Interim Update to the North Carolina General Assembly

UNC Nutrient Management Study

December 2017

NC Policy Collaboratory

https://collaboratory.unc.edu/

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Executive Summary

Legislative Charge

In 2016 the North Carolina General Assembly approved legislation directing UNC-Chapel Hill to conduct a multi-year study and analysis of nutrient management strategies and compilation of existing water quality data specifically in the context of Jordan Lake and Falls Lake.

The legislation outlines two specific provisions that are to be included in the study:

- review data collected by the Department of Environmental Quality and by other stakeholders from water sampling in areas subject to the Falls Lake or Jordan Lake Water Supply Nutrient Strategies and compare trends in water quality to the implementation of the various elements of each of the Strategies and;
- examine the costs and benefits of basinwide nutrient strategies in other states and the impact (or lack of impact) those strategies have had on water quality.

The legislation provides $500,000 annually over six years beginning in FY 2016-17 and directs that the first three years of the study focus on Jordan Lake culminating with a final report by December 2018.

Leadership at UNC-Chapel Hill chose to place the UNC Nutrient Management Study (Study) under the oversight and management of the North Carolina Policy Collaboratory (Collaboratory), which is an entity housed at UNC-Chapel Hill. The Collaboratory was established and funded by the legislature in 2016 to utilize and disseminate the environmental research expertise of the University of North Carolina system for practical use by state and local government.

Given the importance of this work and the large scope of the project, the Collaboratory chose to allocate a portion of its legislative funding to supplement the work of the Study. Consequently, in both fiscal year 2016-17 and 2017-18 more than $600,000 of state funds have been committed to support the work of two dozen faculty, staff, graduate and undergraduate students engaged in research on the Study.

Study Framework

Over the last year the Study team has been working on a number of economic, scientific, and policy research projects that will provide actionable information to inform management of the lake. These research projects are closely connected and are intended to provide a better understanding of the Jordan Lake watershed and help answer the fundamental questions:

1) **What are the sources of nutrients that are fueling impairment of Jordan Lake?**
2) **What are the nutrient management options and how cost-effective are these options?**

In the development of the overall Study plan it became apparent that a holistic approach to the issue of water quality in the Jordan Lake watershed was required. Consequently, a variety of research questions and related factors are being evaluated as part of the study, including:

- Identifying the external nutrient and sediment sources being transported from the watershed to the lake;
- Accounting for the internal nutrient sources and their impact on nutrient loading;
- Evaluating the biological and chemical conditions and hydrodynamics of the lake;

- Analyzing the conditions and factors that drive algal growth;
- Understanding how stakeholders perceive and manage for water quality;
- Reviewing policy and management options; and
- Working to identify financial solutions.

Study Activities

Pursuant to the Study charge, researchers have been reviewing existing water quality data, gathering new data, analyzing water quality, engaging with stakeholders, exploring policy options, and evaluating cost-effective mitigation measures. Some of the specific research and project activities include:

- Newly deployed automated sensors are collecting water quality data at specific points in the Jordan watershed from every five minutes to an hour – day and night – for the next two years. Consequently, the data collected will allow for the development of a highly detailed dataset of both the hydrologic and nutrient dynamics in the streams of the Jordan watershed.

- Suspended sediment concentrations are being measured weekly in waters entering Jordan Lake from creeks and rivers at four different sites.

- Profilers have been deployed in Jordan Lake to measure water velocities through four locations along the lake. In addition, water quality and meteorological data is being collected in a semi-continuous manner. Real time data from the lake can be found at http://jordanlakeobservatory.unc.edu/

- Biological assessments are being conducted using water collected from Jordan Lake to determine the factors fueling algal growth.

- An analysis of previous research on the effectiveness of nutrient mitigation measures to inform management of the lake.

- A series of listening sessions throughout the watershed were conducted to inform the research and future policy decisions.

- A review of nutrient reduction strategies was undertaken to scan other nutrient management programs in the United States and particularly, as directed by the legislature, around the Chesapeake Bay.

- An evaluation of the financing options available to local governments as they implement and pay for nutrient management measures.

Preliminary Findings

The work of the Study team has identified several issues that are worth highlighting as the research enters its second year including:

- Water circulation from the Haw River arm into the New Hope Creek of the arm of the lake following major discharge events may be taking place to a larger extent than previously thought.

- Spring results indicate in the upper New Hope Creek arm of the lake that both nitrogen and phosphorous play a role in fueling algal growth.

- Early results suggest septic systems are large sources of nutrients in the watershed.

- Increasing urbanization of the Jordan Lake watershed over the last twenty years has significant implications for water quality.

- The Chesapeake Bay program and other nutrient reduction efforts across the country offer potential lessons for North Carolina to consider. For example, allowing jurisdictions the flexibility to choose their own mix of nutrient mitigation measures may result in more successful programs.

- The long-standing water quality standard for nutrient-sensitive waters should be reviewed and potentially refined through a consensus based process. Appropriate water quality standards, based on scientific criteria—likely site specific and seasonal—should then be tailored to support designated uses.

- Implementation of nutrient management measures has been fragmented with each sector, each local government, and in some cases each local government department identifying and implementing measures on an individual basis.

- Stakeholders in the watershed are not comfortable with the fairness of the current regulatory system for achieving good water quality in the Jordan Lake watershed.

The initial findings outlined above represent significant issues of concern to the numerous stakeholders. These topics will be further developed and explored as the research continues over the next year and, when appropriate, be accompanied by recommendations.

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Introduction

Study Background

In the 2016 legislative session, the North Carolina General Assembly directed UNC-Chapel Hill to conduct a six-year Study of nutrient management strategies for Jordan and Falls Lakes. The legislation, Session Law 2016-94, includes several sections related to the "Development of a New Comprehensive Nutrient Management Regulatory Framework."

One of these sections, 14.13(c) directs UNC-Chapel Hill to conduct a multi-year study and analysis of nutrient management strategies and compilation of existing water quality data specifically in the context of Jordan and Falls Lake. (*The full text of the legislative language from 14.13 (c) can be found in Appendix 1)*

The legislation provides $500,000 annually over six years beginning in FY 2016 – 17 and ending in FY 2021 -2022. The legislation requires a final report on the results of the study and recommendations for action for Jordan Lake no later than December 31, 2018 and for Falls Lake, no later than December 31, 2021. The legislation also calls for interim updates every year. The first interim update on the Study was submitted by the Collaboratory in December 2016 and this document satisfies the requirement for the second interim update.

The legislation directs that the first three years of the Study focus on Jordan Lake and outlines two specific provisions that are to be included in the Study:

- review data collected by the Department of Environmental Quality and by other stakeholders from water sampling in areas subject to the Falls Lake or Jordan Lake Water Supply Nutrient Strategies and compare trends in water quality to the implementation of the various elements of each of the Strategies and;

- examine the costs and benefits of basinwide nutrient strategies in other states and the impact (or lack of impact) those strategies have had on water quality.

In accordance with the legislative charge, in late 2016 a team of scientists and researchers under the oversight of the Collaboratory began working to get the Study off the ground. The Study team is comprised of more than two dozen researchers, including faculty members, staff, graduate and undergraduate students from UNC-Chapel Hill and N.C. State University. (*A full roster of Study team members can be found in Appendix III).*

What follows in this report is a summary of the research and activities that have been conducted over the last year.

Jordan Lake

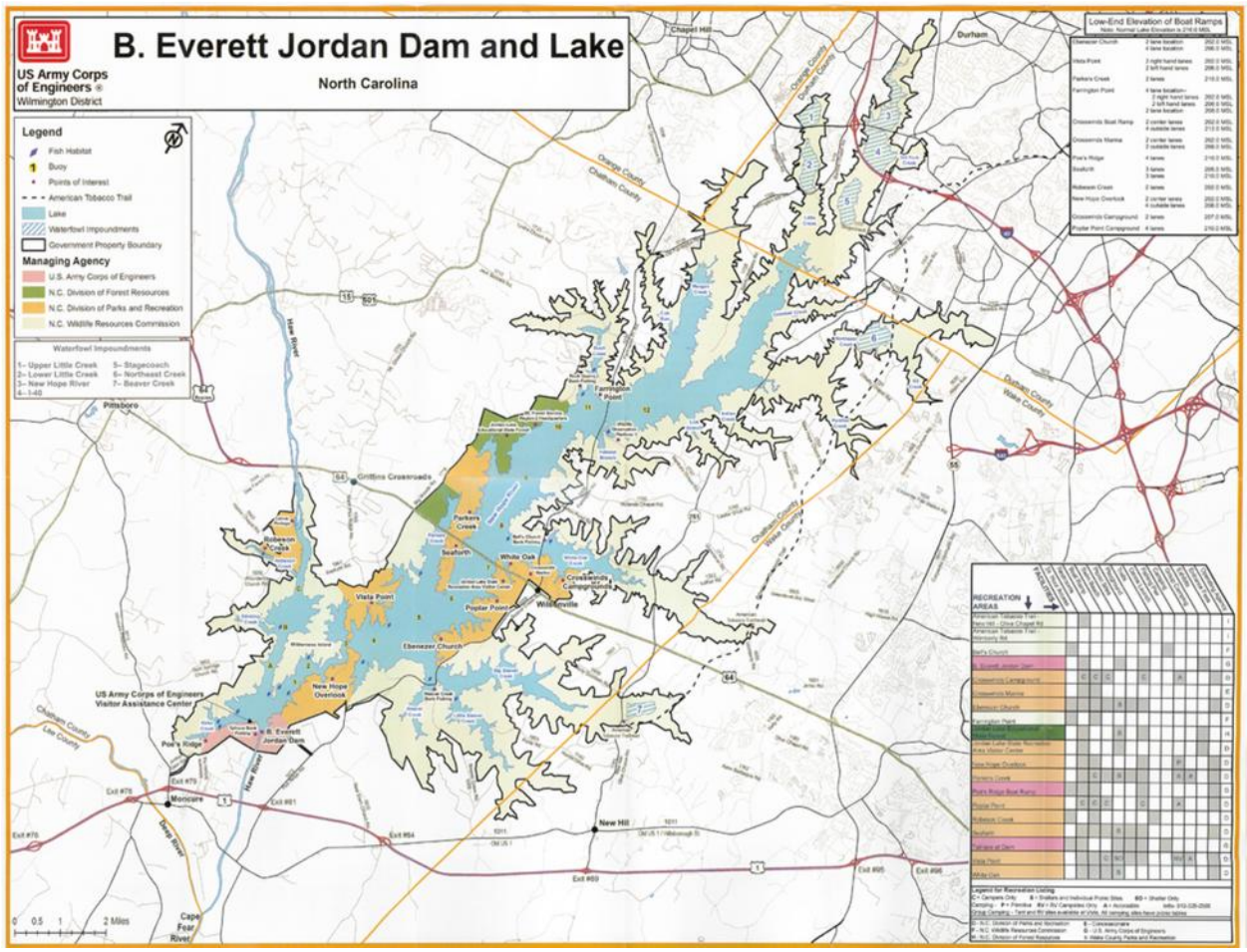

Figure 1. Map of Jordan Dam and Lake

Jordan Lake is a reservoir west of Raleigh and south of Durham in Chatham County. Jordan Lake is owned and operated by the U.S. Army Corps of Engineers which dammed and flooded the Haw River and New Hope River between 1973 and 1983. The reservoir receives water input from the Haw River, Upper New Hope, and Lower New Hope watersheds.

Table 1. Watersheds draining into Jordan Lake (Tetra Tech 2014)

	Haw River	Upper New Hope	Lower New Hope	TOTAL
Acres	859,185	147,485	71,861	1,078,531
Percent of Total	79.7	13.7	6.7	100

Associated with these water inputs are nutrients, sediments, and in some cases, significant debris. The Haw River watershed is mixed agricultural, rural, and urban land while the Upper and Lower New Hope watersheds are principally urban. The primary outflow from the lake occurs over the Jordan Lake Dam and comprises the starting point of the Cape Fear River. The Haw River drains the Haw River watershed

and discharges into the southern Haw River arm of Jordan Lake approximately five miles upstream of the Jordan Lake Dam. The Haw River provides 70-90% of the annual flow into the lake.

The Upper and Lower New Hope watersheds drain into the New Hope Creek arm of Jordan Lake which extends approximately 17 miles upstream from the dam. The Haw River arm and the New Hope Creek arm are naturally separated by a narrow channel referred to as the "s-bends" or "narrows."

Jordan Lake serves as a drinking water supply for hundreds of thousands of Triangle residents. In addition, the lake is a prime recreation area for millions of visitors each year. Jordan Lake also provides critical aquatic habitat and flood control for the downstream region.

In 2002 Jordan Lake was designated as impaired by the U.S. Environmental Protection Agency for high levels of chlorophyll A and high alkalinity. Under this designation the Clean Water Act requires the state to prepare a plan to restore the lake's health by reducing pollution. The Jordan Lake rules are intended to serve as the state's plan.

While commonly referred to as a lake, including in this report, it is important to keep in mind that Jordan Lake is a man-made reservoir. Policy-makers have known that Jordan Lake would have problems with algae since the first plans were discussed. The original Environmental Impact Statement in 1971 concludes:

> **Of primary concern is the possible eutrophic tendency of the lake … The main concern expressed for the New Hope (Jordan) Lake is over the aspect of algae growth; a prime indicator of eutrophication. Studies have shown that, assuming that all other elements necessary are available, the amounts of nitrogen and phosphorous presently found in the influent are adequate to produce algae blooms in the lake. The blooms are likely to occur during the spring, summer, and fall months in the upper reaches of the lake where the nutrients enter. Excessive algae growth can become unsightly and cause taste and odor problems in water supplies. Direct withdrawal of water from the lake can be planned to avoid undesirable water characteristics.**

Jordan Lake Rules

Simultaneous to the creation of this Study the legislature put the Jordan Lake rules on hold. The rules are designed to reduce nutrient over-enrichment in Jordan Lake. The Jordan Lake rules first became effective in 2009, but have been modified by the legislature on multiple occasions in subsequent years.

While the Study is not intended to focus exclusively on the Jordan Lake rules, a brief summary of the rules provides important context for the Study activities.

The rules divide the Jordan Lake watershed into three arms: Upper New Hope, Lower New Hope, and Haw River. Each arm of the lake has nutrient reduction goals, total allowable nutrient loads, point source waste load allocations, and nonpoint source load allocations for both nitrogen and phosphorous.

The rules further identify every local government subject to the rules, which included at the time the rules went into effect, 25 municipalities and 8 counties. Because the arms have such substantial differences in allocations and reduction requirements, the expected costs for nutrient management fall

heavily in certain areas. The Upper New Hope arm has a nitrogen reduction requirement of 35%, while the Haw arm has an 8% reduction goal and the Lower New Hope arm has a goal of 0%.

The Jordan Lake rules are a set of several rules designed to restore and maintain water quality in the lake. The specific rules include:

- Agriculture rules
- Stormwater rules for new development
- Stormwater rules for existing development
- Riparian buffers rules
- Wastewater discharge rules
- Stormwater—state and federal entities
- Fertilizer management rules
- Options for offsetting nutrient loads rules

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Monitoring and Data Collection in Jordan Lake

One major component of the Study involves a multi-part observational program of Jordan Lake's water circulation, water quality, and other relevant factors affecting movement and quality. Much of the data being collected as described below can be viewed at: www.jordanlakeobservatory.unc.edu

Specific objectives of the observational program are:

1) To identify water circulation and exchanges in the lake, in particular, the extent to which the large volume of water entering via the Haw River influences the New Hope Creek arm of the lake.
2) To better quantify the response of important water quality parameters in the lake based on changing conditions (variations in flow, temperature, light and wind) via high frequency (hourly) in situ observations.
3) To better quantify phytoplankton dynamics in Jordan Lake, including nutrient limitation and productivity that are causing the lake to be out of compliance with water quality standards.

Water Circulation and Exchange

Acoustic Doppler current profilers (ADCPs) have been deployed to measure water velocities through the water column at four locations in the lake (see Figures 2a and 2b below). Each ADCP is mounted on a bottom stand with the instrument pointed upward sampling the water column above. The ADCPs are programmed to store 3-minute average water velocities every 10 minutes, with a vertical resolution of 0.5m. These ADCPs were deployed on April 20, 2017 and data collection is planned to last for approximately one year. The ADCPs were serviced in October 2017 and will be again in April 2018 for the purposes of offloading the data for analysis.

Figure 2a. Locations for ADCPs and thermistor strings in the lower portion of Jordan Lake

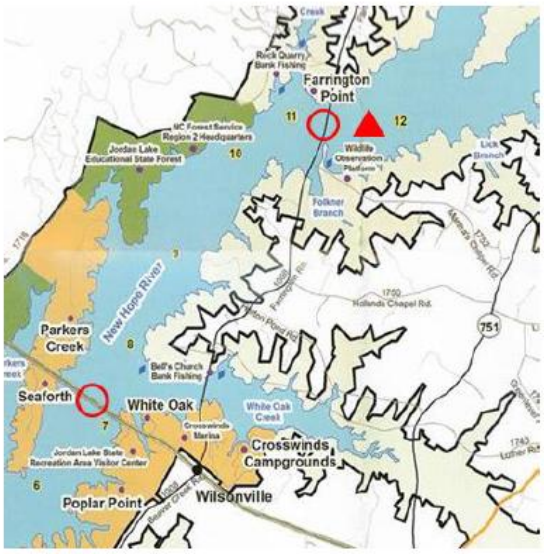

Figure 2b. Locations of ADCPs and thermistor string (circles) and the nutrient limitation bioassays (NC DEQ DWR station CFR086F) in the New Hope Creek arm of Jordan Lake.

Jordan Lake Water Quality Parameters

Near each of the ADCPs a mooring has been deployed to measure temperature, irradiance, conductivity, and water depth to aid in understanding water exchange, thermal stratification, and light extinction. The mooring is arranged in such a way to allow the full water column to be sampled while allowing for a possible change in lake level as much as 30 feet with data being collected every 6 to 12 minutes.

Water quality and meteorological data are also being measured in a semi-continuous manner using an Autonomous Vertical Profiler (AVP), Figure 3. This floating platform has a computer controlled system that allows it to remotely raise and lower a multi-parameter probe and collect vertical profiles of key water quality properties including water temperature, conductivity, in vivo fluorescence, dissolved oxygen concentration, turbidity, and pH. The AVP is programmed to collect a profile every thirty minutes and the data are displayed in near real time at the website noted above. The AVP was deployed in the lower Haw River arm from May through July of this year and in the upper section of the lake since late July 2017.

Figure 3. Autonomous Vertical Profiler (AVP)

Preliminary Finding:

- The Study team is still evaluating data to better understand the water circulation and exchange in the lake. However, evidence of water movement from the Haw River arm into the New Hope Creek arm of the lake following a major discharge event is evident from water quality sampling. As such, water quality management of the New Hope Creek arm will need to consider nutrient loads coming from the much larger Haw River watershed.

Evaluation of Controls on Algal Blooms

The Study is conducting research to determine which nutrients are controlling algal growth. Through the deployment of seasonal biological assessments (bioassays) researchers will gather information to assist in determining the nutrient reductions necessary to maintain Jordan Lake below the bloom thresholds.

A series of bioassays and laboratory analysis using water collected from Jordan Lake are being conducted to:

- Determine the degree of nitrogen and phosphorous limitation on phytoplankton productivity and biomass;
- Determine the potential effectiveness of nutrient reduction (dilution) for reducing algal biomass/chlorophyll a in the lake;
- Provide laboratory validation of observations from in situ instrumentation and determine additional parameters such as nutrient concentrations in the lake; and
- Quantify phytoplankton productivity and the impact of light limitation on productivity and biomass.

The first in a series of these seasonal nutrient addition / dilution bioassays have been conducted on water collected in April and July of 2017.

Preliminary Findings:

- Results from the spring bioassay indicate that phytoplankton in the upper New Hope Creek arm of the lake are likely co-limited by both nitrogen and phosphorous. Consequently, management measures should focus on both of these nutrients.
- The Jordan Lake Response Model from 2002 assumed that light limitation is a significantly greater impediment to nutrient utilization and biomass formation than found to be the case in water collected from the Upper New Hope Creek arm in April 2017.
- Upward mixing of nutrient rich bottom waters may be a significant source of nutrients fueling phytoplankton growth.

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Nutrient and Sediment Loading in the Jordan Watershed

While the data being collected from Jordan Lake will prove invaluable to informing the Study results and making management decisions, just as important is to gain a better understanding of the sources of nutrients and sediments entering Jordan Lake.

Water Quality Data and Stream Monitoring

To address this issue, a team of researchers is working to evaluate the range of hydrologic and water quality conditions that currently predominate upstream of Jordan Lake. This work will address the research question: Where and when within urban watersheds are nutrients coming from and under what conditions?

The ability to reduce nutrient loads is impacted by many factors and the effectiveness of nutrient reduction methods depends on a variety of factors, such as nutrient sources and seasons, flow conditions, etc. In stream reduction methods generally are not effective at high flows, and would require mitigation at source locations. Timing and magnitude of nutrient delivery can vary substantially between adjacent land uses and urban/rural areas. If the bulk of nutrient and sediment loading occurs during high or low flow conditions, different mitigation measures or stormwater control methods would be required.

The major objectives and tasks of this research component in 2017 included:

- Catalogued and reviewed existing water quality data sets collected throughout the Jordan Lake watershed to identify discernible spatial patterns of water quality.
- Designed a sampling network and strategy that will allow for spatial and temporal characterization of the major sources of nutrients and sediments to Jordan Lake in relation to land use with a focus on filling in gaps.
- Calibrated and deployed field and analytical equipment.

The existing discharge data and water quality samples collected by various entities over time, often in different locations and for different periods of time provides context, but is insufficient to determine where and when nonpoint source pollution is delivered to the stream network. Using this existing data

and modeling results as background, the Study is collecting new data at high temporal frequency and fine spatial resolutions to better identify the timing and magnitude of nutrient transport to the stream network.

The Study has instituted a watershed monitoring plan that will enhance the understanding of the factors controlling nutrient loading over a large spatial area. The sampling will highlight specific differences in nutrient loading between high and low density developed watersheds and watersheds on sanitary sewer versus septic systems. Given the region's shared climate, similar soil and geology, these findings will be applicable to the entire Jordan Lake watershed.

Preliminary findings:

- Residential developments with septic systems result in nitrate concentrations that are higher than similar developments on sanitary sewer systems. Importantly, nutrient loading from residential developments on septic systems represent an "unlimited" source versus other limited nutrient sources. While more data will be necessary to confirm this trend, it suggests that septic systems are large sources of nutrients in headwater catchments.

- In areas with the land cover characteristics of dense development large storm events that produce high flow conditions may result in nutrients bypassing stormwater treatment and control measures.

Suspended Sediment Inputs

Suspended sediments in Jordan Lake are a problem for several reasons. High suspended sediment concentrations in lake waters makes it more difficult to filter for water intakes causing additional problems for municipal water supplies. High suspended sediment concentrations in surface lake waters limit the light that can penetrate into the deeper layers of the lake and is a limiting factor for photosynthesis in the lake. As sediments settle to the bottom of the lake they carry contaminants and nutrients with them to deeper waters which can result in their release.

Suspended sediment concentrations are being measured in waters entering the lake from creeks and rivers at four input sites. These samples are occurring on a weekly basis. The sampling allows for the calculation of the sediment discharge rate at each site.

Preliminary finding:

- At low Haw River discharge rates, the mass of sediment entering the lake from the Haw River and the mass of sediments exiting the lake via the dam are very similar. As the Haw River discharge increases, sediment inputs far exceed sediment outputs, causing a large rate of sediment deposition in the lake.

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Effectiveness of Nutrient Mitigation Measures

While a comprehensive evaluation of nutrient mitigation measures or stormwater control methods is beyond the scope of the Study, it is important to acknowledge this issue which forms a critical foundation to any large-scale nutrient management strategy. As such, the Study has benefitted from involvement of N.C. State faculty who are nationally recognized experts on this topic. In addition, other researchers are evaluating how community engagement is closely linked with stormwater management at the community level. The following outlines some of the most up to date research in this field.

Bioretention

One of the most popular stormwater practices in urban and suburban North Carolina is bioretention. The N.C. Department of Environmental Quality defines bioretention as, "the use of plants and soils for removal of pollutants from stormwater via adsorption, filtration, sedimentation, volatilization, ion exchange, and biological decomposition."

While bioretention has been researched intensively to determine the most efficient design with respect to media depth, media selection, vegetative cover, drainage configuration, ponding depth, and capture volume, few long-term studies have attempted to assess the performance of older bioretention cells.

To better understand the long-term performance of bioretention cells, monitoring equipment was used to calculate and measure nitrogen and phosphorous treatment on a fifteen-year-old bioretention cell and characterize the effects of maturation its treatment capabilities. The initial monitoring period in the spring of 2017 continued to show successful reduction of nitrogen and phosphorous. Because previous research has found that effluent concentrations of nitrogen and phosphorous are higher during late summer through winter, it would not be prudent to extrapolate treatment capability of the cell to an annual basis without capturing data from an entire year. As such, monitoring of the cell will continue to gather future results.

Agricultural Best Management Practices

Data from the National Land Use Land Cover Dataset classified land use in the Jordan Lake watershed as following:

Table. 2 Land use change in the Jordan watershed

Land Use	Forest	Agriculture	Urban	Other
1992	62%	22%	11%	5%
2011	46%	22%	21%	11%
% Change	-16%	0	+10%	+6%

Taken together, this twenty-year period in the Jordan Lake watershed indicates that there is increasing urbanization and decreasing forestation, whereas agriculture has remained consistent at less than 25% of the total land area. These land use changes have significant implications for water quality.

An on the ground agricultural survey of producers in the Jordan Lake watershed revealed that four out of nine counties had 100% agricultural land use as pasture and hay, while the other counties had agricultural land use that ranged from 25-55% cropland.

Taken as a whole survey results suggested that producers in the Jordan Lake watershed were minimizing environmental impact of nutrient and soil losses from agricultural fields due to:

- The types of cropping systems used;
- Under fertilization of crops as nutrient inputs were generally below recommended levels; and
- Use of best management practices, primarily buffers and conservation tillage.

One important characteristic of the watershed is that erosion is well controlled and many streams (approximately 60%) are already buffered. The largest nutrient losses are derived from pasture lands due to animal excrement, but research indicates that these losses can be reduced by approximately 50% through the use of a narrow exclusion fence and nutrient management. Additional nutrient losses may also be derived from reducing phosphorous applications on fields that do not need more, but since this represents the minority of agricultural lands, it is doubtful than any real water quality reductions will be realized.

Community Engagement for Stormwater Management

Effective and efficient implementation of nutrient mitigation measures in an urban setting, including stormwater controls necessitates the placement of those controls on private property, and thus, requires significant community buy-in. Some common themes emerged in community level discussions about implementing stormwater controls on private property. These themes include:

<u>Quality of Communication and Trust</u>

Previous restoration projects have been met with community resistance, in part because community input from engagement activities does not seem to guide subsequent actions.

<u>Data and Design</u>

Date is necessary to convince residents that decentralized stormwater management is necessary and that design consultation will ensure the aesthetics of the stormwater controls will not detract from property values.

<u>Funding</u>

Not surprisingly, the source of funding for stormwater controls on private property and how projects would be prioritized was an area of concern.

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Policy and Financial Considerations

As evidenced by the legislative language directing the Study, the factors guiding policy decisions are inextricably linked with financial considerations and the cost effectiveness of regulatory requirements. As such, the Study is spending a significant amount of time addressing these topics in a connected manner.

One group of the Study team began a scan of nutrient management strategies in other parts of the United States, including the Chesapeake Bay. The goal was to identify policy innovations, successes, failures, and other knowledge that could be brought to bear on recommendations for nutrient management in the Jordan Lake watershed.

Concurrent with the policy scan, another group of researchers were engaging with entities that will be responsible for implementing and paying for nutrient management strategies. While the finance team interacted with individuals from a range of sectors (government, agriculture, environmental advocates) most of the focus consisted of exploring the experiences and financing options of local governments.

It is important to note that this is an interim update for the Study and many of the policy and financial issues outlined in this section may evolve as further information is gathered.

Policy Principles

In addition to the lessons offered by the Chesapeake Bay program, other southeastern states offer instructive lessons to learn about their approaches to nutrients and water quality standards. Furthermore, other major multi-state efforts at nutrient management might be worth future study by those interested in a new approach in North Carolina. Those notable nutrient management strategies in the United States beyond the Chesapeake Bay include:

- Gulf of Mexico/Mississippi River

The Mississippi River/Gulf of Mexico Hypoxia Task Force (HTF) is a federal/state partnership established in 1997 to work collaboratively on reducing excess nitrogen and phosphorous entering the Mississippi Basin and ultimately reduce the size of the hypoxic zone in the Gulf of Mexico.

- The Great Lakes

The 2012 Great Lakes Water Quality Agreement is a massive binational commitment between the United States and Canada to improve conditions in the Great Lakes.

- Puget Sound

The Puget Sound Partnership is a Washington State Agency that was formed under and receives partial funding from the EPA National Estuary Program. The Puget Sound represents similar challenges to Jordan Lake, in that stormwater is the main contributor of nutrients to the system.

- Lake Champlain

Lake Champlain in Vermont has shown nutrient impairment for decades resulting in the Lake Champlain State Implementation Plan which focuses on policy commitments to address the major sources of phosphorous that are contributing to exceedance of water quality standards.

In conjunction with North Carolina's long history of working to address nutrient pollution, these programs across the country prove instructive and provide lessons learned to incorporate into future management decisions. The policy principles identified initially by the Study team are intended to provide a source of ideas for discussion, debate, and potential further investigation.

Preliminary Findings:

- Science + Outreach + Governance

Science leads the Study; we expect it to result in a state-of-the art understanding of nutrient fate and transport in and around Jordan Lake. Science in the service of public policy needs outreach and management "baked in" to ensure it is transparent and useful to stakeholders and the ultimate policy makers.

- Start by getting the primary goals right

North Carolina's water quality standards for nutrient sensitive waters were not created for the purpose of protecting Jordan Lake or similar reservoirs. The designated uses should be refined, in a collective, consensus-based process, with the stakeholders. Appropriate water quality standards, based on scientific criteria—likely site specific and seasonal—should then be tailored to support those uses.

- Collective responsibility and accountability

North Carolina has been a national leader in creating groups of people interested in water quality who allocate responsibility among themselves and hold each other accountable. This approach should be retained and expanded.

- Maximize local gains and co-benefits

Beyond the refined water quality standards every opportunity to create and adapt the nutrient management system so as to create local gains and co-benefits should be at least explored, and ideally, developed.

- Serious Stakeholder Engagement

The management strategy we envision requires serious stakeholder engagement and a commitment to the hard work of consensus building. This means a need for funding and other resources to disseminate scientific knowledge that helps the stakeholders engage meaningfully. In particular, the experience from around the country shows how important local units of government and non-governmental organizations are in nutrient management. It cannot be imposed solely from the state or federal government level.

- Constant concern for cost-effectiveness

A scan of nutrient management strategies across the country revealed no panaceas or silver bullets. Successful nutrient management strategies at a watershed scale require a lot of resources. In order for resource commitments to be sustainable, there must be constant concern for cost-effectiveness. In other words, there must be careful attention to the least costly ways to accomplish goals.

- Build a strategy that can learn and adapt

As the scientific monitoring in the Study illustrates, there is more to learn about nutrient management and criteria development for years to come. Hence it is important build a strategy that makes its premises clear, and then is flexible enough to adapt if and when more learning shows those premises to be flawed.

Financing Options

As noted above, understanding the cost-benefit component to any nutrient management strategy is critical in the decision-making process. The Study is exploring a series of economic and financial issues, including specific research questions:

- Who has been or will be responsible for implementing nutrient management requirements driven by the Jordan Lake rules?

- What have existing nutrient management initiatives cost in the watershed and what was the anticipated nutrient reduction for different approaches?

- What methods have been used to generate revenue to cover nutrient management costs?

- How has responsibility for costs been shared/allocated among the different communities that impact or benefit from Jordan Lake?

- What methods are available to reduce costs or increase cost effectiveness of measures?

Different approaches emerge when evaluating how costs should be distributed among the various entities in the Jordan Lake watershed (The “Understanding Stakeholder Perspectives” section below emphasizes this point.) The strongest sentiment emerging from the different groups of interested stakeholders seemed to be that which comes from the Clean Water Act itself—the polluter pays principle. The notion that everyone who contributes to the nutrient pollution should be required to pay to reduce that input is one that everyone understands and agrees with to some extent.

The current Jordan Lake rules are framed with this general premise. The rules regulate and pull revenues from various contributors. However, there is also a desire among many of the interested parties, particularly those who would be deemed contributors to the lake’s nutrient issues, that beneficiaries should pay as well. Some, but not all of the parties responsible for nutrient loading will also receive benefits associated with improved water quality, but the farther away from the shores of the lake, the less pronounced the benefits become.

The following map breaks down the watershed such that we can see the potential for drinking water benefits flowing out of the lake (shown through water intake locations) and wastewater pollution flowing into the lake (shown through major wastewater facility permits) to help illustrate the different ways in which the two principles would impact the greater region.

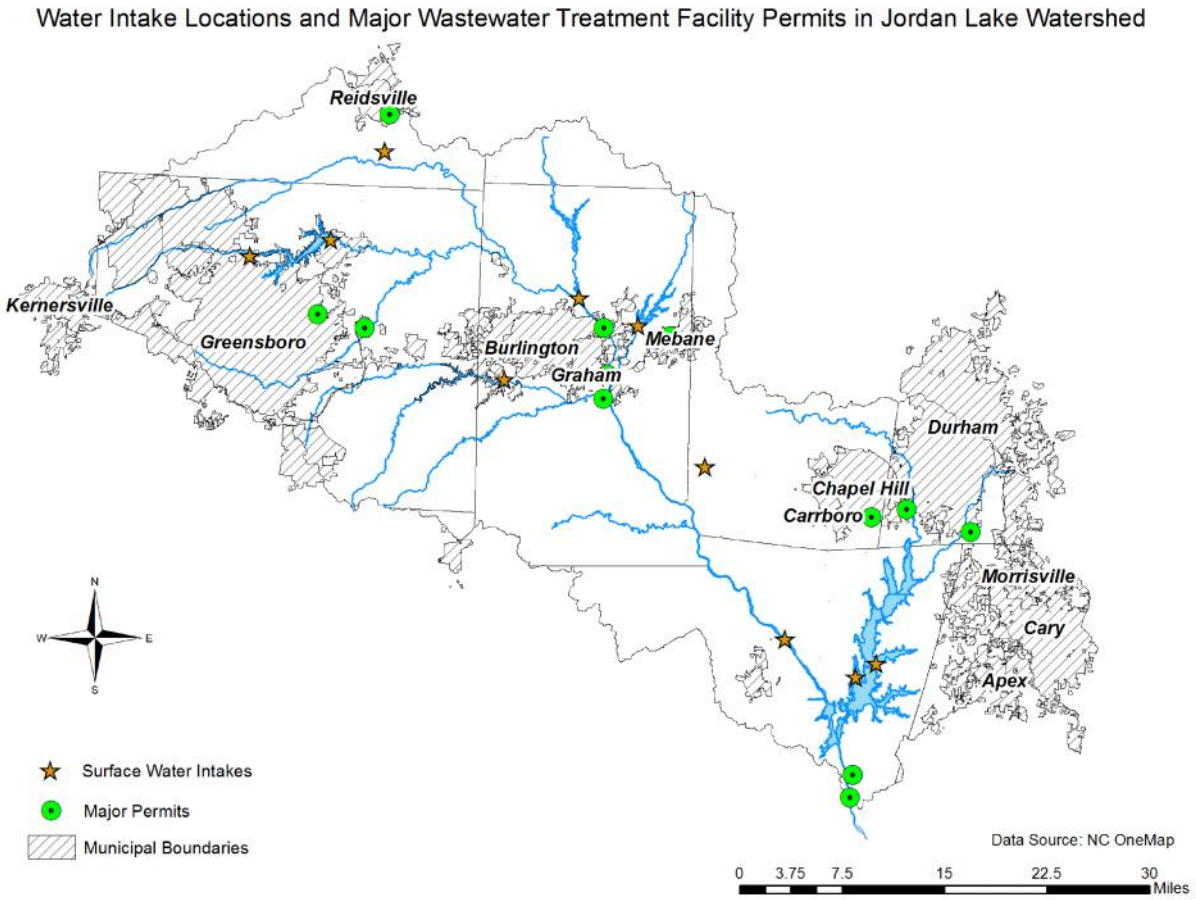

Figure 4. Water intake locations and major treatment facility permits in the watershed

In a complex watershed such as Jordan Lake, there does not appear to be a simple solution when it comes to financing nutrient reduction and management in the lake. If a strictly polluter pays framework is used, then the upstream communities carry the burden while the immediate users of the lake for recreation and water supply reap benefits at a lesser cost. On the other hand, if a strictly beneficiary pays framework is used, the downstream communities pay a premium for use and benefit from the lake while the upstream communities remain unaccountable for how their contributions increase costs for others.

Preliminary findings:

- Some type of financing approach where both upstream communities and those communities benefitting from Jordan Lake contribute towards nutrient management would likely lead to a

more robust financing framework. Given the high cost of some non-point measures, it becomes even more important to find ways of spreading costs among as large a population as possible including beneficiaries outside of the watershed.

- The high costs of nutrient management increase the importance of finding new ways to implement projects that reduce costs or increase available revenue. Most of the projects attributed to the Jordan Lake rules have been financed in fairly traditional ways. Moving away from this standard approach and identifying innovative options for financing projects should be considered in the future. These options include:

Pay for Performance

Several utilities across the country, including the Chesapeake Bay program have experimented with variations of "pay for performance" in which project implementers receive financial benefits for exceeding targets.

Pooling and Aggregating Revenues

This financing option is illustrated by the concept of a watershed improvement district or watershed improvement utility where revenue is collected at a regional level rather than a local government level.

Incentives for Encouraging Investment on Private Property

Incentivizing private investment can be accomplished in a variety of ways, such as reducing stormwater fees for property owners that make investments to improve on-site stormwater management.

Trading and Offsets

Nutrient trading or a vibrant offset market is an approach that has been widely discussed, but which remains difficult to implement.

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Understanding Stakeholder Perspectives

As part of the Study the outreach team is working to understand how key interest groups in the Jordan Lake watershed view water quality and what approaches they recommend for managing nutrients. These stakeholder discussions have a two-fold benefit: informing the type of research undertaken; and adding value to future policy-making decisions.

Involving stakeholders in environmental decision-making has been shown to improve the quality of resulting decisions and provide information that can shape environmental research. Further, the participation of diverse stakeholders can increase the quality of environmental management plans. For these reasons the Study employed focus groups as a primary method of researching stakeholders' views about water quality and nutrient management in the Jordan Lake watershed.

Participants across all focus groups identified a need for scientifically based decision making in finding solutions to problems in Jordan Lake. These participants also identified gaps in knowledge and

additional information needed to better understand how to achieve and maintain good water quality in the lake. Many of the questions raised by the participants cluster in four categories:

- **Water Quality Parameters**

How has water quality in Jordan Lake changed over the last ten years, and what changes, if any, can be attributed to specific management strategies?

What do we know about legacy nutrients: have they been measured, and how much are they contributing to water quality problems in Jordan Lake?

- **Costs**

How much more does it cost to treat wastewater than to treat drinking water?

What is the return on investment of financing buffers for farmers versus other nutrient strategies?

- **Modeling Future Impacts**

How did the models that were used in developing the Jordan Lake rules account for population growth in the region?

How will climate variability affect nutrient management in Jordan Lake?

- **Roles and Responsibilities**

How do the entities, local, state, and federal, jointly manage nutrient pollution in Jordan Lake?

How will the knowledge gained through the UNC Study be used by state legislators, environmental agencies and other decision-makers?

Preliminary Findings:

- Despite general agreement on the description of "good water quality" participants held **divergent views on the current water quality in Jordan Lake**.

- As might be expected, there were also **differing views on who should be responsible for maintaining good water quality in Jordan Lake.**

- Participants in all focus groups had **concerns about the high cost of achieving and maintaining good water quality in Jordan Lake.**

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The Year Ahead

Much of the research outlined in this report will continue into 2018. In particular, the stream monitoring network underway with regular sampling and the data being collected from Jordan Lake are foundational to the Study and any conclusions that might be drawn.

This scientific sampling and data collection will need to continue over time to provide confident conclusions about nutrient sources, transport and fate in and around Jordan Lake. It is only after those conclusions emerge that final recommendations on a nutrient control strategy can be formulated.

Significantly, one new aspect of the research underway in the coming year is designed to better understand the impact of legacy nutrients at the bottom of the lake. Understanding the role of sediments as nutrient source is of critical importance. In Falls Lake—a sister system to Jordan Lake—a nutrient response model attributed 20-50% of the nitrogen and phosphorous loading to release from the sediments. Not considering the sediment nutrient source can lead to inaccurate predictions by nutrient response models and management strategies with unrealistic expectations. As such, researchers have been added to the Study team for the specific purposes of better understanding legacy sediments as a nutrient source.

In the coming year the Study will continue its efforts to integrate the research efforts into the educational mission of UNC. In the fall semester of 2017 several undergraduates participated in a semester long “capstone” course in which they were engaged in field work to collect water samples, conduct GIS analysis of the watersheds sub-basin, and worked collaboratively to share results with researchers on the Study team.

As noted above, a number of the stakeholders with interest in Jordan Lake and the study expressed an interest in learning more about the research underway and how it will be utilized by policy-makers at the local and state levels. Consequently, the Study will strengthen its outreach efforts to promote the current research underway. In order to do so, the Study team will continue to participate in related events and conferences sharing the latest results and findings. Included among those efforts will be a public forum in the spring of 2018.

The information provided in this report is but a brief outline and summary of the research related activities that took place in 2017. A more detailed comprehensive final report will be delivered at the end of 2018 as required by legislation.

Appendix I

Legislative Text of Session Law 2016-94, Section 14.13. ©

Of the funds appropriated to the Board of Governors of The University of North Carolina, the sum of five hundred thousand dollars ($500,000) for each of the fiscal years from 2016 – 2017 through 2021 – 2022 is allocated to the Chief Sustainability Officer at the University of North Carolina at Chapel Hill to designate an entity to oversee a continuing study and analysis of nutrient management strategies (including in situ strategies) and compilation of existing water quality data specifically in the context of Jordan Lake and Falls Lake.

As part of this study, the entity shall

(i) review data collected by the Department of Environmental Quality and by other stakeholders from water sampling in areas subject to the Falls Lake or Jordan Lake Water Supply Nutrient Strategies and compare trends in water quality to the implementation of the various elements of each of the Strategies and;

(ii) Examine the costs and benefits of basin wide nutrient strategies in other states and the impact (or lack of impact) those strategies have had on water quality.

The entity shall report to the Environmental Review Commission, the Environmental Management Commission, and the Department of Environmental Quality as set forth below:

(1) With respect to Jordan Lake, the final results of its study and recommendations for further action (including any statutory or regulatory changes necessary to implement the recommendations) no later than December 31, 2018, with interim updates no later than December 31, 2016, and December 31, 2017.

(2) With respect to Falls Lake, the final results of its study and recommendations for further action (including any statutory or regulatory changes necessary to implement the recommendations) no later than December 31, 2021, with interim updates no later than December 31, 2019, and December 31, 2020. No indirect or facilities and administrative costs shall be charged by the University against the funds allocated by this section. The Department of Environmental Quality shall provide all necessary data and staff assistance as requested by the entity for the duration of the study required by this subsection. The Department shall also designate from existing positions an employee to serve as liaison between the Department and the entity to facilitate communication and handle data requests for the duration of the project.

Appendix II

Study Principles

- **Utilize Science-Based Results to Guide Findings**

The UNC Study will identify those topics in which further research can assist in addressing existing data gaps, trends in water quality, and financial consequences of management decisions.

- **Build Upon Previous Work to Advance the Discussion**

The efforts to address water quality in Jordan Lake have taken place over a number of decades. It is imperative that the UNC Study build on that foundational work and not duplicate previous and existing efforts.

- **Integrate Existing Initiatives**

The research team recognizes that the UNC Study is one project of many that are currently underway in relation to how North Carolina develops and implements nutrient management strategies. As such, the UNC Study will incorporate new findings of these related projects when appropriate.

- **Leverage Current Research**

The research and work undertaken as part of the UNC Study will utilize ongoing research partnerships and expand the scope of current research projects to identify outcomes and results in the most timely and cost-effective manner.

- **Operate in a Transparent Manner**

Results and conclusions from the UNC Study and the background information and data that formed the basis of those conclusions will be publicly available.

- **Engagement with Stakeholders**

A key component of the UNC Study will be to incorporate the guidance and perspectives of a diverse array of citizens and stakeholders throughout the watershed that will help inform not only the UNC Study but future management and policy decisions for the Jordan Lake watershed.

Appendix III

Roster of Study Team Members

Name	Affiliation
Mike Piehler, Technical Lead	UNC Institute of Marine Sciences
Marc Alperin	UNC Department of Marine Sciences
Javier Arce-Nacario	UNC Department of Geography
Larry Band	University of Virginia
Joseph Delesantro	UNC Environment and Ecology
Jon Duncan	Penn State University
Kathleen Gray	UNC Institute for the Environment
Nathan Hall	UNC Institute of Marine Sciences
Jeff Hughes	UNC Environmental Finance Center
Bill Hunt	NCSU Department of Biological and Agricultural Engineering
Rick Luettich	UNC Institute of Marine Sciences
Brent McKee	UNC Department of Marine Sciences
Deanna Osmond	NCSU Department of Crop and Soil Sciences
Hans Paerl	UNC Institute of Marine Sciences
Grant Parkins	UNC Institute for the Environment
Erin Riggs	UNC Environmental Finance Center
Diego Riveros-Iregui	UNC Department of Geography
Tony Rodriguez	UNC Institute of Marine Sciences
Harvey Seim	UNC Department of Marine Sciences
Danielle Spurlock	UNC Department of City and Regional Planning
Richard Whisnant	UNC School of Government

NC Policy Collaboratory Staff

Brad Ives, Director

Jeff Warren, Research Director

Steve Wall, Outreach Liaison

Kasia Grzebyk, Research Assistant