indicate results that exceed benchmark values based on NC water quality standards.

Station	Start date	End date	N results	Median	%>43	Geomean	%>400
ICW01	05/1995	07/2002	81	5	**10**	5	0
ICW03	07/1989	02/1995	39	1	3	2	0
ICW07	07/1989	07/2002	125	1	7	3	2
ICW08	08/1970	07/2002	191	1	8	4	2
LFR02	06/1973	11/1984	89	N/A	N/A	103	17
LFR03	07/1989	04/2005	160	N/A	N/A	95	9
LFR06	09/2002	04/2005	32	N/A	N/A	90	0
LFR11	07/1989	04/2005	161	20	**29**	15	1
LFR13	07/1989	07/2002	126	2	**19**	6	2
LFR14	07/1989	04/1995	32	1	**13**	4	0
LFR15	07/1989	04/1995	31	1	**10**	3	0
LFR19	07/1989	04/2005	72	1	8	3	0
LFR22	07/1989	04/1995	42	1	**10**	2	0
LFR23	07/1989	07/2002	114	1	7	2	1
MS01	05/1995	04/2005	112	39	**48**	29	2

Figure 10: Distribution of Fecal Coliform for AMS stations



DEH- Recreational Beach Monitoring

The DEH performs monitoring at approximately six locations in this watershed as part of the Recreational Beach Monitoring program. In the past, fecal coliform, E. coli, and enterococcus have all been measured in order to assess comparability of the indicators when the standard was changed from fecal coliform to enterococcus in 2004. Summaries of data at each station for fecal coliform and enterococcus are presented in Tables 13-14. Water quality exceedences are shown in bold. All stations are designated Tier II bathing beaches, and are located in SA class waters.

Table 13: Fecal Coliform results from Recreational Beach Monitoring

Station	Start date	End date	N results	Median	%>43
LFR06	6/1997	6/2002	97	33	45
LFR14	6/1997	9/2002	91	6.8	10

Table 14: Enterococcus results from Recreational Beach Monitoring

Values in bold indicate that water quality standards have been exceeded at this location.

Station	Start date	End date	N results	N>276	%>276
LFR06	6/1997	2/2004	68	0	0
LFR11	3/2004	7/2005	29	**2**	**7**
LFR14	6/1997	7/2005	96	**1**	**1**

DEH- Shellfish Sanitation

This section includes a summary of data from a total of twenty-six locations located in the LWP watershed that was provided by the DEH Shellfish Sanitation Section provided. Of these, sixteen locations are actively monitored as part of their ongoing program. In addition to this ambient-type monitoring program, there are ten upstream stations being monitored as part of special study, which began in February 2005 and continues through September 2005.

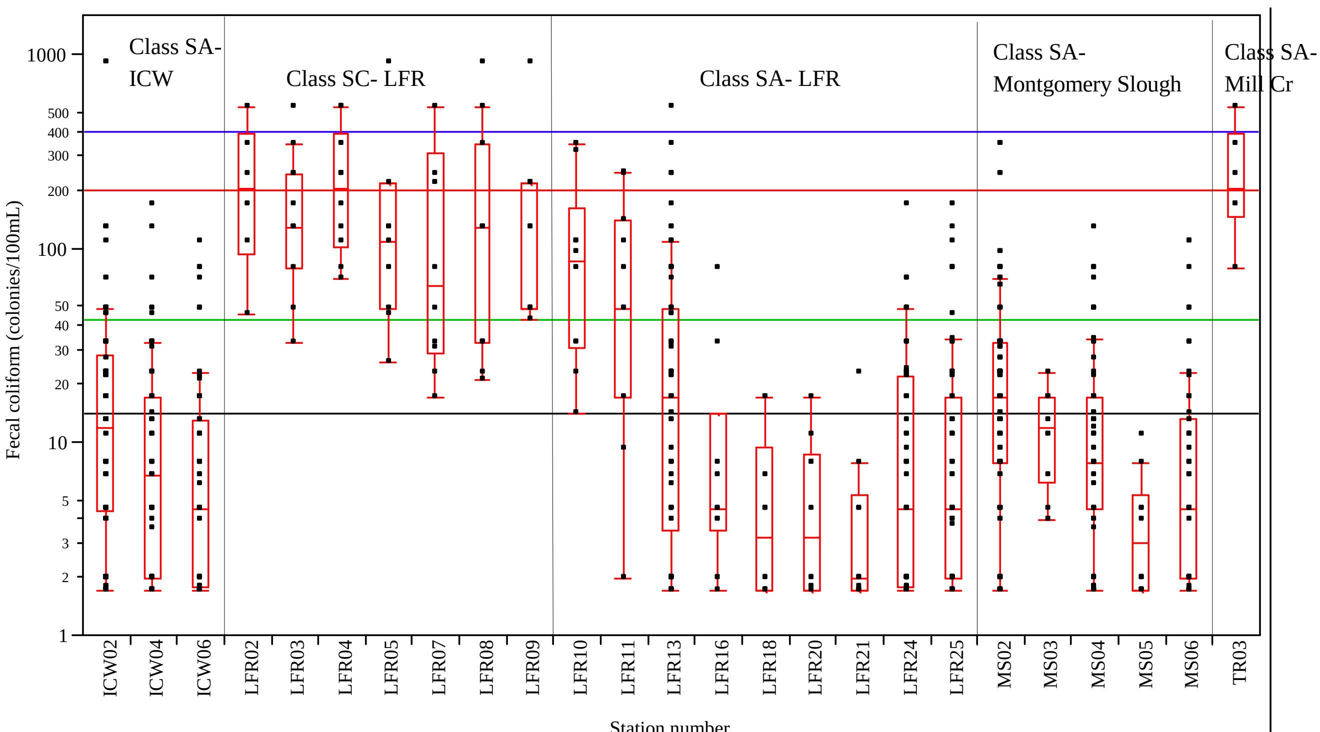
It should be noted that DEH provided results from an additional fourteen stations, but were unable to provide latitude/longitude information or descriptions of the locations. It was felt that without some sort of georeferencing these data were of minimal use and so have been omitted from this summary.

Summaries of Shellfish Sanitation data are presented in Table 15. Distributions are shown in Figure 11.

Table 15: Summary of Shellfish Sanitation fecal coliform monitoring data

Summary station #	Start date	End date	N results	Median	%>43	Geomean	%>400
ICW02	03/1993	06/2005	74	12.0	**16.2**	11.0	1.4
ICW04	03/1993	06/2005	74	6.8	8.1	7.5	0.0
ICW06	03/1993	06/2005	74	4.5	9.5	5.8	0.0
LFR12	03/1993	06/2005	74	17.0	**31.1**	14.7	1.4
LFR15	07/2004	06/2005	10	4.5	**10.0**	6.6	0.0
LFR17	07/2004	02/2005	6	1.9	0.0	3.0	0.0
LFR18	07/2004	06/2005	10	3.3	0.0	3.8	0.0
LFR20	07/2004	06/2005	10	3.3	0.0	3.9	0.0
LFR21	07/2004	06/2005	10	2.0	0.0	3.2	0.0
LFR24	03/1993	06/2005	74	4.5	9.5	6.2	0.0
LFR25	03/1993	06/2005	74	4.5	9.5	6.5	0.0
MS02	03/1993	06/2005	74	17.0	**14.9**	16.7	0.0
MS03	07/2004	06/2005	10	12.0	0.0	10.8	0.0
MS04	03/1993	06/2005	74	7.8	**13.5**	9.6	0.0
MS05	07/2004	06/2005	10	3.0	0.0	3.3	0.0
MS06	03/1993	06/2005	74	4.5	8.1	6.2	0.0
Special study locations							
LFR03	02/2005	08/2005	11	N/A	N/A	143.2	9.1
LFR04	04/2005	08/2005	10	N/A	N/A	194.9	**20.0**
LFR05	02/2005	08/2005	11	N/A	N/A	126.8	18.2
LFR07	04/2005	08/2005	10	N/A	N/A	96.6	**20.0**
LFR08	02/2005	08/2005	11	N/A	N/A	96.3	18.2
LFR09	02/2005	08/2005	11	N/A	N/A	99.2	9.1
LFR10	04/2005	08/2005	10	N/A	N/A	71.7	0.0
LFR11	02/2005	08/2005	11	49	72.7	47.4	0.0
TR03	06/2005	08/2005	6	205	100.0	**216.7**	16.7

Figure 11: Distributions of fecal coliform data collected by DEH Shellfish Sanitation



USGS

USGS' National Water Information System (NWIS) database contains results from a single sampling event in February 2000 at Mill Creek (TR02). The full list of results is included in Appendix 2. Besides this one location, USGS has no stations and no continuous flow gages in this watershed. This is probably due to difficulty of developing accurate rating curves on the coastal plain given the instability of stream channels. The nearest gages maintained by the USGS are on Hood Cr. near Leland (Cape Fear R. basin), Waccamaw R. at Freeland, and Waccamaw R. near Longs, SC.

Groundwater data

The 1989 technical report (NC DENR, DEM 1989b) of water quality issues in Lockwoods Folly recommended that groundwater sampling be performed to "determine underlying stratigraphy and presence of bacteria." Aquifer Protection Section staff have reviewed their files for such a study, or any other available bacterial data from the area. No such information was found.

DWQ Intensive Survey Unit dye study

In 1989, DEM performed a dye study on Davis Cr. to determine if it could be a possible fecal coliform source to Lockwoods Folly. It concluded that Davis Cr. was not a significant source of flow to the Lockwood Folly R.

NPDES permits and aquatic toxicity

There is only one NPDES-permitted facility, Bolivia Elementary School (permit NC0045250), which discharges into Bolivia Br. (HUC 020010). Bolivia Br. is a tributary of Middle Swamp, which in turn feeds into the Lockwoods Folly River. This facility is a minor 100% domestic discharger. Toxicity testing is generally not required for this class of facility, and no aquatic toxicity results have been reported. Its permit does require effluent monitoring for temperature, specific conductance, DO, BOD, pH, TSS, ammonia, fecal coliform, and flow. This facility has a history of monitoring report violations for fecal coliform, ammonia, DO, pH, and BOD going back to 1994 and as recently as spring 2005. A list of limit exceedences is shown in Table 16; listings due to clerical issues (missing signatures, etc.) have been omitted.

Table 16: DMR violations, Bolivia Elementary School, NPDES permit # NC0045250

Violation date	Parameter	Unit	Frequency	Limit	Calc value	Violation type	Violation action
5/31/2005	Coliform, Fecal	#/100ml	2 X month	200	214.48	Monthly Geomean Exceeded	Proceed to NOV
5/25/2005	Coliform, Fecal	#/100ml	2 X month	400	460	Daily Max Exceeded	Proceed to NOV
3/24/2005	Coliform, Fecal	#/100ml	2 X month	400	800	Daily Max Exceeded	Proceed to NOV
1/31/2003	Coliform, Fecal	#/100ml	2 X month	400	560	Daily Max Exceeded	Proceed to NOV
10/31/2000	Ammonia Total as N	mg/l	2 X month	2	2.9	Monthly Ave. Exceeded	DMR conversion history
9/30/2000	Ammonia Total as N	mg/l	2 X month	2	2.8	Monthly Ave. Exceeded	DMR conversion history
12/31/1999	Coliform, Fecal	#/100ml	2 X month	200	337	Monthly Geomean Exceeded	BIMS Pre-Production Violation
12/31/1999	Ammonia Total as N	mg/l	2 X month	4	7.6	Monthly Ave. Exceeded	BIMS Pre-Production Violation
11/30/1999	DO	mg/l	Weekly	6	5.99	Daily Min Not Reached	BIMS Pre-Production Violation
10/31/1999	DO	mg/l	Weekly	6	5.64	Daily Min Not Reached	BIMS Pre-Production Violation
9/30/1998	BOD, 5-Day (20 Deg. C)	mg/l	2 X month	5	6	Monthly Ave. Exceeded	BIMS Pre-Production Violation
8/31/1998	Ammonia Total as N	mg/l	2 X month	2	3.3	Monthly Ave. Exceeded	BIMS Pre-Production Violation
4/30/1998	Flow, in conduit or thru treatment plant	mgd	Weekly	0.01	0.027	Monthly Ave. Exceeded	BIMS Pre-Production Violation
7/31/1996	DO, Oxygen, Dissolved	mg/l	Weekly	6	5.7	Daily Min Not Reached	BIMS Pre-Production Violation
5/31/1996	pH	su	2 X month	6	5.9	Daily Min Not Reached	BIMS Pre-Production Violation
4/30/1996	pH	su	2 X month	6	4.6	Daily Min Not Reached	BIMS Pre-Production Violation
3/31/1996	DO, Oxygen, Dissolved	mg/l	Weekly	6	5.3	Daily Min Not Reached	BIMS Pre-Production Violation
3/31/1996	Nitrogen, Ammonia Total (as N)	mg/l	2 X month	4	15.5	Monthly Ave. Exceeded	BIMS Pre-Production Violation
2/29/1996	Nitrogen, Ammonia Total (as N)	mg/l	2 X month	4	8.9	Monthly Ave. Exceeded	BIMS Pre-Production Violation
3/31/1995	pH	su	2 X month	6	5.9	Daily Min Not Reached	BIMS Pre-Production Violation
2/28/1995	pH	su	2 X month	6	5.6	Daily Min Not Reached	BIMS Pre-Production Violation
1/31/1995	pH	su	2 X month	6	5.9	Daily Min Not Reached	BIMS Pre-Production Violation
11/30/1994	pH	su	2 X month	6	5.6	Daily Min Not Reached	BIMS Pre-Production Violation
12/31/1994	pH	su	2 X month	6	5.1	Daily Min Not Reached	BIMS Pre-Production Violation

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Appendix 1: DWQ Fish community raw data

Waterbody	Station	Latitude	Longitude	Date	Collection No.	Scientific Name	No. Collected
Lockwoods Folly R	US 17	340249	781044	04/28/92	92-09	Lepomis microlophus	1
Lockwoods Folly R	US 17	340249	781044	04/28/92	92-09	Lepomis punctatus	2
Lockwoods Folly R	US 17	340249	781044	04/28/92	92-09	Erimyzon oblongus	3
Lockwoods Folly R	US 17	340249	781044	04/28/92	92-09	Notemigonus crysoleucas	3
Lockwoods Folly R	US 17	340249	781044	04/28/92	92-09	Notropis cummingsae	3
Lockwoods Folly R	US 17	340249	781044	04/28/92	92-09	Lepomis gulosus	4
Lockwoods Folly R	US 17	340249	781044	04/28/92	92-09	Esox americanus	8
Lockwoods Folly R	US 17	340249	781044	04/28/92	92-09	Aphredoderus sayanus	9
Lockwoods Folly R	US 17	340249	781044	04/28/92	92-09	Enneacanthus gloriosus	9
Lockwoods Folly R	US 17	340249	781044	04/28/92	92-09	Anguilla rostrata	10
Lockwoods Folly R	US 17	340249	781044	04/28/92	92-09	Gambusia holbrooki	100
Lockwoods Folly R	US 17	340249	781044	04/02/96	96-11	Ameiurus natalis	1
Lockwoods Folly R	US 17	340249	781044	04/02/96	96-11	Centrarchus macropterus	1
Lockwoods Folly R	US 17	340249	781044	04/02/96	96-11	Enneacanthus gloriosus	1
Lockwoods Folly R	US 17	340249	781044	04/02/96	96-11	Erimyzon oblongus	1
Lockwoods Folly R	US 17	340249	781044	04/02/96	96-11	Lepomis gibbosus	1
Lockwoods Folly R	US 17	340249	781044	04/02/96	96-11	Lepomis macrochirus	1
Lockwoods Folly R	US 17	340249	781044	04/02/96	96-11	Notropis chalybaeus	1
Lockwoods Folly R	US 17	340249	781044	04/02/96	96-11	Anguilla rostrata	2
Lockwoods Folly R	US 17	340249	781044	04/02/96	96-11	Esox americanus	2
Lockwoods Folly R	US 17	340249	781044	04/02/96	96-11	Lepomis gulosus	2
Lockwoods Folly R	US 17	340249	781044	04/02/96	96-11	Lepomis punctatus	2
Lockwoods Folly R	US 17	340249	781044	04/02/96	96-11	Gambusia holbrooki	18
Royal Oak Swp	NC 211	340200	781649	04/25/92	92-11	Ameiurus natalis	1
Royal Oak Swp	NC 211	340200	781649	04/25/92	92-11	Erimyzon oblongus	1
Royal Oak Swp	NC 211	340200	781649	04/25/92	92-11	Etheostoma olmstedi	1
Royal Oak Swp	NC 211	340200	781649	04/25/92	92-11	Gambusia holbrooki	1
Royal Oak Swp	NC 211	340200	781649	04/25/92	92-11	Micropterus salmoides	1
Royal Oak Swp	NC 211	340200	781649	04/25/92	92-11	Ameiurus platycephalus	2
Royal Oak Swp	NC 211	340200	781649	04/25/92	92-11	Lepomis gibbosus	2
Royal Oak Swp	NC 211	340200	781649	04/25/92	92-11	Notemigonus crysoleucas	2
Royal Oak Swp	NC 211	340200	781649	04/25/92	92-11	Noturus gyrinus	2
Royal Oak Swp	NC 211	340200	781649	04/25/92	92-11	Lepomis auritus	3
Royal Oak Swp	NC 211	340200	781649	04/25/92	92-11	Lepomis gulosus	5
Royal Oak Swp	NC 211	340200	781649	04/25/92	92-11	Noturus insignis	5
Royal Oak Swp	NC 211	340200	781649	04/25/92	92-11	Lepomis punctatus	6
Royal Oak Swp	NC 211	340200	781649	04/25/92	92-11	Enneacanthus gloriosus	10
Royal Oak Swp	NC 211	340200	781649	04/25/92	92-11	Notropis chalybaeus	10
Royal Oak Swp	NC 211	340200	781649	04/25/92	92-11	Esox americanus	18
Royal Oak Swp	NC 211	340200	781649	04/25/92	92-11	Aphredoderus sayanus	27
Royal Oak Swp	NC 211	340200	781649	04/25/92	92-11	Notropis cummingsae	40
Royal Oak Swp	NC 211	340200	781649	04/25/92	92-11	Anguilla rostrata	63
Royal Oak Swp	NC 211	340200	781649	05/21/01	2001-44	Ameiurus natalis	2
Royal Oak Swp	NC 211	340200	781649	05/21/01	2001-44	Esox americanus	4
Royal Oak Swp	NC 211	340200	781649	05/21/01	2001-44	Erimyzon oblongus	5
Royal Oak Swp	NC 211	340200	781649	05/21/01	2001-44	Lepomis gibbosus	5
Royal Oak Swp	NC 211	340200	781649	05/21/01	2001-44	Lepomis marginatus	5

Royal Oak Swp	NC 211	340200	781649	05/21/01	2001-44	Notropis petersoni	5
Royal Oak Swp	NC 211	340200	781649	05/21/01	2001-44	Etheostoma olmstedi	6
Royal Oak Swp	NC 211	340200	781649	05/21/01	2001-44	Gambusia holbrooki	9
Royal Oak Swp	NC 211	340200	781649	05/21/01	2001-44	Aphredoderus sayanus	10
Royal Oak Swp	NC 211	340200	781649	05/21/01	2001-44	Lepomis macrochirus	12
Royal Oak Swp	NC 211	340200	781649	05/21/01	2001-44	Lepomis auritus	19
Royal Oak Swp	NC 211	340200	781649	05/21/01	2001-44	Lepomis punctatus	26
Royal Oak Swp	NC 211	340200	781649	05/21/01	2001-44	Enneacanthus gloriosus	49
Royal Oak Swp	NC 211	340200	781649	05/21/01	2001-44	Anguilla rostrata	50
Royal Oak Swp	NC 211	340200	781649	05/21/01	2001-44	Notropis cummingsae	56
Royal Oak Swp	NC 211	340200	781649	05/21/01	2001-44	Notropis chalybaeus	63

Appendix 2: USGS Chemical Data

The following results were collected 2/21/2000 by the USGS at station #355817078121201- Mill Creek near Long Beach, NC. If “<” is shown in the Remark column, the analyte was not detected above the reporting limit. For these non-detects, the value shown in the Result column is the reporting limit.

Method code	Parameter description	Rmk	Result
10	Temperature, water, °C		11.5
20	Temperature, air, °C		11.5
25	Barometric pressure, millimeters of mercury		775
61	Discharge, instantaneous, cubic feet per second		0.44
95	Specific conductance, water, unfiltered, µS /cm at 25 °C		110
300	Dissolved oxygen, water, unfiltered, mg/L		8.1
400	pH, water, unfiltered, field, standard units		6.1
403	pH, water, unfiltered, laboratory, standard units		7.2
453	Bicarbonate, water, filtered, incremental titration, field, mg/L		24
608	Ammonia, water, filtered, mg/L as nitrogen	<	0.02
613	Nitrite, water, filtered, mg/L as nitrogen	<	0.01
623	Ammonia plus organic nitrogen, water, filtered, mg/L as nitrogen		0.19
625	Ammonia plus organic nitrogen, water, unfiltered, mg/L as nitrogen		2.8
631	Nitrite plus nitrate, water, filtered, mg/L as nitrogen		0.13
665	Phosphorus, water, unfiltered, mg/L		0.015
666	Phosphorus, water, filtered, mg/L		0.006
671	Orthophosphate, water, filtered, mg/L as phosphorus	<	0.01
915	Calcium, water, filtered, mg/L		8.68
925	Magnesium, water, filtered, mg/L		1.52
930	Sodium, water, filtered, mg/L		8.48
935	Potassium, water, filtered, mg/L		1.05
940	Chloride, water, filtered, mg/L		14.2
945	Sulfate, water, filtered, mg/L		8
950	Fluoride, water, filtered, mg/L	<	0.1
955	Silica, water, filtered, mg/L		6.57
1046	Iron, water, filtered, µg/L		278
1056	Manganese, water, filtered, µg/L		10.1
4024	Propachlor, water, filtered, recoverable, µg/L	<	0.007
4028	Butylate, water, filtered, recoverable, µg/L	<	0.002
4035	Simazine, water, filtered, recoverable, µg/L	<	0.005
4037	Prometon, water, filtered, recoverable, µg/L	<	0.02
4040	2-Chloro-4-isopropylamino-6-amino-s-triazine, water, filtered, recoverable, µg/L	<	0.002
4041	Cyanazine, water, filtered, recoverable, µg/L	<	0.004
4095	Fonofos, water, filtered, recoverable, µg/L	<	0.003
29801	Alkalinity, water, filtered, fixed endpoint (pH 4.5) titration, laboratory, mg/L as calcium carbonate		21
34253	alpha-HCH, water, filtered, recoverable, µg/L	<	0.002
34653	p,p'-DDE, water, filtered, recoverable, µg/L	<	0.006
38933	Chlorpyrifos, water, filtered, recoverable, µg/L	<	0.004
39086	Alkalinity, water, filtered, incremental titration, field, mg/L as calcium		20

	carbonate		
39341	Lindane, water, filtered, recoverable, µg/L	<	0.004
39381	Dieldrin, water, filtered, recoverable, µg/L	<	0.001
39415	Metolachlor, water, filtered, recoverable, µg/L	<	0.002
39532	Malathion, water, filtered, recoverable, µg/L	<	0.005
39542	Parathion, water, filtered, recoverable, µg/L	<	0.004
39572	Diazinon, water, filtered, recoverable, µg/L	<	0.002
39632	Atrazine, water, filtered, recoverable, µg/L	<	0.001
46342	Alachlor, water, filtered, recoverable, µg/L	<	0.002
49260	Acetochlor, water, filtered, recoverable, µg/L	<	0.002
70300	Residue on evaporation, dried at 180 °C, water, filtered, mg/L		78
82630	Metribuzin, water, filtered, recoverable, µg/L	<	0.004
82660	2,6-Diethylaniline, water, filtered (0.7 micron glass fiber filter), recoverable, µg/L	<	0.003
82661	Trifluralin, water, filtered (0.7 micron glass fiber filter), recoverable, µg/L	<	0.002
82663	Ethalfluralin, water, filtered (0.7 micron glass fiber filter), recoverable, µg/L	<	0.004
82664	Phorate, water, filtered (0.7 micron glass fiber filter), recoverable, µg/L	<	0.002
82665	Terbacil, water, filtered (0.7 micron glass fiber filter), recoverable, µg/L	<	0.007
82666	Linuron, water, filtered (0.7 micron glass fiber filter), recoverable, µg/L	<	0.002
82667	Methyl parathion, water, filtered (0.7 micron glass fiber filter), recoverable, µg/L	<	0.006
82668	EPTC, water, filtered (0.7 micron glass fiber filter), recoverable, µg/L	<	0.002
82669	Pebulate, water, filtered (0.7 micron glass fiber filter), recoverable, µg/L	<	0.004
82670	Tebuthiuron, water, filtered (0.7 micron glass fiber filter), recoverable, µg/L	<	0.01
82671	Molinate, water, filtered (0.7 micron glass fiber filter), recoverable, µg/L	<	0.004
82672	Ethoprop, water, filtered (0.7 micron glass fiber filter), recoverable, µg/L	<	0.003
82673	Benfluralin, water, filtered (0.7 micron glass fiber filter), recoverable, µg/L	<	0.002
82674	Carbofuran, water, filtered (0.7 micron glass fiber filter), recoverable, µg/L	<	0.003
82675	Terbufos, water, filtered (0.7 micron glass fiber filter), recoverable, µg/L	<	0.01
82676	Propyzamide, water, filtered (0.7 micron glass fiber filter), recoverable, µg/L	<	0.003
82677	Disulfoton, water, filtered (0.7 micron glass fiber filter), recoverable, µg/L	<	0.02
82678	Triallate, water, filtered (0.7 micron glass fiber filter), recoverable, µg/L	<	0.001
82679	Propanil, water, filtered (0.7 micron glass fiber filter), recoverable, µg/L	<	0.004
82680	Carbaryl, water, filtered (0.7 micron glass fiber filter), recoverable, µg/L	<	0.003
82681	Thiobencarb, water, filtered (0.7 micron glass fiber filter), recoverable, µg/L	<	0.002
82682	DCPA, water, filtered (0.7 µm glass fiber filter), recoverable, µg/L	<	0.002
82683	Pendimethalin, water, filtered (0.7 µm glass fiber filter), recoverable, µg/L	<	0.004
82684	Napropamide, water, filtered (0.7 µm glass fiber filter), recoverable, µg/L	<	0.003
82685	Propargite, water, filtered (0.7 µm glass fiber filter), recoverable, µg/L	<	0.01
82686	Azinphos-methyl, water, filtered (0.7 µm glass fiber filter), recoverable, µg/L	<	0.001
82687	cis-Permethrin, water, filtered (0.7 µm glass fiber filter), recoverable, µg/L	<	0.005
90095	Specific conductance, water, unfiltered, laboratory, µS/cm at 25 °C		114
91063	Diazinon-d10, surrogate, water, filtered (0.7 µm glass fiber filter), % recovery		108
91065	alpha-HCH-d6, surrogate, water, filtered (0.7 µm glass fiber filter), % recovery		99.1

Appendix 3: Distributions of selected AMS data

Summary station	AMS Station #	Location	method code	method name	N	min	10th	25th	50th	75th	90th	max
ICW01	I9380000	ICW at CM R16 at Beaverdam Cr nr Long Beach	10	Water temperature (°C)	81	6.1	9.9	14.4	20	26.45	29.4	30.6
ICW01	I9380000	ICW at CM R16 at Beaverdam Cr nr Long Beach	45	Precipitation previous 24 hrs. (in.)	62	0	0	0	0	0	0.5	1
ICW01	I9380000	ICW at CM R16 at Beaverdam Cr nr Long Beach	78	Secchi Transparency (m)	56	0.2	0.6	0.8	1	1.2	1.56	2
ICW01	I9380000	ICW at CM R16 at Beaverdam Cr nr Long Beach	94	Conductivity field (umho/cm @25°C)	81	4430	21156	31560	42600	49000	51957.6	54930
ICW01	I9380000	ICW at CM R16 at Beaverdam Cr nr Long Beach	300	Dissolved oxygen (mg/L)	80	4.3	5.13	6.025	6.9	8.3	9.77	11.6
ICW01	I9380000	ICW at CM R16 at Beaverdam Cr nr Long Beach	400	pH (SU)	81	6.8	7.12	7.35	7.5	7.7	7.9	8.1
ICW01	I9380000	ICW at CM R16 at Beaverdam Cr nr Long Beach	480	Salinity (ppt)	72	5.6	15	22.325	27.85	33.1	34.54	143
ICW01	I9380000	ICW at CM R16 at Beaverdam Cr nr Long Beach	530	Residue total nonfilterable (mg/L)	35	3	7.2	15	20	31	50.2	72
ICW01	I9380000	ICW at CM R16 at Beaverdam Cr nr Long Beach	610	Ammonia nitrogen (mg/L)	70	0.01	0.01	0.01	0.04	0.0725	0.15	0.37
ICW01	I9380000	ICW at CM R16 at Beaverdam Cr nr Long Beach	625	Total Kjeldahl nitrogen TKN as N (mg/L)	70	0.2	0.2	0.3	0.4	0.5	0.6	1.7
ICW01	I9380000	ICW at CM R16 at Beaverdam Cr nr Long Beach	630	Nitrate/nitrite NO2 + NO3 as nitrogen (mg/L)	70	0.01	0.01	0.01	0.01	0.0325	0.08	0.28
ICW01	I9380000	ICW at CM R16 at Beaverdam Cr nr Long Beach	665	Phosphorus total as P (mg/L)	70	0.01	0.02	0.02	0.03	0.05	0.069	0.17
ICW01	I9380000	ICW at CM R16 at Beaverdam Cr nr Long Beach	680	T ORG C C MG/L	2	5	5	5	7.5	10	10	10
ICW01	I9380000	ICW at CM R16 at Beaverdam Cr nr Long Beach	1002	Arsenic As total (ug/L)	69	5	5	5	5	5	5	11
ICW01	I9380000	ICW at CM R16 at Beaverdam Cr nr Long Beach	1027	Cadmium Cd total (ug/L)	70	2	2	2	2	2	2	19
ICW01	I9380000	ICW at CM R16 at Beaverdam Cr nr Long Beach	1034	Chromium Cr total (ug/L)	70	25	25	25	25	25	25	25
ICW01	I9380000	ICW at CM R16 at Beaverdam Cr nr Long Beach	1042	Copper Cu total (ug/L)	70	2	2	2	2	2	3.99	9.7
ICW01	I9380000	ICW at CM R16 at Beaverdam Cr nr Long Beach	1045	Iron Fe total (ug/L)	70	20	111	187.5	360	472.5	688	2000
ICW01	I9380000	ICW at CM R16 at Beaverdam Cr nr Long Beach	1051	Lead Pb total (ug/L)	70	10	10	10	10	10	10	130
ICW01	I9380000	ICW at CM R16 at Beaverdam Cr nr Long Beach	1067	Nickel Ni total (ug/L)	70	10	10	10	10	10	10	150
ICW01	I9380000	ICW at CM R16 at Beaverdam Cr nr Long Beach	1092	Zinc Zn total (ug/L)	70	10	10	10	20.5	32.25	51.5	6000
ICW01	I9380000	ICW at CM R16 at Beaverdam Cr nr Long Beach	1105	Aluminum Al - Total (ug/L)	70	200	241	320	475	805	1090	2400
ICW01	I9380000	ICW at CM R16 at Beaverdam Cr nr Long Beach	31616	Fecal coliform MF method (colonies/100mL)	81	1	1	1	5	20	48	390
ICW01	I9380000	ICW at CM R16 at Beaverdam Cr nr Long Beach	71900	Mercury Hg total (ug/L)	70	0.2	0.2	0.2	0.2	0.2	0.2	0.2
ICW01	I9380000	ICW at CM R16 at Beaverdam Cr nr Long Beach	82079	Turbidity lab (NTU)	82	1.5	2.43	3.4	4.55	6.4	9.31	40
ICW03	I9390000	ICW at Sunset Harbor	10	Water temperature (°C)	40	9	10.98	21.025	24.5	28.175	29.94	30
ICW03	I9390000	ICW at Sunset Harbor	45	Precipitation previous 24 hrs. (in.)	19	0	0	0	0	0	1.2	2
ICW03	I9390000	ICW at Sunset Harbor	94	Conductivity field (umho/cm @25°C)	36	50	33956.7	40845.5	46770	50000	51501.3	750000
ICW03	I9390000	ICW at Sunset Harbor	300	Dissolved oxygen (mg/L)	40	4.2	5.12	5.8	6.3	7.3	9.41	11
ICW03	I9390000	ICW at Sunset Harbor	400	pH (SU)	35	7.4	7.6	7.8	8	8.1	8.28	8.7
ICW03	I9390000	ICW at Sunset Harbor	480	Salinity (ppt)	39	17	23.5	27.2	31.5	33.1	35	35.3
ICW03	I9390000	ICW at Sunset Harbor	530	Residue total nonfilterable (mg/L)	39	9	13	21	36	41	70	180
ICW03	I9390000	ICW at Sunset Harbor	610	Ammonia nitrogen (mg/L)	39	0.01	0.01	0.01	0.02	0.05	0.08	0.1
ICW03	I9390000	ICW at Sunset Harbor	625	Total Kjeldahl nitrogen TKN	39	0.2	0.2	0.3	0.4	0.4	0.7	0.9

				as N (mg/L)								
ICW03	I9390000	ICW at Sunset Harbor	630	Nitrate/nitrite NO2 + NO3 as nitrogen (mg/L)	39	0.01	0.01	0.01	0.01	0.01	0.03	0.05
ICW03	I9390000	ICW at Sunset Harbor	665	Phosphorus total as P (mg/L)	39	0.01	0.02	0.03	0.04	0.05	0.06	7.1
ICW03	I9390000	ICW at Sunset Harbor	1002	Arsenic As total (ug/L)	39	5	5	5	5	5	5	5
ICW03	I9390000	ICW at Sunset Harbor	1027	Cadmium Cd total (ug/L)	39	2	2	2	2	2	2	2
ICW03	I9390000	ICW at Sunset Harbor	1034	Chromium Cr total (ug/L)	38	25	25	25	25	25	25	370
ICW03	I9390000	ICW at Sunset Harbor	1042	Copper Cu total (ug/L)	39	2	2	2	2	2	3	6
ICW03	I9390000	ICW at Sunset Harbor	1045	Iron Fe total (ug/L)	4	150	150	185	300	377.5	400	400
ICW03	I9390000	ICW at Sunset Harbor	1051	Lead Pb total (ug/L)	39	10	10	10	10	10	10	10
ICW03	I9390000	ICW at Sunset Harbor	1067	Nickel Ni total (ug/L)	39	10	10	10	10	10	10	13
ICW03	I9390000	ICW at Sunset Harbor	1092	Zinc Zn total (ug/L)	39	10	10	10	10	10	10	10
ICW03	I9390000	ICW at Sunset Harbor	1105	Aluminum Al - Total (ug/L)	5	220	220	325	540	615	680	680
ICW03	I9390000	ICW at Sunset Harbor	31616	Fecal coliform MF method (colonies/100mL)	39	1	1	1	1	10	30	60
ICW03	I9390000	ICW at Sunset Harbor	70507	Phosphorus in total orthophosphate as P (mg/L)	39	0.01	0.01	0.01	0.02	0.02	0.02	0.03
ICW03	I9390000	ICW at Sunset Harbor	71900	Mercury Hg total (ug/L)	39	0.2	0.2	0.2	0.2	0.2	0.2	0.2
ICW03	I9390000	ICW at Sunset Harbor	82079	Turbidity lab (NTU)	39	1.7	2.5	4.3	5.8	7.2	8.4	12
ICW07	I9510000	ICW at CM R42 west of LFR	10	Water temperature (°C)	125	6.7	10.58	15.85	21.9	27	29	30
ICW07	I9510000	ICW at CM R42 west of LFR	45	Precipitation previous 24 hrs. (in.)	87	0	0	0	0	0	0.5	180
ICW07	I9510000	ICW at CM R42 west of LFR	78	Secchi Transparency (m)	57	0.4	0.8	0.9	1	1.3	1.92	2.4
ICW07	I9510000	ICW at CM R42 west of LFR	94	Conductivity field (umho/cm @25°C)	121	50	36003.2	42420	48337	51159	53576	750000
ICW07	I9510000	ICW at CM R42 west of LFR	300	Dissolved oxygen (mg/L)	125	3.2	5.2	6.1	7	8.2	9.44	12.3
ICW07	I9510000	ICW at CM R42 west of LFR	400	pH (SU)	122	7	7.4	7.6	7.8	8.1	8.2	8.5
ICW07	I9510000	ICW at CM R42 west of LFR	480	Salinity (ppt)	116	7.7	24	28.325	32	34	35.13	124
ICW07	I9510000	ICW at CM R42 west of LFR	530	Residue total nonfilterable (mg/L)	76	3	11	16	26.5	41.75	54.9	210
ICW07	I9510000	ICW at CM R42 west of LFR	610	Ammonia nitrogen (mg/L)	110	0.01	0.01	0.01	0.03	0.06	0.119	0.61
ICW07	I9510000	ICW at CM R42 west of LFR	625	Total Kjeldahl nitrogen TKN as N (mg/L)	110	0.2	0.2	0.3	0.4	0.485	0.59	1.2
ICW07	I9510000	ICW at CM R42 west of LFR	630	Nitrate/nitrite NO2 + NO3 as nitrogen (mg/L)	110	0.01	0.01	0.01	0.01	0.01	0.03	0.11
ICW07	I9510000	ICW at CM R42 west of LFR	665	Phosphorus total as P (mg/L)	110	0.01	0.01	0.02	0.04	0.0425	0.06	7.5
ICW07	I9510000	ICW at CM R42 west of LFR	680	T ORG C C MG/L	2	5	5	5	5	5	5	5
ICW07	I9510000	ICW at CM R42 west of LFR	1002	Arsenic As total (ug/L)	111	5	5	5	5	5	5	5
ICW07	I9510000	ICW at CM R42 west of LFR	1027	Cadmium Cd total (ug/L)	111	2	2	2	2	2	2	12
ICW07	I9510000	ICW at CM R42 west of LFR	1034	Chromium Cr total (ug/L)	111	25	25	25	25	25	25	25
ICW07	I9510000	ICW at CM R42 west of LFR	1042	Copper Cu total (ug/L)	111	2	2	2	2	2	4	15
ICW07	I9510000	ICW at CM R42 west of LFR	1045	Iron Fe total (ug/L)	73	50	103.4	175	360	510	696	1000
ICW07	I9510000	ICW at CM R42 west of LFR	1051	Lead Pb total (ug/L)	111	10	10	10	10	10	10	64
ICW07	I9510000	ICW at CM R42 west of LFR	1067	Nickel Ni total (ug/L)	111	10	10	10	10	10	10	22
ICW07	I9510000	ICW at CM R42 west of LFR	1092	Zinc Zn total (ug/L)	111	10	10	10	10	21	37.8	70
ICW07	I9510000	ICW at CM R42 west of LFR	1105	Aluminum Al - Total (ug/L)	73	180	240	385	530	795	1360	1600
ICW07	I9510000	ICW at CM R42 west of LFR	31616	Fecal coliform MF method (colonies/100mL)	125	1	1	1	1	10	40	480

ICW07	I9510000	ICW at CM R42 west of LFR	70507	Phosphorus in total orthophosphate as P (mg/L)	41	0.01	0.01	0.01	0.02	0.02	0.02	0.05
ICW07	I9510000	ICW at CM R42 west of LFR	71900	Mercury Hg total (ug/L)	111	0.2	0.2	0.2	0.2	0.2	0.2	0.2
ICW07	I9510000	ICW at CM R42 west of LFR	82079	Turbidity lab (NTU)	125	1	1.96	3.1	5.5	7.85	10	18
ICW08	I9530000	ICW at NC 130 nr Holdens Beach	10	Water temperature (°C)	226	2	9.57	14	19.4	25.025	28.69	32
ICW08	I9530000	ICW at NC 130 nr Holdens Beach	45	Precipitation previous 24 hrs. (in.)	163	0	0	0	0	0	0.5	1.5
ICW08	I9530000	ICW at NC 130 nr Holdens Beach	78	Secchi Transparency (m)	56	0.1	0.7	0.9	1.1	1.4	1.8	31000
ICW08	I9530000	ICW at NC 130 nr Holdens Beach	94	Conductivity field (umho/cm @25°C)	179	1030	31640	37826	44200	48720	51507	750000
ICW08	I9530000	ICW at NC 130 nr Holdens Beach	300	Dissolved oxygen (mg/L)	223	4.3	5.34	6	6.9	8.4	9.5	15.2
ICW08	I9530000	ICW at NC 130 nr Holdens Beach	400	pH (SU)	204	5.3	6.7	7.5	7.8	8	8.2	8.7
ICW08	I9530000	ICW at NC 130 nr Holdens Beach	480	Salinity (ppt)	170	5	20	25.65	29	32.225	34.47	127.3
ICW08	I9530000	ICW at NC 130 nr Holdens Beach	530	Residue total nonfilterable (mg/L)	123	1	14	21	30	51	65.8	162
ICW08	I9530000	ICW at NC 130 nr Holdens Beach	610	Ammonia nitrogen (mg/L)	104	0.01	0.01	0.01	0.02	0.07	0.21	0.43
ICW08	I9530000	ICW at NC 130 nr Holdens Beach	625	Total Kjeldahl nitrogen TKN as N (mg/L)	103	0.2	0.2	0.3	0.4	0.5	0.6	0.9
ICW08	I9530000	ICW at NC 130 nr Holdens Beach	630	Nitrate/nitrite NO2 + NO3 as nitrogen (mg/L)	105	0.01	0.01	0.01	0.01	0.02	0.064	0.57
ICW08	I9530000	ICW at NC 130 nr Holdens Beach	665	Phosphorus total as P (mg/L)	105	0.01	0.01	0.02	0.03	0.05	0.06	7.8
ICW08	I9530000	ICW at NC 130 nr Holdens Beach	680	T ORG C C MG/L	2	5	5	5	5	5	5	5
ICW08	I9530000	ICW at NC 130 nr Holdens Beach	1002	Arsenic As total (ug/L)	93	5	5	5	5	5	5	5
ICW08	I9530000	ICW at NC 130 nr Holdens Beach	1027	Cadmium Cd total (ug/L)	98	2	2	2	2	2	3.7	60
ICW08	I9530000	ICW at NC 130 nr Holdens Beach	1034	Chromium Cr total (ug/L)	98	25	25	25	25	25	25	70
ICW08	I9530000	ICW at NC 130 nr Holdens Beach	1042	Copper Cu total (ug/L)	98	2	2	2	2	4	41	70
ICW08	I9530000	ICW at NC 130 nr Holdens Beach	1045	Iron Fe total (ug/L)	81	50	120	200	330	510	708	1500
ICW08	I9530000	ICW at NC 130 nr Holdens Beach	1051	Lead Pb total (ug/L)	98	10	10	10	10	10	300	400
ICW08	I9530000	ICW at NC 130 nr Holdens Beach	1067	Nickel Ni total (ug/L)	92	10	10	10	10	10	200	200
ICW08	I9530000	ICW at NC 130 nr Holdens Beach	1092	Zinc Zn total (ug/L)	98	10	10	10	18	33	55.5	1400
ICW08	I9530000	ICW at NC 130 nr Holdens Beach	1105	Aluminum Al - Total (ug/L)	78	170	259	347.5	510	825	1100	1500
ICW08	I9530000	ICW at NC 130 nr Holdens Beach	31616	Fecal coliform MF method (colonies/100mL)	191	1	1	1	1	10	40	650000
ICW08	I9530000	ICW at NC 130 nr Holdens Beach	70507	Phosphorus in total orthophosphate as P (mg/L)	33	0.01	0.01	0.02	0.02	0.02	0.026	0.07
ICW08	I9530000	ICW at NC 130 nr Holdens Beach	71900	Mercury Hg total (ug/L)	97	0.2	0.2	0.2	0.2	0.2	0.2	2
ICW08	I9530000	ICW at NC 130 nr Holdens Beach	82079	Turbidity lab (NTU)	153	1.1	2.6	4	6.2	8.05	10	75
LFR02	I9410000	Lockwoods Folly R at SR 1501 nr Supply	10	Water temperature (°C)	91	0	7.2	11	16	21	25	28
LFR02	I9410000	Lockwoods Folly R at SR 1501 nr Supply	45	Precipitation previous 24 hrs. (in.)	54	0	0	0	0	0	1	1
LFR02	I9410000	Lockwoods Folly R at SR 1501 nr Supply	94	Conductivity field (umho/cm @25°C)	87	25	59.6	85	114	230	426	1400
LFR02	I9410000	Lockwoods Folly R at SR 1501 nr Supply	300	Dissolved oxygen (mg/L)	88	1.8	4.19	5.125	6.25	7.4	8.82	13.5
LFR02	I9410000	Lockwoods Folly R at SR 1501 nr Supply	400	pH (SU)	97	4.7	6	6.3	6.8	7.2	7.6	8
LFR02	I9410000	Lockwoods Folly R at SR 1501 nr Supply	480	Salinity (ppt)	12	0	0	0	0	0	0	0
LFR02	I9410000	Lockwoods Folly R at SR 1501 nr Supply	530	Residue total nonfilterable (mg/L)	38	1	1	2	3	5.25	7	11
LFR02	I9410000	Lockwoods Folly R at SR 1501 nr Supply	610	Ammonia nitrogen (mg/L)	26	0.01	0.01	0.01	0.01	0.03	0.085	0.15

LFR02	I9410000	Lockwoods Folly R at SR 1501 nr Supply	625	Total Kjeldahl nitrogen TKN as N (mg/L)	25	0.2	0.2	0.3	0.4	0.55	0.68	0.9
LFR02	I9410000	Lockwoods Folly R at SR 1501 nr Supply	630	Nitrate/nitrite NO2 + NO3 as nitrogen (mg/L)	26	0.01	0.01	0.045	0.095	0.225	0.521	1.5
LFR02	I9410000	Lockwoods Folly R at SR 1501 nr Supply	665	Phosphorus total as P (mg/L)	26	0.01	0.01	0.01	0.01	0.04	0.053	0.07
LFR02	I9410000	Lockwoods Folly R at SR 1501 nr Supply	1002	Arsenic As total (ug/L)	18	5	5	5	5	5	5	5
LFR02	I9410000	Lockwoods Folly R at SR 1501 nr Supply	1027	Cadmium Cd total (ug/L)	21	2	2	2	2	2	2	2
LFR02	I9410000	Lockwoods Folly R at SR 1501 nr Supply	1034	Chromium Cr total (ug/L)	21	25	25	25	25	25	25	25
LFR02	I9410000	Lockwoods Folly R at SR 1501 nr Supply	1042	Copper Cu total (ug/L)	21	2	2	2	2	2	2	40
LFR02	I9410000	Lockwoods Folly R at SR 1501 nr Supply	1045	Iron Fe total (ug/L)	10	100	110	200	300	620	698	700
LFR02	I9410000	Lockwoods Folly R at SR 1501 nr Supply	1051	Lead Pb total (ug/L)	21	10	10	10	10	10	82	100
LFR02	I9410000	Lockwoods Folly R at SR 1501 nr Supply	1067	Nickel Ni total (ug/L)	15	10	10	10	10	10	10	10
LFR02	I9410000	Lockwoods Folly R at SR 1501 nr Supply	1092	Zinc Zn total (ug/L)	21	10	10	10	10	10	98	280
LFR02	I9410000	Lockwoods Folly R at SR 1501 nr Supply	31616	Fecal coliform MF method (colonies/100mL)	89	1	10	55	100	220	720	600000
LFR02	I9410000	Lockwoods Folly R at SR 1501 nr Supply	70507	Phosphorus in total orthophosphate as P (mg/L)	25	0.01	0.016	0.02	0.02	0.02	0.02	0.03
LFR02	I9410000	Lockwoods Folly R at SR 1501 nr Supply	71900	Mercury Hg total (ug/L)	19	0.2	0.2	0.2	0.2	0.2	0.3	3.3
LFR02	I9410000	Lockwoods Folly R at SR 1501 nr Supply	82079	Turbidity lab (NTU)	35	1.5	1.8	3	4	5.6	6.54	60
LFR03	I9420000	Lockwoods Folly R at NC 211 at Supply	10	Water temperature (°C)	161	2.3	7.84	14.35	21	24.95	27.5	32
LFR03	I9420000	Lockwoods Folly R at NC 211 at Supply	45	Precipitation previous 24 hrs. (in.)	111	0	0	0	0	0	0.45	1.2
LFR03	I9420000	Lockwoods Folly R at NC 211 at Supply	78	Secchi Transparency (m)	54	0.3	0.5	0.5	0.7	0.8	1.05	1.3
LFR03	I9420000	Lockwoods Folly R at NC 211 at Supply	94	Conductivity field (umho/cm @25°C)	158	57	99.6	125	168	339	3991	25348
LFR03	I9420000	Lockwoods Folly R at NC 211 at Supply	300	Dissolved oxygen (mg/L)	161	0.02	3.02	4	5.1	7.05	9.3	11.1
LFR03	I9420000	Lockwoods Folly R at NC 211 at Supply	400	pH (SU)	161	3.7	6.6	6.8	7.1	7.35	7.6	8.8
LFR03	I9420000	Lockwoods Folly R at NC 211 at Supply	480	Salinity (ppt)	138	0	0	0.01	0.1	0.2	3.46	15.4
LFR03	I9420000	Lockwoods Folly R at NC 211 at Supply	530	Residue total nonfilterable (mg/L)	99	1	2	4	6	10	15	90
LFR03	I9420000	Lockwoods Folly R at NC 211 at Supply	610	Ammonia nitrogen (mg/L)	118	0.01	0.01	0.01	0.03	0.06	0.091	0.9
LFR03	I9420000	Lockwoods Folly R at NC 211 at Supply	625	Total Kjeldahl nitrogen TKN as N (mg/L)	118	0.2	0.3	0.375	0.4	0.5	0.7	1.4
LFR03	I9420000	Lockwoods Folly R at NC 211 at Supply	630	Nitrate/nitrite NO2 + NO3 as nitrogen (mg/L)	118	0.01	0.01	0.03	0.07	0.1	0.131	0.18
LFR03	I9420000	Lockwoods Folly R at NC 211 at Supply	665	Phosphorus total as P (mg/L)	118	0.01	0.01	0.02	0.03	0.04	0.05	0.12
LFR03	I9420000	Lockwoods Folly R at NC 211 at Supply	680	T ORG C C MG/L	2	12	12	12	14	16	16	16
LFR03	I9420000	Lockwoods Folly R at NC 211 at Supply	1002	Arsenic As total (ug/L)	124	5	5	5	5	5	5	5
LFR03	I9420000	Lockwoods Folly R at NC 211 at Supply	1027	Cadmium Cd total (ug/L)	124	2	2	2	2	2	2	16
LFR03	I9420000	Lockwoods Folly R at NC 211 at Supply	1034	Chromium Cr total (ug/L)	124	25	25	25	25	25	25	25
LFR03	I9420000	Lockwoods Folly R at NC 211 at Supply	1042	Copper Cu total (ug/L)	124	2	2	2	2	3	5.45	41
LFR03	I9420000	Lockwoods Folly R at NC 211 at Supply	1045	Iron Fe total (ug/L)	86	390	517	717.5	985	1225	1630	2500
LFR03	I9420000	Lockwoods Folly R at NC 211 at Supply	1051	Lead Pb total (ug/L)	124	10	10	10	10	10	10	100
LFR03	I9420000	Lockwoods Folly R at NC 211 at Supply	1067	Nickel Ni total (ug/L)	124	10	10	10	10	10	10	17
LFR03	I9420000	Lockwoods Folly R at NC 211 at Supply	1092	Zinc Zn total (ug/L)	124	10	10	10	10	14.75	23	63
LFR03	I9420000	Lockwoods Folly R at NC 211 at Supply	1105	Aluminum Al - Total (ug/L)	88	150	230	290	365	450	581	1500
LFR03	I9420000	Lockwoods Folly R at NC 211 at Supply	31616	Fecal coliform MF method (colonies/100mL)	160	1	30	56.25	105	187.5	385	2000

LFR03	I9420000	Lockwoods Folly R at NC 211 at Supply	70507	Phosphorus in total orthophosphate as P (mg/L)	42	0.01	0.02	0.02	0.02	0.02	0.02	0.03
LFR03	I9420000	Lockwoods Folly R at NC 211 at Supply	71900	Mercury Hg total (ug/L)	124	0.2	0.2	0.2	0.2	0.2	0.2	0.2
LFR03	I9420000	Lockwoods Folly R at NC 211 at Supply	82079	Turbidity lab (NTU)	159	2.1	3.3	4	5	6.4	7.7	22
LFR06	I9430000	Lockwoods Folly R nr Sandy Hill	10	Water temperature (°C)	30	6	8.34	14	20.15	25.5	29.06	30.3
LFR06	I9430000	Lockwoods Folly R nr Sandy Hill	45	Precipitation previous 24 hrs. (in.)	28	0	0	0	0	0	0.275	1
LFR06	I9430000	Lockwoods Folly R nr Sandy Hill	78	Secchi Transparency (m)	29	0.4	0.5	0.5	0.6	0.9	0.9	1.2
LFR06	I9430000	Lockwoods Folly R nr Sandy Hill	94	Conductivity field (umho/cm @25°C)	30	111	165.1	244.5	4170	17100.25	37408.9	46290
LFR06	I9430000	Lockwoods Folly R nr Sandy Hill	300	Dissolved oxygen (mg/L)	30	3.3	3.94	4.675	6.35	7.7	9.79	11.3
LFR06	I9430000	Lockwoods Folly R nr Sandy Hill	400	pH (SU)	29	6.4	6.7	7.05	7.3	7.45	7.6	7.8
LFR06	I9430000	Lockwoods Folly R nr Sandy Hill	480	Salinity (ppt)	30	0	0.01	0.1	2.25	10.4	23.58	29.5
LFR06	I9430000	Lockwoods Folly R nr Sandy Hill	530	Residue total nonfilterable (mg/L)	10	4	4.3	7	12	24.25	50.8	52
LFR06	I9430000	Lockwoods Folly R nr Sandy Hill	1002	Arsenic As total (ug/L)	10	5	5	5	5	5	5	5
LFR06	I9430000	Lockwoods Folly R nr Sandy Hill	1027	Cadmium Cd total (ug/L)	10	2	2	2	2	2	2	2
LFR06	I9430000	Lockwoods Folly R nr Sandy Hill	1034	Chromium Cr total (ug/L)	10	25	25	25	25	25	25	25
LFR06	I9430000	Lockwoods Folly R nr Sandy Hill	1042	Copper Cu total (ug/L)	10	2	2	2	2	2	2.54	2.6
LFR06	I9430000	Lockwoods Folly R nr Sandy Hill	1045	Iron Fe total (ug/L)	10	400	417	615	795	1250	2000	2000
LFR06	I9430000	Lockwoods Folly R nr Sandy Hill	1051	Lead Pb total (ug/L)	10	10	10	10	10	10	10	10
LFR06	I9430000	Lockwoods Folly R nr Sandy Hill	1067	Nickel Ni total (ug/L)	10	10	10	10	10	10	10	10
LFR06	I9430000	Lockwoods Folly R nr Sandy Hill	1092	Zinc Zn total (ug/L)	10	10	10	10	10	10	29.8	32
LFR06	I9430000	Lockwoods Folly R nr Sandy Hill	1105	Aluminum Al - Total (ug/L)	10	230	242	387.5	485	730	1090	1100
LFR06	I9430000	Lockwoods Folly R nr Sandy Hill	31616	Fecal coliform MF method (colonies/100mL)	32	7	12.1	57	101.5	212.5	294	380
LFR06	I9430000	Lockwoods Folly R nr Sandy Hill	71900	Mercury Hg total (ug/L)	10	0.2	0.2	0.2	0.2	0.2	0.2	0.2
LFR06	I9430000	Lockwoods Folly R nr Sandy Hill	82079	Turbidity lab (NTU)	32	1.7	3.23	4.65	7.05	9.95	19.4	26
LFR11	I9440000	Lockwoods Folly R at Varnamtown	10	Water temperature (°C)	157	5.3	9.98	15.9	22	27.25	29	32.6
LFR11	I9440000	Lockwoods Folly R at Varnamtown	45	Precipitation previous 24 hrs. (in.)	112	0	0	0	0	0	0.5	2
LFR11	I9440000	Lockwoods Folly R at Varnamtown	78	Secchi Transparency (m)	88	0.4	0.5	0.7	1	1.2	1.51	2.1
LFR11	I9440000	Lockwoods Folly R at Varnamtown	94	Conductivity field (umho/cm @25°C)	157	26	5736.4	25308	40210	47301.5	50036	750000
LFR11	I9440000	Lockwoods Folly R at Varnamtown	300	Dissolved oxygen (mg/L)	156	3	4.87	5.525	6.65	7.875	9.5	11.5
LFR11	I9440000	Lockwoods Folly R at Varnamtown	400	pH (SU)	156	6.3	7	7.4	7.7	7.9	8	8.3
LFR11	I9440000	Lockwoods Folly R at Varnamtown	480	Salinity (ppt)	146	0.2	3.08	16.475	25.5	30.875	33.43	36.4
LFR11	I9440000	Lockwoods Folly R at Varnamtown	530	Residue total nonfilterable (mg/L)	91	2	10	14	21	33	50.8	100
LFR11	I9440000	Lockwoods Folly R at Varnamtown	610	Ammonia nitrogen (mg/L)	115	0.01	0.01	0.01	0.04	0.07	0.13	0.32
LFR11	I9440000	Lockwoods Folly R at Varnamtown	625	Total Kjeldahl nitrogen TKN as N (mg/L)	114	0.1	0.2	0.3	0.4	0.5	0.6	1.8
LFR11	I9440000	Lockwoods Folly R at Varnamtown	630	Nitrate/nitrite NO2 + NO3 as nitrogen (mg/L)	115	0.01	0.01	0.01	0.01	0.03	0.07	0.91
LFR11	I9440000	Lockwoods Folly R at Varnamtown	665	Phosphorus total as P (mg/L)	114	0.01	0.01	0.02	0.04	0.05	0.055	12
LFR11	I9440000	Lockwoods Folly R at Varnamtown	680	T ORG C C MG/L	2	5	5	5	5	5	5	5
LFR11	I9440000	Lockwoods Folly R at Varnamtown	1002	Arsenic As total (ug/L)	124	5	5	5	5	5	5	25
LFR11	I9440000	Lockwoods Folly R at Varnamtown	1027	Cadmium Cd total (ug/L)	124	2	2	2	2	2	2	38

LFR11	I9440000	Lockwoods Folly R at Varnamtown	1034	Chromium Cr total (ug/L)	124	25	25	25	25	25	25	210
LFR11	I9440000	Lockwoods Folly R at Varnamtown	1042	Copper Cu total (ug/L)	124	2	2	2	2	2.225	5	25
LFR11	I9440000	Lockwoods Folly R at Varnamtown	1045	Iron Fe total (ug/L)	84	50	160	262.5	375	610	810	2500
LFR11	I9440000	Lockwoods Folly R at Varnamtown	1051	Lead Pb total (ug/L)	123	10	10	10	10	10	10	280
LFR11	I9440000	Lockwoods Folly R at Varnamtown	1067	Nickel Ni total (ug/L)	124	10	10	10	10	10	10	12
LFR11	I9440000	Lockwoods Folly R at Varnamtown	1092	Zinc Zn total (ug/L)	124	10	10	10	10	18.75	37.5	410
LFR11	I9440000	Lockwoods Folly R at Varnamtown	1105	Aluminum Al - Total (ug/L)	85	190	246	355	550	770	1000	1400
LFR11	I9440000	Lockwoods Folly R at Varnamtown	31616	Fecal coliform MF method (colonies/100mL)	161	1	1	2	20	53	148	500
LFR11	I9440000	Lockwoods Folly R at Varnamtown	70507	Phosphorus in total orthophosphate as P (mg/L)	41	0.01	0.01	0.01	0.02	0.02	0.02	0.04
LFR11	I9440000	Lockwoods Folly R at Varnamtown	71900	Mercury Hg total (ug/L)	124	0.2	0.2	0.2	0.2	0.2	0.2	0.2
LFR11	I9440000	Lockwoods Folly R at Varnamtown	82079	Turbidity lab (NTU)	159	1.7	2.7	3.9	5.7	7.2	10	18
LFR13	I9450000	Lockwoods Folly R at CM R8 DNS of Varnamtown (west channel)	10	Water temperature (°C)	124	5.6	10.7	16.15	22	27.275	28.85	30.7
LFR13	I9450000	Lockwoods Folly R at CM R8 DNS of Varnamtown (west channel)	45	Precipitation previous 24 hrs. (in.)	84	0	0	0	0	0	0.5	2
LFR13	I9450000	Lockwoods Folly R at CM R8 DNS of Varnamtown (west channel)	78	Secchi Transparency (m)	56	0.3	0.57	0.725	1.1	1.3	1.7	2.2
LFR13	I9450000	Lockwoods Folly R at CM R8 DNS of Varnamtown (west channel)	94	Conductivity field (umho/cm @25°C)	120	46	19684	39022.5	47216	50575	52585.4	750000
LFR13	I9450000	Lockwoods Folly R at CM R8 DNS of Varnamtown (west channel)	300	Dissolved oxygen (mg/L)	124	3.4	5.05	5.725	6.7	7.95	9.4	12.1
LFR13	I9450000	Lockwoods Folly R at CM R8 DNS of Varnamtown (west channel)	400	pH (SU)	127	6.2	7	7.5	7.8	8	8.1	8.5
LFR13	I9450000	Lockwoods Folly R at CM R8 DNS of Varnamtown (west channel)	480	Salinity (ppt)	115	0.2	12.66	27.1	31	33.7	35	117
LFR13	I9450000	Lockwoods Folly R at CM R8 DNS of Varnamtown (west channel)	530	Residue total nonfilterable (mg/L)	82	3	10.3	15	22.5	37	63.8	170
LFR13	I9450000	Lockwoods Folly R at CM R8 DNS of Varnamtown (west channel)	610	Ammonia nitrogen (mg/L)	113	0.01	0.01	0.01	0.03	0.06	0.16	0.62
LFR13	I9450000	Lockwoods Folly R at CM R8 DNS of Varnamtown (west channel)	625	Total Kjeldahl nitrogen TKN as N (mg/L)	112	0.1	0.2	0.3	0.4	0.5	0.6	1.2
LFR13	I9450000	Lockwoods Folly R at CM R8 DNS of Varnamtown (west channel)	630	Nitrate/nitrite NO2 + NO3 as nitrogen (mg/L)	113	0.01	0.01	0.01	0.01	0.025	0.04	0.14
LFR13	I9450000	Lockwoods Folly R at CM R8 DNS of Varnamtown (west channel)	665	Phosphorus total as P (mg/L)	113	0.01	0.01	0.02	0.03	0.04	0.05	0.13
LFR13	I9450000	Lockwoods Folly R at CM R8 DNS of Varnamtown (west channel)	680	T ORG C C MG/L	2	5	5	5	5	5	5	5
LFR13	I9450000	Lockwoods Folly R at CM R8 DNS of Varnamtown (west channel)	1002	Arsenic As total (ug/L)	112	5	5	5	5	5	5	23
LFR13	I9450000	Lockwoods Folly R at CM R8 DNS of Varnamtown (west channel)	1027	Cadmium Cd total (ug/L)	112	2	2	2	2	2	2	9
LFR13	I9450000	Lockwoods Folly R at CM R8 DNS of Varnamtown (west channel)	1034	Chromium Cr total (ug/L)	112	25	25	25	25	25	25	35
LFR13	I9450000	Lockwoods Folly R at CM R8 DNS of Varnamtown (west channel)	1042	Copper Cu total (ug/L)	112	2	2	2	2	2	4.7	24
LFR13	I9450000	Lockwoods Folly R at CM R8 DNS of Varnamtown (west channel)	1045	Iron Fe total (ug/L)	74	50	125	187.5	330	615	775	4500

LFR13	I9450000	Lockwoods Folly R at CM R8 DNS of Varnamtown (west channel)	1051	Lead Pb total (ug/L)	112	10	10	10	10	10	10	130
LFR13	I9450000	Lockwoods Folly R at CM R8 DNS of Varnamtown (west channel)	1067	Nickel Ni total (ug/L)	112	10	10	10	10	10	10	10
LFR13	I9450000	Lockwoods Folly R at CM R8 DNS of Varnamtown (west channel)	1092	Zinc Zn total (ug/L)	112	10	10	10	10	21.75	45	84
LFR13	I9450000	Lockwoods Folly R at CM R8 DNS of Varnamtown (west channel)	1105	Aluminum Al - Total (ug/L)	74	170	240	327.5	520	770	1100	3000
LFR13	I9450000	Lockwoods Folly R at CM R8 DNS of Varnamtown (west channel)	31616	Fecal coliform MF method (colonies/100mL)	126	1	1	1	2	27.75	99	890
LFR13	I9450000	Lockwoods Folly R at CM R8 DNS of Varnamtown (west channel)	70507	Phosphorus in total orthophosphate as P (mg/L)	41	0.01	0.01	0.01	0.02	0.02	0.02	0.03
LFR13	I9450000	Lockwoods Folly R at CM R8 DNS of Varnamtown (west channel)	71900	Mercury Hg total (ug/L)	112	0.2	0.2	0.2	0.2	0.2	0.2	0.2
LFR13	I9450000	Lockwoods Folly R at CM R8 DNS of Varnamtown (west channel)	82079	Turbidity lab (NTU)	122	1.4	2.4	3.775	5.1	7.325	9.77	23
LFR14	I9460000	Lockwoods Folly R DNS of Varnamtown (center)	10	Water temperature (°C)	33	9	10.4	20.45	22.8	28.1	29.6	31.1
LFR14	I9460000	Lockwoods Folly R DNS of Varnamtown (center)	45	Precipitation previous 24 hrs. (in.)	18	0	0	0	0	0.0575	1.28	2
LFR14	I9460000	Lockwoods Folly R DNS of Varnamtown (center)	94	Conductivity field (umho/cm @25°C)	30	50	29668	40324.5	46965	50025	52390	750000
LFR14	I9460000	Lockwoods Folly R DNS of Varnamtown (center)	300	Dissolved oxygen (mg/L)	33	1	5.58	5.9	6.5	7.4	9.3	11
LFR14	I9460000	Lockwoods Folly R DNS of Varnamtown (center)	400	pH (SU)	34	7.2	7.4	7.75	8	8.1	8.2	8.7
LFR14	I9460000	Lockwoods Folly R DNS of Varnamtown (center)	480	Salinity (ppt)	33	7	21.2	27.2	31.5	33.2	34.84	35
LFR14	I9460000	Lockwoods Folly R DNS of Varnamtown (center)	530	Residue total nonfilterable (mg/L)	32	2	7.9	15.25	25.5	45.25	60.8	160
LFR14	I9460000	Lockwoods Folly R DNS of Varnamtown (center)	610	Ammonia nitrogen (mg/L)	32	0.01	0.01	0.01	0.03	0.0575	0.077	0.1
LFR14	I9460000	Lockwoods Folly R DNS of Varnamtown (center)	625	Total Kjeldahl nitrogen TKN as N (mg/L)	32	0.2	0.23	0.3	0.4	0.4	0.5	0.7
LFR14	I9460000	Lockwoods Folly R DNS of Varnamtown (center)	630	Nitrate/nitrite NO2 + NO3 as nitrogen (mg/L)	32	0.01	0.01	0.01	0.01	0.0175	0.03	0.08
LFR14	I9460000	Lockwoods Folly R DNS of Varnamtown (center)	665	Phosphorus total as P (mg/L)	32	0.02	0.03	0.03	0.04	0.05	0.06	0.08
LFR14	I9460000	Lockwoods Folly R DNS of Varnamtown (center)	1002	Arsenic As total (ug/L)	32	5	5	5	5	5	5	5
LFR14	I9460000	Lockwoods Folly R DNS of Varnamtown (center)	1027	Cadmium Cd total (ug/L)	32	2	2	2	2	2	2	2
LFR14	I9460000	Lockwoods Folly R DNS of Varnamtown (center)	1034	Chromium Cr total (ug/L)	32	25	25	25	25	25	25	25
LFR14	I9460000	Lockwoods Folly R DNS of Varnamtown (center)	1042	Copper Cu total (ug/L)	32	2	2	2	2	3	5.7	23
LFR14	I9460000	Lockwoods Folly R DNS of Varnamtown (center)	1045	Iron Fe total (ug/L)	2	130	130	130	195	260	260	260
LFR14	I9460000	Lockwoods Folly R DNS of Varnamtown (center)	1051	Lead Pb total (ug/L)	32	10	10	10	10	10	10	10
LFR14	I9460000	Lockwoods Folly R DNS of Varnamtown (center)	1067	Nickel Ni total (ug/L)	32	10	10	10	10	10	10	12
LFR14	I9460000	Lockwoods Folly R DNS of Varnamtown (center)	1092	Zinc Zn total (ug/L)	32	10	10	10	10	10	14.2	17
LFR14	I9460000	Lockwoods Folly R DNS of Varnamtown (center)	1105	Aluminum Al - Total (ug/L)	2	200	200	200	305	410	410	410
LFR14	I9460000	Lockwoods Folly R DNS of Varnamtown (center)	31616	Fecal coliform MF method (colonies/100mL)	32	1	1	1	1	10	50	250
LFR14	I9460000	Lockwoods Folly R DNS of Varnamtown (center)	70507	Phosphorus in total orthophosphate as P (mg/L)	31	0.01	0.01	0.01	0.02	0.02	0.02	0.02
LFR14	I9460000	Lockwoods Folly R DNS of Varnamtown (center)	71900	Mercury Hg total (ug/L)	32	0.2	0.2	0.2	0.2	0.2	0.2	0.2
LFR14	I9460000	Lockwoods Folly R DNS of Varnamtown (center)	82079	Turbidity lab (NTU)	32	1.1	3.02	5.25	7.05	7.9	11.4	18
LFR15	I9470000	Lockwoods Folly R DNS of Varnamtown (east channel)	10	Water temperature (°C)	32	9.5	10.6	20.125	22.7	28.3	29.7	31.1

LFR15	I9470000	Lockwoods Folly R DNS of Varnamtown (east channel)	45	Precipitation previous 24 hrs. (in.)	18	0	0	0	0	0	0.65	2
LFR15	I9470000	Lockwoods Folly R DNS of Varnamtown (east channel)	94	Conductivity field (umho/cm @25°C)	29	50	31374	40465	43200	49850	50400	750000
LFR15	I9470000	Lockwoods Folly R DNS of Varnamtown (east channel)	300	Dissolved oxygen (mg/L)	32	1	5.4	5.7	6.3	7.375	9.39	12
LFR15	I9470000	Lockwoods Folly R DNS of Varnamtown (east channel)	400	pH (SU)	33	7.3	7.4	7.65	8	8.1	8.2	8.5
LFR15	I9470000	Lockwoods Folly R DNS of Varnamtown (east channel)	480	Salinity (ppt)	32	12	23.15	27	30	32.725	34.21	35
LFR15	I9470000	Lockwoods Folly R DNS of Varnamtown (east channel)	530	Residue total nonfilterable (mg/L)	31	7	10.2	20	27	42	59.2	140
LFR15	I9470000	Lockwoods Folly R DNS of Varnamtown (east channel)	610	Ammonia nitrogen (mg/L)	31	0.01	0.01	0.01	0.03	0.06	0.078	0.13
LFR15	I9470000	Lockwoods Folly R DNS of Varnamtown (east channel)	625	Total Kjeldahl nitrogen TKN as N (mg/L)	31	0.2	0.3	0.3	0.4	0.5	0.68	0.7
LFR15	I9470000	Lockwoods Folly R DNS of Varnamtown (east channel)	630	Nitrate/nitrite NO2 + NO3 as nitrogen (mg/L)	31	0.01	0.01	0.01	0.01	0.01	0.03	0.06
LFR15	I9470000	Lockwoods Folly R DNS of Varnamtown (east channel)	665	Phosphorus total as P (mg/L)	31	0.02	0.03	0.03	0.04	0.05	0.06	0.08
LFR15	I9470000	Lockwoods Folly R DNS of Varnamtown (east channel)	1002	Arsenic As total (ug/L)	30	5	5	5	5	5	5	5
LFR15	I9470000	Lockwoods Folly R DNS of Varnamtown (east channel)	1027	Cadmium Cd total (ug/L)	31	2	2	2	2	2	2	2
LFR15	I9470000	Lockwoods Folly R DNS of Varnamtown (east channel)	1034	Chromium Cr total (ug/L)	31	25	25	25	25	25	25	25
LFR15	I9470000	Lockwoods Folly R DNS of Varnamtown (east channel)	1042	Copper Cu total (ug/L)	31	2	2	2	2	3	7.6	20
LFR15	I9470000	Lockwoods Folly R DNS of Varnamtown (east channel)	1045	Iron Fe total (ug/L)	2	190	190	190	245	300	300	300
LFR15	I9470000	Lockwoods Folly R DNS of Varnamtown (east channel)	1051	Lead Pb total (ug/L)	31	10	10	10	10	10	10	10
LFR15	I9470000	Lockwoods Folly R DNS of Varnamtown (east channel)	1067	Nickel Ni total (ug/L)	31	10	10	10	10	10	10	20
LFR15	I9470000	Lockwoods Folly R DNS of Varnamtown (east channel)	1092	Zinc Zn total (ug/L)	31	10	10	10	10	10	10	37
LFR15	I9470000	Lockwoods Folly R DNS of Varnamtown (east channel)	1105	Aluminum Al - Total (ug/L)	2	380	380	380	430	480	480	480
LFR15	I9470000	Lockwoods Folly R DNS of Varnamtown (east channel)	31616	Fecal coliform MF method (colonies/100mL)	31	1	1	1	1	10	46	240
LFR15	I9470000	Lockwoods Folly R DNS of Varnamtown (east channel)	70507	Phosphorus in total orthophosphate as P (mg/L)	30	0.01	0.01	0.01	0.02	0.02	0.02	0.03
LFR15	I9470000	Lockwoods Folly R DNS of Varnamtown (east channel)	71900	Mercury Hg total (ug/L)	31	0.2	0.2	0.2	0.2	0.2	0.2	0.2
LFR15	I9470000	Lockwoods Folly R DNS of Varnamtown (east channel)	82079	Turbidity lab (NTU)	31	2	2.78	6.1	7.8	9.6	13.2	15
LFR19	I9480000	Lockwoods Folly R at CM R6 NW Sunset Harbor (west channel)	10	Water temperature (°C)	72	8	10	17.55	22.3	27.9	29.5	30.2
LFR19	I9480000	Lockwoods Folly R at CM R6 NW Sunset Harbor	45	Precipitation previous 24 hrs.	48	0	0	0	0	0	0.5	2

		(west channel)		(in.)							
LFR19	I9480000	Lockwoods Folly R at CM R6 NW Sunset Harbor (west channel)	78	Secchi Transparency (m)	27	0.5	0.5	0.7	0.9	1.2	1.84	2.5
LFR19	I9480000	Lockwoods Folly R at CM R6 NW Sunset Harbor (west channel)	94	Conductivity field (umho/cm @25°C)	68	50	31320	37530	46327.5	50000	51650.6	750000
LFR19	I9480000	Lockwoods Folly R at CM R6 NW Sunset Harbor (west channel)	300	Dissolved oxygen (mg/L)	72	3.8	5.56	6.125	6.95	8	9.6	11.6
LFR19	I9480000	Lockwoods Folly R at CM R6 NW Sunset Harbor (west channel)	400	pH (SU)	72	6.4	7.5	7.7	8	8.1	8.2	8.4
LFR19	I9480000	Lockwoods Folly R at CM R6 NW Sunset Harbor (west channel)	480	Salinity (ppt)	72	2	21.12	27.08	31.15	33.6	34.64	35.2
LFR19	I9480000	Lockwoods Folly R at CM R6 NW Sunset Harbor (west channel)	530	Residue total nonfilterable (mg/L)	51	9	13	19	29	45	67.6	180
LFR19	I9480000	Lockwoods Folly R at CM R6 NW Sunset Harbor (west channel)	610	Ammonia nitrogen (mg/L)	41	0.01	0.01	0.01	0.03	0.06	0.108	0.12
LFR19	I9480000	Lockwoods Folly R at CM R6 NW Sunset Harbor (west channel)	625	Total Kjeldahl nitrogen TKN as N (mg/L)	41	0.2	0.3	0.3	0.4	0.5	0.6	0.7
LFR19	I9480000	Lockwoods Folly R at CM R6 NW Sunset Harbor (west channel)	630	Nitrate/nitrite NO2 + NO3 as nitrogen (mg/L)	41	0.01	0.01	0.01	0.01	0.02	0.03	0.11
LFR19	I9480000	Lockwoods Folly R at CM R6 NW Sunset Harbor (west channel)	665	Phosphorus total as P (mg/L)	41	0.01	0.022	0.03	0.04	0.05	0.068	0.6
LFR19	I9480000	Lockwoods Folly R at CM R6 NW Sunset Harbor (west channel)	1002	Arsenic As total (ug/L)	51	5	5	5	5	5	5	25
LFR19	I9480000	Lockwoods Folly R at CM R6 NW Sunset Harbor (west channel)	1027	Cadmium Cd total (ug/L)	51	2	2	2	2	2	2	2
LFR19	I9480000	Lockwoods Folly R at CM R6 NW Sunset Harbor (west channel)	1034	Chromium Cr total (ug/L)	51	25	25	25	25	25	25	25
LFR19	I9480000	Lockwoods Folly R at CM R6 NW Sunset Harbor (west channel)	1042	Copper Cu total (ug/L)	51	2	2	2	2	2	5.8	14
LFR19	I9480000	Lockwoods Folly R at CM R6 NW Sunset Harbor (west channel)	1045	Iron Fe total (ug/L)	13	110	122	175	270	670	822	830
LFR19	I9480000	Lockwoods Folly R at CM R6 NW Sunset Harbor (west channel)	1051	Lead Pb total (ug/L)	51	10	10	10	10	10	10	10
LFR19	I9480000	Lockwoods Folly R at CM R6 NW Sunset Harbor (west channel)	1067	Nickel Ni total (ug/L)	51	10	10	10	10	10	10	10
LFR19	I9480000	Lockwoods Folly R at CM R6 NW Sunset Harbor (west channel)	1092	Zinc Zn total (ug/L)	51	10	10	10	10	10	10	52
LFR19	I9480000	Lockwoods Folly R at CM R6 NW Sunset Harbor (west channel)	1105	Aluminum Al - Total (ug/L)	13	150	198	290	600	895	1700	2100
LFR19	I9480000	Lockwoods Folly R at CM R6 NW Sunset Harbor (west channel)	31616	Fecal coliform MF method (colonies/100mL)	72	1	1	1	1	20	40.7	260
LFR19	I9480000	Lockwoods Folly R at CM R6 NW Sunset Harbor (west channel)	70507	Phosphorus in total orthophosphate as P (mg/L)	40	0.01	0.01	0.01	0.02	0.02	0.02	0.03
LFR19	I9480000	Lockwoods Folly R at CM R6 NW Sunset Harbor (west channel)	71900	Mercury Hg total (ug/L)	51	0.2	0.2	0.2	0.2	0.2	0.2	0.2
LFR19	I9480000	Lockwoods Folly R at CM R6 NW Sunset Harbor (west channel)	82079	Turbidity lab (NTU)	73	1.3	2.9	4.25	7	11	14.2	22
LFR22	I9490000	Lockwoods Folly R at NW of Sunset Harbor (east channel)	10	Water temperature (°C)	43	9	12.56	20.4	23	28	29.5	31

LFR22	I9490000	Lockwoods Folly R at NW of Sunset Harbor (east channel)	45	Precipitation previous 24 hrs. (in.)	22	0	0	0	0	0	0.99	2
LFR22	I9490000	Lockwoods Folly R at NW of Sunset Harbor (east channel)	94	Conductivity field (umho/cm @25°C)	38	50	31226.4	39868.75	46236	49107	50620	53300
LFR22	I9490000	Lockwoods Folly R at NW of Sunset Harbor (east channel)	300	Dissolved oxygen (mg/L)	42	4.5	5.3	5.7	6.35	7.225	9.48	10.8
LFR22	I9490000	Lockwoods Folly R at NW of Sunset Harbor (east channel)	400	pH (SU)	45	6.9	7.576	7.8	8	8.1	8.2	8.5
LFR22	I9490000	Lockwoods Folly R at NW of Sunset Harbor (east channel)	480	Salinity (ppt)	43	18	25.08	28	31.9	33	35	37.5
LFR22	I9490000	Lockwoods Folly R at NW of Sunset Harbor (east channel)	530	Residue total nonfilterable (mg/L)	42	3	14	19.25	30.5	55.25	72.8	120
LFR22	I9490000	Lockwoods Folly R at NW of Sunset Harbor (east channel)	610	Ammonia nitrogen (mg/L)	42	0.01	0.01	0.01	0.03	0.06	0.104	0.29
LFR22	I9490000	Lockwoods Folly R at NW of Sunset Harbor (east channel)	625	Total Kjeldahl nitrogen TKN as N (mg/L)	42	0.2	0.3	0.3	0.4	0.5	0.6	0.8
LFR22	I9490000	Lockwoods Folly R at NW of Sunset Harbor (east channel)	630	Nitrate/nitrite NO2 + NO3 as nitrogen (mg/L)	42	0.01	0.01	0.01	0.01	0.01	0.03	0.03
LFR22	I9490000	Lockwoods Folly R at NW of Sunset Harbor (east channel)	665	Phosphorus total as P (mg/L)	42	0.02	0.023	0.03	0.045	0.05	0.08	6.2
LFR22	I9490000	Lockwoods Folly R at NW of Sunset Harbor (east channel)	1002	Arsenic As total (ug/L)	42	5	5	5	5	5	5	5
LFR22	I9490000	Lockwoods Folly R at NW of Sunset Harbor (east channel)	1027	Cadmium Cd total (ug/L)	42	2	2	2	2	2	2	8
LFR22	I9490000	Lockwoods Folly R at NW of Sunset Harbor (east channel)	1034	Chromium Cr total (ug/L)	42	25	25	25	25	25	25	210
LFR22	I9490000	Lockwoods Folly R at NW of Sunset Harbor (east channel)	1042	Copper Cu total (ug/L)	42	2	2	2	2	2.25	4	13
LFR22	I9490000	Lockwoods Folly R at NW of Sunset Harbor (east channel)	1045	Iron Fe total (ug/L)	3	180	180	180	280	580	580	580
LFR22	I9490000	Lockwoods Folly R at NW of Sunset Harbor (east channel)	1051	Lead Pb total (ug/L)	42	10	10	10	10	10	10	47
LFR22	I9490000	Lockwoods Folly R at NW of Sunset Harbor (east channel)	1067	Nickel Ni total (ug/L)	42	10	10	10	10	10	10	14
LFR22	I9490000	Lockwoods Folly R at NW of Sunset Harbor (east channel)	1092	Zinc Zn total (ug/L)	42	10	10	10	10	10	10	19
LFR22	I9490000	Lockwoods Folly R at NW of Sunset Harbor (east channel)	1105	Aluminum Al - Total (ug/L)	3	260	260	260	410	1100	1100	1100
LFR22	I9490000	Lockwoods Folly R at NW of Sunset Harbor (east channel)	31616	Fecal coliform MF method (colonies/100mL)	42	1	1	1	1	10	44	180
LFR22	I9490000	Lockwoods Folly R at NW of Sunset Harbor (east channel)	70507	Phosphorus in total orthophosphate as P (mg/L)	42	0.01	0.01	0.01	0.02	0.02	0.02	0.05
LFR22	I9490000	Lockwoods Folly R at NW of Sunset Harbor (east channel)	71900	Mercury Hg total (ug/L)	42	0.2	0.2	0.2	0.2	0.2	0.2	0.2
LFR22	I9490000	Lockwoods Folly R at NW of Sunset Harbor (east channel)	82079	Turbidity lab (NTU)	42	1.7	2.23	4.05	6.7	11	18.8	45
LFR23	I9500000	Lockwoods Folly R at West Channel Islands	10	Water temperature (°C)	110	8.3	11	15	21.4	27	28.68	30
LFR23	I9500000	Lockwoods Folly R at West Channel Islands	45	Precipitation previous 24 hrs. (in.)	75	0	0	0	0	0	0.338	2

LFR23	I9500000	Lockwoods Folly R at West Channel Islands	78	Secchi Transparency (m)	32	0.4	0.6	0.8	1	1.3	1.74	1.8
LFR23	I9500000	Lockwoods Folly R at West Channel Islands	94	Conductivity field (umho/cm @25°C)	106	50	38694	45845	49400	51500	53756	750000
LFR23	I9500000	Lockwoods Folly R at West Channel Islands	300	Dissolved oxygen (mg/L)	111	3.8	5.8	6.3	7.2	8.5	9.68	12.5
LFR23	I9500000	Lockwoods Folly R at West Channel Islands	400	pH (SU)	114	6.5	7.5	7.7	7.9	8.1	8.2	8.5
LFR23	I9500000	Lockwoods Folly R at West Channel Islands	480	Salinity (ppt)	104	0.2	25.4	30	32.5	34	35.4	37.3
LFR23	I9500000	Lockwoods Folly R at West Channel Islands	530	Residue total nonfilterable (mg/L)	69	1	9	15.5	22	33	54	170
LFR23	I9500000	Lockwoods Folly R at West Channel Islands	610	Ammonia nitrogen (mg/L)	103	0.01	0.01	0.01	0.02	0.06	0.14	0.41
LFR23	I9500000	Lockwoods Folly R at West Channel Islands	625	Total Kjeldahl nitrogen TKN as N (mg/L)	103	0.1	0.2	0.3	0.4	0.4	0.5	0.9
LFR23	I9500000	Lockwoods Folly R at West Channel Islands	630	Nitrate/nitrite NO2 + NO3 as nitrogen (mg/L)	103	0.01	0.01	0.01	0.01	0.01	0.03	0.07
LFR23	I9500000	Lockwoods Folly R at West Channel Islands	665	Phosphorus total as P (mg/L)	103	0.01	0.01	0.02	0.03	0.05	0.06	8.4
LFR23	I9500000	Lockwoods Folly R at West Channel Islands	680	T ORG C C MG/L	2	5	5	5	5	5	5	5
LFR23	I9500000	Lockwoods Folly R at West Channel Islands	1002	Arsenic As total (ug/L)	103	5	5	5	5	5	5	5
LFR23	I9500000	Lockwoods Folly R at West Channel Islands	1027	Cadmium Cd total (ug/L)	103	2	2	2	2	2	2	12
LFR23	I9500000	Lockwoods Folly R at West Channel Islands	1034	Chromium Cr total (ug/L)	103	25	25	25	25	25	25	250
LFR23	I9500000	Lockwoods Folly R at West Channel Islands	1042	Copper Cu total (ug/L)	103	2	2	2	2	2.3	6	48
LFR23	I9500000	Lockwoods Folly R at West Channel Islands	1045	Iron Fe total (ug/L)	66	50	106.1	170	255	470	779	1300
LFR23	I9500000	Lockwoods Folly R at West Channel Islands	1051	Lead Pb total (ug/L)	103	10	10	10	10	10	10	88
LFR23	I9500000	Lockwoods Folly R at West Channel Islands	1067	Nickel Ni total (ug/L)	103	10	10	10	10	10	10	19
LFR23	I9500000	Lockwoods Folly R at West Channel Islands	1092	Zinc Zn total (ug/L)	103	10	10	10	10	26	43	79
LFR23	I9500000	Lockwoods Folly R at West Channel Islands	1105	Aluminum Al - Total (ug/L)	67	50	210	320	530	850	1520	2600
LFR23	I9500000	Lockwoods Folly R at West Channel Islands	31616	Fecal coliform MF method (colonies/100mL)	114	1	1	1	1	1	23.5	800
LFR23	I9500000	Lockwoods Folly R at West Channel Islands	70507	Phosphorus in total orthophosphate as P (mg/L)	38	0.01	0.01	0.01	0.02	0.02	0.02	0.03
LFR23	I9500000	Lockwoods Folly R at West Channel Islands	71900	Mercury Hg total (ug/L)	103	0.2	0.2	0.2	0.2	0.2	0.2	0.2
LFR23	I9500000	Lockwoods Folly R at West Channel Islands	82079	Turbidity lab (NTU)	113	1	1.74	2.55	4.7	7.25	10.6	16
MS01	I9385000	Montgomery Slough at SR 1105 nr Long Beach	10	Water temperature (°C)	110	5.7	9.02	13.9	21.35	27.525	29.77	32
MS01	I9385000	Montgomery Slough at SR 1105 nr Long Beach	45	Precipitation previous 24 hrs. (in.)	89	0	0	0	0	0	0.5	2
MS01	I9385000	Montgomery Slough at SR 1105 nr Long Beach	78	Secchi Transparency (m)	4	0.4	0.4	0.5	0.95	1.175	1.2	1.2
MS01	I9385000	Montgomery Slough at SR 1105 nr Long Beach	94	Conductivity field (umho/cm @25°C)	109	4870	17193	25436	34000	40847	45040	51100
MS01	I9385000	Montgomery Slough at SR 1105 nr Long Beach	300	Dissolved oxygen (mg/L)	109	2.8	4.2	5.35	6.4	8.15	9.9	12.7
MS01	I9385000	Montgomery Slough at SR 1105 nr Long Beach	400	pH (SU)	109	6.6	6.8	7	7.3	7.5	7.7	8
MS01	I9385000	Montgomery Slough at SR 1105 nr Long Beach	480	Salinity (ppt)	105	0.01	8.76	15.4	22.3	26.3	29.24	34
MS01	I9385000	Montgomery Slough at SR 1105 nr Long Beach	530	Residue total nonfilterable (mg/L)	45	6	9.6	16	23	33	50.8	83
MS01	I9385000	Montgomery Slough at SR 1105 nr Long Beach	610	Ammonia nitrogen (mg/L)	68	0.01	0.01	0.0325	0.065	0.1375	0.244	0.49
MS01	I9385000	Montgomery Slough at SR 1105 nr Long Beach	625	Total Kjeldahl nitrogen TKN as N (mg/L)	67	0.2	0.3	0.4	0.5	0.6	0.7	1.4
MS01	I9385000	Montgomery Slough at SR 1105 nr Long Beach	630	Nitrate/nitrite NO2 + NO3 as nitrogen (mg/L)	68	0.01	0.01	0.01	0.01	0.0575	0.131	0.19
MS01	I9385000	Montgomery Slough at SR 1105 nr Long Beach	665	Phosphorus total as P (mg/L)	68	0.01	0.02	0.04	0.055	0.09	0.11	0.12
MS01	I9385000	Montgomery Slough at SR 1105 nr Long Beach	680	T ORG C C MG/L	3	4.5	4.5	4.5	6	10	10	10

MS01	I9385000	Montgomery Slough at SR 1105 nr Long Beach	1002	Arsenic As total (ug/L)	77	5	5	5	5	5	5	14
MS01	I9385000	Montgomery Slough at SR 1105 nr Long Beach	1027	Cadmium Cd total (ug/L)	77	2	2	2	2	2	2	10
MS01	I9385000	Montgomery Slough at SR 1105 nr Long Beach	1034	Chromium Cr total (ug/L)	76	25	25	25	25	25	25	25
MS01	I9385000	Montgomery Slough at SR 1105 nr Long Beach	1042	Copper Cu total (ug/L)	77	2	2	2	2	2	4.6	16
MS01	I9385000	Montgomery Slough at SR 1105 nr Long Beach	1045	Iron Fe total (ug/L)	76	50	197	290	540	830	1300	6600
MS01	I9385000	Montgomery Slough at SR 1105 nr Long Beach	1051	Lead Pb total (ug/L)	77	10	10	10	10	10	10	10
MS01	I9385000	Montgomery Slough at SR 1105 nr Long Beach	1067	Nickel Ni total (ug/L)	77	10	10	10	10	10	10	21
MS01	I9385000	Montgomery Slough at SR 1105 nr Long Beach	1092	Zinc Zn total (ug/L)	77	10	10	10	20	34	55.4	530
MS01	I9385000	Montgomery Slough at SR 1105 nr Long Beach	1105	Aluminum Al - Total (ug/L)	77	110	256	390	630	1100	1700	2600
MS01	I9385000	Montgomery Slough at SR 1105 nr Long Beach	31616	Fecal coliform MF method (colonies/100mL)	112	1	1	10	39	110	204	690
MS01	I9385000	Montgomery Slough at SR 1105 nr Long Beach	71900	Mercury Hg total (ug/L)	77	0.2	0.2	0.2	0.2	0.2	0.2	0.2
MS01	I9385000	Montgomery Slough at SR 1105 nr Long Beach	82079	Turbidity lab (NTU)	109	1.8	3.4	4.6	8.5	13	18	39

8.2 INVENTORY OF SPATIAL DATA FOR THE LOCKWOODS FOLLY RIVER LWP

File Name	Description	Source	Spatial Extent	Contact
zoning	Brunswick County Zoning	Brunswick County GIS Department	Brunswick County	Kirby Whitely Brunswick County GIS Dept. 1-800-822-1526
landuse_2004	Brunswick County Land use 2004	Brunswick County GIS Department	Brunswick County	Kirby Whitely Brunswick County GIS Dept. 1-800-822-1526
parcels	Brunswick County Parcel data	Brunswick County GIS Department	Brunswick County	Kirby Whitely Brunswick County GIS Dept. 1-800-822-1526
NLCD2001	National Land Cover Dataset 2001 - Impervious Surface Landsat based landcover database	EROS Data Center	Brunswick County	http://seamless.usgs.gov/
NLCD92	NLCD 92 (National Land Cover Data 1992) is a 21-category land cover classification scheme with a spatial resolution of 30 meters.	EROS Data Center	Brunswick County	http://seamless.usgs.gov/
chorzion.txt chydcrit.txt comp.txt mapunit.txt	SSURGO Detailed Soils - Tabular Attribute Data enhanced attribute data	NRCS Data Mart	Brunswick County	NRCS Soil Data Mart http://soildatamart.nrcs.usda.gov/
brundsl	SSURGO detailed county soils digitized from county soil surveys	NC CGIA	Brunswick county	North Carolina Center for Geographic Information and Analysis http://cgia.cgia.state.nc.us/cgia/
SID Aerial Coverage	aerial imagery	Brunswick County GIS Department	Brunswick county	Kirby Whitely Brunswick County GIS Dept. 1-800-822-1526

File Name	Description	Source	Spatial Extent	Contact
brun_wets brun_crews brun_rest	DCM shapefiles for each county: general wetlands, NC CREWS data, and Restoration/enhancement sites.	NC DCM	Brunswick county	NC Division of Coastal Management; http://www.nccoastalmanagement.net/Wetlands/download.htm
LIDAR-generated DEM			Brunswick county	Kirby Whitely Brunswick County GIS Dept. 1-800-822-1526
lbr_line lbr_poly	1:24,000 Hydrography detailed stream coverage; USGS based; includes use support	Basin Pro 8 (NC CGIA)	statewide	North Carolina Center for Geographic Information and Analysis http://cgia.cgia.state.nc.us/cgia/
nc_eco	NC Ecoregions	NC EEP	statewide	NC Ecosystem Enhancement Progarm
cbl100sl	County Boundaries - areas depicting jurisdictional boundaries of counties in North Carolina	Basin Pro 8 (NC CGIA)	statewide	North Carolina Center for Geographic Information and Analysis http://cgia.cgia.state.nc.us/cgia/
federal_ownership	Federally owned land - the boundaries of all types of land in North Carolina owned and managed by the United States government.	Basin Pro 8 (NC CGIA)	statewide	North Carolina Center for Geographic Information and Analysis http://cgia.cgia.state.nc.us/cgia/
319p	Water quality improvement projects funded by Section 319 of the Clean Water Act.	Basin Pro 8 (NC CGIA)	statewide	North Carolina Center for Geographic Information and Analysis http://cgia.cgia.state.nc.us/cgia/
afsa	Anadromous fish spawning areas - the extent of spawning areas for fish that swim upstream to spawn.	Basin Pro 8 (NC CGIA)	statewide	North Carolina Center for Geographic Information and Analysis http://cgia.cgia.state.nc.us/cgia/

File Name	Description	Source	Spatial Extent	Contact
casha	Areas that are conditionally approved open or closed for shellfish harvesting due to significant rainfall events by DEH.	Basin Pro 8 (NC CGIA)	statewide	North Carolina Center for Geographic Information and Analysis http://cgia.cgia.state.nc.us/cgia/
csha	Areas where shellfish harvesting is prohibited by law.	Basin Pro 8 (NC CGIA)	statewide	North Carolina Center for Geographic Information and Analysis http://cgia.cgia.state.nc.us/cgia/
ctcp	Conservation Tax Credit Properties - properties donated to the state in return for a tax credit.	Basin Pro 8 (NC CGIA)	statewide	North Carolina Center for Geographic Information and Analysis http://cgia.cgia.state.nc.us/cgia/
cwmtf	CWMTF projects - land acquisition sites, target areas, and planning areas for land acquisition to promote water quality improvement funded by the Clean Water Management Trust Fund.	Basin Pro 8 (NC CGIA)	statewide	North Carolina Center for Geographic Information and Analysis http://cgia.cgia.state.nc.us/cgia/
cwmtf_acq	CWMTF land acquisition projects - land acquisition sites, target areas, and planning areas for land acquisition to promote water quality improvement funded by the Clean Water Management Trust Fund.	Basin Pro 8 (NC CGIA)	statewide	North Carolina Center for Geographic Information and Analysis http://cgia.cgia.state.nc.us/cgia/
cwqms	APNEP citizens water quality monitoring sites - private citizens assess water quality. Monthly summaries provided to Citizen Water Quality Monitoring Program Office (CWQMPO).	Basin Pro 8 (NC CGIA)	statewide	North Carolina Center for Geographic Information and Analysis http://cgia.cgia.state.nc.us/cgia/

File Name	Description	Source	Spatial Extent	Contact
fna	Fish nursery area - primary, secondary, and special secondary nursery areas where the initial post-larval and juvenile development of young finfish and crustaceans occurs. Nursery areas are located in the uppermost reaches of the estuaries.	Basin Pro 8 (NC CGIA)	statewide	North Carolina Center for Geographic Information and Analysis http://cgia.cgia.state.nc.us/cgia/
hsds	Hazardous substance disposal site - locations of uncontrolled and unregulated hazardous waste sites (formerly called Superfund Sites), including sites on the CERCLA Information System (CERCLIS) National Priorities List, the State Inactive Hazardous Sites list, the Sites Priority List, and some Department of Defense files.	Basin Pro 8 (NC CGIA)	statewide	North Carolina Center for Geographic Information and Analysis http://cgia.cgia.state.nc.us/cgia/
hunc	8-, 11-, 14-digit hydrologic units - hydrologic Units as designated by the USDA--Natural Resources Conservation Service (NRCS) in North Carolina Hydrologic Unit River Basin Study, September 1994 and reviewed by the NC Division of Water Quality.	Basin Pro 8 (NC CGIA)	statewide	North Carolina Center for Geographic Information and Analysis http://cgia.cgia.state.nc.us/cgia/
huncrb	River basins - hydrologic Units as designated by the USDA--Natural Resources Conservation Service (NRCS) in North Carolina Hydrologic Unit River Basin Study, September 1994 and reviewed by the NC Division	Basin Pro 8 (NC CGIA)	statewide	North Carolina Center for Geographic Information and Analysis http://cgia.cgia.state.nc.us/cgia/

File Name	Description	Source	Spatial Extent	Contact
	of Water Quality			
lmcos0902	Lands in NC managed for conservation and open space relating to many purposes including recreation, wildlife habitat, water quality, and farmland preservation. This is a composite layer from 13 sources, representing an integrated depiction of lands that have been permanently protected or designated for open space.	Basin Pro 8 (NC CGIA)	statewide	North Carolina Center for Geographic Information and Analysis http://cgia.cgia.state.nc.us/cgia/
lmcos0902pts	point file of corresponds with lmcos0902 poly layer above.	Basin Pro 8 (NC CGIA)	statewide	North Carolina Center for Geographic Information and Analysis http://cgia.cgia.state.nc.us/cgia/
nc_animal_ops	Swine lagoons - points representing the approximate center of swine lagoons visible from 1998 digital orthophoto quarter quads. The points have not been related to the 1999 unverified locations of intensive livestock operations registered with the Division of Water Quality. No lagoon or farm attributes are included.	Basin Pro 8 (NC CGIA)	statewide	North Carolina Center for Geographic Information and Analysis http://cgia.cgia.state.nc.us/cgia/
nheo_pt nheo_ln nheo_py	Natural Heritage element occurrences - location of ecologically significant or rare species, and the occurrences of exemplary or unique natural	Basin Pro 8 (NC CGIA)	statewide	North Carolina Center for Geographic Information and Analysis http://cgia.cgia.state.nc.us/cgia/

File Name	Description	Source	Spatial Extent	Contact
	ecosystems and wildlife habitat.			
npdes	Surface water discharge locations as recorded on permits issued for National Pollutant Discharge Elimination System Sites (NPDES).	Basin Pro 8 (NC CGIA)	statewide	North Carolina Center for Geographic Information and Analysis http://cgia.cgia.state.nc.us/cgia/
q3east_in	Flood hazard areas delineated as FEMA Q3 digital files in eastern NC, for planning purposes only, NC Division of Emergency Management. Includes areas in flood hazard zones for 52 counties only (divided into eastern NC and western NC sets).	Basin Pro 8 (NC CGIA)	eastern NC (52 counties)	North Carolina Center for Geographic Information and Analysis http://cgia.cgia.state.nc.us/cgia/
snha	Significant Natural Heritage areas - areas containing ecologically significant natural communities or rare species.	Basin Pro 8 (NC CGIA)	statewide	North Carolina Center for Geographic Information and Analysis http://cgia.cgia.state.nc.us/cgia/
usgs_stream_gages	USGS stream gages - locations of all continuous-record stream gaging stations and all discontinued gages that have a record spanning at least ten years.	Basin Pro 8 (NC CGIA)	statewide	North Carolina Center for Geographic Information and Analysis http://cgia.cgia.state.nc.us/cgia/
wsw03	Water supply watersheds classified as WS-I, WS-II, and WS-IV in the Division of Water Quality's (DWQ) Classification Schedule, effective August 3, 1992, and as originally mapped by CGIA and DWQ staff. Protected and critical watershed designations are included.	Basin Pro 8 (NC CGIA)	statewide	North Carolina Center for Geographic Information and Analysis http://cgia.cgia.state.nc.us/cgia/

File Name	Description	Source	Spatial Extent	Contact
dams2002	Dams registered with NC Dam Safety Program.	Basin Pro 8 (NC CGIA)	statewide	North Carolina Center for Geographic Information and Analysis http://cgia.cgia.state.nc.us/cgia/
prds	Primary roads - interstate routes, US routes, and selects state routes in NC, to be used as a general-purpose roads layer.	Basin Pro 8 (NC CGIA)	statewide	North Carolina Center for Geographic Information and Analysis http://cgia.cgia.state.nc.us/cgia/
pws_wells_03	Public water supply wells - accurate location of public water supply system wells in North Carolina.	Basin Pro 8 (NC CGIA)	statewide	North Carolina Center for Geographic Information and Analysis http://cgia.cgia.state.nc.us/cgia/
rails_active	Active railroads - location of active railroad tracks in NC, based on rr24_100.shp	Basin Pro 8 (NC CGIA)	statewide	North Carolina Center for Geographic Information and Analysis http://cgia.cgia.state.nc.us/cgia/
rails_inactive	Inactive railroads - location of railroad tracks from rr24_100.shp that are not included in rail_active.shp.	Basin Pro 8 (NC CGIA)	statewide	North Carolina Center for Geographic Information and Analysis http://cgia.cgia.state.nc.us/cgia/
sdisch	Municipal discharge points - location of municipal waste treatment plants, derived from the water and sewer survey.	Basin Pro 8 (NC CGIA)	statewide	North Carolina Center for Geographic Information and Analysis http://cgia.cgia.state.nc.us/cgia/
slandapp	Land application sites - locations where treated wastewater or sludge is applied to be absorbed into the soil.	Basin Pro 8 (NC CGIA)	statewide	North Carolina Center for Geographic Information and Analysis http://cgia.cgia.state.nc.us/cgia/

File Name	Description	Source	Spatial Extent	Contact
spipes	Sewer pipes - locations of pipelines for wastewater distribution.	Basin Pro 8 (NC CGIA)	statewide	North Carolina Center for Geographic Information and Analysis http://cgia.cgia.state.nc.us/cgia/
ssysa	Sewer service type A - areas with existing community sanitary sewer systems including collection lines, transport lines, or pumping and treatment facilities that serve the general public and accept domestic wastewater.	Basin Pro 8 (NC CGIA)	statewide	North Carolina Center for Geographic Information and Analysis http://cgia.cgia.state.nc.us/cgia/
ssysb	Sewer service type B - systems do not meet Type A thresholds.	Basin Pro 8 (NC CGIA)	statewide	North Carolina Center for Geographic Information and Analysis http://cgia.cgia.state.nc.us/cgia/
streat	Municipal sewer treatment plants - locations of facilities used to treat wastewater and the related appurtenant works.	Basin Pro 8 (NC CGIA)	statewide	North Carolina Center for Geographic Information and Analysis http://cgia.cgia.state.nc.us/cgia/
swi	Surface water intakes - locations where communities draw raw water from a lake, river, or stream, then treat and distribute it to residences and businesses.	Basin Pro 8 (NC CGIA)	statewide	North Carolina Center for Geographic Information and Analysis http://cgia.cgia.state.nc.us/cgia/
wpipes	Water pipes - locations of pipelines for water distribution.	Basin Pro 8 (NC CGIA)	statewide	North Carolina Center for Geographic Information and Analysis http://cgia.cgia.state.nc.us/cgia/

File Name	Description	Source	Spatial Extent	Contact
wsysa	Municipal water treatment plants - Water Systems defined as public "Community Water Systems" by the NC Department of Environment and Natural Resources are classified as Type A Water Systems. Type A Water Systems are existing systems for provision to the public of piped water for human consumption which serve fifteen (15) or more connections or which regularly serve at least 25 year-round residents.	Basin Pro 8 (NC CGIA)	statewide	North Carolina Center for Geographic Information and Analysis http://cgia.cgia.state.nc.us/cgia/
wsysb	Water service type B - type B systems do not meet Type A thresholds.	Basin Pro 8 (NC CGIA)	statewide	North Carolina Center for Geographic Information and Analysis http://cgia.cgia.state.nc.us/cgia/
wtreat	Municipal water treatment plants - locations of treatment plants where raw water is treated and purified for human consumption.	Basin Pro 8 (NC CGIA)	statewide	North Carolina Center for Geographic Information and Analysis http://cgia.cgia.state.nc.us/cgia/
wwell	Municipal wells - locations where raw water is drawn into a water system from an underground source.	Basin Pro 8 (NC CGIA)	statewide	North Carolina Center for Geographic Information and Analysis http://cgia.cgia.state.nc.us/cgia/
municipal	Brunswick County municipal boundaries	Brunswick County GIS Department	Brunswick county	Kirby Whitely Brunswick County GIS Dept. 1-800-822-1526
project_watershed	boundary of Phase 1 Lockwoods Folly Local Watershed Plan	Lidar	Project area	Stantec Consulting 919-851-6866
subwatersheds	subwatersheds of Phase 1 Lockwoods Folly Local Watershed Plan	Lidar	Project area	Stantec Consulting 919-851-6866

File Name	Description	Source	Spatial Extent	Contact
st_james	St James municipal boundary	Brunswick County GIS Department	Town of St James	Kirby Whitely Brunswick County GIS Dept. 1-800-822-1526
monitoring_locations	locations of DWQ, DEH, and USGS monitoring efforts	DWQ Watershed Assessment Team	Project area	Stantec Consulting 919-851-6866
riparian_buffer_disturbance	The percentage of cells in human-altered land cover types in a 30m buffer of 1:24,000 hydrology		Project area	Stantec Consulting 919-851-6866
stream_erosion_potential	The erodibility of soils within the riparian zone of a given stream segment assessed using an area-weighted average soil erodibility (*k*) factor within a 30m stream buffer polygon.		Project area	Stantec Consulting 919-851-6866
waterfront_vacant_parcels	vacant parcels that border coastal waterbodies and estuarine wetlands may present opportunity to promote the creation of non-hardened stabilization techniques and restoration or creation of shoreline marsh habitat.	Brunswick County GIS Department	Project area	Stantec Consulting 919-851-6866
impaired_waters_line	impaired waters based on the 2003 Lumber River basin plan (line file)	2003 Lumber River Basin Plan	Project area	Stantec Consulting 919-851-6866
impaired_waters_poly	impaired waters based on the 2003 Lumber River basin plan (polygon file)	2003 Lumber River Basin Plan	Project area	Stantec Consulting 919-851-6866