Implementation Plan for the Restoration of the Shellfish Harvesting Areas in the Lockwoods Folly River, Lumber River Basin, Brunswick County, North Carolina

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Executive Summary

The goal of this implementation plan is to meet the established water quality standard for fecal coliform bacteria in shellfishing waters.

> "Organisms of coliform group: fecal coliform group not to exceed a median MF of 14/100 ml and not more than 10 percent of the samples shall exceed an MF count of 43/100 ml in those areas most probably exposed to fecal contamination during the most unfavorable hydrographic and pollution conditions." 15A NCAC 02B.0021 (Tidal Salt Water Quality Standards for Class SA Waters) (MF is an abbreviation for the membrane filter procedure for bacteriological analysis).

Previous studies of the Lockwoods Folly River watershed have noted stormwater runoff, septic systems, and animal waste as sources for fecal coliform contamination. Shellfish waters were open when the watershed was only 1% developed. Closures began in the 1980s when the watershed increased to 2% developed and more. To improve water quality, it is necessary to reduce impacts from all development that occurred after this point by capturing, infiltrating, or treating stormwater runoff. The highest amount of fecal bacteria loading is occurring in the lower portions of the watershed, as well as along Highway 17 and in Oak Island and Bolivia. These areas should be 'targeted' for implementation strategies.

Results from the Total Maximum Daily Loads (TMDL) for the shellfish harvesting areas in the Lockwoods Folly River project support the findings of previous studies. Stormwater is a significant culprit in high fecal contamination levels. Wildlife is the largest source followed by pets, livestock and human sources including septic systems and boat discharges. While pets, livestock, and humans are not the main sources of bacteria in the watershed, their contribution to the contamination of surface waters may be more significant as they are located in the developed areas of the watershed where runoff is higher than in undeveloped areas. Model results show that an 86% reduction in loads in the watershed is required to meet water quality standards. NCDOT is required to reduce their load by 53%.

Based on the TMDL and previous studies, it was determined that 94% of developed land needs to be targeted for stormwater retrofits that will control and infiltrate/treat the 1-year, 24-hour storm. Since most of the development in the watershed is residential, small scale BMPs on a lot by lot basis will be necessary in most areas. It may be possible to incorporate other BMPs in some locations that can treat larger drainage areas.

Reducing stormwater runoff by implementing stormwater retrofits in the first of four measures presented in this implementation plan. The measures will help improve shellfish waters and prevent further degradation. Following is a summary of the actions recommended for each management measure (a full list of the actions is found in Section 5.0) as well as milestones and priorities.

Measure 1: Reduce stormwater runoff from 94% of existing development

Actions include BMP retrofits in existing developed areas including residential neighborhoods, and incentive program for these projects. NCDOT should work with homeowner and property owner associations to treat runoff from roads and residential parcels while local governments should promote low impact development (LID) by using those techniques to retrofit existing government owned properties. An accounting system will be necessary to catalog the BMP retrofit projects.

Milestone: After five years use water quality data and the acres of developed land that have

stormwater reduction practices in place to determine if the number of retrofits is resulting in a decrease of fecal bacteria levels.

Priority: Actions have been recommended for developed lands throughout the watershed for a variety of parties. Locations should be prioritized based on the following factors: landowner willingness to participate, funding, and how effective projects will be based on soils, depth to water table, and space available. Most of the more effective BMPs recommended in this plan require soils with high infiltration capacity and a minimum 3-foot depth to water table.

Measure 2: Prevent stormwater runoff from all new development

Actions focus on the promotion and use of LID in new development projects by local government, NCDOT, and developers. This can be encouraged by developing a financial incentive program. Open space for all new development projects should be at least 40% and an action plan should be created for acquiring preservation sites. The stricter ORW/SA stormwater rules should apply to the entire watershed, not just within the half-mile SA waters buffer area.

Milestone: In 2015, compare existing parcel data with data from 2010 to determine areas with new growth that are conventional developments or low impact developments. If conventional developments are more common than LID, efforts should be increased.

Priority: Currently, development is not occurring at a rapid pace however many lots have been subdivided for conventional development (see Figure 6). It is important to work with these developers in order to minimize impacts from these areas. If these projects are successful in that developers recover their investments, other developers may choose to design neighborhoods using LID techniques.

Measure 3: Control and reduce sources of fecal coliform bacteria

Actions focus on pet waste management, sewer extension, septic system maintenance, and a variety of marina and boater BMPs/programs. Manure management and various BMPs are included for livestock owners. Wildlife bacteria source reduction focuses on geese in developed areas.

Milestone: In five years, review the source reduction actions that have been completed. Survey those that initially participated in specific actions to determine if they are continuing source control efforts.

Priority: Efforts should focus first on the largest source that is easily managed and then work through the smaller sources. Pet waste is the second largest source but is easier to manage than wildlife therefore pet waste controls should be the primary focus. This is followed by source controls for septic system owners, boaters, and livestock owners. Wildlife sources will primarily be addressed through stormwater runoff reduction, however some source control actions have been proposed for geese.

Measure 4: Education/Outreach/Training

There are two main groups of education actions – publications/information and presentations/workshops. The publications/information group includes a website, fact sheets, a tabloid publication describing the TMDL and this implementation plan, informational signage, and press releases to keep a spotlight on efforts in the watershed and keep the public informed. The presentations/workshops group activities focus on how to implement stormwater runoff reduction strategies and on source control for pet owners, septic system owners, boaters, and homeowners in general.

Milestone: In five years, review the education/outreach/training actions that have occurred. Survey the participants to determine if they have taken actions to improve water quality or have changed habits.

Priority: In order to get the public to participate, implementing the education strategies is key. Focusing on organized groups of homeowners such as HOAs and POAs should be the top priority as a larger number of people can be reached that will potentially install stormwater runoff reduction practices on their lots.

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1.0 Introduction

Fecal coliform bacteria are found in the intestinal tract of humans and other warm-blooded animals and are often introduced to waterbodies through point source discharges of wastewater, or via nonpoint source contributions from runoff and failing septic systems. This is of concern in waters designated for shellfish propagation and harvesting because fecal coliform bacteria, while generally non pathogenic, do serve as an indicator of the possible presence of other bacteriological contaminants that can be detrimental to human health, such as Escherichia coli. The Lockwoods Folly River has a strong coastal tradition which includes shellfish harvesting for both personal and commercial purposes. This practice is currently being threatened by bacteria contamination in the river and estuary.

Prior to 1980, the watershed was 1% developed and shellfish harvesting areas in the watershed were open. However, closure of the areas began in the 1980s. During this time, development pressure began to increase. Between 1981 and 1988, development of the watershed increased from 2% of the area to 3.6%. In 1988, 654 additional acres of shellfishing area were closed resulting in a total of 71 percent closure in the watershed. Currently, 17% of the watershed has been developed (including open space and golf courses) and all of the shellfishing waters are now either permanently closed, conditionally closed, or conditionally open. These numbers highlight that the Lockwoods Folly River is demonstrably sensitive to development and human practices which can lead to pathogenic contamination most often associated with feces from warm blooded animals. Fecal coliform bacteria can enter rivers and estuaries through loading of waste from mammals and birds, agricultural practices, and from leaking human waste systems and boat discharges, but most of the bacteria are carried to surface waters by stormwater runoff.

In order to understand current pollutant levels and the reduction of fecal coliform bacteria necessary to improve water quality, a Total Maximum Daily Load (TMDL) was established in 2010 for the Lockwoods Folly River and its tributaries. The load reduction for fecal coliform bacteria needed in the watershed of the restricted shellfish harvesting areas to meet the shellfish criteria was calculated to be 86%. The purpose of a TMDL Implementation Plan is to spell out the measures to be taken to reduce fecal coliform bacteria levels to meet the TMDL. The implementation plan follows the Nine Key Elements for implementing watershed plans that were established by the EPA (U.S. Environmental Protection Agency, Office of Wetlands, Oceans and Watersheds, 2008). The elements and sections where they can be found are as follows:

1. Identify the cause of impairment and pollutant sources along with existing loads that need to be controlled to achieve load reductions. **Section 2.4**

2. Estimate the load reductions expected from management measures. **Section 2.4 and 3.1**

3. Describe the nonpoint source management measures that will need to be implemented to achieve the load reductions in 2 and the critical areas in which those measures will be needed to implement this plan. **Section 3.0**

4. Estimate the amount of technical and financial assistance needed, associated costs, and/or the sources and authorities that will be relied upon to implement this plan. **Section 4.0**

5. Include an information and educational component to enhance public understanding of the project and encourage their early and continued participation in selecting, designing, and implementing the nonpoint source management measure that will be implemented. **Section 3.3**

6. Provide a schedule for implementing the nonpoint source management measures identified in this plan that is reasonably expeditious. **Section 5.0**

7. Describe the interim milestones for determining whether nonpoint source management measures or other control actions are being implemented. **Section 5.0**

8. Provide a set of criteria that can be used to determine whether loading reductions are being achieved over time and substantial progress is being made toward attaining water quality standards. **Section 5.0**

9. Monitor to evaluate the effectiveness of the implementation efforts over time, measured against criteria established under item 8 above. **Section 5.0**

The strategies and actions described in this plan focus on reducing fecal coliform bacteria and the stormwater runoff that carries it to surface waters and wetlands. Everyone in the watershed can do their part to reduce pollution levels including homeowners and other property owners, developers, and local government officials:

- Local government officials: Adopt policies to protect the watershed from future development and promote strategies that will help reduce the impacts of the existing development on water quality (Section 3.3.2).

- Developers: Recommendations include altered development practices to reduce the impacts of new development, stormwater management strategies, and ‘green’ add-ons for new homeowners (Section 3.1 & Appendix 2).

- Homeowners and other property owners including businesses and government-owned facilities: Existing development and daily habits have a measurable impact on fecal bacteria levels. Section 3.1 and 3.2 outline strategies for current residents to reduce their contribution to the contamination of the Lockwoods Folly River. Details and resources are included in Appendix 2.

2.0 Watershed and Background Information

2.1 Description of Impairment

The Lockwoods Folly River is located in south central Brunswick County, south of Wilmington, NC within the Lumber River Basin (NC subbasin 03-07-59, HUC 030402070200). Although part of the Lumber River Basin, the river 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 inlet, and the Intracoastal Waterway (ICWW) is located landward of these islands. Montgomery Slough partially bisects Oak Island towards the seaward side of the island, and is connected to the ICWW in two locations. The Lockwoods Folly estuary drains to the ICWW before reaching the outlet to the Atlantic Ocean (Figure 1).

The River, estuary and their tributaries are located within the A-3 shellfish harvesting area, as designated by the North Carolina Division of Environmental Health (NCDEH). The Lockwoods Folly River and the upriver portion of the estuary are Prohibited for shellfish harvesting due to excessive levels of fecal coliform bacteria. The two downstream portions of the estuary are Conditionally Approved Open and Conditionally Approved Closed. The tributaries of Mill Creek, Mullet Creek, Lockwoods Creek and portions of Montgomery Slough and the Intracoastal Waterway are also Prohibited. Spring Creek is Conditionally Approved Open for shellfish harvesting. All of these segments are listed on the 2008 303(d) list as impaired due to fecal coliform (Table 1).

Waters within the shellfish harvesting classification (Class SA Waters), according to 15A NCAC 02B.0021 (Tidal Salt Water Quality Standards for Class SA Waters), must meet the following water quality standard in order to meet their designated use:

“Organisms of coliform group: fecal coliform group not to exceed a median MF of 14/100 ml and not more than 10 percent of the samples shall exceed an MF count of 43/100 ml in those areas most probably exposed to fecal contamination during the most unfavorable hydrographic and pollution conditions.” (MF is an abbreviation for the membrane filter procedure for bacteriological analysis).

Figure 1. Watershed and Vicinity Map

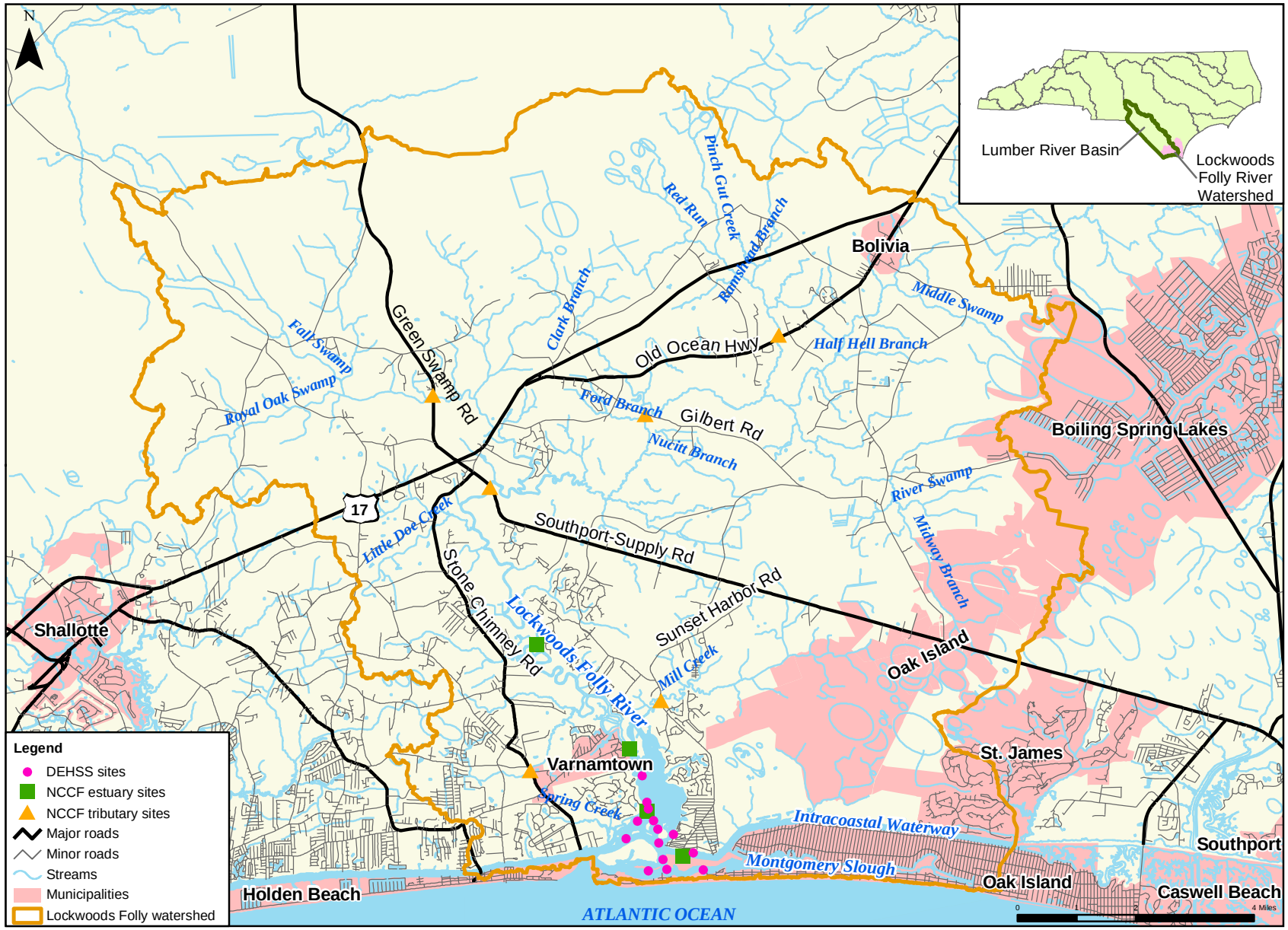


Table 1. Impaired Waterbodies in the Lockwoods Folly River Watershed (2008 303(d) List)

Waterbody Name - (ID)	Description	Water Quality Classification	Acres
Lockwoods Folly River - (15-25-1-(16)a)	From Brunswick County SR 1200 to a line crossing Lockwood Folly River 520 meters north of Myrtle Point of the east shore to a point of the west shore 704 meters north of Mullet Creek	SA, HQW	123.6
Lockwoods Folly River - (15-25-1-(16)b)	From a line crossing Lockwood Folly River 520 meters north of Myrtle Point of the east shore to a point of the west shore 704 meters north of Mullet Creek to a line crossing Lockwood Folly River 146 meters north of Genoes Point on the east shore to a point on the west shore 777 meters south of Mullet Creek	SA, HQW	275.6
Lockwoods Folly River - (15-25-1-(16)c)	From a line crossing Lockwood Folly River 146 meters north of Genoes Point on the east shore to a point on the west shore 777 meters south of Mullet Creek to a line crossing Lockwoods Folly River 628 meters south of Genoes point on the east shore	SA, HQW	207.0
Lockwoods Folly River - (15-25-1-(16)d)	From a line crossing Lockwood Folly River 628 meters south of Genoes Point on the east shore to Gores Landing on the east shore to ICWW	SA, HQW	53.1
Mill Creek - (15-25-1-18-(2))	From Brunswick County SR 1112 to Lockwoods Folly River	SA, HQW	2.0
Montgomery Slough - (15-25v)	From ICWW west of Lockwoods Folly Inlet extending eastward (2.4 Miles)	SA, HQW	2.3
Mullet Creek - (15-25-1-19)	From source to Lockwoods Folly River	SA, HQW	5.7
Intracoastal Waterway - (15-25u)	From a line crossing ICWW south of SR 1112 to Cape Fear River Basin	SA, HQW	403.5
Intracoastal Waterway - (15-25t1)	From a line across the ICWW 2030 meters west of NC 130 bridge to a line crossing ICWW south of SR1112	SA, HQW	292.8
Spring Creek - (15-25-1-21)	From source to Lockwoods Folly River	SA, HQW	2.4
Lockwoods Creek - (15-25-1-20)	From source to Lockwoods Folly River	SA, HQW	0.2

2.2 Watershed Characteristics

The Lockwoods Folly River watershed covers 153 square miles of Brunswick County. Incorporated towns wholly and partially within the watershed include Bolivia, Varnamtown, Oak Island, St. James, and Boiling Spring Lakes.

The watershed is comprised of approximately 73% forest land. Of the forested land, approximately 30% is wooded wetland and 20% is managed pineland. Developed land including residential, commercial, industrial, and office land uses, currently comprise over 9% of the watershed. Golf courses, managed open spaces, and areas cleared for development are another 8% of the watershed. Significant growth has occurred in the watershed over the past 20 years. This growth has occurred around the estuary, along US 17 and NC 211, and on Oak Island.

Streams in the upper headwater region of the watershed are the most degraded as ditching has occurred to facilitate pine production. Elsewhere in the watershed, the major streams are well buffered and relatively unaltered. Soils in the watershed have varying drainage classes and physical properties. One commonality is that over 92% of the soils in the watershed are rated as very limited in terms of septic suitability. This is important because much of the existing

development uses septic systems.

2.3 Previous Studies

Many studies of the Lockwoods Folly River watershed have been conducted in the past few decades in an attempt to determine the causes and sources of pollutants. While a few of the studies had broad goals and objectives that focused on water quality in general, the majority focused on fecal contamination. These previous studies have been valuable in understanding the water quality issues in the watershed; however, implementation of the recommended actions has been slow to develop. Twenty years after the DWQ document noted stormwater and septic systems were the likely culprits, little has been done to prevent additional impacts. More importantly, actions to go back and mediate the affects of existing development have been minor. The focus needs to turn to implementing strategies and taking action to improve water quality. Below is a summary of the key studies.

Findings from Previous Studies

Stormwater runoff, septic systems, and animal waste have been noted as sources for fecal coliform contamination.

Shellfish waters were open when the watershed was only 1% developed. Closures began in the 1980s when land use in the watershed increased to 2% developed and more. To improve water quality, it is necessary to reduce impacts from all development that occurred after this point by capturing, infiltrating, or treating stormwater runoff.

The highest amount of fecal bacteria loading is occurring in the lower portions of the watershed, as well as along Highway 17 and in Oak Island and Bolivia. These areas should be 'targeted' for implementation strategies.

Current development practices and open space policies are insufficient for protecting water quality. A NCSU study conducted in Brunswick County recommended a maximum of 12 to 15% impervious cover with a minimum of 40% open space per development site to adequately infiltrate stormwater.

The Division of Water Quality (DWQ) conducted a study in 1989 to "evaluate the decline in water quality in the Lockwoods Folly River Basin and to offer recommendations to federal, state, and local government agencies and the public on improvements to protect and enhance water quality and reverse the trend of increased shellfish area closures due to bacterial contamination" (Division of Water Quality (previously Division of Environmental Management Water Quality Section), 1989). Six major possible sources of fecal coliform bacteria were identified: 1) surface wastewater discharges; 2) animal waste; 3) influx from the Intracoastal Waterway; 4) sediment; 5) stormwater runoff; and 6) septic tanks. Based on the information available, septic tanks and stormwater runoff were considered to be the primary sources. However, this could not be confirmed due to a lack of data. Recommendations from the study focused on water quality monitoring, on-site wastewater, urban stormwater runoff, agricultural sources, sludge/septage/industrial disposal, landfills, wastewater discharges, wetlands, and education (Appendix 1). Some of the specific recommendations were implemented such as a low density development rule and not allowing new domestic or industrial NPDES permitted discharges.

The NCSU College of Design conducted a study in Brunswick County to evaluate water quality impacts based on different types of development in order to provide recommendations for planning and zoning (Tomlinson, 2007). The study recommended reducing the water quality

impacts created by expanses of lawn areas in residential areas by “limiting strip clearing practices, removing control of clearing from the individual homeowner, and requiring the lawn area to be no greater than 20% of the total area of a development site” (Tomlinson, 2007). The study also recommended limiting the amount of impervious surfaces to a maximum between 12% and 15%. The study noted that even with limiting the amounts of impervious and lawn surfaces, infiltration systems will be necessary to offset development impacts to water quality. The study suggested Brunswick County should integrate low-impact development practices including infiltration into the Unified Development Ordinance (UDO). Finally, an open space area of 40% not including wetlands was recommended in order to facilitate runoff volume reduction.

The NC Ecosystem Enhancement Program (NCEEP) funded the development of a local watershed plan for the Lockwoods Folly River watershed (Stantec, 2007). The study involved the assessment of historical and current watershed conditions, identification of major causes and sources of watershed degradation, working with stakeholders to determine major watershed issues and focus areas, and prediction of future watershed conditions under different management and land use scenarios using a pollutant load model. The results found that streams in the upper portions of the watershed have the greatest degradation; however, the highest pollutant loadings occur in the lower portions of the watershed. As such, the highest priority areas for reducing water quality impacts from fecal coliform bacteria loading were found to be along the Lockwoods Folly River from its mouth to Highway 17, as well as the portions of the watershed in Oak Island and Bolivia. The plan provided watershed restoration and protection recommendations including stream and wetland restoration opportunities, preservation, and stormwater best management practices that could be used for compensatory mitigation purposes.

In 2007 NCEEP also partnered with Brunswick County and the North Carolina Coastal Federation to develop strategies to preserve and restore water quality in the Lockwoods Folly River. A Roundtable was appointed by the County Board of Commissioners to develop the strategies. The findings from the watershed plan, which was under development concurrent with the Roundtable, were used along with reports and information from other water quality professionals. A low impact development economic study and a land suitability analysis were also conducted. The strategies “provide a range of options, including changes in land development policies, education programs, and site preservation and retrofit techniques” (Lockwood Folly Watershed Rounddtable, 2007). County staff has been tasked with reviewing and implementing the strategies. Specific strategies that will help to reduce fecal coliform bacteria levels have been included in this implementation plan and are noted throughout the document.

In 2008 NCCF and Stantec received a 319 grant to establish a TMDL for the Lockwoods Folly River. The project also included educational information, a stakeholder process with local and state officials, and the design of stormwater BMPs. The TMDL is described in the next section.

2.4 Total Maximum Daily Load Report

The water quality goal of the TMDL study was to determine the allowable pollutant load of fecal coliform bacteria to the estuary such that water quality standards would still met at all times in order to re-open shellfishing waters in the Lockwoods Folly River watershed. To accomplish this, the TMDL development process included an investigation of current water quality, a source assessment, a water quality model, and the calculation of the bacteria load reduction required.

2.4.1 Water Quality Characterization

The Shellfish Sanitation and Recreational Water Quality Branch of the NCDEH is responsible

for classifying shellfish harvesting waters to ensure oysters and clams are safe for human consumption. There are nine monitoring sites sampled by Shellfish Sanitation (DEHSS) which are located within the modeled Lockwoods Folly estuary (Figure 1). The observed data indicate that as of 2007, water quality standards were being violated at five of the nine sites (Table 2). Fecal coliform levels began to drop after 2007, possibly due to a statewide drought highlighting the effect of stormwater runoff on fecal coliform levels. As precipitation levels have increased since the drought, fecal coliform levels in the estuary have also increased.

Table 2. Summary Statistics of Water Quality Data (as of December 2007)

Station	Last 30 Sample Geometric Mean (MPN/100mL)	Last 30 Sample Median (MPN/100mL)	Last 30 Sample 90th Percentile (MPN/100mL)
5A	10	8	53
6A	na	na	na
7	11	8	85
7A	10	4	125
8	9	5	71
10	7	5	45
13	5	4	30
14A	na	na	na
14B	na	na	na

na = not available, <30 samples collected and summary statistics could not be calculated

2.4.2 Causes and Sources Fecal Contamination

There are no point sources of fecal coliform in the watershed. However, there are many types of nonpoint sources contributing fecal loads to the restricted shellfish harvesting areas. Fecal coliform bacteria from non-human sources originate from excretions from pets, livestock, and wildlife. Bacteria from these sources are delivered to waterbodies via stormwater runoff. As the amount of development and impervious cover has increased in the watershed, so have stormwater runoff and the fecal loading from these sources. Nonpoint source contributions to the bacterial levels from human activities generally arise from malfunctioning or improperly-sited septic systems or illicit connections of sanitary sewage to the stormwater conveyance system. Approximately 92% of the watershed has soils that are unsuitable for septic systems. Sewage discharge from boats is another human source of fecal bacteria.

A source assessment was conducted as part of the TMDL report. This assessment estimated the relative amount of bacteria that is available for runoff from each fecal bacteria source in the watershed. The source assessment did not determine the actual loads to the estuary from each nonpoint source category. Loads from boat discharge were not included in the source assessment as these are difficult to quantify. Boat discharges are not allowed; however, it is likely that they occur and it is unclear how many boaters violate this regulation or how often.

The assessment estimated that the available fecal bacteria can be attributed mainly to wildlife (about 52%). Pets contribute about 30% of the available bacteria while livestock contribute approximately 15%. The analysis estimated that humans may only contribute about 3% of the available bacteria via septic systems. However, this analysis estimated available fecal bacteria on the land surface throughout the watershed, but not actual loads to the estuary. The actual relative contribution from the sources is likely different. For example, while wildlife has a high percentage of available bacteria, most occurs in the undeveloped areas of the watershed where

stormwater is better infiltrated and the bacteria may not reach surface waters. Conversely, pet waste occurs primarily in developed areas with higher levels of impervious surface. These impervious surfaces convey stormwater and pollutants quickly and directly to surface waters, increasing the contribution of fecal bacteria loads from developed areas than undeveloped areas. Therefore, loads from sources which occur in developed areas, such as pets, livestock and human sources, may be higher than determined by the source assessment. These developed areas are shown on Figure 3.

As noted above, fecal bacteria loads from boat sewage discharges are difficult to quantify due to a lack of data, but this *direct* load may occur throughout waterways in the watershed, increasing the human contribution than what was estimated in the source assessment. The untreated discharge of one weekend boater can potentially contribute the same amount of bacterial pollution in the water as does the treated sewage of 10,000 people (San Francisco Estuary Partnership, 2009).

It is clear that there are fecal coliform bacteria throughout the watershed and it can be carried to surface waters during rain events. In addition, fecal bacteria may be reaching the estuary via groundwater in places where septic drainfields are located in soils with high water tables. A plan to reduce the sources of fecal bacteria and to prevent the transport of fecal bacteria by stormwater is detailed in this document.

Findings from the TMDL Study

Results from the TMDL Study support the findings of previous studies. Stormwater is a significant culprit in high fecal contamination levels.

Sources include pets, livestock, and wildlife. Human sources include septic systems and boat discharges.

Pets, livestock, and humans are not the main sources of bacteria in the watershed; however, their contribution to the contamination of surface waters may be more significant as they are located in the developed areas of the watershed where runoff is higher than in undeveloped areas

Model results show that an 86% reduction in loads in the watershed is required to meet water quality standards. NCDOT is required to reduce their load by 53%.

2.4.3 TMDL Results

The TMDL model used land use, soils, stream, precipitation, and water quality data to determine the current load of fecal coliform bacteria being delivered from the watershed to the estuary. The model was then used to determine the reduction of fecal bacteria loads needed to meet North Carolina water quality standards for fecal coliform. The load reduction needed in the Lockwoods Folly River watershed was estimated to be 86%. The TMDL is divided into a wasteload allocation (WLA) which represents point sources, a load allocation (LA) which represents nonpoint sources, and a margin of safety (MOS) which is added in recognition of the many uncertainties in the understanding and simulation of water quality in natural systems. While WLA generally pertain to point sources, EPA policy now requires that permitted stormwater sources also be included in the WLA.

There are currently two permitted stormwater dischargers in the watershed: NCDOT and the Town of Oak Island. However, Oak Island's contribution to the pollutant load to the Lockwoods Folly estuary could not be calculated. Stormwater runoff from Oak Island flows into Montgomery Slough and the ICWW. These waters are impaired however they were not included in the TMDL model process as the hydrodynamics of this system were not conducive to modeling. The 86% reduction is not applicable to these areas. However, the reduction strategies described in this

plan are applicable to these areas. NCDOT's contribution to fecal bacteria loading in the watershed was tracked separately in the model from other land use types in order to calculate their wasteload allocation and load reduction requirements. Therefore, the WLA shown in Table 3 represents the allowable contribution from NCDOT. NCDOT must reduce its existing contribution by 53% in order to achieve its wasteload allocation.

It is important to remember that all stormwater, whether from an NPDES permitted area or not, can and should be addressed using management measures including, but not limited to, those described in this implementation plan.

Table 3. TMDL Summary

Waterbody	Pollutant	Existing Load	WLA	LA	MOS	TMDL	Reduction Needed*
Lockwoods Folly River (15-25-1-(16)c) Lockwoods Folly River (15-25-1-(16)a), Lockwoods Folly River (15-25-1-(16)b), Lockwoods Folly River (15-25-1-(16)d), Mill Creek, Mullet Creek, Spring Creek, Lockwoods Creek	Fecal coliform (counts/day)	6.910E+12	2.097E+11	7.855E+11	1.106E+11	1.106E+12	84%

WLA = wasteload allocation; LA = load allocation, MOS = margin of safety

*When the MOS is included, the total required reduction is 86%

3.0 Management Measures

In order to reach the TMDL, major reductions in fecal bacteria loading are necessary. Pollutants such as fecal bacteria can be transported from the land to surface water by a variety of means including stormwater runoff and indirectly, ground water infiltration.

All fecal bacteria sources in the Lockwoods Folly River watershed are effectively nonpoint sources (stormwater behaves has a nonpoint source). There are two main types of management measures that can be used to reduce fecal bacteria loading from nonpoint sources: stormwater runoff reduction and source control. Education along with policies and programs are essential for the effective implementation of these management measures.

Measure 1: Reduce stormwater runoff from 94% of existing development

Measure 2: Prevent stormwater runoff from all new development

Measure 3: Control and reduce sources of fecal coliform bacteria

Measure 4: Education/Outreach/Training

The action items for these measures are described in the following sections and then summarized in Section 5. Each section also states where the measures should be implemented (Figures 3 and 4) and who should implement them. An accounting system to measure the effects of the implemented efforts is vital to this plan. This system is described in Section 3.1.

3.1 Stormwater Runoff Reduction and Prevention

Stormwater runoff reduction practices intercept stormwater and associated pollutants prior to delivery to a waterbody. This can be achieved through the use of stormwater best management practices (BMPs) by capturing the runoff, treating it and then releasing it, or permanently keeping it from surface water or ground water resources. Fecal bacteria removal can be achieved through drying, sun exposure, sedimentation, and filtration. However, the conditions found in some BMPs are ideal for fecal bacteria growth instead of removal, including moist soils and readily available nutrients. Other times BMPs are a source of fecal bacteria as they attract animals that then defecate in and around them.

The best BMPs to reduce fecal coliform bacteria are those that substantially limit the volume of water that leaves the BMP since that is what carries any untreated pollutants to surface waters. Reducing high flows is important as they can cause erosion and mixing of bottom sediments where fecal coliform bacteria thrive.

Instead of using BMP removal efficiencies that vary greatly depending on the study, this plan puts into place a simple accounting system based on historic land use conditions and water quality data. According to historic data, waters in the estuary started to close to shellfishing after 1% of the watershed (excluding Oak Island) was developed. When the 86% reduction specified in the TMDL was calculated, 17% of the watershed was developed. In order to restore water quality to a state that will allow for shellfishing, enough stormwater must be

Stormwater Runoff and Existing Development

About 94% of developed land needs to be targeted for stormwater retrofits that will control and infiltrate/treat the 1-year, 24-hour storm.

Since most of the development in the watershed is residential, small scale BMPs on a lot by lot basis will be necessary in most areas. It may be possible to incorporate other BMPs in some locations that can treat larger drainage areas.

captured and infiltrated/treated to mimic conditions found when just 1% of the area was developed. The difference between acres of pre-impaired development (approximately 1182 acres) and acres of existing development (16,885 acres) is 15,703 acres. This equates to treating roughly 94% of the developed land. The 1-inch, 24-hour storm or 3.8 inches should be used when calculating BMP size. This measure supports Roundtable strategy 7 that called for the identification of sites for water quality retrofit to reduce or eliminate unwanted runoff.

ACTIONS:

- Promote BMP retrofits to capture the 1-year, 24-hour storm in existing developed areas including residential neighborhoods with an emphasis on infiltration opportunities in A & B soils (Figure 3).
- Create an incentives program for neighborhood stormwater reduction projects that could include a competition sponsored by a local vendor or media outlet.
- Use LID techniques to retrofit existing government owned properties such as schools, the community college, and municipal and county government complexes to infiltrate the 1-year, 24-hour storm.
- Promote LID for all new and re-development on public/government owned properties such as parks, schools, the community college, and others.
- Develop a financial incentives program for the use of LID in all new development. (Note that Roundtable Strategy 8 called for a financial incentive program to encourage developers to take alternative approaches that support water quality objectives).
- Work with developers to offer ‘green‘ add-on amenities for new homes in conventional neighborhoods such as permeable pavers, cisterns, and rain gardens.
- Create an accounting system which catalogs BMP retrofit projects, the area treated, and the storm size (i.e. the 1.5 inch or 3.8 inch storm)

A number BMPs have been selected for use in the watershed based on pollutant removal and stormwater runoff reduction ability in order to accomplish the actions listed above. Some BMPs can only be implemented at a large scale; there are others that can be implemented by individuals on a small scale. Section 3.1.1 is written for individual homeowners. Section 3.1.2 is written for county and municipal government, homeowners’ or property owners’ associations (HOAs/POAs), non-residential property owners, and developers - essentially anyone that owns or manages a number of properties, or properties with higher levels of impervious surface than those associated with a single house.

3.1.1 Individual Homeowner

Homeowners and other property owners can install a variety of BMPs to capture and infiltrate/treat runoff from the roof and driveway of their homes. Table 4 contains a list of BMPs that individual homeowners can install on their properties. The BMPs are listed in order of effectiveness, with the best at the top of the list. The ranking is based on fecal coliform removal efficiency and ability to reduce stormwater flow as described in the DWQ Stormwater Manual. Homeowners should not be

discouraged if they cannot select the best BMP. All of the BMPs in the list will help improve water quality to some degree. Ideally, homeowners should aim to capture the 3.8 inch storm. However this is not always possible due to space constraints or cost therefore homeowners should at least capture the first 1.5 inches of a rain event.

Homeowners should take the following steps when planning and selecting a BMP:

1. Determine which BMPs are suitable for the physical characteristics of their property, including soils and depth to water table as noted in Table 4.
2. Select the BMP with the highest treatment rating for fecal coliform bacteria. A ranking based on removal efficiency and stormwater runoff reduction is included in Table 4. If BMPs with lower efficiencies are selected, consider installing a series or 'treatment train' of BMPs to improve pollutant removal.
3. Consider the placement of the BMP on the property ensuring that it will capture runoff during storms.
4. Take care to avoid jurisdictional wetlands, streams, buffers, 100-year floodplains, septic drain fields, and wells among others.
5. Finally, cost and maintenance efforts for each BMP should be considered. BMPs like other features in your home or yard require some level of maintenance in order to effectively treat and manage runoff.

Descriptions of each of the BMPs as well as links to plans and instructions are found in Appendix 2. Many of these BMPs can be built by the homeowner and do not require engineered drawings.

Table 4. Stormwater BMPs for Homeowners

BMP Type	Fecal Coliform Removal Efficiency[1]	Effect on Stormwater Flow[1]	Ranking	Works with High Water Table?[2]	Works with Poorly Drained Soils?[2]
Backyard raingarden	High	High		N	N
Dry well	High	High		N	N
Backyard wetland	Medium	High		Y	Y
Rainwater harvesting	Low	Medium		Y	Y
Rooftop disconnection	Low	Medium		Y	Y

1 = Based on DWQ Stormwater BMP Manual and best professional judgment
2=Taken from DWQ Stormwater BMP Manual

3.1.2 Government, HOAs/POAs, Non-residential Property Owners, and Developers

The BMPs recommended for individual homeowners may also be useful for governments, HOAs/POAs, non-residential property owners, and developers and therefore are included in this section. The recommended BMP list also includes larger-scale BMPs that can capture and treat runoff from a larger area or from small areas with high levels of impervious surface (Table 5). In addition, low impact development (LID) techniques are included as this method of development works to maintain natural hydrology and minimize the impacts associated with impervious surfaces (see Appendix 2 for more information). County and municipal governments should set an example for the public by retrofitting BMPs on all government owned developed property. They should also utilize LID techniques for all new building projects. HOA/POAs and non-

residential property owners may be able to use some of the homeowner BMPs depending on the size of the area to be treated. Developers should utilize LID design techniques for all new construction in the watershed. Alternatively, in conventional developments, builders can offer "add-ons" to home models including cisterns, permeable pavement, or a backyard rain garden.

The BMPs are listed in order of effectiveness, with the best at the top of the list. The ranking is based on fecal coliform removal efficiency and ability to reduce stormwater flow as described in the DWQ Stormwater Manual. Where possible the most effective BMPs should be used. Ideally BMPs should be sized to capture a 3.8 inch rainfall. This may not be possible due to size or cost constraints. In those cases, BMPs should capture and treat at a minimum the 1.5 inch storm event. The following are a few key factors to remember when selecting, planning, and installing BMPs (North Carolina Department of Environment and Natural Resources Division of Water Quality, 2007):.

1. Determine which BMPs are suitable for the physical characteristics of the site since no one BMP is best for every site. Considerations include the size of the drainage area and amount of impervious area which determines the space required for different BMPs, the depth to the water table, soil type, and if an elevation change is required for the BMP to function correctly.

2. Select the BMP (from the list created in step 2) with the highest treatment rating for the pollutant you are treating (in this case fecal coliform bacteria and other pathogens). If BMPs with lower efficiencies are selected, consider installing a series or treatment train of BMPs to improve pollutant removal.

3. Consider blending the BMP into the natural environment and ensure that it conforms to the natural features of the landscape.

4. Take care to avoid jurisdictional wetlands, streams, buffers, 100-year floodplains, septic drain fields, and wells among others.

5. Finally, construction costs and operation and maintenance efforts for each BMP should be considered. BMPs like other landscape features, require some level of maintenance in order to effectively treat and manage runoff.

The DWQ Stormwater BMP Manual as well as the NCSU BAE Stormwater Engineering website has extensive information on each of the BMPs. Links to these and other resources are included with the descriptions of the BMPs found in Appendix 2.

Table 5. Stormwater BMPs for Large or Small Scale Developed Areas

BMP Type	Fecal Coliform Removal Efficiency[1]	Effect on Stormwater Flow[1]	Ranking	Works with High Water Table?[2]	Works with Poorly Drained Soils?[2]
Bioretention	High	High		N	N
Backyard raingarden	High	High		N	N
Dry well	High	High		N	N
LID techniques	High	High		Y	Y
Backyard wetland	Medium	High		Y	Y
Pond retrofit/naturalization	Medium	High		Y	Y
Stormwater wetland	Medium	High		Y	Y
Wet detention basin	Medium	High		Y	Y
Rainwater harvesting	Low	Medium		Y	Y
Rooftop disconnection	Low	Medium		Y	Y
Level spreaders and filter strips	Medium	Low		Y	Y
Riparian buffer restoration	Medium	Low		Y	Y
Green roofs	Low	Low		Y	Y
Permeable pavement	Low	Low		N	Y

1 = Based on DWQ Stormwater BMP Manual and best professional judgment
2=Taken from DWQ Stormwater BMP Manual

3.1.3 Identified BMP opportunities

Several BMP retrofit opportunities have already been identified in the Lockwoods Folly River watershed by various parties. BMPs at two of these locations have been constructed, with designs at two other sites completed as listed below:

- Brunswick County Government Complex (construction completed) – stormwater wetland
- Sunset Harbor (construction complete) – pervious pavement, rain gardens, re-grading for runoff prevention
- River Run Plantation boat ramp (design complete) – bioretention
- Winding River boat ramp (design complete) – rain garden and bioretention

Additionally, as part of the Lockwoods Folly Detailed Assessment and Targeting of Management Report (Stantec, 2007) conducted by EEP, an atlas of BMP opportunities was created. The objective of this study was not restrictively for fecal bacteria, but for stormwater pollutants in general. An initial site assessment was conducted at each of the identified BMP opportunities with recommended BMP types and sizes. However, further site evaluation at each site is needed to determine the actual BMP type that is appropriate, taking into consideration depth to water table, on site soils, and quantity of impervious surfaces. The full report containing the BMP opportunity atlas is available online at: http://www.nceep.net/services/lwps/pull_down/by_basin/lumber_RB.html. The atlas contains a full description of each site with maps, photos, and estimated BMP costs. A summarized list of the BMP opportunities and estimated costs is included in Table 6. The locations of the BMPs are included in Figure 3. Note that the list includes some grassed swales which are not appropriate for fecal bacteria load reduction. The sites will need to be reevaluated for the suitability of other BMPs to treat for fecal coliform bacteria.

Table 6. Identified BMP Opportunities and Estimated Cost

Location	BMP Type(s)	Estimated Cost[1]
Zion Hill Rd, adjacent to Virginia Williamson Elementary School	Stormwater wetland	$2,600
Bolivia Elementary School	Bioretention	$52,000
Brunswick Technical College	Bioretention and Existing pond retrofit	$80,000
Stone Chimney Rd, intersection with NC 211	Stormwater wetland	$18,600
Brunswick Community Hospital	Stormwater wetland and Existing pond retrofit	$11,370
Supply Elementary School	Bioretention	$155,000
Members Club, Town of St. James	Stormwater wetland	$6,400
Oak Island Recreation Center	Stormwater wetland	$10,590
Oak Island Hospital	Bioretention	$31,000
Lockwood Folly Country Club	Existing pond retrofit and Swales	$25,200
Town of Oak Island, West Yacht Drive	Ditch conversion to swales	$6,075
Harbor Ridge Drive	Swales	$16,740

1 = Cost is an engineer's estimate. Actual costs will vary.

3.1.4 NCDOT Projects

NCDOT needs to reduce fecal coliform loads by 53% in order to meet the TMDL. Most of the NCDOT roads drain to adjacent swales. Stormwater runoff from adjacent developed land also flows to these swales where fecal coliform bacteria levels may increase. Stormwater runoff flows in these swales before discharging into surface waters at bridge crossings and culverts. NCDOT should divert stormwater runoff from roadside swales into additional BMPs that promote infiltration. Where infiltration is not feasible a treatment train approach should be used such as a stormwater wetland paired with a restored riparian buffer.

ACTIONS:

- Work with HOA/POAs and others in the targeted areas to identify suitable BMP retrofit locations to treat stormwater runoff from roads and residential parcels (Figure 3).
- Use LID design alternatives for new NCDOT linear projects. This will set an example for others and demonstrate the practical use of LID measures in linear transportation projects.

A Clean Water Management Trust Fund grant was awarded to increase the knowledge and acceptance of LID measures by NCDOT hydrologic engineers. NCDOT will be including LID measures in its Best Management Practices Toolbox.

3.2 Source Control

Source control pertains to practices which reduce the amount of fecal bacteria available for runoff from land surfaces. As mentioned previously, these sources include pets, livestock, humans, and wildlife. Source control is important in the Lockwoods Folly watershed as many neighborhoods are located in areas with high water tables and poorly drained soils. Stormwater

BMPs that can be used in these areas do not reduce fecal coliform bacteria as effectively as infiltration BMPs. In these cases, it is important to minimize the amount of bacteria.

Most methods of source control are easy to implement and not costly. However, educating people on what source control is and convincing them to change their habits can require time and education. There is a substantial amount of published educational materials which are readily available for the source control measures listed below. References for these educational materials have been included.

3.2.1 Pet waste

Pet contributions to fecal bacteria loading usually occur through runoff from urban and residential areas (Figure 3). Pet owners have an opportunity to eliminate fecal bacteria loads to the estuary by simply collecting their pet's waste when out at the park, on a walk, or even in their own backyard. Information, links, and references on how to implement the following actions are located in Appendix 2.

ACTIONS:

- Promote pet waste management programs to HOAs and local governments. Pet waste stations should include educational signage. Promote pet waste stations at all trails and parks.
- Conduct pet waste education campaign to include distribution of educational postcards.
- Promote pet waste ordinance similar to City of Wilmington requiring all pet owners to have pet waste removal bags when off their property with their pet.

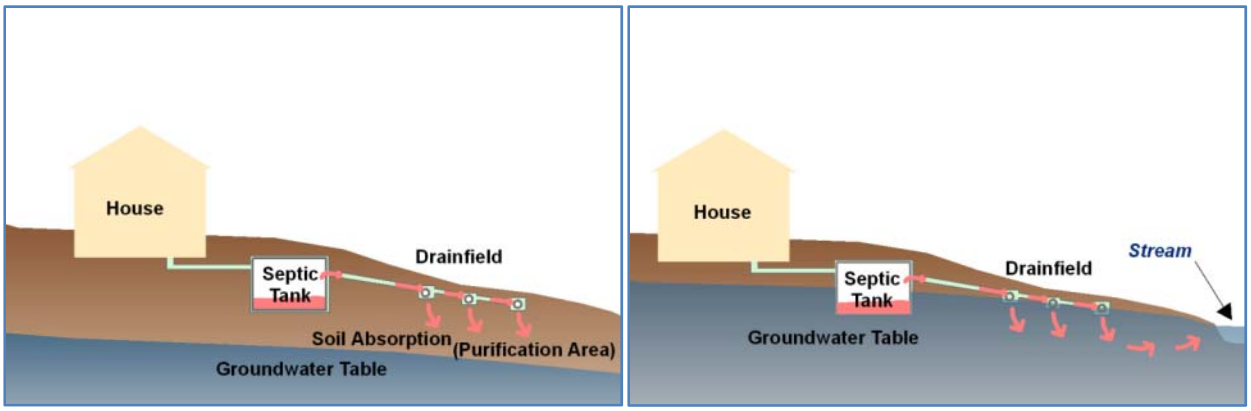
3.2.2 Septic System

Human contributions to fecal bacteria loading can occur due to wastewater facility discharges or the failure of septic systems. Septic systems are located throughout the watershed, except in the Town of Oak Island, St. James, and the Winding River neighborhood. Septic systems can fail especially when not properly maintained or when they are located in an area with unsuitable soils. Obvious signs of failure are sewage backing up into the house, slowly draining fixtures, and smell of raw sewage accompanied by extremely soggy ground. However, failing septic systems are not always easy to identify if the failure involves untreated sewage entering a stream via groundwater. When the groundwater table is near the ground surface, partially treated sewage exits the drainfield and enters into the groundwater. The contaminated groundwater drains into nearby surface waters leading to high levels of fecal bacteria and other bacteria.

Many of the septic systems in the watershed are located in areas with soils that are likely unsuitable. Regulations have changed over the decades and it is likely that many systems permitted in the past would not have received permits today. Extending sewer service to existing developed areas is one way to eliminate the possibility of septic failure. The Town of Oak Island is installing sewer connections throughout the island during 2010. This effort will eliminate approximately 4,300 septic systems that drain to the Intracoastal Waterway and Montgomery Slough. That leaves approximately 6,800 septic systems in the watershed. A

percentage of these are not performing properly. Continuing to reduce the number of septic systems in the watershed is an important step in eliminating human contributions of fecal bacteria.

Figure 2. Functioning versus Failing Septic System Due to High Groundwater Table



ACTIONS:

- Encourage neighborhoods to cooperate in the sewer extension program under the Neighborhood Water and Sewer Main Extension policy. Promote the Rural Sewer Program Policy for individual land owners.
- Conduct a septic maintenance educational campaign with the Cooperative Extension and County Health Department.
- Distribute the publication "Improving Septic System Maintenance in Coastal Communities" (Osmond, Lawrence, & Young, 2003) to residences with septic systems.

3.2.3 Boat Program

Sewage discharge from commercial and recreational vessels can have a significant effect on fecal coliform concentrations depending on the number of boats that discharge, and the location of the discharge (i.e., open ocean versus the estuary). As noted earlier, the untreated discharge of one weekend boater can potentially contribute the same amount of bacterial pollution in the water as does the treated sewage of 10,000 people (San Francisco Estuary Partnership, 2009).

In the Lockwoods Folly River watershed there are currently seven marinas, with a total of approximately 330 boat slips. These marinas include the two marinas in Varnamtown, the Winding River marina, Seascape Marina, Blue Water Point Marina, St. James Marina, Hewett Marina, and Holden Marina (Figure 3). Additionally, there are countless docks along the shorelines. Currently, there is only one pump-out facility for boat sewage within the watershed, located at the St. James Marina.

ACTIONS:

- Promote the Clean Marinas Program and other Division of Coastal Management programs (Marina Pumpout Program, BMP Manual for North Carolina Marinas, and A Boater's Guide).
- Petition for No-discharge Zone status.

3.2.4 Livestock Waste

Figure 3 shows the locations of farms throughout the watershed with livestock or domesticated animals (cattle, horses, hogs, and chickens) identified during the NCDEH Shellfish Sanitation Shoreline Survey (Division of Environmental Health, Shellfish Sanitation and Recreational Water Quality, North Carolina Department of Environment and Natural Resources, 2007). There may be additional farms that house animals that were not part of the Shoreline Survey.

Regulations and inspections are in place to govern the activity on the single hog farm in the watershed. The remaining farms are small and unregulated. All farms with livestock, regardless of size, can be environmental risks. "It doesn't matter if there is one animal or many, if animal housing, pastures and manure is not properly managed, there is a potential to harm the environment or cause problems for neighbors" (Westendorf & Rice, 2008). Actions for reducing fecal contamination from livestock operations are listed below. Information for livestock owners on how to minimize their contribution to fecal contamination can be found in Appendix 2.

ACTIONS:

- Partner with Cooperative Extension to promote manure management plans for livestock owners.
- Promote pasture management and riparian buffer restoration to improve stormwater infiltration.
- Promote fencing to keep all animals out of surface waters including streams and wetlands.
- Hog farm should continue to meet permit requirements. Promote the use of economically feasible alternatives to manage the facility when such alternatives are identified.

3.2.5 Wildlife

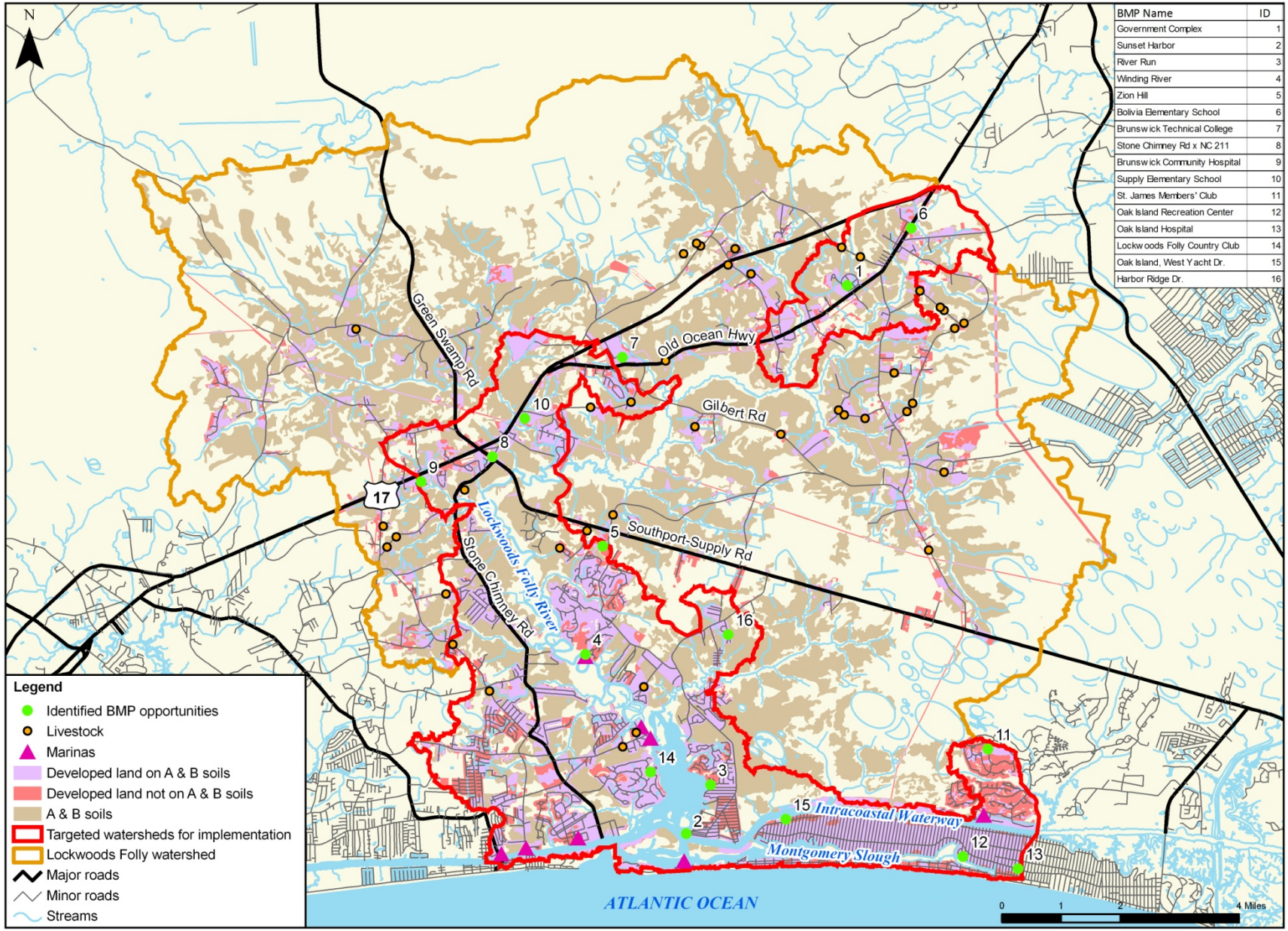
Wildlife is one of the main sources of fecal coliform bacteria in the watershed. Since it is so widespread, managing it through stormwater runoff reduction as described in Section 3.1 is the most effective manner to reduce impacts on water quality. Reducing the source contribution of fecal bacteria from wildlife is an important second measure. Concentrations of wildlife in urban areas can be of particular concern because 1) stormwater runoff is higher due to the extent of impervious surfaces, and 2) they often deposit their waste directly into surface waters. Therefore, they can be major sources of fecal coliform bacteria, particularly in lakes and ponds where large

resident populations have become established near beaches (Center for Watershed Protection, 1999). The following are actions aimed specifically at reducing the wildlife source of fecal coliform in developed areas by discouraging resident goose populations.

ACTIONS:

- Create a wildlife education program that includes lawn care strategies such as reducing fertilizer use, lawn size, and frequency of mowing. The program should also inform residents not to feed geese using signage at targeted pond areas.
- Create an atlas of amenity ponds found in many neighborhoods which can be retrofitted with buffers and vegetated shallow areas to deter geese. Educate HOAs on the benefits of this type of pond naturalization.

Figure 3. Fecal Bacteria Sources and BMP Retrofit Opportunities Map



3.3 Education, Programs, and Policies

This section describes measures that when implemented will help encourage or require homeowners and property owners, businesses, and government officials to carry out the strategies contained in sections 3.1 and 3.2. Preservation is also included in this section.

3.3.1 Education, Training, and Workshops

One of the key elements for implementing a watershed plan according to the EPA Nine Key Elements is an information and education program that includes a comprehensive strategy to educate both the public and participating agencies in the implementation of nonpoint source measures to effectively reduce the bacterial pollution. While this document contains a variety of ideas with something for virtually every landowner in the watershed, it is unlikely the majority of people will have access to it. Information and educational outreach efforts such as those that have already occurred in the watershed are vital for ensuring people understand what is happening with water quality and how they can use the strategies included in this document to help improve it.

A number of individuals and groups have been actively working on public education and will continue to do so. For example, during the TMDL development as well as during other projects that have occurred with the watershed, the North Carolina Coastal Federation has worked to inform the public by maintaining a website with information about the watershed and writing press releases for the local newspapers. More importantly, volunteers who live in the watershed have worked with NCCF to collect data used in developing the TMDL and to implement best management practices. These volunteers can help spread the information contained in this implementation plan. NCCF will produce a tabloid summarizing the implementation plan and distribute it to the public.

While the Lockwoods Folly Roundtable no longer meets, County staff continues to promote the strategies at planning and zoning meetings when development within the watershed is discussed. County staff along with municipal staff and other agency representatives has participated throughout the TMDL development process. An Education and Outreach Specialist is a position with Cooperative Extension that was created as a result of the Roundtable strategies. However, this position is currently vacant and funding for the position depends on county commissioner approval. Dependent on funding, these different groups can work to carry out educational outreach efforts. The proposed efforts generally fall into two categories: 1) publishing and distributing material to the public (items 1-4), and 2) presenting materials to the public at workshops, trainings, and meetings (items 5-10). It is important to implement efforts from both categories as published information may reach a large audience but presentations may offer a better opportunity to help people understand and convince them to act. Education components mentioned in previous sections are included in this list.

ACTIONS:

- Produce a tabloid publication describing the TMDL and TMDL implementation plan projects including implementation measures.

- Create a Lockwoods Folly River watershed website with links to previous studies and education materials, announcements for upcoming training opportunities, funding sources, implementation measures, and updates.

- Create fact sheet flyers for distribution to agencies, homeowners, HOAs, POAs, and other informational portals around the watershed. Fact sheets can be general (methods of fecal bacteria source control and stormwater runoff reduction) or specific (horse owner BMPs, cattle owner BMPs, septic system users, pet owners, and boaters). Many fact sheets have already been created by Cooperative Extension such as a Stormwater Management for Homeowners pamphlet (http://www.soil.ncsu.edu/assist/homeassist/stormwater/). Other publications and resources are mentioned in Appendix 2 of this document. Electronic fact sheets could be posted on Lockwoods Folly River watershed website. For example, Oak Island has a website dedicated to stormwater management with presentation, publications, and resources listed (http://www.oakislandcleanwater.org/).

- Install informational signage at all public property, boat access points, and at completed stormwater BMP projects. These provide simple and effective educational tools on the importance of clean water for the restoration of the Lockwoods Folly watershed.

- Create press releases and hold media tours of the watershed and completed projects to help keep a spotlight on the efforts in the watershed and keep the public informed on the status of the implementation plan and the results of projects.

- Give presentations to Property and Home Owner Associations, Garden Clubs, and other community groups on everyday source elimination activities and how to implement stormwater runoff reduction strategies for their homes, neighborhoods, and businesses. Stormwater runoff reduction strategies should focus on simple backyard solutions such as rain gardens, pocket wetlands, and impervious disconnection (Tables 4 & 5). Some presentations could include demonstrations of one of the alternatives at a home within the watershed.

- Promote participation in the Cooperative Extension and NCSU Residential Rain Garden Certification Program to landscapers, contractors, builders, and others. The purpose of the 2-day training class is to train landscape professionals on site selection, design, installation, plant selection, and maintenance of rain gardens. The class is held multiple times a year in different locations across the state (http://www.bae.ncsu.edu/stormwater/extension.htm):

- Organize multi-media presentations by stormwater specialists and other professionals to the public and governmental agencies on the implementation strategies with the goal of obtaining support and possible funding.

- Hold training workshops for agency personnel, consultants, landscape architects, developers, and others on the most appropriate BMP types and installation practices in the Coastal Plain. Workshops may include field trips to completed stormwater best management projects within the watershed. NCSU also offers BMP design classes and maintenance certification

- Give presentations aimed at specific groups including livestock owners, pet owners, boaters, and septic system users that focus on specific best management practices and issues that pertain to each group

3.3.2 Programs and Policies

A number of policies are in place at the county and municipal level that will help protect water quality from new impacts including zoning and stormwater regulations as described in the following sections. However, these policies do not usually apply to existing development unless there are additions or other changes. The existing development in the Lockwoods Folly River watershed led to its degradation. Reducing or even eliminating impacts from future development will not be enough to improve water quality.

Development Ordinances

Brunswick County has a Conservation and Protection District in its zoning regulations. This designation is used to permanently protect and preserve environmentally sensitive lands as well as historical, cultural, and archaeological areas. While water or wastewater service is discouraged in this area, residential building is allowed as long as there is very low impact on the environment. This ordinance is a vehicle for preserving land within the watershed (Section 3.3.3). The Water Quality Protection Overlay applies to all land in an area extending 575' landward of the mean high water line for a portion of the river, specifically the area south of Genoe's Point and Mullet Creek to the Intracoastal Waterway. All development within this overlay must limit built upon impervious area to no more than 25% of the lot, provide a riparian buffer of 30 feet, place structures at least 75 feet from the mean high water line, and comply with an additional State or Federal regulations. This overlay district was a management measure described in the 1989 Lockwoods Folly River Basin Water Quality Evaluation Report (Division of Water Quality (previously Division of Environmental Management Water Quality Section), 1989). However, State stormwater rules for coastal counties amended in 2008 have stricter requirements than the ones described in the overlay district (see Stormwater section below).

The County requires open space and recreation areas for residential projects. The percentage of area depends on the zoning district and ranges from 3-15% for conventional neighborhoods. Planned unit developments (PUDs) must provide between 20-40% open space which is also dependent on the zoning district. This open space must include all floodways (AEFW), the 30-foot undisturbed stream buffers, jurisdictional wetlands, and areas specified on the County-Wide Greenways Master Plan.

The NCSU Alternative Build-Out Scenarios study (Section 2.3) recommended 40% open space not including wetlands in order to facilitate runoff volume reduction. In order to meet this recommendation, the County needs to promote PUDs over conventional development or increase open space requirements for all developments.

In all residential zoning districts, two development types are permitted – conventional or cluster (Planned Unit Development). The Planned Unit Development (PUD) clusters homes on a portion of the development site on smaller lots than those permitted in conventional development in order to promote environmental sensitivity, use the land efficiently, and provide additional common space. Some nonresidential uses are allowed using the PUD option. The addition of open space and the placement of structures and impervious surfaces in specific areas allows for greater stormwater infiltration in PUDs. Cottage housing developments, which are smaller single family houses built around open space using low impact development

techniques, are permitted as PUDs. This incorporation of LID into development policies was the second Roundtable strategy. In addition to incorporating LID, the Roundtable had the following recommendation to the county: "*Strategy 1:* (*A) Assess water quality risk according to natural systems in watershed and develop future land use policies and ordinances that fit land use density and landscape design to the level of water quality risk. And (B) Sewer extension policies that: (1) give priority services to communities with malfunctioning septic tanks, and (2) ensure that land use and development policies in sewer service areas are consistent with risks to water quality*."

Oak Island's zoning contains an open space district that protects areas of environmental concern. Also for subdivisions, there is an open space requirement of 15% of the gross acreage or one half acre, whichever is greater. The Town also permits PUDs in order to promote innovative land uses. Oak Island should consider expanding its open space requirements and PUD regulations. This will become more critical when large tracts of land are developed in the newly annexed portions of the Town located on the mainland from the ICWW north to Boiling Spring Lakes.

Existing Zoning Ordinances Overview

Brunswick County

- Conservation and Protection Zoning District – used to permanently protect environmentally sensitive lands by restricting development to very low impact residential development.
- Water Quality Protection Overlay – current Coastal Stormwater Rule is stricter.
- Planned Unit Development – promotes cluster development/LID to increase open space and allow for greater stormwater infiltration. Open space requirement: 20-40%

Town of Oak Island

- Open Space District – protects areas of environmental concern.
- Open space requirement - a minimum of 15% or ½ acre of open space (whichever is greater) in residential subdivisions.
- Planned Unit Development – promotes cluster development and innovative land uses. Open space requirement: minimum of 15%.

ACTIONS:

- In Brunswick County, promote PUD with 40% open space over conventional development or increase open space requirements to 40% for all development.
- In Oak Island, increase the open space requirements in PUD to 40%, especially in the newly annexed areas of the Town.

Stormwater – Regulations, Ordinances, and Programs

The State of North Carolina has a Coastal Counties Stormwater Law that applies to Brunswick County. This law requires different stormwater control dependent on location and the percentage of built upon area. For developments within 575 feet of Outstanding Resource Waters (ORW) there is a low density option that limits development to 12% built upon area, requires runoff to be transported through vegetated swales, and requires a 50-foot riparian buffer for new development activities (30-feet for redevelopment). The high density option is for developments with greater than 12% built upon area. These developments must use infiltration systems and other BMPs to control and treat 1.5 inches of rainfall or the difference in stormwater runoff between predevelopment and post development, whichever is greater. As with the low density option, a 50-foot riparian buffer for new development activities (30-feet for redevelopment) is required. For both options, direct discharge to Class SA waters or an increase in the volume of stormwater flow through conveyances that drain to SA waters is prohibited. No development may exceed 25% built upon area in this 575-foot zone. These same requirements apply to all development near Class SA waters (generally one-half mile) with the exception of the 25% built upon cap.

For all other areas, low density development must have less than 24% built upon area, runoff must be transported through vegetated conveyances, and a 50-foot buffer for new development (30 feet for redevelopment) must be maintained. For high density developments (greater than 24% built upon area), the development must control and treat the runoff from 1.5 inches of rain using infiltration and other BMPs. The same buffer rules apply. The NCSU Alternative Build Out Scenarios study (Section 2.3) recommended impervious surfaces should account for no more than 12-15% regardless of distance to SA waters. Brunswick County and Oak Island could consider applying the stricter ORW/SA stormwater rules to the entire watershed.

Brunswick County has adopted a Stormwater Quality Management and Discharge Control Ordinance in order to protect water quality by reducing stormwater discharges, establishing minimum criteria, and encouraging sustainable development. The ordinance states that drainage systems should provide “natural infiltration, control velocity, control flooding, extend the time of concentration of stormwater runoff, and control to the Maximum Extent Practicable the impacts of development” (Brunswick County, 2002). Meeting these conditions is required of all development. In addition, a stormwater management plan and permit are required for all commercial, industrial, or other non-residential development as well as major subdivisions. A plan is also required when the activity occurs within the 30-foot CAMA riparian buffer or when filling or excavating the land surface by 4 inches, or when the disturbance area is one or more acres in size. The permit addresses five issues:

1) Protection and enhancement of riparian areas, stormwater flow into riparian buffers must be diffuse flow;

2) Control of peak stormwater discharges for the 1-year, 24-hour storm and the 10-year, 24-hour storm unless the increase in peak flow between pre- and post-development is less than 5% and/or the overall impervious cover is less than 15% and all pervious portions are used to the maximum extent possible to convey and control runoff.

3) Control of the export of pollutants to the Maximum Extent Practicable;

4) Use of BMPs – specifically project design BMPs (LID) used to minimize the negative impacts of development and then structural BMPs to reduce remaining impacts; and

5) BMP maintenance.

Oak Island, a NPDES Phase II community, also has a stormwater ordinance that "establishes minimum requirements and procedures to control the adverse effects of increased post-development stormwater runoff and nonpoint and point source pollution associated with new development and redevelopment" (Town of Oak Island, 2010). The Town has set general standards for non-residential development and redevelopment as well as residential projects that will add 10,000 square feet or more of built upon area. LID practices must be used to develop controls that will mimic the existing natural hydrology as well as capture and treat the first one and one-half inches of rainfall (treatment of the difference in stormwater runoff from pre-development and post-development conditions for a 1-year, 24-hour storm is required for high density projects within one-half mile of class SA waters). When LID practices are not achievable, the state coastal stormwater management measures for controlling runoff for low and high-density development must be followed. A 50-foot riparian buffer is required for new development while a 30-foot buffer is necessary for all redevelopment. Finally, an erosion and sedimentation control plan are required for all development and redevelopment.

All residential projects that add less than 10,000 square feet of built upon area, must use a combination of infiltration systems and other best management practices to control and treat the runoff from all surfaces generated by 1.5-inches of rainfall.

Stormwater management is not required of existing development that was in place before these ordinances and regulations took effect. However, existing development is a major source of pollutants and runoff. The county and local municipalities should consider encouraging landowners to retrofit their properties to the same level that new development must. The boundaries of the aforementioned stormwater rules and planned new developments in the watershed are depicted in Figure 4.

Existing Stormwater Rules and Programs Overview

- Coastal Stormwater Rules – more stringent stormwater rules for areas within ½ mile of SA waters.
- Brunswick County Stormwater Quality Management and Discharge Control Ordinance – adopted by Brunswick County in order to protect water quality by reducing stormwater discharges, establishing minimum criteria, and encouraging sustainable development.
- NPDES Phase II Stormwater Rules (Town of Oak Island) – requires LID practices for new development to mimic the natural hydrology for the 1.5 inch storm. The 1-year, 24-hour storm (3.8 inches) is required for areas within ½ mile of SA waters.

ACTION:

- Apply the stricter ORW/SA rules to the entire watershed, not just within the buffer area.

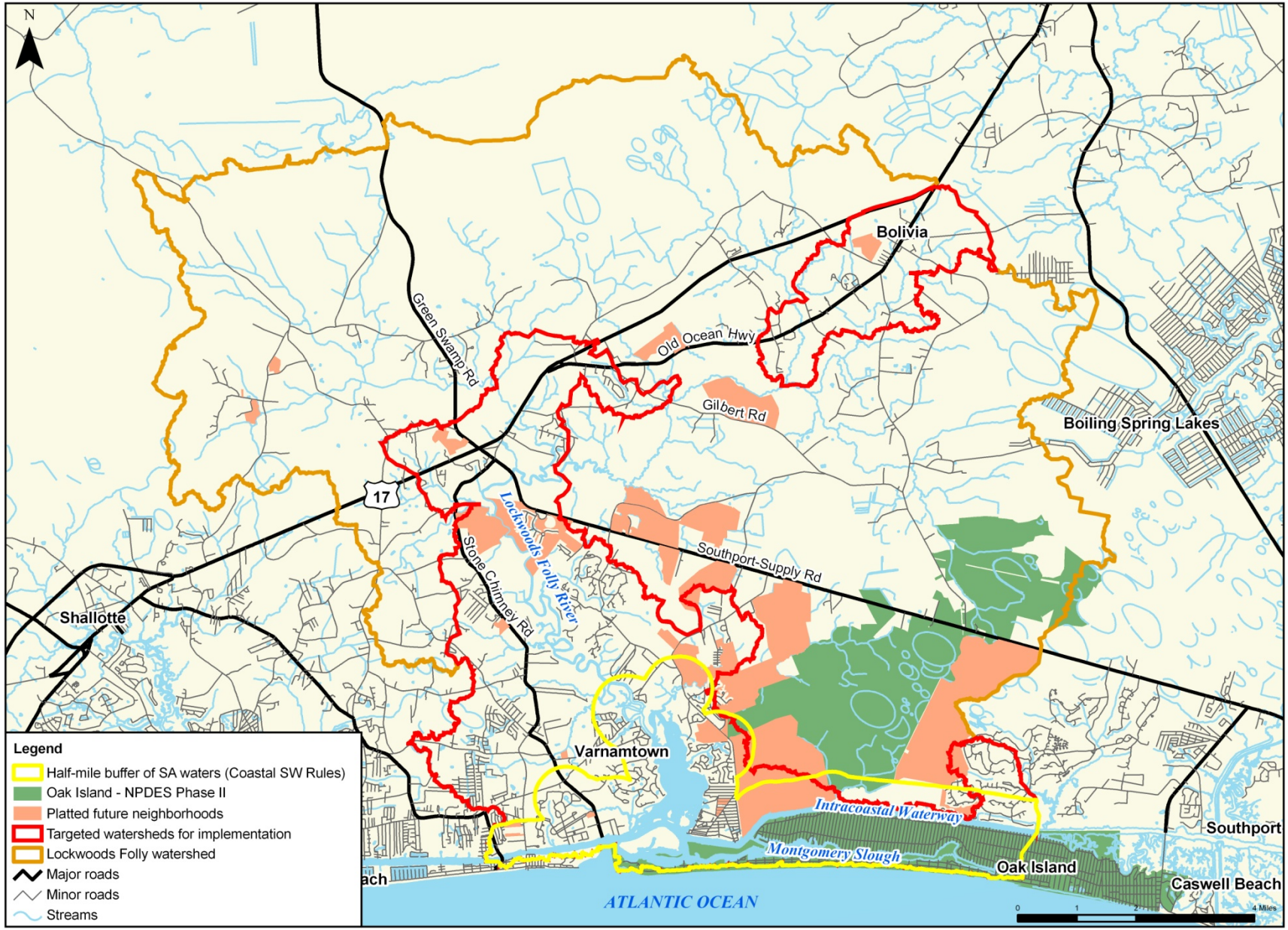
3.3.3 Preservation

The fourth Roundtable strategy calls for an "action plan to acquire strategic sites and parcels to protect and restore water quality" (Lockwood Folly Watershed Rounddtable, 2007). A study was conducted in order to identify which parcels to protect. Only undeveloped parcels greater than 50 acres were considered in the analysis. At the time of the study there were 174 parcels that met those criteria. Parcels were prioritized by analyzing hydrologic soil group, land cover, presence of coastal or non-coastal wetlands, proximity to surface water, and stream order (Lynch, 2005). The study did not take into account the cost of land acquisition or condition of the parcel (i.e., forest compared to pine plantation). Preservation and land acquisition will help prevent additional impacts to water quality that would likely result if the same area was developed.

ACTION:

- Create an action plan for acquiring strategic preservation sites as identified in Lynch 2005. The action plan will include identifying how much land is to be preserved and a date by which the properties will be preserved.

Figure 4. Stormwater Regulations and Planned New Development Areas Map



4.0 Technical and Financial Assistance

4.1 Costs Associated with Implementation

The total costs associated with implementing this plan vary depending on which management measures are implemented and in how many locations. Instead of a total cost, this section contains information on the cost of individual measures (Table 7). Some of the stormwater runoff reduction measures are more costly than others but may be more effective. Stormwater runoff reduction strategies are listed in order of effectiveness for fecal bacteria removal. The effectiveness of other measures such as education programs or source control cannot easily be compared to stormwater runoff reduction measures.

Table 7. Implementation Costs

BMP Type	Cost per unit
Stormwater runoff reduction	
Bioretention	\$200 per ft^3 cell size
Backyard raingarden	\$3 - \$12 per ft^2
Dry well	\$4 - \$9 per ft^3 of storage volume
LID techniques	n/a
Backyard wetland	\$170 - \$550 depending on surface area
Pond retrofit/naturalization[1]	\$13/yd^3 grading, \$1.20/ft^2 planting, \$3,000 weir
Stormwater wetland[1]	\$13/yd^3 grading, \$1.20/ft^2 planting, \$3,000 weir
Wet detention basin[1]	\$13/yd^3 grading, \$1.20/ft^2 planting, \$3,000 weir
Level spreaders and filter strips	\$5 - \$20 per ft
Riparian buffer restoration	\$400 per acre
Rainwater harvesting	\$200 per rain barrel, \$1000 per 1400-gal cistern, \$10,000 per 10,000-gal cistern
Green roofs	\$9 - \$12 per square foot of roof
Permeable pavement	\$8 - \$12 per square foot of pavement
Downspout disconnection	\$9 per downspout
Source control	
Pet waste education program	\$5,000
Pet waste station	\$320 per station
Livestock manure management education program	\$5,000
Wildlife education program	\$5,000
Boat pumpout station	\$10,000 average, \$60,000 maximum
Boat education	\$5,000
Septic education program	\$5,000
Septic maintenance	\$220 (pumpout), \$3000 (repair) per house
Cooperative Extension Education Outreach staff funding	\$40,000/year

To place some of these unit costs into context, costs have been calculated for different practices and combination of practices for a 0.5 acre lot, with an assumed roof surface area of 1,200 square feet, and a driveway area of 1,000 square feet. In order to use most of these practices

the driveways must be graded in such a way that stormwater runoff flows over an unpaved (lawn or mulched surface) area where the BMP can be installed before entering the stormdrain system. Otherwise, permeable pavement would have to be installed to capture runoff from the driveway. For rain gardens, a range is given as cost depends on the installer – a lower cost if the homeowner installs it and a higher cost if done by a landscape professional or other contractor.

Table 8. Homeowner BMP Costs for a Typical Half-acre Lot

BMP	1.5-inch storm	3.8-inch storm
Rain garden (entire lot)	$650 – $1,200	$1,600 – $3,200
Rainwater harvesting (roof) and rain garden (remainder of lot)[1]	$3,000 (rainwater) plus $300 - $1,200 (rain garden)	$2,000 (rainwater) plus $780 - $3,000 (rain garden)
Rain garden (half of lot)	$390 – $1,500	$1,000 – $3,800
Dry well (roof only)	$2,250	$5,700
Permeable Pavement (driveway only)	$8,000 – $12,000	$8,000 – $12,000

1= Assumes use of multiple rain barrels for 1.5-inch storm and 2 cisterns for 3.8-inch storm

4.2 Technical Assistance Associated with Implementation

There are several sources of technical assistance for the implementation measures proposed in this implementation plan. Appendix 2 contains further description of stormwater runoff and source control BMPs along with links to guidance documents and educational materials. Additional assistance is available from various organizations including at the State level, the North Carolina Department of Natural Resources. They offer technical assistance to businesses, farmers, local governments, and the public through education programs provided by DENR staff. There are also several local sources for technical assistance. These include the County Health Department, the local Cooperative Extension, the Brunswick County Soil and Water Conservation District, the Town of Oak Island, and the North Carolina Coastal Federation. Following is a description of each of the local sources and how they may be able to assist in plan implementation.

- The Brunswick County Health Department issues permits for septic tanks. The Department is also a source for information regarding proper maintenance and siting of septic systems. There website provides basic information on septic system do's and don'ts, as well as contact information for questions regarding septic systems http://www.brunswickcountync.gov/Departments/EnvironmentalHealth/WastewaterSystems. Their office is located at the county government complex in Bolivia, NC.

- The North Carolina Cooperative Extension is an educational partnership which offers numerous programs implemented at the county level. The extension provides educational materials and training opportunities for local watershed management, septic system installation and maintenance, livestock manure management, pet waste management programs, riparian buffers, and stormwater BMP installation and maintenance including LID strategies. The Extension has centers located in every county in North Carolina. The Brunswick County office is located at the government complex in Bolivia and the website is http://brunswick.ces.ncsu.edu/. Currently, the education and outreach specialist position is vacant and unfunded. Filling this position is one of the most important steps in this implementation plan as the person in this role will be able to provide educational materials and presentations on a variety of topics. He/she

can help coordinate workshops and training led by other Cooperative Extension staff specialists in many different fields.

- The NCSU Stormwater Group often also provides training and workshops on many of the structural BMP measures and strategies for both developers and individual homeowners described in this document (http://www.bae.ncsu.edu/stormwater/).

- The Brunswick County Soil and Water Conservation District (BSWCD) is also a source for technical assistance (http://bswcd.org/). The BSWCD assists landowners with the installation of BMPs to improve water quality in the Lumber River Basin and may provide cost share assistance to individual homeowners and businesses. The BSWCD offices are also located in Bolivia at the county government complex.

- The Town of Oak Island has a stormwater director and a stormwater advisory board that work to implement the Oak Island Stormwater Program. They can provide technical assistance for issues such as impervious cover disconnection and dry wells as these are required on new and redeveloped properties. Also, the Town of Oak Island Stormwater Division's stormwater website provides information on stormwater issues and solutions on a local scale (http://oakislandcleanwater.org/). Finally, the Town is currently switching over from septic systems to sewer throughout the Town. Utility staff may be a source of information regarding lessons learned during the process that can be shared with other towns and communities within the watershed contemplating a switch from septic to sewer service.

- The North Carolina Coastal Federation works to educate citizens on a variety of environmental issues by providing information through their website, press releases, newspaper articles, and meetings. NCCF and volunteers of the organization work to find funding and implement projects such as stormwater BMPs to help improve water quality. NCCF works with many agencies and local governments and can assist people interested in implementing the strategies put forth in this plan.

4.3 Funding Sources

The methods available for financing retrofit projects are based upon county and municipal powers for taxing, making special assessments, borrowing, issuing bonds, receiving public and private grants and donations, charging user fees, establishing special funds, and receiving revenue sharing funds (Golgowski, 1985). The Stormwater Utility in the Town of Oak Island charges fees which are used to maintain its stormwater management services in order to meet the existing and future stormwater needs of the Town. A stormwater utility does not exist for the county areas or municipalities in the remainder of the watershed. A dedicated funding source for land protection activities, such as a utility, could be used for both non point source reduction and for landowner meetings, education, and purchase of conservation easements and fee title purchases to further the Lockwood Folly Strategies. Roundtable strategy 5B called for seeking Wild and Scenic River designation for the Lockwoods Folly River. While this designation does not protect the river from development pressures, it may increase opportunities for access to public money available for land purchase or easements from willing property owners.

However, other funding opportunities are available from the Federal and State government. He following is a list of funding sources. Some have limited availability as they target agricultural lands which make up a small fraction of the land use in the watershed.

- EPA Environmental Education Grants: With annual funding between $2 and $3 million dollars, the Grant Program sponsored by EPA's Environmental Education Division awards

grants to help support environmental education projects to enhance public awareness and knowledge of environmental issues. More than 75% of the grants awarded from this program receive less than $15,000. http://www.epa.gov/enviroed/grants.html

- EPA Section 319(h) Grants: This program provides Federal funding to State and Tribal governments to fund eligible projects which prevent, control and/or abate nonpoint source pollution. In North Carolina, these grants are administered through the North Carolina Department of Environment and Natural Resources Division of Water Quality.

- EPA Five Star Restoration Program: The program provides challenge grants and technical support to enable community-based restoration projects. It also aims to provide environmental education and training to students, conservation corps, citizen groups, corporations, landowners, and government agencies through projects that restore wetlands and streams. The average amount awarded is $10,000 per project. (http://www.epa.gov/owow/wetlands/restore/5star/)

- EPA Targeted Watersheds Grant Program: is a competitive grant program that provides funding to community-driven environmental watershed projects and promotes water resource protection and restoration through cooperative conservation. (http://www.epa.gov/twg/twg_basic.html)

- EPA Continuing Program Grant: is a baseline grant program awarded primarily to States and Tribes. These grants are available under specific statutes (such as Clean Air Act Section 105, Clean Water Act Section 106, Resource Conservation and Recovery Act Section 3011) or under a combination of these programs into a Performance Partnership Grant. The purpose of these grants is to help support ongoing State and Tribal environmental programs, such as air, water, and waste.

- EPA Project Grants: are available to a broader range of recipients for a wide spectrum of Agency priorities such as pollution prevention, watershed planning, environmental justice, and environmental education. These project grants change from year to year and some of them are managed by the U.S. EPA HQ in Washington, DC.

- EPA Water Pollution Control Program: The U.S. EPA provides annual grants to State water pollution control agencies and Indian Tribes to assist them in establishing and maintaining programs to prevent and control water pollution. Water Pollution Control grants are authorized by Section 106 of the Clean Water Act.

- EPA Water Quality Management Planning Program: are awarded to States to support unified watershed assessments and watershed restoration priorities. The grants are authorized by Section 604(b) of the Clean Water Act and are generally awarded to State water quality agencies as continuing environmental program agreements. States are obligated to give 40% of the grant money to Regional Public Comprehensive Planning Organizations and Interstate Organizations.

The EPA Catalog of Federal Funding Sources for Watershed Protection, which includes details about the programs listed above, can be found at http://cfpub.epa.gov/fedfund/. Additional funding sources are listed below.

- CCAP (Community Conservation Assistance Program): CCAP is a voluntary, incentive-based program designed to improve water quality through the installation of various BMPs on urban, suburban and rural lands, not directly involved in agricultural production. CCAP consists of educational, technical and financial assistance provided to landowners by local

soil and water conservation districts. (http://www.enr.state.nc.us/DSWC/pages/ccap_program.html)

- Smithfield Environmental Enhancement Grants Program (EEG): The EEG Program provides reimbursement money to organizations for projects that improve the environmental quality of North Carolina. The EEG Program funds immediate restoration or improvement projects to restore and protect impaired, degraded or endangered surface waters, groundwater and other natural resources. In addition, the EEG Program promotes long-term environmental enhancement in programs to conserve and protect targeted natural areas. (http://www.ncdoj.gov/Top-Issues/Improving-the-Environment/Environmental-Grants.aspx)

- USACE 206 Aquatic Ecosystem Restoration Program: provides the Army Corps of Engineers the authority to restore degraded aquatic ecosystems. Projects begin after a non-Federal sponsor requires assistance under the program. The Corps provides the first $100,000 of the feasibility study costs, after which the non-Federal sponsor must contribute 50% of the study costs. Furthermore, the sponsor provides 35% of the design and construction cost and 100% of the cost of operation and maintenance.

- Clean Water State Revolving Fund Program: Title VI of the Clean Water Act created the Clean Water State Revolving Fund (CWSRF) program. These State-run programs operate much like environmental banks that are funded with State and Federal contributions. The CWSRF provides low interest rates and flexible loan terms for funding wastewater treatment plants, nonpoint source pollution control and estuary protection. The CWSRF assists a variety of borrowers including municipalities, farmers, homeowners, small businesses and nonprofit organizations. Loans are available at a low interest rate for a maximum of twenty (20) years. (http://www.epa.gov/owmitnet/cwfinance/cwsrf/)

- Clean Water Management Trust Fund: The Clean Water Management Trust Fund (CWMTF) was created by the North Carolina General Assembly as a grant program to clean up impaired waters and assist in protecting pristine waters of the state. Grants are issued to local governments, state agencies, and conservation non-profit groups to help finance projects that address water pollution issues. (http://www.cwmtf.net)

- Resource Conservation and Development Program: The Resource Conservation and Development Program (RC&D) encourages and improves the capability of civic leaders in designated RC&D areas to plan and carry out projects for resource conservation and community development. Program objectives focus on “quality of life” improvements achieved through natural resources conservation and community development. Such activities lead to sustainable communities, prudent land use, and the sound management and conservation of natural resources. The Cape Fear RC&D serves Brunswick County along with Bladen, Columbus, New Hanover, and Pender Counties. (http://www.capefearrcd.org/welcome.html)

- USDA Conservation Reserve Program (CRP): The CRP provides technical and financial assistance to eligible farmers and ranchers to address soil, water, and related natural resource concerns on their lands in an environmentally beneficial and cost-effective manner. The program provides assistance to farmers and ranchers in complying with Federal, State and tribal environmental laws, and encourages environmental enhancement. (http://www.nrcs.usda.gov/programs/crp/)

- USDA Conservation Reserve Enhancement Program (CREP): The CREP is a voluntary land retirement program that helps agricultural producers protect environmentally sensitive land, decrease erosion, restore wildlife habitat, and safeguard ground and surface water. The

program offers cost-share, rental payments with an incentive payment to protect riparian areas including exclusion fencing, alternative watering systems and riparian easements. (http://www.fsa.usda.gov/FSA/webapp?area=home&subject=copr&topic=cep)

- USDA Environmental Quality Incentives Program (EQIP): EQIP provides payments of up to 75% of incurred costs and income forgone of certain conservation practices and activities. Program practices and activities are carried out according to an EQIP program plan of operations developed in conjunction with the producer that identifies the appropriate conservation practice or measures needed to address the resource concerns. The practices are subject to NRCS technical standards adapted for local conditions. (http://www.nrcs.usda.gov/programs/eqip/index.html#prog)

- USDA Stewardship Incentive Program (SIP): The SIP provides technical and financial assistance to encourage non-industrial private forest landowners to keep their lands and natural resources productive and healthy. Qualifying land includes rural lands with existing tree cover or land suitable for growing trees and which is owned by a private individual, group, association, corporation, Indian tribe, or other legal private entity. Eligible landowners must have an approved Forest Stewardship Plan and own 1,000 or fewer acres of qualifying land. Authorizations may be obtained for exceptions of up to 5,000 acres. (http://www.nrcs.usda.gov/programs/sip/)

- USDA Wildlife Habitat Incentive Program (WHIP): is a voluntary program for conservation-minded landowners who want to develop and improve wildlife habitat on agricultural land, nonindustrial private forest land, and Indian land. The Natural Resources Conservation Service administers WHIP to provide both technical assistance and up to 75 percent cost-share assistance to establish and improve fish and wildlife habitat. WHIP cost-share agreements between NRCS and the participant generally last from one year after the last conservation practice is implemented but not more than 10 years from the date the agreement is signed. (http://www.nrcs.usda.gov/programs/whip/)

- USDA Wetland Reserve Program (WRP): The WRP is a voluntary program offering landowners the opportunity to protect, restore, and enhance wetlands on their property. The USDA Natural Resources Conservation Service (NRCS) provides technical and financial support to help landowners with their wetland restoration efforts. The NRCS goal is to achieve the greatest wetland functions and values, along with optimum wildlife habitat, on every acre enrolled in the program. This program offers landowners an opportunity to establish long-term conservation and wildlife practices and protection. (http://www.nrcs.usda.gov/programs/wrp/)

- US Fish and Wildlife National Coastal Wetlands Conservation Grant Program: Under the program the U.S. Fish and Wildlife Service provides matching grants to States for acquisition, restoration, management, or enhancement of coastal wetlands. The grants will be used to acquire, restore, or enhance coastal wetlands and adjacent uplands to provide long-term conservation benefits to fish, wildlife, and their habitat. (http://www.fws.gov/coastal/CoastalGrants/)

- National Fish and Wildlife Foundation (NFWF): The NFWF is a non-profit created by Congress in 1984 that 2directs public conservation dollars to the most pressing environmental needs and matches those investments with private funds. The four Keystone Programs of the NFWF include birds, freshwater fish, wildlife and habitat, and marine and coastal systems. (http://www.nfwf.org/)

- Southeast Rural Community Assistance Project (RCAP): Southeast RCAP's Loan Fund provides low-interest loans to rural communities for predevelopment costs, system upgrades, and new construction of water and wastewater services and facilities. (http://www.sercap.org/carolina_n.htm)

- The Clean Vessel Act Grant Program (CVA) provides grant funds for the construction, renovation, operation, and maintenance of pumpout stations and waste reception facilities for recreational boaters, and also for educational programs that inform boaters of the importance of proper disposal of their sewage. Funds for the CVA are administered through the Sport Fish Restoration and Boating Trust Fund. (http://wsfrprograms.fws.gov/subpages/grantprograms/CVA/CVA.htm)

- The Estuary Restoration Act (ERA): The purpose of the ERA is to promote the restoration of estuary habitat, provide assistance for and promote efficient financing of estuary habitat restoration projects, and to develop and enhance monitoring, data sharing and research capabilities. Costs of projects funded under the ERA must be shared with non-Federal parties. (http://www.usace.army.mil/CECW/ERA)

- North Carolina Department of Transportation: The NCDOT will appropriate funds toward installing BMPs associated with NCDOT land in the watershed.

5.0 Measurable Goals and Milestones

5.1 Goals

The goal of this implementation plan is to meet the established water quality standard for shellfishing waters.

> "Organisms of coliform group: fecal coliform group not to exceed a median MF of 14/100 ml and not more than 10 percent of the samples shall exceed an MF count of 43/100 ml in those areas most probably exposed to fecal contamination during the most unfavorable hydrographic and pollution conditions." 15A NCAC 02B.0021 (Tidal Salt Water Quality Standards for Class SA Waters) (MF is an abbreviation for the membrane filter procedure for bacteriological analysis).

Four management measures were presented in this implementation plan that will help improve shellfish waters and prevent further degradation. Action items described in the previous sections are summarized and organized by management measure below.

Measure 1: Reduce stormwater runoff from 94% of existing development

A. Promote BMP retrofits to capture the 1-year, 24-hour storm in existing developed areas including residential neighborhoods with an emphasis on infiltration opportunities on A & B soils (Figure 3).

B. Create an incentives program for neighborhood stormwater reduction projects that could include a competition sponsored by a local vendor or media outlet.

C. NCDOT to work with HOA/POAs and others in the targeted areas to identify suitable BMP retrofit locations to treat stormwater runoff from roads and residential parcels (Figure 3).

D. Use LID techniques to retrofit existing government owned properties such as schools, the community college, and municipal and county government complexes to infiltrate the 1-year, 24-hour storm.

E. Create an accounting system which catalogs BMP retrofit projects, the area treated, and the storm size (i.e. the 1.5 inch or 3.8 inch storm).

Measure 2: Prevent stormwater runoff from all new development

A. Promote LID for all new and re-development on public/government owned properties such as parks, schools, the community college, and others.

B. Develop a financial incentives program for the use of LID in all new development.

C. Work with developers to offer 'green' add-on amenities for new homes in conventional neighborhoods such as permeable pavers, cisterns, and rain gardens.

D. Use LID design alternatives for new NCDOT linear projects. This will set an example for others and demonstrate the practical use of LID measures in linear transportation projects.

E. In Brunswick County, promote PUD with 40% open space over conventional development or increase open space requirements to 40% for all development.

F. In Oak Island, increase the open space requirements in PUD to 40%, especially in the

newly annexed areas of the Town.

G. Apply the stricter ORW/SA rules to the entire watershed, not just within the half-mile SA waters buffer area.

H. Create an action plan for acquiring strategic preservation sites as identified in Lynch 2005. The action plan should include identifying how much land is to be preserved and a date by which the properties will be preserved.

Measure 3: Control and reduce sources of fecal coliform bacteria

A. Promote pet waste management programs to HOAs and local governments. Pet waste stations should include educational signage. Promote pet waste stations at all trails and parks.

B. Promote pet waste ordinance similar to City of Wilmington requiring all pet owners to have pet waste removal bags when off their property with their pet.

C. Encourage neighborhoods to cooperate in the sewer extension program under the Neighborhood Water and Sewer Main Extension policy. Promote the Rural Sewer Program Policy for individual land owners.

D. Distribute the publication “Improving Septic System Maintenance in Coastal Communities” (Osmond, Lawrence, & Young, 2003) to residences with septic systems.

E. Promote the Clean Marinas Program and other Division of Coastal Management programs (Marina Pumpout Program, BMP Manual for North Carolina Marinas, and A Boater’s Guide.)

F. Petition for No-discharge Zone status.

G. Partner with Cooperative Extension to promote manure management plans for livestock owners.

H. Promote pasture management and riparian buffer restoration to improve stormwater infiltration.

I. Promote the use of fencing to livestock owners to keep all animals out of surface waters including streams and wetlands.

J. The hog farm should continue to meet permit requirements. Promote the use of economically feasible alternatives to manage the facility when such alternatives are identified.

K. Create an atlas of amenity ponds found in many neighborhoods which can be retrofitted with buffers and vegetated shallow areas to deter geese. Educate HOAs on the benefits of this type of pond naturalization.

Measure 4: Education/Outreach/Training

A. Produce a tabloid publication describing the TMDL and TMDL implementation plan projects including implementation measures.

B. Create a Lockwoods Folly River watershed website with links to previous studies and education materials, announcements for upcoming training opportunities, funding sources, implementation measures, and updates.

C. Create fact sheet flyers for distribution to agencies, homeowners, HOAs, POAs, and other informational portals around the watershed. Fact sheets can be general (methods of fecal bacteria source control and stormwater runoff reduction) or specific (horse owner BMPs, cattle owner BMPs, septic system users, pet owners, and boaters).

D. Install informational signage at all public property, boat access points, and at completed stormwater BMP projects. These provide simple and effective educational tools on the importance of clean water for the restoration of the Lockwoods Folly watershed.

E. Create press releases and hold media tours of the watershed and completed projects to help keep a spotlight on the efforts in the watershed and keep the public informed on the status of the implementation plan and the results of projects.

F. Give presentations to Property and Home Owner Associations, Garden Clubs, and other community groups on everyday source elimination activities and how to implement stormwater runoff reduction strategies for their homes, neighborhoods, and businesses.

G. Promote participation in the Cooperative Extension and NCSU Residential Rain Garden Certification Program to landscapers, contractors, builders, and others.

H. Organize multi-media presentations by stormwater specialists and other professionals to the public and governmental agencies on the implementation strategies with the goal of obtaining support and possible funding.

I. Hold training workshops for agency personnel, consultants, landscape architects, developers, and others on the most appropriate BMP types and installation practices in the Coastal Plain.

J. Conduct pet waste education campaign to include distribution of educational postcards.

K. Conduct a septic maintenance educational campaign with the Cooperative Extension and County Health Department.

L. Create a wildlife education program that includes lawn care strategies such as reducing fertilizer use, lawn size, and frequency of mowing. The program should also inform residents not to feed geese using signage at targeted pond areas.

M. Give presentations aimed at specific groups including livestock owners, pet owners, boaters, and septic system users that focus on specific best management practices and issues that pertain to each group

5.2 Timeline and Milestones for Implementation

Implementation measures need to start as soon as possible and should continue indefinitely into the future. While measures that apply to currently developed land may one day be achieved, new construction is likely to occur for many decades. Working towards completing as many of the action items from the four management measures is important. The following presents a milestone for each measure, as well as information on what actions should be the top priorities for each measure. Interested parties can take responsibility for the different actions listed under each management measure and determine the appropriate start date (Table 9).

Measure 1: Reduce stormwater runoff from 94% of existing development

Milestone: After five years use water quality data and the acres of developed land that have stormwater reduction practices in place to determine if the number o retrofits is resulting in a

decrease of fecal bacteria levels.

Priority: Actions have been recommended for developed lands throughout the watershed for a variety of parties. Normally, projects would be prioritized by selecting those that treat the greatest area for the lowest price. However, this method is not appropriate for the Lockwoods Folly watershed. There are few areas where large scale projects will lead to a large reduction in fecal coliform bacteria. Since the developed areas are largely residential, projects will need to be implemented on a lot by lot basis. When space and drainage patterns allow, projects may be constructed to treat a group of houses. Since projects are needed in almost all of the developed areas, a method of prioritization is needed. Factors to consider for prioritization are landowner willingness to participate, funding, and how effective projects will be based on soils, depth to water table, and space available. Most of the more effective BMPs (Tables 4 and 5) recommended in this plan require soils with high infiltration capacity and a minimum 3-foot depth to water table.

Measure 2: Prevent stormwater runoff from all new development

Milestone: In 2015, compare existing parcel data with data from 2010 to determine areas with new growth that are conventional developments or low impact developments. If conventional developments are more common than LID, efforts should be increased.

Priority: Currently, development is not occurring at a rapid pace however many lots have been subdivided for conventional development (see Figure 6). It is important to work with these developers in order to minimize impacts from these areas. If these projects are successful, other developers may choose to design neighborhoods using LID techniques.

Measure 3: Control and reduce sources of fecal coliform bacteria

Milestone: In five years, review the source reduction actions that have been completed. Survey those that initially participated in specific actions to determine if they are continuing source control efforts (i.e. If 5 horse owners came to a workshop about manure and pasture management, conduct a survey to determine if the owners carried out the activities they were taught).

Priority: Efforts should focus first on the largest source that is easily managed and then work through the smaller sources. Pet waste is the second largest source but is easier to manage than wildlife therefore pet waste controls should be the primary focus. This is followed by source controls for septic system owners, boaters, and livestock owners. Limited source control actions have been proposed for wildlife as wildlife sources will primarily be addressed through stormwater runoff reduction.

Measure 4: Education/Outreach/Training

Milestone: In five years, review the education/outreach/training actions that have occurred. Survey the participants to determine if they have taken actions to improve water quality or have changed habits (i.e. If 100 dog owners received information on the impacts of pet waste, conduct a survey to determine how many currently collect their pets waste).

Priority: In order to get the public to participate, implementing the education strategies is key. Focusing on organized groups of homeowners such as HOAs and POAs should be the top priority as a larger number of people can be reached that will potentially install stormwater runoff reduction practices on their lots.

Table 9. Timeline for Implementation

Measure/Action	Responsible Parties	Start Date
1/A		
1/B		
1/C		
1/D		
2/A		
2/B		
2/C		
2/D		
2/E		
2/F		
2/G		
2/H		
2/I		
3/A		
3/B		
3/C		
3/D		
3/E		
3/F		
3/G		
3/H		
3/I		
3/J		
3/K		
4/A		
4/B		
4/C		
4/D		
4/E		
4/F		
4/G		
4/H		
4/I		
4/J		
4/K		
4/L		
4/M		
5/A		
6/A		
6/B		

5.3 Tracking and Monitoring Plans

One of the action items outlined in this implementation plan is the creation of an accounting system to track the BMP retrofits which are installed in the watershed. The accounting system will track the number of BMPs installed, the area treated by each BMP, and the size of the storm each BMP is designed to treat (e.g. the 1.5 inch versus the 3.8 inch storm). This system will assist in tracking progress toward meeting the measure of capturing runoff for the 1-year 24-hour storm from 94% of the developed land in the watershed.

Data collection and analysis of bacteria at the nine monitoring stations in the estuary will continue to be performed by the Shellfish Sanitation Section of DEH (DEHSS). DEHSS also performs sampling at five monitoring sites in the ICWW and Montgomery Slough. DEHSS conducts sampling at least six times per year at these sites. The system is well-suited for monitoring and classifying shellfish waters and it can serve to track the effectiveness of TMDL implementation and water quality improvements. Continued monitoring allows for adaptive management of this implementation plan. The need for changes to implementation measures can be assessed according to improvements or degradation in water quality as determined by monitoring.

6.0 Works Cited

Bartlett, C. (2006). *Stormwater Knowledge, Attitude and Behaviors: A 2005 Survey of North Carolina Residents.* Retrieved July 2010, from NCDENR Stormwater and Runoff Pollution: http://www.ncstormwater.org/pdfs/stormwater_survey_12506.pdf

Bentrup, G. (2008). Conservation Buffers: Design Guidelines for Buffers, Corridors, and Greenways. *General Technical Report SRS-109* .

Brunswick County. (2002). *Brunswick County Stormwater Management Manual.*

Brunswick County. (2002). *Stormwater Quality Management and Discharge Control, Brunswick County Code.* Brunswick County.

Center for Watershed Protection. (1999). *Watershed PrtoectionTechniques Vol 3 No. 1.* Ellicot, MD: Center for Watershed Protection.

Center for Watrshed Protection. (1999). *Watershed PrtoectionTechniques Vol 3 No. 1.* Ellicot, MD: Center for Watershed Protection.

City of Wilmington. (2009). *Ordinance Amending Chapter 12 of the City Code to Address Illicit discharges to the Stormwater System and Protect Public Water and Sewer Systems (OBG-1-0809).* Wilmington.

Division of Environmental Health, Shellfish Sanitation and Recreational Water Quality, North Carolina Department of Environment and Natural Resources. (2007). *Report of Sanitary Suvey April 2002 through February 2007.*

Division of Water Quality (previously Division of Environmental Management Water Quality Section). (1989). *Lockwoods Folly River Basin Water Quality Evaluation Report.* Raleigh, NC: NCDENR.

ENSR International. (2005). *Mitigation Measures to Address Pathogen Pollution in Surface Waters: A TMDL Implementation Guidance Manual for Massachusetts.* Boston, MA: USEPA New England Region-1.

Evans, R. (1992). *Lockwoods Folly Numerical Circulation Study.* Vicksburg, MS: Department of the Army Waterways Experiment Station, Corps of Engineers.

Golgowski, G. a. (1985). Review of Approaches and Techniques Used to Assist in Financing the Retrofitting of Existing Urban Storm Drainage Systems. *Stormwater Management: "An Update"* .

Hathaway, J., & Hunt, W. (2008). *Urban Waterways: Removal of Pathogens in Stormwater.* Raleigh: North Carolina Cooperative Extension Service.

Hunt, W., & Lord, B. (2006). *Urban Waterways: Bioretention Performance, Design, Construction, and Maintenance.* North Carolina Cooperative Extension Service.

Lockwood Folly Watershed Rounddtable. (2007). *Lockwood Folly River Water Qulaity Strategy.* Bolivia, NC.

Lynch, A. (2005). *Property Selection for Water Quality Protection in Brunswick County, North Carolina.* Durham.

MacGowan, B. (2010). *The Canada goose: A wildlife success story?* Retrieved July 2010, from Grounds Maintenance for Golf & Green Industry Professionals: http://grounds-mag.com/mag/grounds_maintenance_canada_goose_wildlife/

NCDENR Division of Coastal Management. (2007). *Boater's Guide to Protecting North Carolina's Coastal Resources.* Retrieved July 2010, from Division of Coastal Management:

http://www.nccoastalmanagement.net/Marinas/BoaterGuide2004.pdf

North Carolina Department of Environment and Natural Resources Coastal Nonpoint Source Pollution Program. (2007). *http://www.nccoastalmanagement.net/Marinas/NC%20Marina%20BMP%20Manual.pdf*. Retrieved July 2010, from NCDENR Divsion of Coastal Management: http://www.nccoastalmanagement.net/Marinas/NC%20Marina%20BMP%20Manual.pdf

North Carolina Department of Environment and Natural Resources Division of Water Quality. (2007). *"Redbook" Surface Waters and Wetlands Standards.* Raleigh: Environmental Management Commission.

North Carolina Department of Environment and Natural Resources Division of Water Quality. (2007). *Stormwater Best Management Practices Manual.* Raleigh: NCDENR.

North Carolina State University. (2009). *Low Impact Development: A Guidebook for North Carolina.* Raleigh: North Carolina Cooperative Extension Service.

Northern Virginia Soil and Water Conservation District. (n.d.). *Agriculutral Best Management Practices for Suburban Horse Operations*. Retrieved July 2010, from Fairfax County VA Northern Virginia Soil & Water Conservation District: http://www.fairfaxcounty.gov/nvswcd/horse.htm

Office of Watersheds Philadelphia Water Department. (2006). *A Homeowner's Guide to Stomrwater Management.* Retrieved July 2010, from Partnership for the Deleware Estuary : http://www.delawareestuary.org/pdf/HomeownersGuideSWMgmnt.pdf

Osmond, D., Lawrence, G., & Young, J. (2003). *Improving Septic System Maintenance In Coastal Communities.* Raleigh: North Carolina Cooperative Extension Service.

Rice, M. (2005). *Small-Scale Farmers and the Environment: How to be a Good Steward.* Retrieved July 2010, from eXtension.org: http://www.extension.org/mediawiki/files/9/90/1_FrmrEnv.pdf

San Francisco Estuary Partnership. (2009). *How Boat Sewage Dishcarges Affect the Environment*. Retrieved 2010, from San Francisco Estuary Partnership: http://www.sfestuary.org/pages/index.php?ID=15

SBTDC-Boating Industry Services North Carolina Clean Marina Program. (2007, November). *Best Management Practices for N.C. Marinas.* Retrieved July 2010, from Division of Coastal Management: http://www.nccoastalmanagement.net/Marinas/NC Marina BMP Manual.pdf

Stantec. (2007). *Lockwoods Folly River Local Watershed Plan.* Raleigh: North Carolina Ecosystem Enhancement Program.

Stormwater Manager's Resource Center (SMRC). (n.d.). *Pollution Prevention Fact Sheets: Animal Waste Collection.* Retrieved 2010, from Stormwater Manager's Resource Center (SMRC): http://www.stormwatercenter.net/

Tomlinson, J. (2007). *Water Quality Impacts of Alternative Buiild-Out Scenarios for Brunswick County, North Carolina.* Raleigh: North Carolina State University and NCDENR Division of Water Quality.

Town of Oak Island. (2010). *Code of Ordinances Town of Oak Island, North Carolina Chapter 18 Article V Stormwater Management.* Oak Island.

U.S. Environmental Protection Agency, Office of Water. (1993). *Guidance Specifying Management Measures for Sources of Nonpoint Pollution in Coastal Waters.* Washington DC: EPA 840-B-92-002.

U.S. Environmental Protection Agency, Office of Wetlands, Oceans and Watersheds. (2008). *Handbook for Developing Watershed Plans to Restore and Protect Our Waters.* Office of Water Nonpoint Source Control Branch. Washington DC: EPA 841-B-08-002.

Westendorf, M. (2009). *Stall Waste Production and Mangement.* Retrieved July 2010, from eXtension.org: http://www.extension.org/pages/Stall_Waste_Production_and_Management

Westendorf, M., & Rice, M. (2008). *Manure Management on Small Farms.* Retrieved July 2010, from eXtension.org: http://www.extension.org/pages/Manure_Management_on_Small_Farms

Winston, R. J., & Hunt, W. F. (2009). *Field Evaluation of Level Spreader - Vegetated Filter Strips to Improve Hydrology and Water Quality.* American Society of Agricultural and Biological Engineers www.asabe.org.

Appendix 1. Excerpts from *Lockwoods Folly River Basin Water Quality Evaluation Report* (DWQ 1989)

III. RECOMMENDATIONS

The following recommendations are made based on the conclusions from this water quality study. These statements should be regarded as recommendations instead of mandatory directives. Grouped by major subject areas, these recommendations suggest future studies, management policies, and actions to be taken to control and eventually decrease the fecal coliform contamination levels in the Lockwoods Folly River. Suggested agencies and groups who might coordinate their efforts in attaining each goal are listed in parentheses at the end of each recommendation. (See Appendix A for a list of abbreviations.)

A. Overall Management Plan

In order to initiate and hasten water quality improvements, management strategies recommended for coastal Outstanding Resource Waters should be implemented in the area of the Lockwoods Folly River Basin which was proposed for ORW. The proposed area extends from north of the AIWW to a line drawn from Genoes Point to Mullet Creek. These strategies direct the Environmental Management Commission (EMC) to require the following:

1. Projects within 575 feet of the mean high water line which require a Sedimentation and Erosion Control Plan or a CAMA major development permit must comply with the low density option of the coastal Stormwater Runoff Disposal rules (25% built-upon area or one third acre lots).

2. NPDES permits will be issued only for non-domestic, non-industrial process type discharges (such as non-industrial process cooling or seafood processing discharges). A mandatory public hearing is required for any proposed NPDES permit to this basin.

3. New non-discharge permits required by the EMC may need to comply with reduced loading rate requirements and increased buffer zones adjacent to drainage ways, to be determined on a case-by-case basis. A maximum decrease of 25% from existing loading rate requirements and a maximum increase of 25% above the standard buffer zone to drainage ways may be required.

4. New marinas in this basin must create upland basins (dig basin out of high ground).

In addition, the Coastal Resources Commission should continue to allow maintenance dredging for access to existing facilities, for existing federally authorized channels, and for existing activities such as agriculture. No new dredge or fill activities will be allowed where significant shellfish or submerged aquatic vegetation bed resources occur. Existing procedures will continue to be used for projects affecting wetlands.

Other environmental and resource agencies should be encouraged to follow management strategies that provide the protection and priority given to coastal ORWs. These agencies and the strategies which should be encouraged are as follows:

1. Coastal Resources Commission- Development in the Area of Environmental Concern (AEC) would be subject to permitting by the Division of Coastal Management. The AEC would be expanded from 75 feet to 575 feet. All development within 575 feet of the mean high water line must comply with low density requirements.

2. Soil and Water Conservation Commission- Highest priority given to agricultural landowners needing assistance from the North Carolina Agricultural Cost Share Program.

3. Division of Forestry Resources- Inform major landowners of the importance of using Best Management Practices (BMPs) should timber harvesting occur on their land.

4. Sedimentation Control Commission- Increased inspections for all construction and mining activities adjacent to the river.

In addition to the management strategies outlined above, DEM should address long-term water quality concerns by initiating the formation of a committee representing local, state and federal agencies following the results of the studies outlined below. These agencies could include State of North Carolina: Divisions of Environmental Management (Water Quality and Groundwater Sections), Health Services, Marine Fisheries, and Shellfish Sanitation, Federal Government: U.S.G.S., S.C.S., Corps of Engineers, County Government: Brunswick County Departments of Health and Planning, Brunswick Soil and Water Conservation District and local citizens groups. This committee would develop an overall management plan for the basin to restore the Lockwoods Folly River to shellfishing. This plan should be comprehensive and discuss all sources of bacteria found to be significant during this additional work.

B. Water Quality Monitoring

1. Goal: To strengthen the documentation of bacterial problems and subsequent remedial actions.

   a. Include a follow-up list in each DHS survey to document actions taken to correct violations previously cited by DHS. This list would be useful in an attempt to efficiently track the resolution of violations (DHS).

   b. Create additional ambient stations on the Lockwoods Folly River to increase the data base for future decisions (DEM).

   c. Document the extent and contribution of urban

drainage to bacteria in the river (DEM).

d. Determine levels of fecal coliform bacteria in Davis Canal. Conduct dye studies to determine possible movement of fecal coliform bacteria out of Davis Canal and the AIWW into Lockwoods Folly River (DEM).

e. Monitor selected subdivision drainage networks after rainfall events to document stormwater contributions to the current water quality problems (DEM).

2. Goal: To document the effects of completed and future dredging activities on flushing and dilution of pollutants and closure of shellfish waters.

a. Compile existing data on dredging and siltation in the mouth of the Lockwoods Folly River (U.S. Army Corps of Engineers, DEM, DHS).

b. Conduct flow modeling to predict the effect on flushing for alternative channel dredging alignments (U.S. Army Corps of Engineers, DWR, DEM).

C. On-Site Wastewater Treatment Systems

These recommendations follow a dual track: those intended to reduce the likelihood of short-term increases in fecal coliform from future development, and those intended to reduce fecal coliform to acceptable levels in the long term.

Short Term Recommendations

1. Goal: To reduce the likelihood of groundwater, and eventual surface water, contamination resulting from cumulative impacts of on-site wastewater treatment systems placed in unsuitable soils.

a. Current state and county rules and regulations for on-site wastewater system siting should be strictly followed for all existing platted and undeveloped lots (Brunswick County, Brunswick County Health Department, DHR, DEM).

b. Minimum lot sizes which have sufficient area to treat the wastewater and which are set back a sufficient distance from water supply wells, streams, drainage systems, and shellfishing waters should be incorporated into appropriate county ordinances and regulations (e.g., Brunswick County Subdivision Regulations) (Brunswick County, Brunswick County Health Department, DHS).

c. Draining very wet soils in order to allow septic tanks should be discouraged (Brunswick County, Brunswick County Health Department, DHS, DEM).

d. Sampling and/or predictive groundwater modeling for bacteria and nitrate should be required for large subsurface disposal systems (DEM, DHS).

e. Existing septic tanks should be inspected to document the extent of inadequate or nonexistent systems (Brunswick County Health Department, DHS).

f. Groundwater sampling should be done to determine underlying stratigraphy and presence of bacteria. Sampling may include transects, placed perpendicular to the river in order to examine lateral transport (DEM).

g. Additional studies should be conducted to confirm that septic tanks (especially from densely populated areas) are a major contributor of fecal coliform bacteria. These studies should be conducted during wet weather and may include groundwater sampling, modeling, remote sensing, and/or dye studies (DEM).

h. Continue to perform follow-up inspections on DEM-permitted nondischarge systems currently under repair.

Long Term Recommendations

1. Goal: To reduce fecal coliform to acceptable levels while allowing future growth in the basin.

   a. If studies conducted in 1.(f) or 1.(g) are definitive, then groundwater modeling should be performed to determine what setback from surface waters or other measure is sufficient to protect these waters from bacterial contamination from septic tanks (DEM).

   b. If studies conducted in 1.(g) or 1.(h) above are definitive, then detailed engineering studies should be performed to develop alternative treatment systems for individual lots or regional wastewater treatment systems for the two areas near the mouth of the river. The negative effects of a central sewage treatment system should also be addressed. (Brunswick County, DEM, Brunswick County Health Department, DHS).

   c. Funding for these regional wastewater treatment systems should be pursued from local, state, and federal sources (Brunswick County, Brunswick County Health Department, DEM, DHS, U.S. EPA).

D. Urban Stormwater Runoff

1. Goal: To reduce the instream impacts stormwater runoff may have from future development.

a. All new developments, especially those in close proximity to surface waters, should be encouraged to use the low density option as outlined in the Coastal Stormwater Regulations (15 NCAC 2H .1000). This would limit built-upon area to 25 percent for areas draining to SA (shellfishing) waters and 30 percent for areas draining to non-SA waters (Brunswick County, DEM).

b. A vegetative buffer, at least 50 feet in flow length, should be maintained around impervious areas (Brunswick County, DEM).

c. Golf course ponds should be designed for irrigation, not discharge. Direct discharge into SA waters should be discouraged (Brunswick County, DEM).

d. Boat ramps and waterside parking should be graded in such a manner that runoff from adjacent areas does not flow directly to surface waters. If this is not possible, stormwater infiltration devices should be designed to protect adjacent surface waters (Brunswick County, DEM).

e. Prior to DEM approval of engineered systems for stormwater control adjacent to SA waters, the applicant should perform adequate groundwater studies and/or predictive groundwater modeling to demonstrate that fecal coliform bacteria will not reach surface waters through groundwater flow (DEM).

f. A study should be conducted to determine the fecal coliform bacteria contributions from existing marinas in the basin (Brunswick County, DEM, DHS).

g. Any new marinas should be designed, constructed, operated, and maintained in order to minimize their contribution of fecal coliform bacteria to surface waters (Brunswick County, DEM, DHS).

h. The need and possibility of installing a retrofit stormwater treatment system for densely developed areas should be determined (Brunswick County, DEM).

E. Agricultural Sources

1. Goal: To minimize the impacts that agricultural practices, especially animal operations, may have on surface waters.

a. Locate existing animal operations which are impacting water quality and in need of best management practices (Brunswick County SWCD, SCS).

b. Target the Lockwoods Folly River Basin as a high priority area in the Agriculture Cost Share Program (ACSP) if the need determined in (a) above warrants it.

c. Encourage all eligible farmers, especially those with animal operations, to participate in the ACSP (Brunswick SWCD, SCS, DEM).

d. Designate animal operations as needed to encourage the use of agricultural best management practices (DEM).

F. Sludge/Septage/Industrial Disposal

1. Goal: To ensure proper disposal of these wastes in order to minimize groundwater and surface water contamination.

a. Determine disposal practices, sites, and application rates for septage (Brunswick County Health Department, DHS, DEM).

b. Continue requiring ultimate sludge disposal plans for the issuance/re-issuance of a permit for a wastewater treatment plant. In addition, a "manifest system" should be developed as described below. When sludge is removed from a wastewater treatment plant, an entry should be made in the plant's log indicating where the sludge is being taken, the hauler, and the approval document authorizing the disposal. This will help ensure that sludges are being properly disposed of in an environmentally sound manner at an acceptable permitted site (DEM, Brunswick County).

G. Landfills

1. Goal: To minimize the impact that landfills may have on surface waters.

a. Modify existing landfill operations so that leachate is incapable of direct contact with surface water by either:

i. Complete closure of landfill cells at all times to prevent liquid in the cells from entering the sedimentation basins (DHR, Brunswick County), or

ii. Routing of leachate to designated leachate collection basins (DHR, Brunswick County).

H. Wastewater Dischargers

1. Goal: To ensure that all appropriate facilities are permitted and operated to minimize surface water quality impacts.

a. Issue permits to the two fish houses discovered without NPDES permits (DEM).

b. Monitor seafood processing establishments for fecal coliform bacteria since these businesses were not in operation during the course of the study (DEM).

c. Inspect at increased frequency all discharges which have a history of improper maintenance or operation (DEM).

I. Wetlands

1. Goal: To encourage the preservation of wetlands in the Lockwoods Folly River Basin in order to protect their valuable contribution to water quality.

a. Encourage all agencies active in the basin to preserve wetlands under their jurisdiction (Brunswick County, Brunswick County Health Department, DEM, DHS, SCS, Brunswick County SWCD, DCM, U.S. Army Corps of Engineers, U.S. EPA).

J. Education

1. Goal: Develop and implement a NPS Education program for residents and businesses in the Lockwoods Folly River Basin.

a. Heighten public awareness of the individuals' role in preventing NPS pollution by providing specialized educational programs for different audiences such as homeowners, farmers, businesses, elected officials, and the media (Brunswick County, Brunswick County Health Department, DHS, DEM, Brunswick County SWCD, SCS, Ag. Extension, Streamwatch Groups, citizen groups, and other local agencies).

b. Establish an education committee to be responsible for this goal (Brunswick County).

IX. CONCLUSIONS: SOURCES OF BACTERIA IN THE LOCKWOODS FOLLY RIVER

There are six major possible sources of the fecal coliform bacteria in the river: 1) surface wastewater discharges; 2) animal waste; 3) influx from the Intracoastal Waterway; 4) sediment; 5) stormwater runoff; and 6) septic tanks. A definitive answer awaits the further studies outlined in the beginning of this report. However, based on available data, it is probable that septic tanks and stormwater runoff are the primary sources of bacteria in the river.

Surface wastewater discharges are less likely to be major sources because there are only three NPDES permits in the basin. Based on their nature and location in the basin, they are not likely to be sources of bacteria although additional monitoring is recommended to confirm this belief.

Animals also do not appear to be a major source of bacteria. Wild animals (including bear and deer) are undoubtedly present in the Green Swamp and throughout the watershed. However, monitoring on remote tributaries found only low levels of bacteria.

Similarly, only small numbers of livestock are apparently present in the basin. As monitoring above and below a hog lot on Scotts Branch demonstrates, animal operations can be a source of bacteria, especially during storms. Additional work is recommended to identify all animal operations in the watershed in order to more fully assess and subsequently minimize their impact.

Another possible source of bacteria is from the Long Beach area and the Atlantic Intracoastal Waterway. Bacteria may enter the river at rising tide and become trapped in the basin. This may well play a role in bacteria problems in the river. This report recommends additional work to examine this possibility. However, this possible cause is not consistent with the pattern of shellfish closure in the river.

Sediment could be a source of bacteria in the river, especially during high flows or heavy boating activity. This report recommends additional work to examine sediment's contribution to fecal coliform levels in the river.

Stormwater runoff is another possible source of bacteria in the river. Developed areas near Varnamtown and Sunset Harbor could contribute bacteria during storms. Additional sampling and observation of stormwater runoff patterns is recommended.

Septic tanks are the remaining possible source. Most septic tanks (and platted, undeveloped lots) in the watershed are located on soils with severe limitations for septic tanks primarily due to very excessive drainage. On these soils there is a high potential for groundwater contamination and eventual

transport to the Lockwoods Folly River. According to the DHS and DEM monitoring data, highest levels of bacteria tend to occur near Varnamtown where the river broadens. Similarly, the shellfish closure pattern has proceeded down river toward the mouth. In addition, residences in this area of the basin have become predominantly occupied year-round in the last 10 years.

When the nature of the basin's soils is combined with very dense lots (especially near Varnamtown and Sunset Harbor), the importance of septic tanks is probably increased. Unless onsite wastewater treatment systems are carefully designed, located, and maintained, future development of platted lots will likely exacerbate existing water quality problems.

All these patterns are consistent with a septic tank, along with stormwater runoff, source for the bacteria. The most likely process for the observed bacterial pattern is a cumulative region-wide failure of the septic tanks. Given the excessively drained soils in the area, a few septic tanks probably present only a small potential of groundwater contamination. However, as septic tank density and the permanent occupancy rate increase, it is likely that widespread, underground failures occur and eventually reach the river. Therefore, although all relevant regulations have apparently been followed, intensive urban development on these soils could result in a widespread failure with associated ground and surface water contamination. The timing of urban development near the river is also consistent with this hypothesis. It is likely that, as septic tanks in other areas fail underground, bacteria are carried into the upper river portion on tides.

Additional studies are needed to verify if septic tanks and stormwater runoff are major sources of bacteria. If these studies confirm this then two primary actions would need to be taken as described in Section III: 1) develop plans for alternative treatment systems for individual failing systems on a subdivision basis or install central sewer systems in the lower part of the basin and 2) establish minimum lot sizes as part of the county's subdivision regulations. Appendix D presents initial cost estimates for central sewer systems for the southern part of the watershed. Treatment plants for the existing and platted lots in the basin would cost $4.6 million and $3.4 million for the Varnamtown and Sunset Harbor parts of the basin, respectively. This is considered to be a long-term solution that will probably require county, state, and federal assistance to develop funding.

It is essential that the county and municipalities evaluate the potential increase in development that often accompanies central sewage treatment systems in coastal areas. While many of the lots that could be served by the proposed treatment systems have already been platted, there will also be pressure to develop unplatted areas at densities above those recommended in this report. Local officials should keep in mind the increased stormwater runoff that will result from any further development

in the watershed. DEM will carefully review stormwater management plans for new development in this regard.

Appendix 2. BMP Descriptions and Resources

Stormwater Runoff Reduction BMPs

Bioretention

Pollutant removal: HIGH Effect on stormwater flow: HIGH

Location: retrofit for existing development, new development

Bioretention cells remove pollutants using physical, chemical, and biological processes including absorption, microbial action, plant uptake, sedimentation, and filtration. Bioretention areas differ from other stormwater BMPs such as detention ponds and stormwater wetlands because they only hold water for short periods of time. They usually drain down within 24 to 48 hours after a rain event. A typical bioretention area includes a set of underdrains overlain by a specialized sandy fill media that ranges from 2 to 4 feet deep. The underdrain allows treated stormwater to enter the stormdrain system or be discharged into a grass channel. Alternatively, an upturned 'elbow' underdrain can be installed to provide internal water storage (IWS) which will increase infiltration time (http://www.bae.ncsu.edu/stormwater/PublicationFiles/IWS.BRC.2009.pdf). This could result in little or no discharge from the bioretention cell to a storm drain system or swale. It is possible that in some areas of the Lockwoods Folly watershed, an underdrain is not necessary if highly permeable sandy soils surround the cell. Eliminating the underdrain system can reduce the cost of the BMP. However, bioretention with an IWS will receive more pollutant removal credit than other bioretention cells which is important if a developer is seeking to meet removal goals established by local and state regulations.

Vegetation in a bioretention cell must be able to tolerate wet conditions for short periods of time while the cell drains and then dry conditions between rain events. Many typical landscaping plants can be used surrounded by a mulch layer. It is important to spread out the vegetation to allow sufficient sunlight to reach the mulch layer which covers the surface. UV exposure is the primary mechanism of pathogen removal via die-off (Hunt & Lord, 2006). Alternatively grass can be used as the vegetative cover. Bioretention cells should be located in areas where the water table is at least 2 feet below the bottom of the bioretention cell. When the water table is too high, it reduces the volume of filter media and may lead to overflow. When consistently flooded with water from a high water table, the area will function more as a stormwater wetland. Bioretention can be used in residential, commercial, and other areas. The small area requirements can make it an attractive BMP option for developers and other groups looking for stormwater infiltration solutions in high density or already developed areas. Bioretention design specifications, research, and extension publications are available at http://www.bae.ncsu.edu/topic/bioretention/.

Backyard Rain Gardens

Pollutant removal: HIGH Effect on stormwater flow: HIGH

Location: retrofit for individual houses or other small buildings, new development

A rain garden is a planted depression designed to absorb rainwater runoff from impervious surfaces such as driveways, roofs, sidewalks, and compacted lawns, trapping water before it reaches storm drains and streets. Runoff is decreased in two ways: the trapping of the rainwater increases infiltration to groundwater, and the plantings absorb excess water and transfer it to the atmosphere via transpiration. Rain gardens also have the added benefit of providing habitat beneficial to wildlife. When properly landscaped, standing water is only present in the garden for a day or two after a rain event as it slowly filters into the ground, and does not become a breeding ground for mosquitoes. Rain gardens should be located between the source of runoff (roofs and driveways) and the runoff destination (storm drain, stream, or wetland). Rain gardens cannot be located in areas where the water table is near the surface or in poorly drained soils. A homeowner can test the soil in their yard by digging a 1-foot deep hole in the desired rain garden location and filling it with water. If the water is still there after two days (and no rain) the soil is impermeable. Homeowners in this situation who want to treat stormwater from their houses could instead install pocket stormwater wetlands.

Rain gardens are relatively easy to plan and can be installed by individual homeowners and landscapers. A PowerPoint presentation created by NCDENR on how to install a rain garden can be found at: http://www.enr.state.nc.us/upclose/pages/raingarden.html. Additionally, a residential rain garden certification program is offered by the NC Cooperative Extension (see rain garden section below). For further information on rain gardens, including information on how to plan and select vegetation and keeping it maintained, visit: http://www.bae.ncsu.edu/topic/raingarden/index.htm http://www.millcreekwatershed.org/assets/files/howto.pdf

Dry Wells

Pollutant removal: HIGH Effect on stormwater flow: HIGH

Location: retrofit on individual drain spouts, new development

Dry wells are an alternative to the standard rooftop disconnection with better pollutant removal and flow reduction capabilities. Dry wells are small excavated pits which receive runoff from the downspouts of roofs. The downspout can feed directly or indirectly into the dry well. The wells are filled with stone or gravel and temporarily store stormwater runoff until infiltration into the surrounding soil occurs. Like other infiltration techniques, there should be a two-foot separation between the bottom of a dry well and the water table. The required dimensions of a dry well are dependent upon the size of the building's roof and the amount of rainfall that is required to be captured. Additionally, dry wells should be placed at least 10 feet from the individual house and

25 feet from buildings that are downhill from the dry well. Details on how to site and size a dry well can be found at http://www.delawareestuary.org/pdf/HomeownersGuideSWMgmnt.pdf.

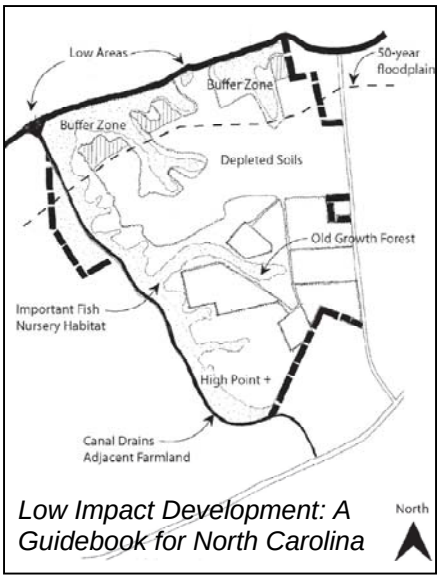
The Town of Oak Island stormwater ordinance currently requires the use of dry wells on new and redeveloped residential properties. However, this BMP type can also be used throughout the watershed by individual homeowners and developers and also at commercial developments. Dry wells are best suited for treating runoff from small drainage areas such as a single rooftop and are not appropriate for treating large impervious surfaces such as parking lots.

LID Strategies

Pollutant removal: HIGH Effect on stormwater flow: HIGH

Location: new development, limited retrofit of existing development

Low Impact Development (LID) is an approach to land development that uses various land planning and design practices and technologies to conserve and protect natural resources systems and at the same time reduce infrastructure costs. In terms of water quality, LID is a comprehensive stormwater management technology which minimizes the effects of development on water quality degradation. It is a decentralized approach to stormwater management that integrates several small-scale BMP techniques which when used across a site help to manipulate stormwater runoff to more closely mimic the natural hydrology of the land.



Low Impact Development: A Guidebook for North Carolina

LID techniques can be applied both across a multi-parcel development site and on individual lots. Some site-scale LID techniques include reducing road and driveway widths, reducing parking areas, permeable pavement, treated parking lot runoff, smaller and landscaped cul-de-sacs, minimizing the use of curb and gutter, vegetated open channels, cluster and open-space development, maintaining green space, and disconnecting impervious surfaces. Natural areas can be conserved by preserving native plant and tree areas and minimizing clearing and grading. At the lot level, LID techniques include open space design, shorter setbacks and frontages, common walkways, and shared driveways. Homes can also incorporate many of the BMPs listed in this implementation plan such as green roofs, rainwater harvesting, and backyard rain gardens and wetlands (Brunswick County, 2002). While many of these techniques are best suited to new developments, others can be used to retrofit existing development.

Brunswick County along with various other partners developed an LID guidance manual in 2007 which details LID principles and techniques. The manual is available at http://www.brunswickcountync.gov/Portals/0/bcfiles/en_Brunswick_County_LID_Guidance_Manual.pdf. More recently a statewide guidance manual was developed by North Carolina State University (North Carolina State University, 2009). The manual along with online training and links to resources is available at the NCSU LID Portal: http://www.ncsu.edu/lid. The Low Impact Development Center website has a comprehensive selection of publications including fact sheets, manuals, brochures, presentations, design manual as well as links to other sources (http://www.lowimpactdevelopment.org/).

Backyard Stormwater Wetlands

Pollutant removal: MEDIUM Effect on stormwater flow: HIGH

Location: retrofit for individual houses or other small buildings, new development

Backyard stormwater wetlands temporarily store, filter, and clean runoff from roofs and lawns. These wetlands often offer the same environmental benefits of natural wetlands in terms of water quality and plant and animal habitat. Runoff is trapped similar to a rain garden; however, it stays above or near the ground surface for a longer period of time. For this reason, stormwater wetlands are more feasible when the water table is within 2 feet of the ground surface or when soils do not drain well. Stormwater wetlands can be created by planting wetland vegetation in existing wet areas in a yard. Alternatively, a small depression can be expanded and planted with wetland plants to hold even more water. Backyard wetlands are relatively easy to plan and can be installed by individual homeowners and landscapers.

The vegetation that can be planted in a backyard wetland will depend on how long the soil remains saturated. For example, species such as bulrushes, jewelweed, and cardinal flower grow well in alternating wet and dry periods, whereas lilies and pond weed grow better in permanently flooded areas. A variety of species should be planted to avoid a monoculture and potential mosquito hazard. For more information on how to site, size, construct, and select plants for a backyard wetland, visit http://www.bae.ncsu.edu/stormwater/PublicationFiles/DSWC.Manual.2007.pdf.

Pond Retrofit/Naturalization

Pollutant removal: MEDIUM Effect on stormwater flow: HIGH

Location: retrofit existing ponds, new development

Many ponds that are present in the Lockwoods Folly River watershed currently were built as amenities for golf courses or housing developments. These ponds were not necessarily sized for water quantity or quality control for stormwater management. These ponds can be retrofitted to enhance their stormwater Stormwater Runoff reduction potential. To retrofit a pond for stormwater management, the current capacity of the pond along with the size of the contributing watershed would have to be calculated. This information helps determine what size storm the pond can hold. If space allows, the pond can be expanded to capture runoff from larger storms. Outlet structures and overflows would also need to be installed. As stated in the previous section, a littoral shelf and a natural buffer should be installed on existing ponds for additional water quality benefits. The buffer and shelf act as a deterrent to geese. The buffer helps filter water before entering the pond and the shelf provides a shallow area where sunlight exposure can destroy fecal bacteria. If retrofitting a pond through resizing and installing structures is not desirable or possible, grading the edge to create a shelf and planting it with thick vegetation will deter geese from using the pond. This will help decrease the fecal bacteria load.

Stormwater Wetlands

Pollutant removal: MEDIUM Effect on stormwater flow: HIGH

Location: retrofit for existing development, new development

Stormwater wetlands serve many purposes. They improve water quality, improve flood control, enhance wildlife habitat, and provide education and recreation opportunities. Particulates, soil-bound pathogens, and other pollutants are removed through sedimentation and filtration. Vegetation in the wetland takes up some of the nitrogen and provides a media for microbes to digest nitrate, organics, and pathogens. Finally, exposure to sunlight and dryness removes pathogens.

Stormwater wetlands are constructed with a number of features including a forebay, shallow water areas, deep pools, occasionally submerged areas, upland areas, and outlets. Stormwater enters the forebay first, which is a 2-3 foot deep pool, where sediment and litter settle out of the water. Forebays are designed with good access so they can be cleaned out when necessary and usually account for 10% of wetland area. Deep pools, about 5-10 percent of a stormwater wetland, provide fish habitat for mosquito eating fish. Shallow water (0.5 to 1 foot deep) makes up a large portion, 40%, of the wetland and is where wetland vegetation grows. Occasionally submerged areas, or shallow land, is only wet during storm events and provides a place for vegetation that likes to be wet only some of the time. This area accounts for 30-40% of the wetland. Finally upland areas can be included in the wetland design to allow for observation points. The diverse vegetation found in a stormwater wetland helps prevent mosquitoes by attracting other insect and bird species. The vegetation also provides aesthetic value for the community.

Stormwater wetlands work best in areas where water naturally flows and the water table is closer to the surface since wetland vegetation prefers a wet environment. While a stormwater wetland is usually sized to be 2-5% of the area it treats, smaller wetlands can be constructed with some of the flow bypassing the system. More information on stormwater wetlands can be found at http://www.bae.ncsu.edu/stormwater/PublicationFiles/SWwetlands2000.pdf

A potential drawback to stormwater wetland installation is that recent research has indicated these systems may cause an increase in fecal contamination levels. However, in areas where infiltration is not feasible due to a high seasonal water table or restrictive soils, stormwater wetlands should be used as they still control the effects of runoff during a rain event by lowering the peak discharge. In addition, routing in a wetland can be designed to increase the retention time which may help lower fecal bacteria levels.

Wet Detention Basins

Pollutant removal: MEDIUM **Effect on stormwater flow: *HIGH***

Location: retrofit for existing development, new development

Wet detention basins or ponds are designed to retain stormwater from large drainage areas and then treat it. The basin has a permanent pool and space for additional runoff. There is a forebay where heavy particles can settle out of the water. The basin also has a shallow ledge, known as a littoral shelf, constructed along the edge of the permanent pool. During a storm event, runoff enters the basin through the forebay and mixes with the water in the permanent pool. The water slowly discharges over a period of a few days. Treatment mechanisms include sedimentation which removes particulates and some of the fecal coliform bacteria which bind to them. Second, there is biological uptake of pollutants by plants, algae, and bacteria found in the basin (North Carolina Department of Environment and Natural Resources Division of Water Quality, 2007). By retaining the water for periods of time, bacteria and other pathogens may be killed off by exposure to UV light. In order to deter wildfowl congregation, vegetation along the edge of the basin should not be kept short.

Level Spreader – Filter Strips

Pollutant removal: MEDIUM **Effect on stormwater flow: LOW**

Location: retrofit for existing development, new development

Past research has shown level spreaders to be ineffective in treating stormwater flows. However, recent studies have shown level spreaders paired with vegetated filter strips to be a promising BMP option, particularly in areas with high water tables, such as in the Coastal Plain (Winston & Hunt, 2009).

A level spreader is a device used to disperse concentrated runoff uniformly over the ground surface as sheet flow. This resulting sheet flow enhances pollutant filtering and runoff infiltration and also reduces erosion potential of stormwater flow. Level spreaders are typically used to convey runoff from impervious surfaces to vegetated filter strips. As stormwater passes through the filter strip vegetation, some of the water infiltrates. Ideally, the filter strip will remove sediment and other pollutants from the runoff before it reaches a stream.

The level spreader – filter strip can be implemented in areas that currently use curb cuts or roof downspouts from larger impervious areas. As such, this BMP technique is not necessarily recommended for use by individual homeowners, but instead could be implemented in common areas by developers, HOAs, or other groups. Given that it can be used in areas with a high water table, the level spreader – vegetated filter strip system provides a suitable alternative to bioretention, permeable pavement, and other BMP practices that require a separation of 2 feet between the practice and the water table.

The level spreader – filter strip does not provide enough storage to reduce the peak discharge

and its ability to remove fecal bacteria is average. By itself, the practice can be used to achieve diffuse flow. However, in the Lockwoods Folly watershed, level spreaders – filter strips should be used in conjunction with other BMPs to improve performance. For example, a level spreader – filter strip can be placed at the outlet of a wet detention basin or stormwater wetland providing secondary treatment and more opportunities for infiltration and evaporation.

The Stormwater BMP Manual (North Carolina Department of Environment and Natural Resources Division of Water Quality, 2007), has a recently updated chapter on level spreaders – filter strips It should be noted that are several factors which could lead to a level spreader – vegetated filter strip being ineffective. These factors include lack of maintenance, poor design, inappropriate riparian topography and/or vegetation, and poor construction methods. NCDENR revised design guidelines in 2006 in order to eliminate some of these factors. NCSU has also released materials containing information on how to properly design and install level spreaders: http://www.bae.ncsu.edu/stormwater/PublicationFiles/LevelSpreaders2006.pdf.

Restored Riparian Buffers

Pollutant removal: MEDIUM **Effect on stormwater flow: LOW**

Location: anywhere there is open water

A riparian buffer is a vegetated area adjacent to a stream or body of water, usually forested, which helps to shade and partially protect the stream from impacts from adjacent land uses. Buffers can help to protect water quality by a) slowing water runoff and enhancing infiltration; b) trapping pollutants in surface runoff; c) trapping pollutants in subsurface flow; d) stabilizing soil; and e) reducing bank erosion. In terms of pathogen removal, the most important functions of riparian buffers pertain to reducing runoff, enhancing infiltration, and trapping pollutants in runoff. CAMA stormwater rules currently require 50 feet of riparian buffer for new development on Class SA waters (30 feet for redevelopment). However, there are several areas in the watershed with less riparian buffer, due to historic land use conversion which removed vegetation around streams. The restoration of buffers in these areas could assist in reducing fecal bacteria loading in the watershed.

Riparian buffers are most effective on low order streams and ephemeral channels. The use of level spreaders, which diffuse stormflow, have been shown to improve the performance of riparian buffers. Additionally, the use of varied buffer widths can be beneficial as some areas have more concentrated storm flows than others. Buffers can reduce pathogens in surface runoff from urban lands, pasture land, manure-applied fields, and livestock operations. However, they are generally ineffective by themselves to meet water quality standards in these situations. Buffers need to be combined with other BMPs such as stormwater ponds, stormwater wetlands, and level spreaders to meet standards (Bentrup, 2008).

This BMP strategy can be implemented by local governments. The County's stormwater ordinance states that the county is seeking to restore and enhance impaired buffers within its jurisdiction. Individual homeowners with streams on their property can also do their part to restore buffers by planting native trees and shrubs along the stream or at the very least eliminate mowing and clearing activities within 30 to 50 feet of the stream. Small ditches also carry stormwater and pollutants. Restoring riparian buffers along ditches can also help to reduce fecal bacteria loads.

Rainwater Harvesting

Pollutant removal: LOW Effect on stormwater flow: MEDIUM

Location: retrofit for individual houses or other buildings, new development

Rainwater harvesting includes the use of rain barrels and cisterns to collect rainwater running from roofs for future use. The peak discharge is reduced dependent on the size of the container. The barrels and cisterns themselves provide no stormwater quality treatment. However, treatment can be achieved by using the water in a method that prevents it from flowing to surface waters. Rainwater harvesting can be a potentially easy and cost-effective method to reduce stormwater runoff in residential and commercial areas. In residential areas, rain barrels or small cisterns are installed below the drainspouts of roofs, and should include a connection hose, an overflow spout, and a lid to keep out mosquitoes. The barrel capacity usually ranges from 60 to 80 gallons while residential cisterns measure from 100 to 1,400 gallons. Ideally, the quantity and size of the collection containers should be sized to capture the first 3.8 inches of rain. However, for every inch of rain that falls on a 1,200 square foot area, approximately 748 gallons of runoff is produced. Commercial sized cisterns have a much larger capacity, up to 10,000 gallons. They can be installed above or below ground on existing and new non-residential facilities such as commercial properties and institutions.

Rainwater harvesting is only effective in reducing stormwater flows if the water is used at a later time. If the water from a rain barrel or cistern is not used regularly, it will remain full and not be able to capture runoff from future storms. Therefore, rain barrels and cisterns must be installed in such a manner as to facilitate the reuse of the collected rain water on site. Rain barrels could prove popular as alternative water sources for watering landscape plants especially as droughts occur and watering restrictions take effect in the North Carolina. Water collected in cisterns can also be reused for landscaping and irrigation, and due to their larger size can provide reuse water for washing vehicles, flushing toilets, or other nonpotable purposes. These methods for reusing water are more suitable for installation in new development, as retrofitting existing development for indoor nonpotable rainwater reuse can be cost prohibitive. Cooperative Extension and the Stormwater BMP Manual have additional information on rainwater harvesting (http://www.bae.ncsu.edu/stormwater/PublicationFiles/RooftopRunoff2009.pdf and http://portal.ncdenr.org/web/wq/ws/su/bmp-ch19)

Green Roofs

Pollutant removal: LOW **Effect on stormwater flow: LOW**

Location: retrofit for individual houses or other buildings, new development

Green roofs are vegetated rooftops which reduce runoff from roof surfaces by trapping rain water in the soil media and increasing evapotranspiration through the vegetation. Additional benefits to green roofs include prolonged roof life and decreased energy costs by providing additional insulation. There are two general types of green roofs: extensive and intensive. Extensive green roofs generally include soil media with low-lying vegetation growing across it. This type of green roof is less expensive and requires less maintenance than intensive green roofs. Intensive green roofs are more elaborate, providing a garden-like environment on a roof top which can support pedestrian traffic. They have a deeper soil layer and can grow trees and shrubs. They also are expensive to construct and require intense maintenance such as irrigation and fertilization. Extensive green roofs are a more appealing option than intensive due to their lower costs. Succulents can be used on extensive green roofs as they do not require irrigation.

Permeable pavement

Pollutant removal: LOW **Effect on stormwater flow: LOW**

Location: retrofit for individual houses or other buildings, new development

Whereas standard asphalt and concrete are completely impervious, permeable pavements allow water to pass through their surfaces. After water infiltrates, it temporarily collects in a gravel storage layer beneath the pavement. When water passes through a permeable pavement many pollutants, including fecal bacteria, can be removed as water passes out of the pavement and into the surrounding soil. Permeable pavement types include pervious concrete, pervious asphalt, pervious interlocking concrete pavers, concrete pavers, and plastic reinforced grass pavement.

Permeable pavement is usually used for paved areas with low traffic volumes including patios, residential parking pads, driveways, fire lands, overflow parking areas, and some daily parking areas. All permeable pavements are more expensive to construct than traditional asphalt. However, the total system cost (i.e. stormwater pipes and BMPs) may be less expensive when permeable pavements are incorporated due to the reduction in peak runoff. Additionally, when used in areas with sandy soils permeable pavements are less expensive and their performance is enhanced. Permeable pavements on flat slopes and with deeper gravel layers provide greater runoff reduction. Also, regular maintenance such as street sweeping increases the infiltration capacity of the permeable pavement (North Carolina State University, 2009).

Rooftop disconnection

Pollutant removal: LOW Effect on stormwater flow: LOW

Location: retrofit for individual houses or other buildings, new development

Rooftop disconnection involves the prevention of rooftop runoff into the storm drain system by directing flow from downspouts onto vegetated areas where it can soak into or filter over the ground. This can reduce the effects of stormwater flow. Site constraints must be taken into account to ascertain the appropriateness of rooftop disconnection. These constraints include amount of vegetated area, topography, and appropriate soils. A permeable, vegetated treatment area of sufficient size must be available downslope of the downspout. Also, downspouts should be located on gradual slopes to prevent water damage to basements and foundations. However, if slopes are too steep (>5%), a series of terraces may be necessary to adequately treat runoff. In terms of soils, downspout disconnections work best in undisturbed sandy soils which allow greater infiltration. Compacted or clay soils reduce the effectiveness. Pairing rooftop disconnection with a backyard rain garden or pocket wetland will likely increase fecal bacteria removal.

Source Control BMPs

Pet waste

Pet owners have an opportunity to eliminate fecal bacteria loads to the estuary by simply collecting their pet's waste when out at the park, on a walk, or even in their own backyard. Waste should be flushed down the toilet or disposed of in the garbage. Another option is to burry waste in a small trench in your yard. Waste disposal units can be purchased for installation. Decomposition occurs within these units.

On a larger scale, a pet waste management program could be implemented by local property and homeowner associations (POA/HOA) or by local governments. These programs generally include pet waste collection stations and educational campaigns. Pet waste collection stations are comprised of an educational message, instructions for proper use, plastic bags for collecting waste, and a garbage can for disposal. These stations should be located where pet owners need them most, such as parks and neighborhood common areas. These stations can be built to suit the needs of different areas. For example, bags and signs can be added near existing garbage cans in order to avoid the expense of adding additional waste receptacles.

Studies have demonstrated that pet waste can be a significant pollutant source; however, surveys have shown that citizens do not believe that it is an important water pollution problem (Stormwater Manager's Resource Center (SMRC)). Additionally, some studies reported as little as 27% of the pet-owning population picks up after their pets (Bartlett, 2006). Therefore, in addition to the installation of pet waste collection systems, it is recommended that educational campaigns be conducted to increase the public's awareness of pet waste as a water pollutant source. These campaigns can include easily distributable postcards (available from http://www.eenorthcarolina.org/consumer/petcard.htm) which can be placed in veterinary clinics, animal shelters, and other sites or mailed to residents of the watershed.

Lastly, Brunswick County or the individual municipalities could develop an ordinance to require pet owners to correctly dispose of pet waste. The City of Wilmington has adopted a pet waste ordinance that requires removal of fecal matter immediately from any public property (including water). The ordinance also requires anyone with a dog off of their property must have a suitable

scooper (plastic bag) in their possession (City of Wilmington, 2009).

Septic Systems

Many of the septic systems in the watershed are located in areas with soils that are likely unsuitable. Regulations have changed over the decades and it is likely that many systems permitted in the past would not have received permits today. Extending sewer service to existing developed areas is one way to eliminate the possibility of septic failure. Continuing to reduce the number of septic systems in the watershed is an important step in eliminating human contributions of fecal bacteria.

The County has two policies that allow property owners to petition and receive sewer service. The first is the Rural Sewer Program Policy which allows connection to the system if sewer mains are installed along the road in front of the parcel. However, the owner must pay for installation and must have a pump installed. Few property owners have taken advantage of this policy due to the expense associated with installation and maintenance of a pump. The second policy is more feasible as it involves providing sewer service to a neighborhood. The Neighborhood Water and Sewer Main Extension policy allows residents in existing neighborhoods to petition the County Board of Commissioners for the installation of water or sewer service. An interested resident must initiate the process which includes a petition that is circulated to all property owners. If more than 50% of the property owners are in favor, the process moves forward. Funds are limited and therefore projects are given a priority rating to determine which will proceed. Property owners are required to pay their share of the total cost of constructing the sewer main needed to provide service to their property. Participation in the sewer extension program should be encouraged.

Since sewer connection will not be feasible for all septic system owners, they can take other measures to ensure their systems are functioning properly. Owners need to know where and what type of system they have. They should find out how old the system is and what type of maintenance has occurred. Day-to-day management and periodic maintenance and repair should be carried out by septic system users. Maintenance includes but is not limited to pumping out the tank and preventing damage to the drainfield. A septic system education campaign can be implemented to help owners understand their systems and maintenance issues. An education campaign may include workshops at the Brunswick County Government Complex where Cooperative Extension has a septic system demonstration site. Cooperative Extension also has many documents available for septic system owners. The Septic System Owner's Guide helps owners understand the basics of owning and operating a septic system (http://www.soil.ncsu.edu/publications/Soilfacts/AG-439-22/AG-439-22.pdf). A second publication focuses on improving septic system maintenance in coastal communities. This document was prepared to help septic system owners "focus on potential problems with surrounding water that may be caused by an improperly placed, constructed, or maintained septic system" (Osmond, Lawrence, & Young, 2003) (available at: http://www.soil.ncsu.edu/assist/cas/SepticCAS.pdf). The document contains a series of questions for the owner to determine if their system may be impacting water quality. Extension agents are available to assist owners in assessing systems.

Septic system education can mainly be directed at owners of existing dwellings where systems may have been permitted in areas that would not be permitted under today's regulations. However, septic system education is also important for homeowners of new houses with newly permitted septic systems even though the placement regulations are stricter. Maintenance is still necessary to ensure the system will continue to function as designed.

Livestock Waste

Fecal bacteria contributions from livestock occur through manure spreading processes and direct deposition during grazing. One larger livestock establishment is present in the watershed. This farm, located on Galloway Road, currently houses approximately 100 head of beef cattle, 7200 hogs, and 6 donkeys (personal communication, Dale Clemmons). There are also several other small farms scattered throughout the watershed with a small number of cattle, horses, and poultry. In the Shoreline Survey conducted by NCDEH Shellfish Sanitation, these smaller farms were reported to house approximately 25 horses, 25 hens, and 20 head of cattle total (Division of Environmental Health, Shellfish Sanitation and Recreational Water Quality, North Carolina Department of Environment and Natural Resources, 2007). There may be additional farms that house animals that were not part of the Shoreline Survey.

While there are regulations and inspections in place to govern the activity on the hog farm, the other farms are small and unregulated. All farms with livestock, regardless of size, can be environmental risks. “It doesn’t matter if there is one animal or many, if animal housing, pastures and manure is not properly managed, there is a potential to harm the environment or cause problems for neighbors” (Westendorf & Rice, 2008). Therefore all landowners with animals should read the following strategies to determine what actions are appropriate for their situation.

The hog farm in the watershed is covered under the Swine Waste Management System General Permit AWG100000. The waste from the facility is pre-treated in two anaerobic waste lagoons and is subsequently treated using land application. The permit does not allow discharges into surface waters or wetlands from the lagoon or from the fields where the waste is applied. If a discharge from a lagoon occurs, the permittee must notify the appropriate state officials and then take action to correct the problem and make sure it does not recur. This type of permit meets EPA’s guidelines that state a lagoon should be able to contain all of the waste plus the runoff from the 25-year, 24-hour frequency storm. The facility has had no violations in its history.

Fecal bacteria could be available for runoff from the application sites. In addition, if the lagoon is clay-lined, the liner could become compromised leading to groundwater infiltration. However, at this time, the state regulators have not determined an economically feasible alternative to better manage these facilities.

This farm also contains cattle as do a number of other small farms in the watershed. On all farms, cattle should not be allowed to enter streams or ponds that are connected to streams. Instead, alternative water sources should be made available for the animals. This will prevent cattle from defecating in surface waters. Manure management should include collection and storage of manure and bedding wastes before spreading them on fields. Manure should be collected at least every three days. Stored manure should be covered and kept out of the path of runoff from other areas of the farm. Any runoff from the stored manure should be diverted from surface waters. It is important to manage the quantity of manure spread on fields (Rice, 2005). Pasture management is equally important as a healthy pasture will have more infiltration during rain events thereby reducing runoff. Rotational grazing should be used to prevent overgrazing. Riparian buffers should be maintained along surface waters to provide additional filtering of runoff (additional information on riparian buffers is located in the Stormwater BMPs section of Appendix 2). Finally, water tanks should be located on level surfaces to reduce erosion. These same management measures apply to horses and other grazing animals.

Spreading manure is not always a viable option due to limited land and lack of equipment. In addition, manure cannot be spread on horse pastures unless it is fully composted. Composting

reduces the amount of raw-manure polluted runoff, reduces the volume of the manure, and can be used in yards, gardens, and pastures. Information on how to compost horse manure can be found at the Cooperative Extension website (http://www.extension.org/). A final option is to have an off-site compost facility collect the manure.

Brunswick County Cooperative Extension is a local resource with information on improving animal management and protecting water quality. In addition, the website www.extension.org provides information for animal owners on a variety of topics including manure management.

Wildlife

Waste from wildlife is a significant source of fecal bacteria in some watersheds. This is particularly true when human activities, including the feeding of wildlife and habitat modification, result in the congregation of wildlife. Concentrations of geese, gulls, and ducks are of particular concern because they often deposit their waste directly into surface waters. Therefore, they can be major sources of fecal coliform bacteria, particularly in lakes and ponds where large resident populations have become established near beaches (Center for Watershed Protection, 1999). Canada geese were almost extirpated in the early 1900s, but have rebounded dramatically. Often those that become a nuisance are not migratory, but are instead a permanent resident population.

As direct deposition of fecal matter into surface waters is of particular concern, strategies to limit wildlife access to water systems are significant methods for reducing fecal bacteria loads. In particular, geese and other waterfowl prefer unimpeded access to surface waters from the shoreline, as is often provided in ponds in residential neighborhoods and golf courses where vegetation is mowed all the way to the waterline. Therefore the following strategies can be used to manage geese and other waterfowl populations in their access to waterbodies: a) creating vegetative buffers along water (>30 inches high and 20-30 feet wide); b) adding rock barriers to vegetative buffers; and c) installing fence barriers (MacGowan, 2010). In addition to deterring waterfowl, vegetative buffers provide other water quality benefits as discussed in the riparian buffers section of Appendix 2.

There are several other strategies which will require public education in order to implement. These other strategies primarily relate to discouraging resident goose populations:

1. Do not feed geese: Feeding concentrates geese in areas and may reduce the effectiveness of other deterrent measures. Post signs in areas where this occurs
2. Reduce fertilizer use: Geese prefer fertilized to unfertilized grass.
3. Reduce lawn size: This minimizes foraging sites for geese.
4. Reduce or eliminate mowing: Tall grass blocks line of sight, which is a goose's primary defense against predators. This lack of defense deters geese from an area.

Boat Program

There are numerous practices which can be implemented by both boat owners and marinas to help protect the Lockwoods Folly River from fecal contamination. In the Division of Coastal Management's (DCM) *A Boater's Guide,* practices which boat owners can implement include: a) not dumping sewage overboard; b) using pumpout facilities for holding tanks; c) using restrooms on shore; d) maintenance and proper use of marine sanitation devices; and e) emptying portable toilets at dump stations or at home. A map of available marinas with pumpout stations in the state is available at the following website:

http://www.ncwildlife.org/Boating_Waterways/documents/NCCoastaBoatingGuideMap.pdf.

DCM has established a Marina Pumpout Program which provides financial assistance to marinas and other boat-docking facilities for the installation and renovation of pumpout and dump stations in North Carolina. The program provides 75 percent of the required funds, with a 25 percent match required from the marina. A 25 percent match is also required of local governments installing pumpouts at public docks. Information on the program, as well as guidelines for applying to the pumpout grants program can be found at: http://www.nccoastalmanagement.net/marinas/pumpout.htm. There are no marinas with the Clean Marina distinction in the Lockwoods Folly watershed.

DCM also recommends that boat owners patronize Clean Marinas. NC Clean Marina is a voluntary program for marina operators who implement best management practices which go above and beyond regulatory requirements for protecting water quality. Information for marina operators on how to be compliant with Clean Marina requirements can be found at: http://www.nccoastalmanagement.net/marinas/clean.htm. Marinas which meet the requirements are allowed to fly the Clean Marina flag at their facilities.

NCDENR has prepared a *Best Management Practices Manual for North Carolina Marinas* which serves as a guidebook and educational tool for marina operators and boat owners (North Carolina Department of Environment and Natural Resources Coastal Nonpoint Source Pollution Program, 2007). The manual provides tips on various types of practices that can be put in place at individual marinas, including the installation of pumpouts and educational materials to be provided to boat owners. The manual can be downloaded at: http://www.nccoastalmanagement.net/Marinas/NC%20Marina&20BMP%20Manual.pdf.

Further protection from boat discharge can be provided to the Lockwoods Folly River by obtaining a No Discharge Zone designation for the river and estuary. Currently the Clean Water Act requires that boats installed with toilets have a Marine Sanitation Device (MSD). Type I and II MSDs treat sewage while Type III systems are holding tanks until waste can be disposed of on shore. It is illegal to discharge untreated sewage (Type III) within three miles of shore. States can prohibit the discharge of any sewage, treated or untreated, in places where greater water quality protection is needed by designating an area as a No Discharge Zone. To obtain this designation for the Lockwoods Folly River and surrounding waterbodies, the NC Division of Water Quality would have to petition the EPA. In 2010, this No Discharge designation was granted to waters in New Hanover County, North Carolina. Furthermore, North Carolina enacted a law in July of 2010 which requires that all marinas in No Discharge Zones install pumpout stations, providing these waters with additional protection for water quality impacts from boat discharge.