Concepts and Principles for the Upper Neuse River Basin Association (UNRBA) Recommendations for a Revised Falls Lake Nutrient Management Strategy

Prepared for
Upper Neuse River Basin Association

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Statement of Purpose:

This document frames the concepts and principles that have been identified by the Upper Neuse River Basin Association (UNRBA) members and watershed stakeholders as important in developing a revised Falls Lake Nutrient Management Strategy. This document supports the Consensus Principles II that will be submitted as part of the UNRBA's recommendations for a revised nutrient management strategy. This document includes the core concepts and principles that need to be evaluated during the readoption of the rules and addressed in the final version of the rules. This document was not developed to provide specific regulatory language or regulatory requirements.

Executive Summary

Background and Supporting Information

Falls Lake Reservoir was constructed and filled in the late 1970s/early 1980s. Several pre-impoundment evaluations of the reservoir predicted that it would be eutrophic (overly productive biologically) but still meet its designated uses (DNER 1973, NCDEM 1983, USACE 1974): drinking water supply, recreational use, aquatic life use, and flood control. Based on information provided in the US Army Corps of Engineers (USACE) 2013 Falls Lake Master Plan and the NC Division of Water Resources (DWR) 2021 Falls Lake Status Report, the designated uses of the reservoir are being met, and the reservoir provides:

- Flood control for downstream communities preventing over $600 million in cumulative flood damages from construction through 2012
- Water supply for over a half-million customers treating 41 million gallons per day
- A regional recreation resource including swimming, fishing, and boating
- Habitat to aquatic and terrestrial wildlife (no nutrient-related fish kills have been reported since the 1980s)

Falls Lake was listed on the 303(d) list of impaired waters for exceedances of the North Carolina (NC) chlorophyll-a criterion of 40 micrograms per liter (µg/L). Chlorophyll-a measures the green pigment in a water sample and is used as an indicator for algal growth. Monitoring by the Division of Water Resources (DWR) and other organizations show elevated chlorophyll-a levels at some locations and times of year in the lake, especially in shallow areas. However, these levels are lower than predicted, and they have not resulted in any demonstrated water quality conditions that impair designated uses.

In 2005, the NC General Assembly passed a bill requiring the NC Environmental Management Commission (EMC) to develop a Nutrient Management Strategy for Falls Lake. To support this effort, DWR used predictive modeling of the watershed and the reservoir to develop the Falls Lake Rules which set two stages of nutrient reduction requirements for the lake. The two stages of nutrient reductions are relative to a "baseline" year of 2006. Both the monitoring and modeling were developed on a compressed time schedule with limited data. As a result, there is significant uncertainty in the nutrient load reduction targets and the ability of the lake to meet the chlorophyll-a criterion regardless of the nutrient load reductions achieved.

Based on DWR's 2010 Fiscal Analysis of the Falls Lake Rules, the nutrient load reductions prescribed by the Rules were estimated to cost $604 million for Stage I and $946 million for Stage II. In addition, a review by Cardno ENTRIX (2013) concluded that the required load reductions were not technically, financially, or logistically feasible. For example, each square foot of existing development would have to be treated by at least two stormwater control measures (SCMs) to meet

the Stage II requirements. Retrofitting existing development given site constraints with even one SCM is often not possible.

Recognizing the uncertainty associated with model-based load reduction targets, Section 5(f) of the Falls Lake Rules included an adaptive management provision allowing for a re-examination of the Stage II requirements. The decade-long evaluation process by the UNRBA and the four-year study period funded by the NC Collaboratory have provided exceptional scientific information and knowledge about conditions in the lake and its watershed. Falls Lake is at risk of increasing eutrophication, but data and analyses indicate a relatively stable trophic condition. The lake currently meets its designated uses. Furthermore, nutrient reduction efforts in the watershed and changes in environmental conditions have resulted in significant reductions in nutrient loading to the lake since the baseline year of 2006. These conditions have not yet reflected significant and demonstrative reductions in chlorophyll-a in the lake. Due to the slow response of nutrient cycling in the lake and its sediments, the full implications of reduced loading over the last 17 years have not fully manifested. It is likely that these positive changes in the nutrient balance will be reflected over a much longer time given the large store of nutrients present in the lake sediments and the continued addition of nutrients from the watershed.

Other watersheds in the country face similar challenges. The Chesapeake Bay Program Scientific and Technical Advisory Committee (STAC) released a Comprehensive Evaluation of System Response in May 2023. Similar to the Falls Lake watershed, the report concludes that "current efforts to reduce nutrient loads will not meet the TMDL targets" and that "estuary water quality has been slow to respond to realized nutrient and sediment reductions in many regions of the Bay." This report focuses on an estuary that drains a much larger watershed with more opportunities for implementation given the relative amount of agricultural land and urban land in the watershed. Even with additional opportunities for implementation in the Chesapeake Bay watershed, the report concludes that "additional nutrient reductions will improve water quality, but water quality criteria may be unattainable in some regions of the Bay under existing technologies" and that "the legal requirements of the Clean Water Act (the water quality goal) divert attention away from considering multiple means of improving living resources (support of aquatic life as the designated use)."

As noted above, the current Falls Lake Nutrient Management Strategy is not technically, financially, or logistically feasible due to the unique characteristics of the watershed and the reservoir. A revised Nutrient Management Strategy for Falls Lake based on the science available and sound management principles is needed to protect this resource. While it is impossible to change the fundamental characteristics of this watershed and reservoir that make it eutrophic, a regulatory framework for nutrient management is essential for maintaining designated uses. The critical management objective for Falls Lake must be to mitigate impacts from existing activities in the watershed and to design and manage land use changes while continuing to maintain and improve water quality in Falls Lake. Without reasonable, balanced, and economically supportable actions, the risk of increased eutrophication, degradation of water quality, and adverse impacts to designated uses is a real possibility in the face of changing land use patterns and climatological conditions.

Key Findings from Information Gathering, Monitoring, and Modeling Studies

Before the comprehensive monitoring and modeling effort began, the UNRBA conducted an open and transparent planning process to ensure the requirements for a re-examination specified in the Falls Lake Rules were met. The state-approved monitoring and modeling quality assurance project plans (QAPPs) ensured the work of the UNRBA was conducted in a scientific and quality-assured manner. Since the monitoring effort started in 2014, the UNRBA has made considerable effort and investment to further the scientific understanding of the watershed and the lake. The UNRBA has

worked closely with researchers, third-party model reviewers, and DWR modeling staff to review and vet the watershed and lake models. Key findings from the UNRBA monitoring and modeling efforts are listed here and further described in the sections below as well as the UNRBA modeling reports:

- Efforts to reduce loading from the watershed since the baseline year of the Rules and DWR modeling (2006) have significantly reduced nutrient loading to Falls Lake.
  - Major wastewater treatment plants have reduced total nitrogen loads by 57 percent and total phosphorus loads by 73 percent (based on four-year average of loads discharged from 2015 to 2018).
  - Over 350 stormwater control measures and best management practices have been implemented to mitigate loading from existing development.
  - Requirements to limit nutrient export from development occurring since 2012 (i.e., new development) have been implemented by every local government in the watershed.
  - Atmospheric deposition of total nitrogen has decreased by approximately 20 percent since baseline.
  - Best management practices implemented on agriculture including nutrient management plans, livestock exclusion, and stream buffer restoration have reduced loading from this source. The acreage of agriculture has declined 44 percent since baseline due to economic and other pressures.
- 75 percent of the watershed is unmanaged, and opportunities for further nutrient reductions are limited.
- Precipitation is the key driver of increases in nutrient loading to the lake and an important driver of increase/decrease in lake residence time which is a controlling factor for algal growth.
- The watershed soils and lake sediments adsorb nutrients that can be released slowly over decades, extending the time that changes in the watershed will result in water quality changes in the lake.
- Reductions to the nutrients applied or deposited in the watershed do not have an equivalent reduction in delivered loading to Falls Lake. Only 20 percent of the loads applied to the watershed reach the lake, so reducing a pound applied or released will only result in approximately 0.2 pounds reduction to the lake.
- Levels of algae indicated by chlorophyll-a are not well correlated to nutrient loading. The hydrology, morphology, retention time, depth, and characteristics of the different areas of the lake are just as important as nutrient loading.
- Nutrient concentrations in Falls Lake are relatively low. Chlorophyll-a can reach high concentrations even when nutrient concentrations remain low.
- Falls Lake is meeting its designated uses:
  - Algal toxin levels are below U.S. Environmental Protection Agency (EPA) guidelines for drinking water and recreation (DWR 2021).Nutrient-related fish kills have not occurred in nearly 40 years since the lake was filled (NCDEQ annual fish kill reports).
  - Recreation is not limited by water quality (USACE 2013).
  - The City of Raleigh provides safe drinking water to over 500,000 customers and indicates that Falls Lake is an excellent source of raw water (DWR 2021)
  - In 2023, the American Water Works Association ranked the City of Raleigh 3rd in its international “"Best of the Best" Water Taste Test”

- Forested areas are important to the ecological health of the watershed and should be protected. Natural areas, including forests, cycle nutrients and provide important nutrients to waters that sustain aquatic life.
- North Carolina is the only state that limits chlorophyll-a everywhere in a waterbody using instantaneous measurements. A summary of other state's approaches to chlorophyll-a standards is summarized in the April 7, 2020 PFC meeting presentation (slides 57 to 68)
- Several scenarios were evaluated with the UNRBA watershed and lake models. None of the scenarios were able to achieve delivered nutrient loading to Falls Lake that would meet Stage II of the Falls Lake Nutrient Management Strategy nor were any of the scenarios able to meet the chlorophyll-a standard everywhere in Falls Lake. Even a scenario that converts all land to forest and wetlands and removes all watershed-scale human inputs was not able to achieve these goals and standards (rates of atmospheric deposition were not changed for this scenario).
- Lake modeling indicates that an additional 50 percent reduction in total nitrogen delivered to Falls Lake would be needed to achieve the chlorophyll-a water quality standard 90 percent of the time. Achieving this level of additional reduction would require treating runoff from natural areas like forests. An evaluation of a pump-and-treat approach using an algal harvesting system studied by the City of Durham indicates that at least 138 systems would be needed to meet this level of nitrogen loading. However, there is not sufficient water consistently available in the stream network to run this many systems. While these systems should remain an option to consider as part of the revised nutrient management strategy, constraints like cost and land availability will limit widespread application.
- Achieving measurable load reductions to Falls Lake will require a systems approach directed at realistic and incremental change in the nutrient balance. The Stage I Interim Alternative Implementation Approach (IAIA) approved by the EMC provides a useful framework for the revised nutrient management strategy. Additional information about the IAIA is available in the UNRBA Resource Library.
- Stakeholder participation in the process is critical to developing a successful strategy.
- A watershed approach for non-point sources provides nutrient management for all waters draining to Falls Lake, including upstream water supply impoundments.

Recommendations for a Comprehensive Approach to Nutrient Management Proposed by the UNRBA

The UNRBA has been working with other watershed stakeholders to study the Falls Lake watershed since 2011. These collaborative efforts have included discussions with internal and external stakeholders who recommend that the revised nutrient management strategy incorporate the fundamental principles of IAIA including using an investment-based, joint-compliance framework on the implementation of projects and activities beneficial to water quality across the watershed.

Based on the extensive work conducted by the UNRBA, the successes of the IAIA Program, and the feedback from external and internal stakeholders, the UNRBA Path Forward Committee (PFC) developed a list of foundational principles for a revised nutrient management strategy. It is anticipated that the jurisdictional governing boards or commissions of the UNRBA will sign a document stating their commitment to a list of foundational principles submitted as part of the UNRBA's recommendations. Below is a brief description of some of these principles which are further described later in this document:

Embrace a systems approach focusing on right-sized solutions. Progressive management of this watershed will require looking beyond individual pipes and parcels of land. Nutrient load reductions will be incremental as project identification and implementation are very challenging. A more

comprehensive approach that considers the atmosphere, soils, surface water, groundwater, and physical, biological, and chemical processes of the system will expand the opportunities for meaningful change. A triple-bottom line approach that considers environmental benefits, costs, and impacts to citizens must be an integral aspect of developing the revised strategy. The tools and models built by the UNRBA predict how management actions in the watershed affect nutrient loading to, and water quality in, Falls Lake. The UNRBA is also conducting economic analyses that consider capital, maintenance, and operational costs of nutrient management activities. By focusing on the whole watershed and local implementation, the proposed strategy aims to improve water quality across the watershed and not prioritize activities solely based on the reduction of nutrients to Falls Lake. Projects will result in reductions in nutrient loading through incremental and sustained progress across the watershed, but may also address other pollutants, long-term watershed sustainability, etc. This comprehensive approach is needed to provide lasting protection of the lake and its designated uses. Focusing on watershed health also addresses the sub-impoundments (e.g., Lake Michie, Little River Reservoir, Lake Orange, Lake Buter, etc.) used for water supply within the basin. Allowing investments throughout the watershed will positively impact water quality across the basin.

Because of the holistic nature of the recommendations, the UNRBA also recommends that its implementation for non-point sources be considered by the State as addressing all waterbodies in the watershed that are currently listed, or may be in the future, on the State's 303(d) list of waters for pollutants related to nutrients. These other waters may be considered Category 5 waters in future Integrated Reports if additional point source controls are required.

Create an adaptive program with scheduled assessments and reevaluation. The UNRBA recommends that the rules exclude the specifics of the program because it will be extremely difficult to adapt to new information and conditions. Rather, the UNRBA recommends development of an approved program document referenced by the rules with specific assessment, renewal, and reevaluation periods. The UNRBA recommends the revised strategy include a formal review period to evaluate how well the program is working in terms of water quality, necessary changes, and evolving technologies. The UNRBA proposes a full evaluation in 25 years following the date the revised rules are readopted with interim evaluations every five years. Interim evaluations and reporting years can address concerns or changes that occur during the 25-year period and assist with tracking trends and accomplishments over the longer 25-year period. As with the IAIA, annual reports are recommended to track implementation and compliance with annual investment commitments. It is in the interest of the state and the citizens of the watershed that these assessments be done in partnership with DWR.

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Cooperate and collaborate with stakeholders – The UNRBA has worked very closely with its members and external partners since the re-examination process began. Extraordinary access and participation by all stakeholders have been promoted by the UNRBA, and transparency has been an important theme in sharing the work and status of the re-examination effort. Internal and external stakeholders are invited to provide comments during monthly status meetings. The UNRBA has hosted several Technical Stakeholder Workshops, Regulatory Forums, or joint Symposia with the NC Collaboratory to hear and incorporate feedback in the process. The UNRBA has worked closely with researchers, third-party model reviewers, and DWR modeling staff to review and vet the watershed and lake models. The UNRBA also worked with DWR, representatives of agriculture, environmental

groups, and land conservation organizations to expand the list of practices with state-approved nutrient credits. This nutrient credit project led to the addition of three nutrient reduction practices eligible for use on existing development and led to the state allowing for over- and under-sized practices to receive an appropriate amount of credit for existing development retrofits. Nutrient practice development should be an ongoing commitment of an investment-based system. The UNRBA proposed a credit for land conservation and continues to work with DWR on securing a credit for this excellent practice in protecting the watershed and lake. The nutrient credit project formed strong working relationships with the organizations involved and ultimately led to discussions regarding the IAIA. The UNRBA recognizes that without these partners, a revised nutrient management strategy cannot be successful. The UNRBA encourages input during the crafting of the revised strategy from all stakeholders to identify opportunities, constraints, and solutions to achieve a shared vision to maximize the serviceable life of the reservoir and maintain its designated uses.

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Expand the types of projects and provide opportunity for other voluntary partners – The IAIA includes a broad range of eligible projects and activities approved by DWR for compliance with Stage I Existing Development Rules. The UNRBA members and stakeholders have discussed many types of additional projects and activities related to nutrient reduction opportunities for inclusion in the revised nutrient management strategy that would apply to specific types of land use, discharges, etc. As with the IAIA, the UNRBA recommends a provision for expansion of the list of eligible activities to be include in the revised strategy.

To apply a systems approach, opportunities that intersect with other watershed landowners and partners should be considered (e.g., a stream restoration project funded by a local government on private land under an agreement with the landowner). The UNRBA is not proposing that inclusion of other partners come with investment requirements, but where opportunities exist for improving water quality and quantity, the revised strategy allows and promotes local government participation in other watershed improvement actions.

Establish a Watershed Organization with tiered participation. The UNRBA anticipates investment requirements for its members under the revised nutrient management strategy. The potential partners (e.g., agriculture and institutions) would not have the burden of investment requirements. To foster cooperation and establish a functioning, holistic program, the UNRBA proposes establishment of a "Watershed Organization" with tiered membership. Those local governments, state and federal agencies, and utilities with investment requirements would be in Tier 1 and could support administration and implementation of the program through funding. Those without investment requirements could be in Tier 2. This tier would not be expected to fund the program but could participate on committees to identify opportunities and constraints, participate in decision making, etc. Committees specific to a sector (e.g., agriculture) could be chaired by a representative of that sector (i.e., committees may be chaired by a Tier 2 member). Annual compliance reporting and tracking of investment requirements for the Tier 1 members could be managed by the Watershed Organization, similar to the current IAIA. The initiation date of the Watershed Organization will be determined by the readoption of the Falls Lake Rules, which must be achieved in accordance with Session Law 2018-5 Section 13.8.(a). This session law specifies that the EMC must begin rule re-adoption no later than December 31, 2024. It is anticipated by DWR that readoption of the rules will occur no later than 2027.

Develop a fair and equitable strategy. The UNRBA strives to develop a revised nutrient management strategy that protects the watershed and Falls Lake in a fair and equitable manner. An investment-

based, watershed-health approach will continue to be most effective when all parties in the watershed are fully engaged and committed. This should include those with drainage to the lake and those benefiting from the ongoing management of the watershed and lake for reducing nutrient and other water quality impacts. As with the IAIA, the proposed framework provides equity by including those using Falls Lake and other intake points (e.g., Lake Michie, Lake Butner) as a water supply. Equity is also addressed through tiered membership in the program as some sectors can fund activities through taxes and fees, and others are comprised of local landowners and businesses that do not have this ability. The requirements of the revised strategy will consider these and other equity factors. Stakeholder feedback on this proposal and the UNRBA economic analyses will also be considered as the program is developed.

Consider environmental and social justice issues. The program should consider environmental and social justice issues in implementation of the revised nutrient management strategy (funding, siting, public input, public access, etc.). The revised rules should promote opportunities for equitable stakeholder participation by encouraging input and participation from the public and interest groups. Multiple state and federal databases and tools exist to support this effort. Jurisdictions participating in this program should make efforts to assure that the projects and actions do not create social justice issues.

Measure compliance by investment levels and track nutrient reductions as supplemental information. As with the IAIA, the UNRBA recommends that compliance under the revised strategy be tracked by investment and the amount of nutrient reductions be tracked as supplemental information. One of the fundamental differences of the IAIA compared to conventional regulatory approaches is that compliance is tracked by required investment in eligible activities rather than counting the nutrient pounds reduced. This approach provides three key benefits: 1) local governments can plan for required investment levels as part of their budgeting process, 2) activities that do not have state-approved nutrient credits that are known to be beneficial to water quality and quantity can be incorporated into the program, and 3) projects can occur within jurisdictional boundaries that benefit citizens across the watershed as well as downstream water quality. Representatives of agriculture have indicated that they prefer to maintain ownership of their nutrient loss tracking and reporting. This cooperative approach would allow that to continue while potentially leveraging funding from other sectors. Department of Transportation (DOT) representatives have indicated an interest in participating in this revised program.

Nutrient Reduction Opportunities

Nitrogen and phosphorus are naturally occurring elements that are necessary in appropriate amounts for a healthy ecosystem. These nutrients cycle through the air, soils, groundwater, surface water, plants, algae, and other organisms. The UNRBA recognizes the importance of continuing to address nutrient loading using conventional methods, and significant progress cannot be made in this unique watershed if only conventional methods are used. A watershed-approach is needed to limit inputs to the system and sequester nutrients before they reach Falls Lake.

The UNRBA recommends that all opportunities for nutrient reduction be considered in the revised strategy, not as requirements but rather as potential opportunities for cooperation.

Proposed Legislative Changes

The NC Collaboratory is funding a study to evaluate potential changes to the Falls Lake Rules that would allow for a more collaborative, system-based approach to nutrient management in the watershed. The UNRBA is working with the lead author of this study, Dan McLawhorn, to better understand existing legal constraints on its proposals and where legislative changes may be required. A link to the presentation on this topic at the 2023 Falls Lake Nutrient Management Study

Symposium hosted by the NC Collaboratory is available here. The UNRBA will begin developing recommendations for potential rule changes after its December 2023 submittals and plans to coordinate this effort with DWR. Rules will be amended to be consistent with the General Statutes and Session Laws which apply to the program.

Status of the UNRBA Recommendations

This Concepts and Principles Document was developed based on input from the PFC and the Board of Directors, as well as input from external stakeholders, including staff from DWR and representatives from agriculture, DOT, and Non-Governmental Organizations (NGOs). These discussions identified several program components to guide development of the revised Falls Lake Rules. Many program components are designed to promote flexible implementation of the rules. These concepts and principles have been distilled into an updated set of Consensus Principles (called Consensus Principles II) for consideration by the governing bodies of the UNRBA members (e.g., county commissioners, town councils, city councils, utility boards). Once the individual governing bodies have signed the Consensus Principles II and endorsed the UNRBA recommendations for the revised nutrient management strategy, the UNRBA will submit these documents to the EMC and DWR.

As the rules readoption process unfolds, discussions among UNRBA members and other external stakeholders will continue. Additional recommendations and responses to stakeholder feedback will be considered during this process.

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Background and Supporting Information

History of the Reservoir and Characteristics of Falls Lake and its Watershed

The history of Falls Lake reservoir provides important context for its current water quality. The "lake" is a man-made body that results in an impoundment of the Neuse River at the natural fall line of the river at "the Falls of the Neuse." The placement of the Falls Lake Dam converted a natural, riverine environment to one with hydrologic, habitat, and ecological conditions very different from those that existed previously. This conversion has resulted in factors that affect water quality that were not present before the river was dammed. The reality of this history brings us to the regulatory and water quality policy crossroads of how this management effort should proceed over the coming decades.

The Falls Lake reservoir project was authorized by Congress as part of the Flood Control Act in 1965 and began filling in January 1983. Figure 1 shows an old earthen dam uncovered during the construction of the Falls Lake dam in the late 1970s. The Congressionally authorized uses of Falls Lake include flood control, drinking water supply, recreation, fishing, aquatic life, and wildlife. Design and construction of the impoundment were conducted by the U.S. Army Corps of Engineers (USACE), which continues to manage and operate the reservoir today.

Figure 1. Construction of the Falls Lake Dam, photograph courtesy of the US Army Corps of Engineers as cited by the Wake Forest Historical Museum.

Pre-impoundment studies predicted that Falls Lake would be highly eutrophic (over-enriched with nutrients), especially in the shallow, upper end of the lake (DNER 1973, USACE 1974, NCDEM 1983). These studies also predicted that chlorophyll-a concentrations would be high and that dissolved oxygen would be depleted in deeper portions of the lake during thermally stratified (warm summer) conditions.

Laboratory analysis of chlorophyll-a measures the green pigment in a water sample and is used as an indicator for algal growth. In 1979, the NC EMC established a chlorophyll-a criterion of 40 µg/L. The driving force for this water quality standard was poor water quality conditions on the Chowan River in northeastern NC. The Chowan River is a tributary to Albemarle Sound. Water quality conditions in this estuary in the 1970s resulted in demonstrated impairments to the waterbody that directly impacted the classified, designated uses. In response to these impacts, the Division of Environmental Management (predecessor agency of what is now the Division of Water Resources, DWR) evaluated these conditions and convened a group of established scientists and subject matter experts. This group provided a recommendation for a benchmark level of algal activity, using chlorophyll-a as indicator. This threshold would guide regulatory action to address the problems on the Chowan River. The agency, through the EMC, adopted the benchmark level as a standard and applied this value to all waterbodies in the state. The evaluation that led to this standard was not specifically referenced to use support impacts in reservoirs.

Despite the water quality predictions provided in the pre-impoundment studies, it was concluded that the expected levels of algal activity would not impede the anticipated designated uses of Falls Lake. NC allowed the construction of the dam under Section 401 of the Clean Water Act (the Water

Quality Certification required for permitting of a "fill" under Section 404). Evaluations conducted as part of the reexamination process have demonstrated that the lake is meeting its designated uses. There have not been nutrient-related fish kills since the lake was filled. The City of Raleigh is able to use Falls Lake to provide drinking water to over 500,000 customers and was awarded 3rd place in the 2023 American Water Works Association's international ""Best of the Best" Water Taste Test." Dissolved oxygen levels are sufficient to provide aquatic habitat to many species, and the lake supports recreational activities throughout the year.

Monitoring by DWR and other organizations show elevated chlorophyll-a levels at some locations and times of year in the lake. However, these levels are lower than predicted, and they have not resulted in any demonstrated water quality or use-related conditions that impair designated uses. For example, the earlier studies predicted summer average chlorophyll-a concentrations of 110 µg/L in the upper part of the lake while data collected from August 2014 to October 2018 show a summer average concentration of 41 µg/L. These data are summarized in the UNRBA 2019 Monitoring Report.

The decade-long evaluation process by the UNRBA and the 4-year study period funded by the NC Collaboratory have provided exceptional scientific information and knowledge about conditions in the lake and its watershed. Falls Lake is at risk of increasing eutrophication, but data and analyses indicate a relatively stable trophic condition at this time. Falls Lake is eutrophic, but it is not increasing in the level of enrichment. The lake currently meets its intended uses.

Nutrient reduction efforts in the watershed and changes in environmental conditions have resulted in significant reductions in nutrient loading to the lake since the designated "baseline" year of 2006. These conditions have not yet reflected significant and demonstrative reductions in chlorophyll-a in the lake. Due to the slow response of nutrient cycling processes in the lake and its sediments, the full implications of reduced loading over the last 17 years may not have fully manifested. However, lake water quality has stabilized since the Rules were enacted, and the lake is continuing to meet its designated uses. The revised strategy should include a long-term water quality review process to track water quality in Falls Lake and the other water supply impoundments in the basin.

Other watersheds in the country face similar challenges. The Chesapeake Bay Program Scientific and Technical Advisory Committee (STAC) released a Comprehensive Evaluation of System Response in May 2023. Similar to the Falls Lake watershed, the report concludes that "current efforts to reduce nutrient loads will not meet the TMDL targets" and that "estuary water quality has been slow to respond to realized nutrient and sediment reductions in many regions of the Bay" This report focuses on an estuary that drains a much larger watershed with more opportunities for implementation given the relative amount of agricultural land and urban land in the watershed. Even with additional opportunities for implementation in the Chesapeake Bay watershed, the report concludes that "additional nutrient reductions will improve water quality, but water quality criteria may be unattainable in some regions of the Bay under existing technologies."

Falls Lake was sited and constructed within a hydrologic, geologic, and nutrient balance environment that produced a unique morphological configuration and a reservoir environment that was destined to be eutrophic. All reservoirs in Piedmont NC strongly demonstrate a eutrophic nature, and this condition is unavoidable. Previous monitoring and evaluation as well as study, research, and assessment efforts over the last 11 years document this condition in Falls Lake. While all Piedmont reservoirs have different characteristics, site-specific water quality factors, and management challenges, the level of understanding of these factors and challenges are well understood for Falls Lake and its watershed. A revised Nutrient Management Strategy for Falls Lake needs to be based on the available science and sound management principles. While it is impossible to change the fundamental characteristics of this watershed and reservoir, a regulatory framework for nutrient

management is essential to maintaining designated uses. The critical management objective for Falls Lake must be to mitigate impacts from existing activities in the watershed and to design and manage land use changes while continuing to maintain and improve water quality in Falls Lake. Without reasonable, balanced, and economically supportable actions, the risk of increasing eutrophication, degradation of water quality, and adverse impacts to designated uses is a real possibility.

Regulatory and Statutory Requirements for Falls Lake, the UNRBA Response, and the Limitations of the Current Management Approach

Statutory Requirements and the Rules

In 2005, the NC General Assembly passed Senate Bill 981 requiring the NC EMC to develop a nutrient management strategy for Falls Lake. The bill also directed the Commission to "consider the cost of the proposed measures in relation to the effectiveness of the measures. These measures could include, but are not limited to, buffers, erosion and sedimentation control requirements, post-construction stormwater management, agricultural nutrient reduction measures, the addition of nutrient removal treatment processes to point source permitted wastewater treatment plants, the removal of point source discharging wastewater treatments through regionalization and conversion to non-discharge treatment technologies, and any other measures that the Commission determines to be necessary to meet the nutrient reduction goals."

In 2009, Senate Bill 1020 was passed to provide credit for early implementation of practices installed before the Rules were adopted. This bill also delayed adoption of the Rules from July 1, 2009, to January 15, 2011, and required that "stormwater management programs to reduce nutrient loading from new development be implemented no later than 30 months after the Rules become effective." Additional measures listed for consideration in the nutrient management strategy were included in this bill: "measures to address nutrient inputs from on-site wastewater treatment systems, control of atmospheric deposition, allowing the sale and purchase of nutrient offsets, and allowing trading of nutrient loading allocations and credits for nutrient reductions." The bill also specified design standards for sedimentation and erosion control for land-disturbing activities and stated that this section of the bill would not be delayed and would have a start date of January 1, 2010. These requirements were addressed in the Falls Lake Rules.

To support rules development, DWR used predictive modeling of the watershed and the reservoir to develop the Falls Lake Rules, which set two stages of nutrient reduction requirements for the lake. In January 2011, the Falls Lake Rules were adopted by the EMC. The Rules state:

> *The objective of Stage I is to, at minimum, achieve and maintain nutrient-related water quality standards [chlorophyll-a criterion] in the Lower Falls Reservoir [downstream of Highway 50] as soon as possible but no later than January 15, 2021, and to improve water quality in the Upper Falls Reservoir [upstream of Highway 50]. The objective of Stage II is to achieve and maintain nutrient-related water quality standards throughout Falls Reservoir. This is estimated to require a reduction of 40 and 77 percent in average annual mass loads of nitrogen and phosphorus respectively, delivered from the sources named in Item (6) in the Upper Falls Watershed from a baseline of 2006. The resulting Stage II allowable loads to Falls Reservoir from the watersheds of Ellerbe Creek, Eno River, Little River, Flat River, and Knap of Reeds Creek shall be 658,000 pounds of nitrogen per year and 35,000 pounds of phosphorus per year. (15A NCAC 02B .0275)*

However, both the monitoring and modeling were developed on a compressed time schedule with limited data. As a result, there is significant uncertainty in the nutrient load reduction targets and

the ability of the lake to meet chlorophyll-a water quality criteria regardless of the nutrient load reductions achieved.

In the 2010 Fiscal Analysis for Proposed Nutrient Strategy for Falls of Neuse Reservoir (hereinafter DWR Fiscal Analysis), DWR estimated compliance with Falls Lake Rules to cost $1.54 billion, with $604 million for Stage I requirements and $946 million for Stage II requirements. According to the USEPA Municipal Preliminary Screener, Stage II reductions alone ranked as a "Large Impact" to affected communities with each household contributing approximately $1,400 per year (Cardno ENTRIX 2013).

The DWR Fiscal Analysis described its cost estimates as "conservative high-end" because it assumed that technological advancements would lead to more effective nutrient removal measures and more cost-effective compliance options before the Rules took effect (DWR 2010). However, the analysis also presented evidence that costs could be much higher and nutrient reductions could be impossible to meet. Using a watershed assessment of Ellerbe Creek conducted by the City of Durham, DWR extrapolated data to estimate a total, high-end cost of the Rules. The resulting estimate was $1.5 billion to achieve **one third of nitrogen reductions** and **one half of phosphorus reductions** required by the Rules. DWR addressed this possibility: "This suggests a much greater ultimate cost than we have estimated as high-end, or simply unachievable reductions. We expect, however, that more cost-effective solutions to conventional BMP [best management practices] retrofits will continue to emerge, making costs of this nature unnecessary" (DWR 2010, p.85). The 2011 Rules established two portions of Falls Lake for assessing compliance: upstream and downstream of Highway 50. These portions are called assessment units (AUs) which are used under NC's 303(d) assessment process to determine compliance with water quality standards as required under Section 303(d) of the Federal Clean Water Act. NC has incrementally increased the number of AUs in Falls Lake over the past two decades to 12 AUs. The UNRBA has sought to stabilize the 303(d) process to be consistent with the Rules. The UNRBA offered the following comments to the EMC in a letter dated February 18, 2022: "The current dynamic assessment approach (changing AU's) represents a moving target and results in considerable confusion about attaining and maintaining compliance with the water quality standard. Consistent AUs should be established based on the lakes limnologic and morphologic characteristics consistent with EPA guidance. It is also important that the assessment approach be aligned with the management strategy laid out in the Falls Lake Rules. The Draft IR [now final] now includes 12 assessment units (7 upstream and 5 downstream of Highway 50). Falls Lake has a robust monitoring program performed by both the Division of Water Resources and the Center for Applied Aquatic Ecology. Combined, this effort represents approximately 28 monitoring stations in the lake. Applying the current Assessment Methodology continues to increase the number of Assessment Units and challenges the ability of ever attaining the water quality standard for chlorophyll-a in Falls Lake. This "station-by-station" approach does not reflect the physical morphology of the lake. Since the 2008 water quality assessment the number of AUs for Falls Lake has changed from 2 to 12. The increasing number of units has not been due to changes in standards or classification or even designated uses. Rather, it represents the expansion of data collection and the variability of the monitoring results."

The established path for addressing waters that are not meeting water quality standards is laid out in the Federal Clean Water Act (first adopted in 1972). It is a model that has resulted in dramatic improvement of water quality across the country. Companion legislation in NC has been consistent with this framework. It is a "command and control" framework that is based on clear cause and effect of identified pollutant sources impacting downstream water quality. It has worked extremely well when the need for reduced pollution is primarily due to point sources or specific land use activities.

For more disparate watershed related water quality issues, the conventional framework is mostly ineffective. There are extremely limited situations where such regulatory efforts have been successful in reducing the impacts of non-point sources to the degree necessary. One well-known example of the struggles of managing a watershed-based water quality concern is the Chesapeake Bay program. With the application of tremendous financial and management resources, improvements have been elusive. Progress has been and continues to be made, but it remains a challenge to meet. The Chesapeake Bay Program STAC states in their May 2023 Comprehensive Evaluation of System Response that "the legal requirements of the Clean Water Act [the water quality goals in the Bay] divert attention away from considering multiple means of improving living resources [support of aquatic life as the designated use]." The "dead zone" at the mouth of the Mississippi River in the Gulf of Mexico provides another example of the monumental difficulty of achieving significant mitigation of existing land use within a watershed.

Individual degraded streams throughout the country have similar challenges. The Federal 303(d)-process identifies streams with degraded biological integrity, among other programs, usually resulting from watershed-based impacts. In NC, many of these situations do not lend themselves to establishing a Total Maximum Daily Load (TMDL) or do not have the regulatory authority to establish a Water Quality Management Plan that will effectively address the degraded biological integrity of the stream. Most of these streams stay on the 303(d) list of impaired waters and do not have actions in place to manage the pollutant sources within the watershed.

Nutrient issues are predominantly caused by watershed impacts and non-point sources distributed throughout the watershed feeding the reservoir, estuary, or slow-moving stream or river. The long-established framework of "put limits on the sources and solve the problem" does not work in these situations. This is not a failure of intention but rather a failure to identify the true need for a management framework and to define a feasible management system to address the real problem. Faced with similar challenges, the Chesapeake Bay STAC indicates that "additional funding of existing implementation efforts is unlikely to produce the intended nutrient reduction outcomes" and that "achieving and sustaining substantial nonpoint pollutant reductions will likely require development and adoption of new implementation programs and tools."

In other words, the conventional framework does not work for watershed-based water quality issues. That is certainly true based on the findings of the scientific work on Falls Lake. To move this process forward with broad support and allocation of resources to maintain and improve water quality in Falls Lake, an updated nutrient management strategy for Falls Lake is essential.

The conventional source-control framework does not work for watershed-based water quality issues, particularly for the Falls Lake watershed which is mostly unmanaged lands. An updated approach is required to move this process forward with broad support and allocation of resources to maintain and improve water quality in Falls Lake.

In order to develop a more scientifically valid approach, a comprehensive reexamination effort was undertaken by the UNRBA as allowed by the Falls Lake Rules. The Falls Lake UNRBA reexamination effort and the research funded by the NC Collaboratory provide a unique and deep understanding of this watershed and reservoir. It is now the most monitored and studied reservoir in NC. The careful assessment of the data and information by subject matter expert review, statistical comparisons, and watershed and lake modeling provides clarity on how this watershed and lake behave. This level of information is not available for other NC reservoirs and was not available when the current Falls Lake Rules were developed.

However, scientific knowledge and understanding alone cannot effectively consider the unique characteristics of this watershed and lake in developing an improved management approach. Water quality management policy is an essential component in deciding the most effective way to maintain and improve water quality in Falls Lake, now and in the future. The science provides clear evidence regarding specific management actions that can meet the water quality standard for chlorophyll-a throughout the lake. The cause-and-effect aspects of nutrients in this watershed and lake cannot be dramatically changed. Despite significant reductions in nutrient loading to Falls Lake since the mid-2000s, chlorophyll-a concentrations have remained stable. While the chlorophyll-a concentrations are above the standard of 40 µg/L in some parts of the lake, there are no reports of impacts to water treatability, fish kills, algal scums, or mats. This evaluation indicates that the current water quality standard for chlorophyll-a is not well correlated to uses in this lake and is therefore not applicable to Falls Lake. The standard is incorrect for this system and cannot be achieved. Thoughtful and effective management actions, consistent with the scientific findings and feasible to implement, are needed to protect water quality in Falls Lake. The characteristics of this watershed and lake indicate that dramatic changes are not possible. A eutrophic Falls Lake will always exist.

A reasonable management objective should be to prevent a trophic condition that will impede designated uses. This watershed is becoming more urban and suburban, and that transition will continue. Development in the watershed is an essential economic factor for this region and the jurisdictions within the watershed. Land use is shifting away from its historic composition to more intensely developed areas within the watershed. The New Development Rules currently in place mitigate this shift, but long-term changes in the hydrology and nutrient balance within the watershed are still expected. Controls on runoff from new development manage the first inch of runoff from a developed site. While most rainfall events in our region do not exceed one-inch, higher rainfall storms, sometimes several inches, are becoming more frequent. A portion of storms greater than 1 inch bypasses treatment and delivers untreated flow and nutrients to Falls Lake. Larger storms also saturate pervious areas in the watershed including unmanaged lands. Saturated soils result in surface and subsurface transport of nutrients to streams.

Without other watershed mitigation efforts, nutrient loading to Falls Lake will continue to increase over time. Development increases the amount of impervious surface and results in compacted soils. These changes alter the hydrologic and water quality properties of the development site and downstream waters. Land preservation is a critical safeguard for keeping the watershed as natural as possible, particularly considering a recent decision by the US Supreme Court regarding protection of wetlands that do not have a "continuous surface connection to waters of the US" (Sackett versus EPA, Docket number 21-454). Other waters may also be at risk depending on interpretation of the decision. Land conservation should be a voluntary aspect of the revised management strategy and should be recognized by the State as a critical component of a long-term nutrient management strategy. The Raleigh Watershed Protection Program has a target of preserving 30,000 acres of high priority lands by 2045. Retrofits on existing land use are also useful, but 75 percent of the watershed is currently forested, wetlands, or other unmanaged lands. The Interim Alternative Implementation Approach (IAIA) is a sustainable model for keeping the watershed as stable as possible as it includes land conservation as an eligible practice in addition to more conventional stormwater control measures and best management practices.

Unmanaged land in this watershed is a critical reason that lake water quality continues to support designated uses. The composition of the watershed, implementation of new development rules, and the improvements that have been made since the baseline year of 2006 have resulted in a stable trophic condition. There is a tremendous opportunity to structure a management approach that is broadly supported, economically viable, and aimed at an achievable goal. This document identifies

the concepts and principles that outline a revised strategy based on the latest science, good public policy, and common ground among the many stakeholders.

Reexamination of the Rules Under the Adaptive Management Provision-

While the Rules were being developed, UNRBA member jurisdictions developed the Consensus Principles to address key provisions of the rules and recognize uncertainties about the basis for the requirements. The Consensus Principles are a memorandum of agreement between the jurisdictions in the watershed that called for a two-stage approach to nutrient reductions and the potential for reexamination of Stage II. This adaptive management provision was critical because it put in place a review process ahead of the very restrictive provisions of Stage II. In basic terms, the Falls Lake Rules adopted by the EMC allow for a "reexamination" of the required actions under Stage II. An entity is allowed to initiate and conduct a reexamination using a DWR-approved assessment process as laid out in the rules (15A NCAC 02B .0275 (5)(f)) and to bring findings back to the Division and the EMC.

The UNRBA began planning for the reexamination under the cited provision in 2011. In 2013, a framework for conducting the reexamination was developed and approved by DWR. This framework established the plan to review historic data and models for Falls Lake, develop recommendations for additional monitoring, conduct the monitoring, and develop modeling tools to allow assessment of the lake and evaluate different management approaches. The UNRBA's plan included a watershed model and three lake water quality models.

The primary purpose of the UNRBA monitoring program was to provide the necessary data and information to support development of the models that would be used to evaluate updated management approaches. Prior to collecting data, the UNRBA evaluated all available data that had been collected on Falls Lake and its watershed. The monitoring program and other provisions of the reexamination required approval by DWR. The UNRBA secured necessary approvals from DWR for evaluation of the current Falls Lake Nutrient Management Strategy including the UNRBA Monitoring Plan and UNRBA Monitoring Quality Assurance Project Plan (QAPP). These documents and the publicly accessible database are available in the UNRBA resource library.

Also as required by the Rules, the UNRBA submitted and DWR approved the Description of the Modeling Framework and the UNRBA Modeling QAPP that specifies how the models should be developed and assessed for performance. The UNRBA conducted a model selection process and selected the following models: the Watershed Analysis Risk Management Framework (WARMF) to conduct watershed and lake modeling, the Environmental Fluid Dynamics Code (EFDC) as the second lake model, and a statistical/Bayesian model as the third lake model. The purposes and relationships of these models toward developing a revised strategy is described in the Conceptual Modeling Plan (Figure 2). The UNRBA has not only provided DWR with the required documentation for the reexamination but has also provided documentation of all its process and decision-making including model selection and discussions of the contracts and scopes of work for those efforts. DWR representatives regularly attend the meetings of the UNRBA, and many follow-up discussions have occurred with the agency to ensure there is a clear

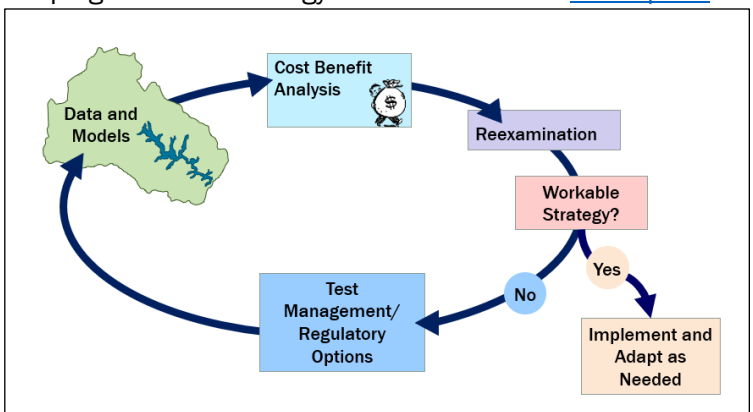


Figure 2. UNRBA Conceptual Modeling Plan for the Reexamination of Stage II

understanding of the work being done to support the UNRBA's recommendations on a revised nutrient management strategy.

In 2016, the NC General Assembly passed legislation (Section 14.13.(a)) that established the NC Collaboratory. One of the initial charges of this organization was to study nutrient management strategies in general and for Jordan and Falls Lakes specifically. This initial legislation required the Falls Lake study to be completed by December 2021. The General Assembly later passed legislation to extend the deadline to December 2023 to allow the UNRBA reexamination process to complete. This legislation also includes a reference to other evaluations of the Falls Lake Nutrient Management Strategy. The bill requires the EMC to consider that information along with the report by the NC Collaboratory.

Following the creation of the Collaboratory, the UNRBA coordinated closely with the organization and its researchers. This allowed the UNRBA to provide input each year on what additional studies would enhance and better inform its work. The UNRBA has shared all its data, work, and preliminary results with the Collaboratory. The Collaboratory also provides subject matter expert and third-party review of the UNRBA modeling efforts. This extremely valuable contribution has been occurring while the models were under development rather than after. This integrated approach allowed the reviewers to provide input and feedback as the models were developed and allowed the modeling team to incorporate adjustments before the models were finalized. Third party reviews increase transparency and provide an extra layer of assurance that the models can be relied upon to support regulatory and policy decisions.

By the end of this reexamination process, the UNRBA membership will have invested approximately $10 million to support this effort. This is an unprecedented effort by a regulated community in NC to provide study and research to DWR, EMC, and the General Assembly to support the development of a management approach on a critically important water body. The purpose of this document is to compile key findings from the available studies and present a document that identifies important concepts and principles that should be included in a revised nutrient management strategy for Falls Lake. This document includes notes derived from discussions or materials generated by the Executive Director, Co-chairs of the Path Forward Committee (PFC), Chair of the Modeling and Regulatory Support Workgroup (MRSW), the Scenario Screening Workgroup and its subgroups, members of the MRSW, PFC, and Board of Directors, workshop/symposium participants, and interested stakeholders who have participated in this process. Most of these discussions are based on presentations that are available on the UNRBA meeting page. Most of this input and discussion has occurred during UNRBA meetings. These meetings are open and all attendees, including stakeholders outside of the UNRBA membership, are invited to attend and provide input.

Key Findings from the Monitoring and Modeling Studies

UNRBA Monitoring Program

Routine water quality monitoring in the watershed began in August 2014 and continued through October 2018. The watershed monitoring program obtained monthly samples on 20 water quality parameters from 38 tributary stations. This effort resulted in more than 38,000 measurements and created a database that covered essentially every sub-watershed to Falls Lake. Targeted special studies were also conducted to provide a detailed understanding of the functions of the watershed and lake. It was essential to the analyses and modeling that this data and information collection effort identified the variation of the input of nutrients and other parameters into the lake. It was also a major objective to carefully document and measure Falls Lake's physical, chemical, biological, and geological characteristics. These special studies included storm event sampling, high-flow event sampling, lake sediment depth and quality, lake sediment nutrient storage and release, lake

bathymetry, constriction point monitoring of water movement and water quality from segment to segment of Falls Lake, and light extinction data. For example, Figure 3 shows the water depth information resulting from the UNRBA bathymetric study. This figure also shows how Interstate 85 and Highway 50 segment the lake into what is referred to below as the upper, middle, and lower lake segments.

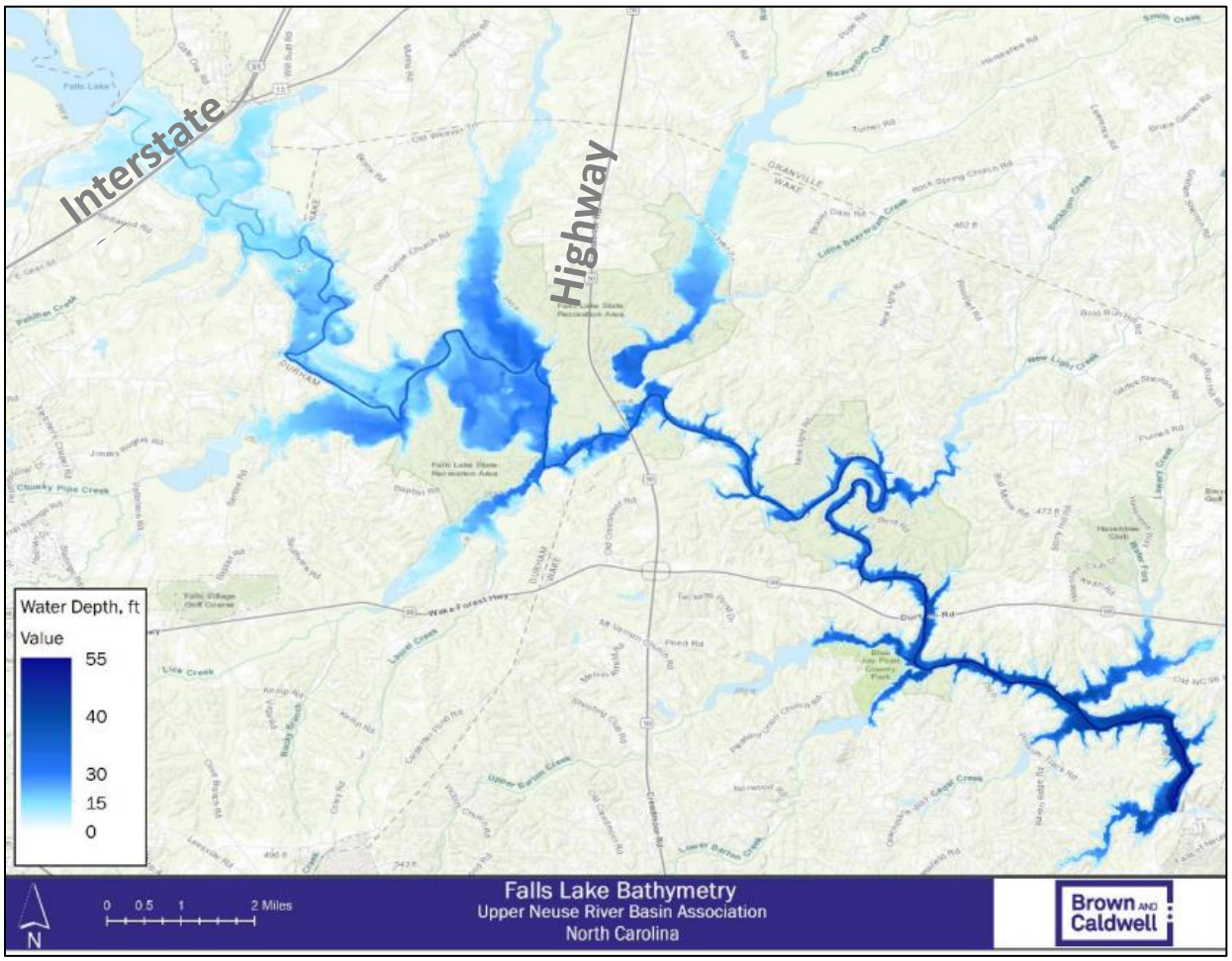


Figure 3. Falls Lake Water Depth

The UNRBA invested approximately $3.5 million in the monitoring effort to fill data gaps in the previous monitoring and modeling effort and provide an improved understanding of the lake and the watershed. In addition to providing an annual report of the monitoring effort as it proceeded, the UNRBA developed a comprehensive monitoring report in 2019 that summarizes the monitoring data and special studies. These efforts provided a comprehensive database that covered the key nutrient-related water quality considerations of the lake, including nutrient loading summaries by source and through time, lake residence time, dissolved oxygen concentrations, and algal toxin data. The UNRBA's monitoring data, DWR data, and data collected by other organizations (NC State University Center for Applied Aquatic Ecology, and the cities of Durham and Raleigh), has been evaluated and included in the data evaluation. This data has been used to develop watershed loading and lake water quality simulation models. The research funded by the Collaboratory has also provided critical insight and understanding of the watershed and lake. Monitoring studies conducted by the US Forest Service in the watershed have provided important information regarding nutrient loading from forested areas. All of this has been incorporated into the UNRBA's evaluation of this

watershed-lake system to inform and support the concepts and principles for the revised nutrient management strategy.

While the UNRBA's complete effort includes comprehensive modeling and the development of tools that can assess the effectiveness of potential management approaches, the data, special studies, and information developed to support the modeling provides an excellent reference and basis for understanding this lake and watershed. The data itself is a "model" by conveying the status of water quality, spatial and temporal variation, and correlations among data sets. A large and extensive database provides important graphical and statistical information that informs further analysis and decision-making. The UNRBA's comprehensive monitoring report, which includes historic data, provides essential insight into the Falls Lake system and documents conditions that must be considered in the regulatory decision-making process.

As a result of the UNRBA's evaluation of the data, one critical finding is that nutrient loading is not the only driver of algal growth in the lake. At times, algal growth and changes in algal activity are independent of short-term changes in nutrient loading and nutrient concentrations in the lake. Other influences such as lake sediment nutrient release, hydrology, and hydraulics in the lake and watershed can be more important in determining the trophic conditions in the lake than nutrient concentrations or loading.

Physical conditions in the lake as well as chemical and biological variation are important drivers of algal growth. The amount of time the water remains in Falls Lake is controlled by the tributary inflows to the lake and releases from the dam which are controlled by the USACE. The release protocol for the dam is directed first at flood control and then, under low-flow situations, water supply and minimum releases to support downstream aquatic life. The longer the water remains in the lake, the more algal activity and growth. Other environmental issues arise during long detention periods including temperature increases and more pronounced fluctuations in dissolved oxygen and pH. This hydrologic condition also impacts lake stratification and the quality of water just above the lake sediment-water interface, impacting the rate of nutrient cycling in bottom sediments. Algal species distribution is impacted as well. Changes in detention time and environmental, chemical, and other physical characteristics impact the function of the arms of the lake including denitrification and settling of suspended materials.

The release protocol for the dam is directed first at flood control and then, under low-flow situations, water supply and minimum releases to support downstream aquatic life. The longer the water remains in the lake, the more algal activity and growth.

High-flow events impact algal conditions in the lake, particularly in the upper portion of the reservoir where the five major tributaries provide more than 60 percent of the flow to Falls Lake. Nutrient inputs in terms of tributary loading are driven by stream flows.

During wetter rainfall periods, high nutrient loading from the watershed associated with high precipitation and stream flows can transport higher sediment and nutrient loads to Falls Lake. These events may increase flushing and reduce residence times. Figure 4 shows the Flat River nearly rising to the bridge deck following a high rainfall event.

Figure 4. Flat River rising near the bridge deck following a UNRBA High Flow Sampling Storm Event

Periods of low loading from the watershed correspond to small inflows and longer residence times when algae are provided longer periods for growth. Sporadic storm events that occur during periods of long detention can provide pulses of nutrients to Falls Lake that may remain stagnant in the lake for an extended time.

The complex relationship between hydrologic condition, nutrient loading, and lake residence time means there is not a predictable cause-and-effect relationship between loading and algal growth. Figure 5 shows that in upper Falls Lake (upstream of Interstate 85), chlorophyll-a concentrations have been declining since the 1980s. This part of the lake historically had more variability in chlorophyll-a concentrations as demonstrated by the longer boxes and whiskers in Figure 5. Chlorophyll-a data were not collected in the upper lake between 2008 and 2012. Since data collection restarted in 2013, chlorophyll-a concentrations have been relatively stable. The middle part of the lake (between Interstate 85 and Highway 50) has lower chlorophyll-a concentrations and less variability than the upper lake. Chlorophyll-a concentrations in this segment have been relatively stable since 2001. In the lower part of the lake (downstream of Highway 50), chlorophyll-a concentrations have been relatively stable over the life of the reservoir, even in the 1980s when concentrations in the upper lake were much higher. During the UNRBA 2014 to 2018 monitoring period, chlorophyll-a concentrations in Falls Lake were highest in 2017 (especially below Highway 50) compared to other UNRBA monitoring years, but nutrient loads that year were approximately half (see the following discussion of UNRBA Watershed Modeling for more information on this characteristic).

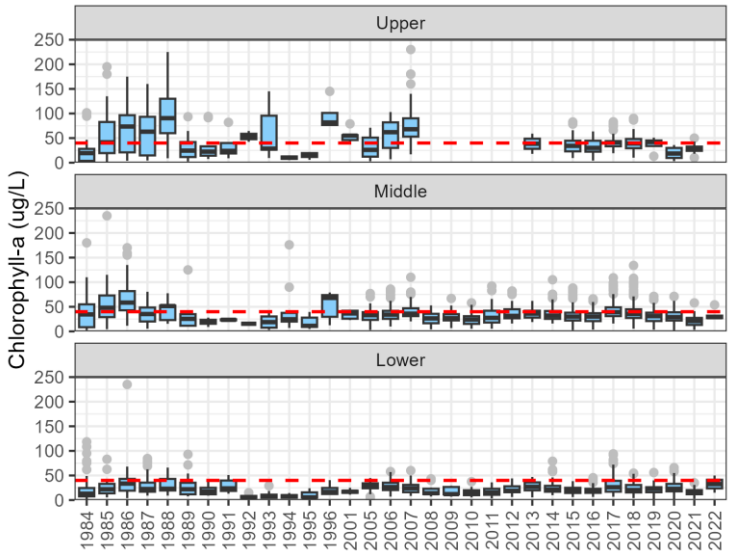


Figure 5. Distribution of Chlorophyll-a Measurements in Upper Falls Lake (upstream of Interstate 85), Middle Falls Lake (between Interstate 85 and Highway 50) and Lower Falls Lake (downstream of Highway 50 to the Dam)

Two additional sources of nutrient loading affect the lake directly. Atmospheric deposition contributes nitrogen, phosphorus, and organic carbon directly to the surface of Falls Lake as well as to the contributing drainage area. Atmospheric deposition data incorporated into the monitoring and modeling shows total nitrogen loads from atmospheric deposition have declined by approximately 20 percent since 2006 (DWR 2021). The bottom sediments within Falls Lake accumulate, release, and cycle nutrients. The UNRBA 2019 monitoring report estimated that lake sediments release approximately 200,000 pounds of total nitrogen each year (10 percent to 25 percent of the watershed load depending on rainfall and the year referenced) and 14,000 pounds of total phosphorus (5 percent to 15 percent of the watershed load depending on rainfall and the year referenced). These preliminary estimates of lake sediment releases have been refined through the UNRBA lake modeling efforts and Collaboratory studies.

The UNRBA 2019 monitoring report estimated that lake sediments release approximately 200,000 pounds of total nitrogen each year (10 percent to 25 percent of the watershed load depending on rainfall and the year referenced) and 14,000 pounds of total phosphorus (5 percent to 15 percent of the watershed load depending on rainfall and the year referenced)

To summarize, the hydrology, morphology, retention time, depth, and characteristics of the different areas of the lake contribute significantly to nutrient loading and chlorophyll-a levels in the lake. These aspects of the lake are beyond the control of the regulated entities in the watershed. While the UNRBA aims to manage nutrient loading in the watershed, it recognizes it is not the only factor to consider in developing a revised nutrient management strategy.

Many important data results and relationships contribute to an updated and improved understanding of this lake and watershed. The best way to examine those in detail is to access the UNRBA 2019 Monitoring Report.

UNRBA Watershed Modeling

The UNRBA has worked extensively with local governments, researchers, state and federal agencies, and utilities to obtain the most comprehensive and complete data available to develop a revised watershed model for Falls Lake. The UNRBA selected the Watershed Analysis Risk Management Framework (WARMF) model partly because it is the same model that DWR used to support development of the Falls Lake Nutrient Management Strategy. Data summaries and discussions related to the Falls Lake and watershed WARMF model development are documented in Modeling and Regulatory Support Workgroup (MRSW) meeting materials and the UNRBA Watershed Modeling Report (BC and Systech Water Resources 2023).

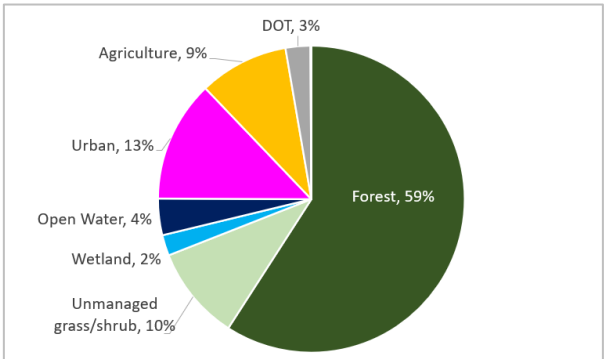
Development of a watershed model is an essential component of a fully informed management approach. The UNRBA has invested significant resources into an effective watershed model development process. The following summary of the watershed modeling effort is provided as context for the UNRBA recommendations for a revised nutrient management strategy. The modeling was reviewed extensively by subject matter experts, third-party model reviewers funded by the NC Collaboratory, and DWR modeling staff. The UNRBA has a high level of confidence in the results of this modeling. A more complete description of the model and the development process is available in the UNRBA Watershed Modeling Report (BC and Systech Water Resources 2023).

Land Use Data and Existing Development Retrofits

A primary input to watershed models is land use data. The Falls Lake watershed is comprised predominately of unmanaged lands (75 percent, Figure 6). Unmanaged lands represent natural areas or areas where former land management activities are no longer occurring (unmanaged grass/shrub areas). Opportunities to reduce nutrient loading from natural areas are very limited.

Opportunities to reduce nutrient loading from natural areas are very limited.

Less than 10 percent of the watershed is used for agriculture, which has declined nearly 45 percent from the baseline year. This decline in production has reduced nutrient loading to the lake. The NC Department of Agriculture and Consumer Services (NCDA&CS) indicates that there are few additional actions that can be taken in the watershed to further reduce nutrient loading from active farmland. Most of the streams in the watershed are buffered, conservation tillage is commonly used, and nutrient management plans and the high cost of fertilizer have lowered the amounts of fertilizer applied. These limited opportunities for additional reductions from agriculture are important to consider in the development of a revised management strategy.



75 percent of the watershed area is in unmanaged land uses: forests, grassland, shrubland, wetlands, or open water.

Figure 6. Distribution of Land Uses in the 492 thousand-acre Falls Lake Watershed (2014 to 2018)

Approximately 13 percent of the land is classified as developed, most of which is low intensity and non-DOT road rights of way. There are areas in the watershed like the City of Durham and central municipal areas in the smaller cities and towns where development is represented by more intensive "downtown" impervious land use, but this area is a small subset of the 13 percent classified as urban. In areas that are already densely developed, installation of engineered stormwater control measures (SCMs) is limited due to existing legal, logistical, technological, and economic constraints. Depending on soil conditions and other constraints, the application of some green infrastructure (including rain gardens and similar approaches) is possible with the cooperation of private property owners. The UNRBA's IAIA program encourages these type projects, but nutrient loading reductions are modest. Overall, the opportunity for SCM retrofits on these areas is extremely limited. Even if there were a high level of funding available, private ownership and logistic difficulties may not allow retrofits to occur on most developed sites. The NC General Assembly has prohibited the use of local government eminent domain to condemn property for control of stormwater impacts.

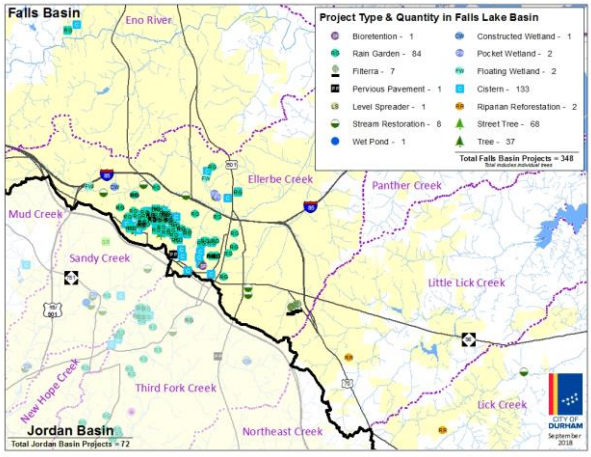


Figure 7. City of Durham Existing Development Retrofits as of December 2015

New development is already managed by every jurisdiction in the watershed under the current Falls Lake New Development Rule.

An example of installation of SCMs in an urban environment is in the City of Durham where the City installed over 350 nutrient and flow reduction measures by the end of 2015 on developed sites to improve water quality (Figure 7). Other local governments in the watershed have also installed retrofits to treat existing development. These projects were accounted for during calibration of the watershed model and were used for support of the IAIA concept. Installation of these projects illustrates the commitment of the jurisdictions in this watershed to mitigate water quality impacts of existing land use in the watershed.

More focused research on the question of applying retrofits was done through NC State University (Hunt et al. (2012), funded by the North Carolina Urban Water Consortium Stormwater Group, through the Water Resources Research Institute of The University of North Carolina). This study assessed opportunities and costs for the installation of SCM retrofits in several developed watersheds including Ellerbe Creek in the City of Durham. The findings indicated that if every potential existing development retrofit identified in the Ellerbe Creek watershed were implemented (at a cost of $16 million capital and $7 million annual maintenance costs), it would only reduce nitrogen loads by approximately 10 percent and total phosphorus loads by 25 percent. These reductions are much lower than the Stage II reduction requirements prescribed in the Falls Lake Rules (40 percent for total nitrogen and 77 percent for total phosphorus).

Development in the watershed occurring after 2011 is subject to the new development rules in the Falls Lake Nutrient Management Strategy. These rules have been implemented by the local governments and require installation of stormwater control measures to limit the amount of nutrients leaving the development to 2.2 pounds per acre of total nitrogen 0.33 pounds per acre of total phosphorus; 50 percent of these reductions must occur on site and 50 percent can be obtained through offsite credits acquired from the State. These amounts were set so that as lands in the watershed were developed, the load delivered to Falls Lake would not increase. The City of Durham began implementing new development requirements before the rules were passed and the loading targets were established. These interim development controls were adopted to reduce the amount of development requiring retrofits once the rules were passed. State law no longer allows for this type of proactive approach.

Soil Properties, Hydrologic, and Nutrient Application Data

Soils data and precipitation data are key drivers of hydrologic response and determine actual loading to streams from nutrients “applied” or deposited in the watershed. These inputs not only determine stream flows and nutrient loads delivered to Falls Lake but also the ability of nutrients to be stored and cycled in the system. Soil hydrologic and chemistry data were obtained from the US Department of Agriculture Natural Resources Conservation Service and the US Geologic Survey. Radar precipitation data for 78 locations in the watershed were provided by the NC State Climate Office (with support from NC Department of Transportation).

Human inputs of nutrients to the land surface are also an important part of the nutrient balance. The model accounts for monthly nutrient application to land surfaces on urban and agricultural lands. Atmospheric deposition of nitrogen and phosphorus is also applied to water surfaces and all land within the watershed, including unmanaged lands.

The passage of the Falls Lake Nutrient Management Strategy resulted in the formation of the Watershed Oversight Committee (WOC) for the Falls Lake Basin. Under the Rules, the WOC is charged with compiling, analyzing, and reporting data related to agricultural production, nutrient reductions, and compliance with the Falls Lake Nutrient Management Strategy. The WOC includes staff from the NCDA&CS Division of Soil and Water Conservation (DSWC), the USDA Natural

Resources Conversation Service, North Carolina Cooperative Extension, and the NC Department of Environmental Quality (DEQ), as well as agricultural and environmental interests from within the watershed. Information on the acreage of crops and pasture in the watershed and the amount and timing of nitrogen application was provided by the WOC for each county for inclusion in the watershed model. Assumptions regarding potassium and phosphorus application rates were obtained from the report "Delineating Agriculture in the Neuse River Basin" (Osmond and Neas 2011).

For developed lands, pervious surfaces such as lawns also receive nutrient application to support plant growth. Less information is available to develop the modeling assumptions for these areas because the owner types and individual preferences and practices vary widely (homeowners, institutions, parks, etc.). Fortunately, two publications that included local homeowner surveys are available to provide reasonable estimates of nutrient application for these types of areas (Fleming 2013 and Osmond and Hardy 2004). These data were used to help build the watershed model and provide a level of accounting for this source in the watershed that is not normally available.

Wastewater Treatment

The model also accounts for the treatment of wastewater as either point source discharges or non-point sources. Point sources are wastewater treatment plants (WWTPs) that can be considered major (discharging more than one million gallons per day) or minor (discharging less). Non-point sources are onsite wastewater treatment systems (e.g., septic systems and discharging sand filter systems).

There are four minor WWTPs (as defined by EPA) in the Falls Lake Basin that treat less than 1 million gallons per day of wastewater. Effluent data for these four facilities was provided by DWR. Two of these facilities are currently in compliance with the Falls Lake Rules, and two are not. While these systems do not contribute significantly to the nutrient load delivered to Falls Lake (one percent or less), they do represent an opportunity for incremental reduction in nutrient loading.

Effluent discharges from the major WWTPs (treating more than 1 million gallons per day of wastewater) were obtained directly from the North Durham Water Reclamation Facility, Town of Hillsborough, and the South Granville Water and Sewer Authority. Over $80 million have been invested to upgrade and optimize these three facilities since 2006. Based on DWR's 2021 Status Report for Falls Lake, these three discharges have reduced their collective total nitrogen and total phosphorus loads by 57 percent and 73 percent, respectively, from the 2006 baseline.

Sources of Nutrient Loading Delivered to Falls Lake

During the UNRBA study period (2014 to 2018), annual rainfall each year was average to high. Under these conditions, WWTPs contributed approximately 6 percent of the total nitrogen load and 3 percent of the total phosphorus load delivered to Falls Lake (Figure 7). These estimates are based on actual discharges, not permit limits.

A lower rainfall condition was also simulated with the model to represent DWR's baseline modeling period more closely (around 20 percent less rainfall than 2014-2018). Under these lower rainfall conditions, the model estimates that WWTPs would contribute approximately 10 percent of the total nitrogen load and 6 percent of the total phosphorus load delivered to Falls Lake. Based on the work of the Scenario Screening Group of the UNRBA and contact with the major system owners, further reducing the nutrient loading from these facilities would be extremely expensive and energy intensive. Additional reductions would also not significantly impact the total loads delivered to Falls Lake. Considering the contributions from watershed sources delivered to the lake, further reductions at WWTPs would have little impact on lake water quality. When looking at the types of actions that

will be most effective in reducing nutrient loading to the lake, it is important to recognize that this watershed is not dominated by point source loading.

One source of nutrients, atmospheric deposition, affects all the land uses and waterbodies in the watershed including the surface of Falls Lake, and not all of this source originates within the watershed. While atmospheric deposition of nitrogen has decreased by approximately 20 percent since the baseline period based on monitoring data from the National Atmospheric Deposition Program, it still contributes more than 40 percent of the total nitrogen that is applied or deposited to the watershed. Note that not all of this load is delivered to the lake. Figure 8 shows the projected amounts of nutrient load delivered from watershed sources to Falls Lake. There is also a component of the load that falls directly onto lake surfaces, and this contributes approximately 6 percent of the total nitrogen load to Falls Lake. As a point of reference, this percentage of loading from the atmosphere directly to the lake surface is the same contribution of total nitrogen load delivered from point sources.

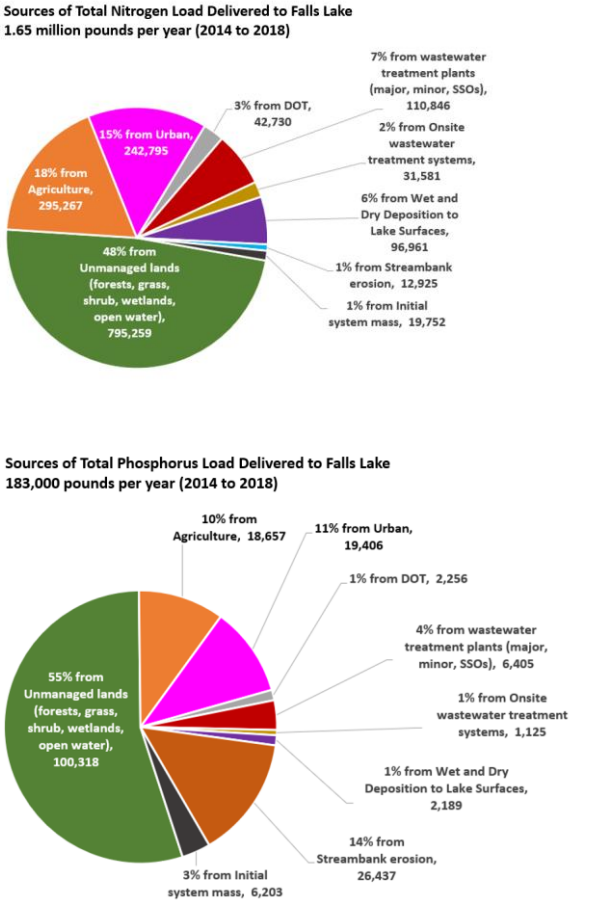


Figure 8. Sources of Delivered Total Nitrogen (top) and Total Phosphorus (bottom) Loads to Falls Lake Based on the Watershed Model

The watershed model simulates stream bank erosion separately from the individual land uses. Loads from stream bank erosion are calculated based on the erosivity of the stream bank soils, the amount of flow in the stream and resulting shear stresses, and stream bank stability metrics due to root systems and other soil characteristics. The model estimates that during 2014 to 2018, stream bank erosion contributed approximately 14 percent of the total phosphorus load delivered to Falls Lake. Because nitrogen content is low in the soil, the amount of nitrogen loading from streambank erosion is not significant. The Collaboratory has recently funded a study to identify the most likely areas of streambank erosion as a result of this modeling and at the request of the UNRBA. This study will be extremely helpful in identifying potential stream restoration sites for future investment projects.

Impacts of Watershed Processes on Delivered Nutrient Loads to Falls Lake

Based on the data compiled for the UNRBA watershed model, an average of 8.6 million pounds of total nitrogen per year were applied or deposited in the watershed in 2014 to 2018. Relative to the baseline period of calendar year 2006, this amount has decreased by approximately 37 percent. Most of the nutrients applied, deposited, or released to the watershed are removed from the system by crop harvesting, denitrification, and other physical, chemical, and biological processes. During the UNRBA study

Reducing one pound of nutrients in the watershed does not translate to reducing one pound delivered to Falls Lake.

period (2014 to 2018), approximately 1.65 million pounds of total nitrogen were delivered to Falls Lake each year. Thus, the watershed processes and crop harvesting reduce the total nitrogen applied to the watershed by approximately 81 percent prior to delivery to Falls Lake. For total phosphorus, the watershed processes reduced the amounts applied, deposited, or released to the watershed by approximately 84 percent. These reductions due to watershed processes and crop harvesting are important considerations for the revised nutrient management strategy. Reducing one pound of nutrients in the watershed does not translate to reducing one pound delivered to Falls Lake. On average, depending on the project location, a one-pound reduction of input may result in 0.2 pounds reduction delivered to Falls Lake. The 770 square-mile watershed is processing a significant amount of nutrients before they reach Falls Lake.

The UNRBA's watershed modeling has also improved understanding of the importance of soil chemistry on the transport, retention, and release of nutrients in the watershed. Soils in the watershed contain iron and aluminum that bind nutrients and release them slowly over time. This understanding must be factored into the revised strategy in terms of compliance dates and to moderate expectations about the length of time it will take for actions that reduce nutrients to impact water quality in the lake. The Chesapeake Bay STAC reported similar findings: realized nutrient load reductions had not translated to expected improvements in water quality.

The modeling also demonstrates that the significant efforts to reduce point and non-point source nutrient loading have had an important impact on delivered loads to Falls Lake. Because most of the land in the watershed is unmanaged (forests, wetlands, etc.) and extensive efforts have already reduced loading from human activities, approximately one-half of the delivered nutrient and carbon load to Falls Lake originates from unmanaged lands (Figure 8). Natural areas, including forests, cycle and provide important nutrients to waters that sustain aquatic life. Land preservation is a critical safeguard for keeping the watershed as natural as possible. These mostly natural areas dominate the drainage area and are important to the health of the watershed and the lake. Even watersheds that are 100 percent forested contribute flow, nutrients, and carbon to downstream waters – healthy ecosystems require nutrients and carbon to support life. Throughout UNRBA meetings, discussions, and document reviews, multiple stakeholders and experts have expressed that conservation must be a component of a revised nutrient management strategy. The scientific work supports this conclusion. The UNRBA's efforts and implementation of the IAIA support this activity as a critical component of future management.

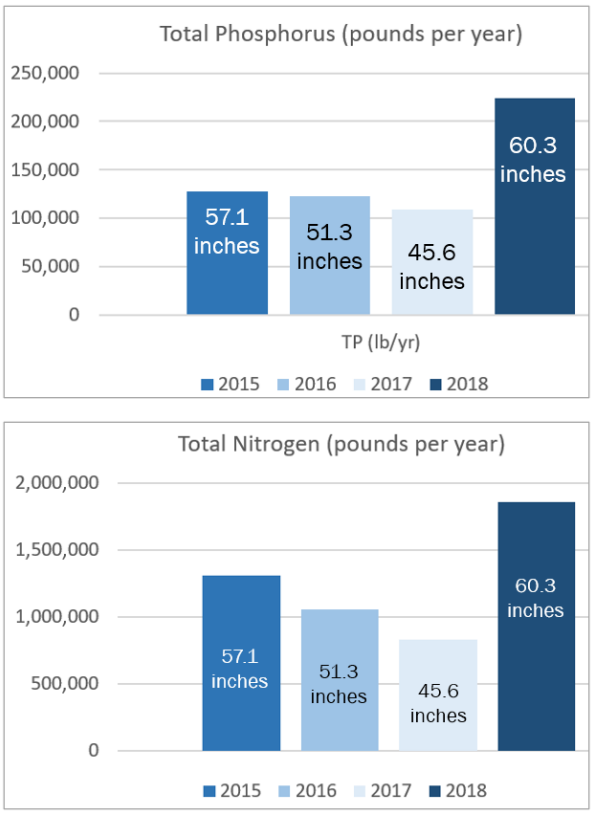


Figure 9. Annual Nutrient Loads Delivered to Falls Lake from the Watershed

As noted above, another important finding is the importance of precipitation and flow on delivered loading to Falls Lake (Figure 9). During an average rainfall year like 2017 (approximately 45 inches of rain at Raleigh Durham International Airport, RDU), delivered total phosphorus and total nitrogen loads were

approximately half of those delivered during a very wet rainfall year like 2018 (approximately 60 inches of rain at RDU).

The predictive models were developed and calibrated to observed water quality data from the monitoring period (2015-2018). The calibrated models were used to evaluate the impacts of different management options and model assumptions on delivered nutrient loading, lake water quality, and designated uses. The UNRBA convened a Scenario Screening Workgroup comprised of UNRBA members and representatives from DWR, agriculture, the US Forest Service, NC DOT, and environmental advocacy groups to prioritize these evaluations. Sensitivity analyses evaluate how much the parameters of concern (like chlorophyll-a) change when a model input or model parameter is changed (e.g., how much do simulated chlorophyll-a concentrations change if the modeled growth rate of algae is increased or decreased by 20 percent?). Scenarios were used to simulate different conditions than the model was originally calibrated for (e.g., how would simulated chlorophyll-a concentrations change if the USACE operated the lake differently?) Several model sensitivity analyses and model scenarios (e.g., 20 percent more or less rainfall) were evaluated using the watershed model to understand the impacts on delivered nutrients. The scenario with the greatest impact to delivered loading was the change in rainfall amount (Appendix H of the UNRBA Watershed Modeling Report). The majority of delivered load comes from non-point sources, and most of these areas are natural, unmanaged lands. This finding further demonstrates the limitations on additional, large-scale nutrient reductions as natural areas like forests are considered a balanced condition of nutrient inputs and outputs.

Implications for a Revised Nutrient Management Strategy

The watershed modeling results support the conclusion that achieving measurable load reductions to Falls Lake will require a systems approach directed at realistic and incremental change. The relatively small amount of managed land, constraints on the ability to install retrofits, relative effectiveness of load reduction projects, and the long response time of the watershed and lake will require a long-term effort to make progress. The revised rules should provide an adaptive management provision to reevaluate conditions in the future and make changes to the approach as needed (discussed later in this document). Any effective management approach must be flexible and include specific provisions for modifying the strategy as projects and improvements are tracked and as understanding about the system is supplemented. These recommendations for adaptive management are similar to the Chesapeake Bay STAC: "refining restoration goals over time should be considered as knowledge evolves about what future conditions are possible, what local communities and the partnership at-large see as priorities, and what is required to attain those possible futures."

The current Falls Lake Rules require a 40 percent reduction of total nitrogen and a 77 percent reduction of total phosphorus load delivered to Falls Lake relative to the baseline year of 2006. While significant progress has been made, there is no feasible means to achieve these reductions, and as a result, a reexamination of the Rules is needed.

Lake Water Quality Modeling

Three lake water quality models for Falls Lake were developed. Two of these simulate the physical, chemical, and biological processes (e.g., settling of sediment and algae, growth and decay of algae, nutrient uptake rates) in the lake and have been calibrated to match water quality observations collected in Falls Lake.

Researchers funded by the NC Collaboratory have been studying nutrient-related processes in Falls Lake since 2019. Some of these researchers also provided third-party and subject matter expert review of the lake and watershed models. The results of these research studies have been

incorporated into the development of the lake models developed by the UNRBA. For example, researchers found that denitrification in the lake arms reduces nitrogen before reaching the main part of the lake. They also measured rates of nitrogen fixation by blue-green algae where the algae can "import" nitrogen from the atmosphere to support their growth. The researchers found that rates of nitrogen fixation in Falls Lake are currently low. Reports on these and other studies funded by the NC Collaboratory are available online at https://nutrients.web.unc.edu/resources/. The UNRBA models were developed with significant input from the Collaboratory researchers and modeling staff at DWR.

UNRBA Lake Water Quality Models Developed to Support the Reexamination

One of the process-based models is a complex hydrodynamic/water quality/sediment nutrient release model that uses the Environmental Fluid Dynamics Code (EFDC) model framework. One of the reasons EFDC was selected is because it was used by DWR to set the nutrient load reduction requirements specified in the Falls Lake Nutrient Management Strategy. The other UNRBA lake model is a simpler hydrologic/water quality model that uses the Watershed Analysis Risk Management Framework (WARMF). One reason this lake model was selected is because it is directly linked to the WARMF watershed model. This direct linkage generates results for lake water quality when changes in the watershed are simulated. The DWR Falls Lake WARMF model did not include the WARMF Lake model for Falls Lake in the development of the current Falls Lake Nutrient Management Strategy (other impoundments in the watershed were simulated with WARMF Lake).

The UNRBA set up both the EDFC and WARMF Lake models for Falls Lake to use the information from the WARMF watershed model to simulate stream flows and associated sediment, nutrient, total organic carbon, and chlorophyll-a concentrations delivered to Falls Lake. This linked approach is a significant development in the assessment of changes in the watershed and how those are manifested in the lake. Previous modeling did not use a watershed model to provide input files to the lake model. Without this component of the modeling, there is no way to evaluate the feasibility of proposed management activities.

The UNRBA reexamination also includes the development of a third lake model to evaluate how designated uses are affected by lake water quality. This statistical model is primarily data driven and incorporates Bayesian techniques that allow expert opinion to be considered when relationships between parameters and designated uses are difficult to quantify or costly to measure. The UNRBA convened a Technical Advisors Workgroup including users of the lake for feedback on how lake water quality affects their organizations use of Falls Lake for recreation and drinking water supply. This workgroup included representatives from Triangle Fly Fishers, Wake County Parks and Recreation, City of Raleigh Water Treatment Plant, and other local experts in the fields of water chemistry and lake processes.

Comparison of UNRBA Lake Models to Water Quality Data and Algae Data Collected in Falls Lake

The findings of the three lake models for the study period are consistent with the evaluations presented in the UNRBA 2019 comprehensive monitoring report:

- Concentrations of nutrients in Falls Lake are usually relatively low for the study period (2014 to 2018).
- Ammonia releases from lake sediments are higher in the deeper areas of the lake.
- Chlorophyll-a can reach high concentrations even when nutrient concentrations remain low (Figure 10, 1984 to 2020)). Chlorophyll-a is better correlated to total nutrients than inorganic nutrients because algae consume inorganic nutrients and store nutrients as organic material in their cells.

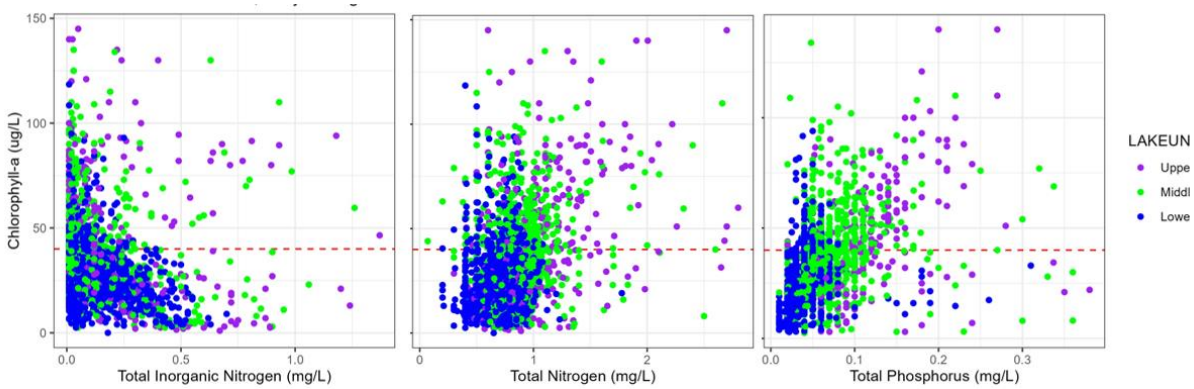


Figure 10. Comparison of Observed Chlorophyll-a Concentrations in Falls Lake to Nutrient Concentrations in Falls Lake (1984 to 2020) Excludes *outliers that are greater than five standard deviations from the mean.*

DWR assesses the presence of different algal species in Falls Lake by counting and identifying algal cells in a water sample. This information is used to estimate the amount of space in the water that algae occupy. This estimate is called biovolume, and DWR provides these estimates monthly at three locations in Falls Lake. As chlorophyll-a is an indicator of algae growth, these two measures are expected to increase and decrease together. However, when the biovolume estimates in Falls Lake are compared to the chlorophyll-a concentrations, they do not always track together. Depending on environmental stressors and dominant algae groups, chlorophyll-a can reach high concentrations even when total biovolume is low (Figure 11). This complicates simulation of chlorophyll-a because the models are designed to predict more chlorophyll-a when more algae are present. Shifts in algal groups and complex algal metabolic and species variation relationships complicate the water quality assessment of Falls Lake.

The lake models can simulate three algal groups, typically modeled as green algae, diatoms, and blue green algae. However, evaluation of DWR algal group data shows that significant concentrations in chlorophyll-a were sometimes caused by species not categorized as one of these three groups. The DWR data also show that green algae are a very small component of the algae in Falls Lake. The alternate species of algae were simulated as a group called "green/other algae."

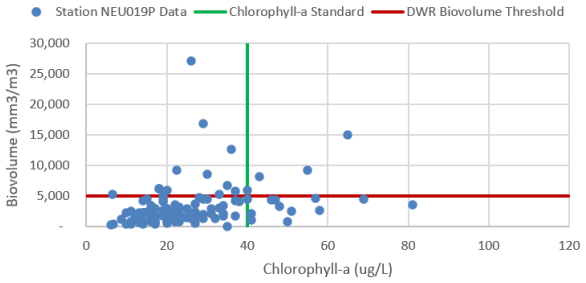


Figure 11. Scatter plot of algal biovolume (the amount of space occupied by algae in a water sample) and chlorophyll-a at a station below Highway 50 *At this station, nearly 80 percent of the exceedances of the chlorophyll-a standard occur when the biovolume is less than the threshold for a bloom.*

Evaluation of Lake Model Scenarios

Following calibration to observed lake water quality data, WARMF Lake and EFDC were used to predict changes in lake water quality resulting from changes in the watershed or lake operations. One of the scenarios evaluated was a land conversion to "all forest" and wetlands with removal of watershed-scale human inputs (rates of atmospheric deposition were not changed for this scenario). This scenario simulates all lands as forests but leaves wetlands in place. It also removes point sources, fertilizer application, and onsite wastewater treatment systems. This scenario establishes the lowest potential loading to Falls Lake and resulting lake water quality. **Even this hypothetical "all**

forest" scenario does not achieve the Stage II nutrient allocations prescribed in the Falls Lake Rules or compliance with the chlorophyll-a criterion at all lake monitoring stations.

Figure 12 shows the simulated and observed chlorophyll-a concentrations using the UNRBA Falls Lake WARMF model developed for 2014 to 2018. The model was developed and calibrated to observations collected from 2015 to 2018 while 2014 was used to initialize the model. The orange line shows the calibrated model, and the dots show the observations. The top half of the figure shows results at Interstate 85 in the upper part of the lake. The bottom half of the figure shows results in the lower part of the lake near the dam. As with the box and whisker plot shown in Figure 5, the upper lake has higher and more variable chlorophyll-a concentrations than the lower lake. While the "all forest" no watershed-scale human inputs scenario (green line) has lower chlorophyll-a concentrations than the calibrated model, it still exceeds the 40 µg/L chlorophyll-a standard (red dashed line) in the upper lake. At Interstate 85, approximately 32 percent of the simulated chlorophyll-a concentrations exceed 40 µg/L under this hypothetical scenario. For the calibrated model (2015 to 2018 conditions), 38 percent of the simulated chlorophyll-a values exceed 40 µg/L at this location. Therefore, while the percent exceedance decreases, not even this hypothetical scenario can meet the chlorophyll-a standard everywhere, all the time in Falls Lake. Therefore, it is not possible to achieve the chlorophyll-a standard in Falls Lake as currently applied.

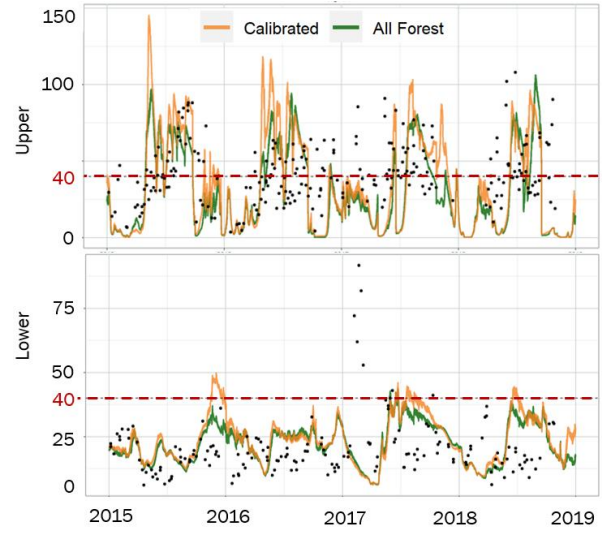


Figure 12. Simulated Chlorophyll-a Concentrations in Upper Falls Lake at Interstate 85 (top) and Lower Falls Lake near the Dam (bottom)

Significant reductions in nutrient loading to Falls Lake have been achieved since the baseline period. Another scenario was evaluated with the EFDC model to determine if these reductions from the watershed would eventually lead to reductions in the amount of nutrients cycled into and out of the Falls Lake sediments and whether this would lower simulated chlorophyll-a concentrations. While changes to the internal nutrient releases were predicted, the simulated chlorophyll-a concentrations did not change significantly. This finding indicates that algae and chlorophyll-a levels will be very resistant to changes in nutrient loading or other conditions of the lake.

A question that was frequently asked by stakeholders is the importance of USACE lake operations on nutrient storage, algal growth, and chlorophyll-a concentrations in Falls Lake. A scenario was evaluated that simulates an outflow structure at normal pool elevation so that water is not retained for flood control purposes. Because the USACE already targets this elevation in their operations, this scenario did not significantly affect simulated water quality in Falls Lake. Maximum values of some parameters either increased or decreased or shifted in time. However, the percent of simulated chlorophyll-a concentrations at I-85 exceeding 40 µg/L (37 percent) was nearly the same as the calibrated model (38 percent). Scenarios were also evaluated to determine the percent reduction in nitrogen and phosphorus loading to Falls Lake that would be required to meet the chlorophyll-a standard at least 90 percent of the time in the upper part of the lake where concentrations are usually highest. This analysis shows that an additional 50 percent reduction in total nitrogen loading beyond what has already been achieved would be required.

Implications for a Revised Nutrient Management Strategy

Given the vast amount of data collected in the watershed and lake, and the unavoidable constraints on further reductions in nutrient loading, a more reasonable implementation program with achievable water quality standards is the most correct path. A long-term, continued program based on investment in water quality management in the watershed and lake is needed. This approach will provide continued progress on protecting and improving water quality. The information developed during this evaluation process shows a reservoir that is eutrophic but meeting its designated uses. It also shows a lake that is subject to elevated algal activity and ongoing development in the watershed. To mitigate the impacts of development, implementation of the New Development Rule is an important management component of the strategy. The full impact of new development includes additional loading to the lake at flows exceeding SCM design standards. Land conservation and promoting the retention and creation of natural areas in the watershed are also essential components of an effective, ongoing strategy. Actions to improve watershed health and address current nutrient loading will provide protection of this important water resource.

Pump-and-Treat Scenario

As discussed in previous sections, one model scenario revealed that removal of all human-generated nutrient inputs and conversion of all land to forests would not meet the chlorophyll-a standard in Falls Lake. This means that all sources in the watershed would have to be treated to levels below that of a wooded watershed to comply with chlorophyll-a standards. This level of treatment would require a pump-and-treat system. To illustrate the cost, tremendous challenges, and economic impact of applying pump-and-treat systems to potentially meet the chlorophyll-a standard, a hypothetical implementation of an algal harvesting system called an algal floway is described below.

System Description

The City of Durham pilot tested a small-scale algal floway nutrient removal system that pumps water out of Falls Lake, releases the water to flow across shallow, open conveyances that grow algae, and then discharges the treated water back into the lake. The cultivated algae consume (remove) nitrogen and phosphorus as the water flows across the conveyance. These algae are periodically harvested along with the nutrients stored in their cells. The harvested material is transported to another location and treated to convert it into a soil amendment or to be disposed of alternatively (landfill, etc.). Reports associated with the pilot test, conceptual design, and 2021 construction cost estimates are available online at https://www.durhamnc.gov/4678/Algal-Floway.

Based on the pilot study results, the City of Durham evaluated the feasibility and operational aspects of a full-scale algal floway which could treat 10 million gallons of water per day. Approximately 2,000 wet tons of cultivated algae would be removed from the floway each year. The amount of nitrogen removed by the algae would range from 3,000 to 6,000 pounds each year. This range assumes the water level at the withdrawal point (either a tributary to Falls Lake or the lake itself) would always be high enough to pump water into the treatment system and that the concentrations of nutrients from the pumped water were like those observed in the pilot study. The cost to construct this facility was estimated at $7.9 million with annual expenses over a 20-yr service life of $170,000 per year. These costs do not include the cost of land or the effort of successfully siting the system.

Reductions Required to Meet the Chlorophyll-a Standard Ninety Percent of the Time

As noted in previous sections, the UNRBA watershed modeling estimates the current delivered total nitrogen load to Falls Lake averages 1.65 million pounds per year. The UNRBA EFDC lake model estimates that a 50 percent reduction in this total nitrogen load would be required to meet the

chlorophyll-a standard 90 percent of the time in the upper part of the lake. A 50 percent reduction in total nitrogen load from 2014 to 2018 levels translates to a reduction of 825,000 pounds per year on average. This is a massive reduction goal on top of the reductions already achieved since 2006. Multiple pump-and-treat type systems would be needed to achieve this level of reduction. Many, if not all of these systems, would be treating nutrients from unmanaged lands including forests and wetlands that do not receive watershed-scale human inputs (however, nutrients are "applied" to these areas from atmospheric deposition).

Implementation

Assuming the highest estimate of nitrogen removal (6,000 pounds per year, which is unlikely), removing 825,000 pounds of nitrogen per year would require 138 full-scale algal floways. These floways would generate an estimated 276,000 wet tons of harvested algae, which would need to be transported to an offsite treatment facility. A rough extrapolation of the pilot study estimates the cost of 138 algal floways at $1.1 billion for construction and $23.4 million per year for operation and maintenance. These facilities have an assumed life span of 20 years, meaning that life-time costs would be approximately $1.6 billion (construction plus 20 years of operational costs). Treatment beyond 20 years would require additional construction or repair costs. This is a conservative cost estimate as site selection, land costs, and legal costs are not included.

These costs assume the maximum amount of treatment based on the pilot study. Assuming the low end of the treatment range (3,000 pounds of nitrogen removed per year per system), construction costs would double to $2.2 billion, and operation and maintenance would double to $46.9 million for a total of $2.7 billion for the 20-year life span of the systems.

Feasibility

While hypothetical costs can be estimated for 138 systems, there are many logistical reasons that warrant this approach infeasible:

- The City of Durham has faced challenges siting even one of these systems, so siting 138 would be unachievable.
- This number of systems would require treatment of 1.38 billion gallons of water per day (10 million gallons per day times 138 systems). This is more water than entered Falls Lake during the average to high precipitation conditions that were evaluated by the UNRBA (only 239 million gallons per day to 476 million gallons per day). If sufficient water is not present in the tributary or lake where pumping occurs, the systems cannot fully operate, and pumps may be stressed.
- More than 276,000 wet tons of algae would have to be harvested, transported, and composted each year. This would likely require construction of a dedicated composting facility.
- The effectiveness of the floways is estimated based on the results of a pilot study. For the sake of illustration, constant removal efficiencies for all 138 systems are assumed. However, cumulative effects for multiple systems are unknown, and removal efficiency for a given floway could decrease significantly if incoming water had already been treated by an upstream floway. Similarly, some of these systems would have to be placed in areas that were predominately forested. Inflow concentrations from these areas would likely be lower than the pilot study, and removal efficiencies would be lower.
- Processing that volume of water and removing that level of nutrients from the system could have unknown environmental and ecological impacts.
- Addition of 138 algal floway footprints and algal harvest transportation could have negative environmental impacts such as increased impervious area and greenhouse gas emissions.

- Community acceptance of widespread installation and maintenance could present an additional hurdle to implementation.
- Local governments cannot condemn land for stormwater treatment, so all systems would require willing landowner participation.

Implications for a Revised Nutrient Management Strategy

Given the cost and constraints listed above, the use of pump-and-treat systems to reduce total nitrogen loads to Falls Lake by 50 percent from recent levels is not feasible. Because of the nutrient reductions that have already been achieved, the mostly natural state of this watershed, and the relative stability of chlorophyll-a concentrations in Falls Lake, nutrient load reductions at the scale necessary to achieve compliance with the chlorophyll-a standard are not reasonable.

This hypothetical pump-and-treat scenario is presented to illustrate the challenges faced by UNRBA members and others in this watershed. The UNRBA is not attempting to avoid costs or responsibility. Rather, this scenario and the modeling discussed previously demonstrates UNRBA's commitment to finding management strategies that will protect water quality instead of applying conventional approaches to try to reach an unrealistic goal.

The data show that achieving the chlorophyll-a standard as currently assessed is not attainable in all areas of Falls Lake. The UNRBA has extensively researched this system and evaluated several scenarios to guide readoption of the Falls Lake Rules. The result of these efforts and discussions with stakeholders indicate that the most effective means to reduce nutrient loading from the watershed and protect water quality in Falls Lake is a measured and incremental investment program that focuses on watershed health. The path forward requires a revised nutrient management strategy that focuses on clear, attainable objectives that continue to maintain the reservoir's designated uses. To move management actions forward with broad support from stakeholders, the revised strategy should not focus on nutrient pounds delivered to Falls Lake with the only goal being attainment of the chlorophyll-a standard. There are finite resources within this watershed, and those allocated to this effort need to be used for enhancing and protecting the entire watershed in sustainable, resilient, and meaningful ways.

Economic Considerations

As recommended in the Framework for a Reexamination Strategy of Stage II of the Falls Nutrient Strategy, the UNRBA planned to supplement monitoring and modeling efforts with a cost-benefit analysis (CBA). The CBA would update the DWR Fiscal Analysis by comparing modeling scenarios that would meet the chlorophyll-a standard in Falls Lake. However, monitoring data and calibrated models revealed that none of the scenarios investigated would comply with the chlorophyll-a standard as currently applied. As no reasonable means of meeting the standard was identified, a formal CBA of nutrient management strategy alternatives could not be conducted during the development of these recommendations. However, the UNRBA will cooperate with DWR to assist in developing a more thorough economic analysis during the rule revision process to evaluate impacts of rule language and alternative strategies as needed. The UNRBA continues to compile information from the local governments to support this effort.

Stakeholder Involvement

Some of the efforts on this vital component of the reexamination have already been briefly noted in this document. Stakeholder engagement for this effort is not limited to specific events but rather is an ongoing commitment to develop the science, support a revised strategy, communicate preliminary findings, and share perspectives on how these findings guide the reexamination.

The UNRBA membership has consistently used consensus to make decisions within the Association's more formal meetings and in conducting its business. The UNRBA is committed to reaching its decisions based on input from its members and representatives as well as other stakeholders. External stakeholders participate through attendance and participation at UNRBA meetings, which are open to the public. External stakeholders also have access to review UNRBA project activities, materials developed to describe and present its work, and documents generated by the UNRBA and its contractors in support of its objectives. As noted, stakeholders are invited to comment on these materials during meetings and in writing to provide input to the work of the UNRBA. Stakeholders have been included as members of workgroups created to support the UNRBA's decisions on many critical topics. Input from the NC DEQ, and its lead agency on the Falls Lake strategy, DWR, has been sought at every step regarding the work of the UNRBA. This agency is the organization that will move the readoption of the Falls Lake Rules forward. The UNRBA has and will continue to provide and enhance input opportunities during stakeholder meetings and workshops. Securing UNRBA input and recommendations to the DWR process is critical to developing a revised strategy and revised rules.

Stakeholder engagement will be expanded as rule revisions are developed. This outreach will include developers and home builders, the USACE, farmers and landowners (outreach to be led by representatives of agriculture), local Soil and Water Conservation Districts, County Health Departments, EPA, and members of the NC General Assembly. This input is critical to the success of implementing a revised nutrient management strategy for Falls Lake.

The Falls Lake Nutrient Management Strategy is an important, ongoing, programmatic commitment for local governments in the watershed. These governments are responsible for implementation of the New Development Rule requirements; identifying, funding, and managing watershed improvement projects; and achieving reductions of nutrient impacts from existing development. It is anticipated that this responsibility will continue, and the revised management strategy will continue to count on these local governments for implementation. The success of water quality management in this watershed requires an effective partnership between regulatory agencies and affected parties. Progress cannot be achieved without trust and collaboration between the state regulatory agencies, citizens, local governments, and landowners in this watershed.

Stage I Existing Development Interim Alternative Implementation Approach

The cooperative and collaborative nature of the UNRBA and its extensive stakeholder engagement process resulted in the development of an innovative and promising approach for ensuring progress for on-the-ground projects and activities that will improve watershed health. This approach addresses the challenges associated with reducing nutrient loading from existing development in the watershed by expanding opportunities for partnerships and the types of projects and activities eligible for compliance.

Beginning in 2018, the UNRBA began exploring an alternative option for achieving compliance with Stage I existing development nutrient load reductions under the Falls Lake Rules. To overcome some of the obstacles present in the current Rules, the UNRBA and its stakeholders developed the IAIA with the goal of protecting and improving water quality in the watershed and lake. The concept was originally suggested by environmental advocacy groups active in the watershed and engaged with the UNRBA and its efforts. The UNRBA worked with its members, representatives from environmental groups, conservation organizations, staff at DWR, other interest groups, and regulated entities to develop an alternative approach for meeting the Stage I Existing Development Rule. This compliance framework uses financial investment in eligible projects and activities that benefit water quality and quantity both for the lake and the watershed. This approach does not rely on the difficult compliance approach of counting pounds of nutrient reductions associated with individual projects,

rather it promotes actions that reduce nutrients, offset impacts, and improve watershed health associated with developed land in the watershed. This approach recognizes long-term benefits and emphasizes protecting lake uses and improving water quality in the watershed and lake. It also engages upstream jurisdictions in the watershed and direct users of the lake in a coordinated and mutual commitment to produce a positive future for water quality in this watershed and lake. The engagement of local governments that represent both lake users and those areas that drain to the lake provides a critical link between upstream actions and downstream benefits. The IAIA Program Document (approved by the EMC in January 2021) and other materials are available here. **The following list identifies the activities and projects currently eligible for use under the IAIA. It is anticipated this list would be expanded in a similar manner allowed under the IAIA.**

- All state-approved practices with established nutrient credits including SCMs and retrofits.
- Green infrastructure and other BMPs that include water quality and quantity improvements.
- Stream and riparian buffer restoration and enhancement.
- Programmatic measures beyond baseline program activities (i.e., levels in 2006) for years after the start of the IAIA program.
  - Fertilizer application education of businesses and homeowners
  - On-site wastewater treatment system inspection programs, maintenance tracking, repair, replacement, and pump-out programs, education of owners regarding proper maintenance, and training of professionals who inspect and repair onsite systems
  - Pet waste pickup education, waste management stations, and enforcement
- Infrastructure improvements including:
  - Repair and replacement of leaky infrastructure
  - Reduction of sanitary sewer overflows
  - Extension of sewer lines to areas using onsite systems (targeting areas with known failure issues) or package plants
- Illicit discharge detection and elimination.
- Land conservation in high priority areas including isolated and connected wetlands, land in forest succession, non-pasture grassland, scrubland, and forests (as determined through an appropriate evaluation resource, i.e., land conservation programs that identify water quality aspects of available preservation sites); the Raleigh Watershed Protection Program has a target of preserving 30,000 acres of high priority lands by 2045.
- Floodplain restoration and reconnection.
- Greenways and parks with water quality and quantity benefits (water quality benefits would be identified as specific project components and documented within the adopted development plans).
- Projects and activities that focus on flooding and have an associated water quality benefit.
- Operation and maintenance costs associated with preserving long-term functionality of practices implemented under the IAIA.
- Hydrilla removal and control

The IAIA is a voluntary program that allows jurisdictions to use a joint compliance approach. The program was designed as a pilot effort to inform the development of the revised nutrient management strategy for Falls Lake. The initial period for undertaking this program was set at five years, but the IAIA is interim because it only applies until the Falls Lake Rules are readopted as required by the NC General Assembly (expected in 2025 or later). The continuation of this approach

to mitigate impacts from existing land use in the watershed is well-suited to the specific challenges of addressing non-point source impacts in the watershed using a long-term management approach.

Year 1 of the IAIA was hugely successful with all participants meeting or exceeding their minimum investment requirements. Participants were required to commit $1.5 million to eligible projects and actions. Annual compliance reporting shows that $5.5 million was committed in the first year. A wide range of projects were implemented including land conservation, green infrastructure, stormwater control measures, illicit discharge detection and elimination, and stream restoration.

Stakeholder feedback received in 2022 and 2023 encouraged the incorporation of this investment-based approach into the revised nutrient management strategy. For example, John Huisman (DWR) said the IAIA demonstrates "positive momentum in the implementation of the Falls Lake Rules and the commitment of the local governments to improve water quality" and that "this is a great success that we can point to as an example for other watersheds." Peter Raabe of American Rivers said, "the adoption of this approach to improving our water supplies for people and nature is a groundbreaking modernization of our clean water regulation. It will deliver benefits that communities will see and appreciate every day and is only possible due to the great work of the UNRBA members and NC DEQ."

Development of the UNRBA Recommendations for a Revised Management Strategy

The efforts of the UNRBA and other organizations including the Collaboratory have greatly improved the scientific understanding of the relationship between nutrients and algae in the lake, nutrient processing, and movement in the watershed, and how those factors should shape a revised strategy for managing water quality in Falls Lake. Revised policies must consider the science and realities of how, and to what extent, actions will impact the entire system. Good policy must be built on good science.

The revised strategy should consider that significant load reductions have occurred since the Rules were passed, and further reductions will be limited by technological, logistical, and economic constraints. The outlook for this watershed and lake is promising because the UNRBA recognizes the importance of protecting Falls Lake, maintaining designated uses, and improving water quality. There is an established and positive relationship between upstream jurisdictions and downstream users of the lake. Jurisdictions in this watershed seek to continue and expand the partnership established between the members of the UNRBA, DEQ/DWR, and the public interest community. A strategy cannot work effectively unless there is mutual agreement on the actions needed and a commitment to manage and oversee those actions for the long-term.

Simply using the models to simulate reduced loading until the standard is met will not work as a regulatory approach. There are significant limitations that existing land use places on the ability to change nutrient input to the lake. It is essential to establish the link between the watershed and the lake and acknowledge the sources and relative amounts of loading.

The concepts and principles aim to establish a revised nutrient management strategy consistent with the long-term realities of how this system responds to changes in the watershed and the length of the time it will take for water quality in the lake to respond. These challenges are best addressed through a flexible, progressive management program. The strategy must also include provisions for ongoing adaptive management plans that continue actions for the long term, assess progress using an appropriate timeline, and adjust the strategy moving forward.

Falls Lake has a specific and complex relationship with its watershed. Efforts on the ground intended to improve water quality in the lake are slow to manifest. Any strategy that expects change to occur quickly is not realistic. Nutrient and water quality management actions and improvements to lake water quality must be assessed over decades.

During 2022, the UNRBA moved into the discussion of concepts and principles for a revised strategy. This critical process began before the modeling was finalized. Discussions of the work completed by the UNRBA and the Collaboratory have occurred over the last several years and inform these recommendations. The lessons learned from the development and implementation of the IAIA have also established some clear guidelines for achieving effective management of the lake and watershed.

Falls Lake is the most thoroughly studied reservoir in NC and among the most studied in the country. As summarized above, the 2014 to 2018 UNRBA monitoring program provided fundamental data and information that was previously not available at this level of detail. The 2019 comprehensive report along with the preliminary results of the Collaboratory research provides an informed picture of the system. The modeling provides further clarification of the system as well as tools to test scenarios and management actions and their impacts on lake water quality.

This document frames the concepts and considerations that have been identified by the UNRBA members and watershed stakeholders as they reference the scientific findings and modeling results. The UNRBA expects to submit these recommendations for the revised strategy to DWR and the EMC by December 2023.

Recommendations for a Comprehensive Approach to Nutrient Management

The UNRBA has been working with other watershed stakeholders to study the Falls Lake watershed since 2011. This work is intended to support the reexamination of Phase II of the Falls Lake Rules. These efforts have led internal and external stakeholders to propose that the revised nutrient management strategy incorporate the fundamental principles of IAIA including using an investment-based, joint-compliance framework on the implementation of projects and activities beneficial to water quality across the watershed.

The IAIA includes a broad range of eligible projects and activities approved by DWR for compliance with Stage I Existing Development Rules. The UNRBA members and stakeholders have discussed many types of additional projects and activities related to nutrient reduction opportunities for inclusion in the revised nutrient management strategy that would apply to specific types of land, discharges, etc. As with the IAIA, the UNRBA recommends including a provision for expanding the list of eligible activities in the revised strategy. Potential expanded activities are organized by topic in this section. However, many of the opportunities and potential partners overlap, and the organization of this document attempted to account for this overlap. Additional projects and activities may be added as the revised nutrient management strategy is implemented.

Because of the holistic nature of the recommendations, the UNRBA also recommends that its implementation for non-point sources be considered by the State as addressing all waterbodies in the watershed that are currently listed, or may be in the future, on the State's 303(d) list of waters for pollutants related to nutrients. These other waters may be considered Category 5 waters in future Integrated Reports if additional point source controls are required. Separate, State-required nutrient management requirements should not be applied to managed lands in separate areas of the watershed (draining to an upstream watershed impoundment, arms of Falls Lake, etc.). However, water quality in all areas of the watershed should be tracked, particularly sub-watersheds with water-supply impoundments. The adaptive management provisions of the revised rules should address changing conditions in these waterbodies and allow for revisions to the program to address concerns as they arise.

The UNRBA anticipates investment requirements for its members under the revised nutrient management strategy. The potential partners (e.g., agriculture and institutions) would not have the burden of investment requirements. To foster cooperation and establish a functioning, holistic program, the UNRBA proposes establishment of a "Watershed Organization" with tiered membership. Those local governments, state and federal agencies, and utilities with investment requirements would be in Tier 1 and could support administration and implementation of the program through funding. Those without investment requirements could be in Tier 2. This tier would not be expected to fund the program but could participate on committees to identify opportunities and constraints, participate in decision making, etc. Committees specific to a sector (e.g., agriculture) could be chaired by a representative of that sector (i.e., committees may be chaired by a Tier 2 member). Annual compliance reporting and tracking of investment requirements for the Tier 1 members could be managed by the Watershed Organization, similar to the current IAIA. The initiation date of the Watershed Organization will be determined by the readoption of the Falls Lake Rules, which must be achieved in accordance with Session Law 2018-5 Section 13.8.(a). This session law specifies that the EMC must begin rule re-adoption no later than December 31, 2024. It is anticipated by DWR that readoption of the rules will occur no later than 2027. Additional details about the Watershed Organization and tiered membership are provided in the section called Program Administration.

Establishment of a Fair and Equitable Program

The UNRBA strives to develop a revised nutrient management strategy that protects the watershed and Falls Lake in a fair and equitable manner. The Falls Lake Rules affect a variety of sectors, some of which can fund compliance through taxes or fees and others that do not have that ability. Beyond financial capabilities, not all communities have the staff resources to fully evaluate potential projects and choose the best options for their citizens. The collaborative nature of a watershed organization will allow regulated parties to share resources and expertise as each member is working towards a common goal. Members will have the option to participate in multi-jurisdictional projects or invest in-kind contributions (i.e., use of equipment, labor and technical service hours, etc.) which allows for significant flexibility in meeting investment requirements.

The watershed organization structure addresses an inherent inequality with conventional water quality regulation: upstream/downstream distribution of costs and benefits. Traditionally, upstream sectors may bear the brunt of expenses for mitigative action without experiencing the corresponding benefits. While downstream sectors may have little influence over incoming water quality and are at the mercy of upstream actions (or inactions). The UNRBA recommendations seek to correct this imbalance by bringing users together to improve and protect valuable water resources regardless of their location within the watershed. The UNRBA recognizes that everyone within the watershed has the potential to be affected by poor water quality, and the recommended investment approach to manage existing development provides a way of fair and equitable means for creating and benefiting from watershed improvements. As with the successful IAIA, the revised strategy should allow projects to be implemented anywhere within the watershed with an expanded suite of compliance activities. Many of the approved activities produce benefits beyond nutrient reduction, such as infrastructure repair, community amenities with a water quality focus (parks, etc.), and high priority land conservation. The result is a fair and equitable strategy where citizens can benefit from projects in their communities and address their unique priorities while protecting water quality in the reservoir.

The UNRBA recommendations for a revised strategy will be most effective when all parties in the watershed are fully engaged and committed to the common goal of watershed protection and improvement. Beyond being a moral obligation to society, a fair and equitable strategy garners

public support and encourages participation, which ultimately results in a more effective nutrient management strategy. Encouraging stakeholder involvement, providing transparent record keeping, facilitating multiple funding vehicles, and offering an expanded suite of compliance activities all contribute to a fair and equitable program. The UNRBA acknowledges that the success of the program depends on participation, and willing participation depends on each member, and each citizen, being treated with respect, equality, and fairness.

Consideration of Environmental and Social/Community Impact Issues

The revised nutrient management strategy should consider environmental and social impact issues in implementation of the program. The revised rules should promote opportunities for equitable stakeholder participation by encouraging input and participation from the public and interest groups. The UNRBA believes that a voluntary and collaborative approach will give more opportunities for communities to be heard and included in the decision-making process. In addition, members are encouraged to employ the multitude of state and federal databases and tools that exist to protect historically underserved communities and individuals. One such tool is the EPAs EJSCREEN tool that can be used to assess whether potential for environmental justice issues may arise within a project's service area. Efforts should be made to ensure that the programs and actions of the regulatory system for nutrient management in Falls Lake and its watershed do not create environmental or social justice issues.

Measuring Compliance Under an Investment-Based, Joint Compliance Approach

As with the IAIA, the UNRBA recommends that compliance under the revised strategy be tracked by investment and the amount of nutrient reductions be tracked as supplemental information. One of the fundamental differences of the IAIA compared to conventional regulatory approaches is that compliance is tracked by required investment in eligible activities rather than counting the nutrient pounds reduced. This approach provides two key benefits: 1) local governments can plan for required investment levels as part of their budgeting process and 2) activities that do not have State-approved nutrient credits that are known to be beneficial to water quality and quantity can be incorporated into the program. Pledged investment levels remove fiscal uncertainty and simplify compliance administration, freeing members to prioritize water quality projects with more comprehensive and sustainable benefits that meet water quality objectives while addressing the unique needs of their communities.

This method of compliance is reminiscent of the EPA's Integrated Planning framework first launched in 2012 and included in the Water Infrastructure and Improvement Act (WIAA) (H.R.7279) of 2019. The integrated planning framework was developed as a means to address the increasingly complex challenges of meeting Clean Water Act (CWA) requirements. "An integrated plan is a process that identifies efficiencies from separate wastewater and stormwater programs to best prioritize capital investments and achieve our human health and water quality objectives. This approach can also lead to more sustainable and comprehensive solutions, such as green infrastructure, which improve water quality and provide multiple benefits that enhance community vitality" (https://www.epa.gov/npdes/integrated-planning-municipal-stormwater-and-wastewater). The success of Integrated Planning shows that moving beyond nutrient tracking into a more comprehensive means of compliance can result in sustainable solutions that reduce pollution sources rather than simply controlling or treating discharges. In fact, many municipalities who have undertaken similar programs have exceeded CWA requirements and saved money by synchronizing water quality goals with capital improvement projects.

Representatives of agriculture have indicated that they prefer to maintain ownership of their nutrient loss tracking and reporting, and this cooperative approach would allow that to continue while

potentially leveraging funding from other sectors. DOT representatives have also indicated an interest in participating in this revised program.

Site-Specific Chlorophyll-a Standard and 303(d) Listing Considerations

The UNRBA is proposing a path forward in our recommendations that sets an ambitious process toward protecting Falls Lake and for continuing those efforts into the future, but the current standard and 303(d) water quality assessment process should be adjusted to better reflect conditions in Falls Lake. The UNRBA could apply much additional financial resources, time, and effort to secure a new standard through administrative, legislative, or legal means. However, the time associated with these efforts would delay watershed improvement actions and put Falls Lake at risk of water quality degradation that could impact uses. Options include a variance, use-attainability analysis, judicial review, legislative action, or other effort to address the compliance issues. UNRBA membership recommends focusing time and financial resources on collaborative projects that address water quality and watershed health. A request for a site-specific standard may still be needed, and the goal would be to promote progress by setting an achievable goal for the watershed and the lake.

The established goal for improving water quality in Falls Lake is the current water quality standard for chlorophyll-a. As part of a comprehensive consideration of an effective nutrient management strategy for Falls Lake, it is appropriate to provide some comments related to this goal.

The UNRBA continues to evaluate and consider a site-specific chlorophyll-a standard for Falls Lake. The current standard was adopted in 1979 to address use support issues on the Chowan River.

The scientific data, research efforts, and an assessment of uses of Falls Lake shows no use impairment. The current standard is not appropriate for the lake because the designated uses are being met despite exceedances of the criterion in some locations. The 303(d)-assessment methodology being applied is not consistent with scientific evaluations of lake quality in NC or any reservoir environment in similar regions of the US.

Even if the UNRBA does not submit a new standard petition as part of this reexamination, the 303(d) assessment methodology should be adjusted for Falls Lake consistent with the science of using chlorophyll-a data to assess overall reservoir quality (how eutrophication is indicated for the reservoir as a whole rather than a station-by-station assessment). The 303(d) assessment methodology for Falls Lake should establish stable and consistent assessment segments based on the physical and limnologic characteristics of the reservoir. On several occasions, the UNRBA has provided comments and requests for an adjusted methodology for Falls Lake.

The data and scientific evaluations provide fundamental information about the reservoir and the watershed. The modeling and scenarios demonstrate the limitations of what can be achieved in terms of additional nutrient load reductions and attainment of the chlorophyll-a standard and the amount of time to realize changes given the soil chemistry in the watershed. Because 75 percent of the watershed is unmanaged and significant reductions in nutrient loading have already occurred since the baseline period of the Rules, additional, large-scale nutrient reductions are not likely to occur. Rather than focus on attainment of the chlorophyll-a standard, the goals of the revised strategy should be incremental improvements and long-term protection of the designated uses of Falls Lake.

The UNRBA supports an adjusted 303(d) assessment methodology and site-specific chlorophyll-a standard for Falls Lake and will continue to cooperate and collaborate with DEQ-DWR, Environmental Protection Agency (EPA), and other stakeholders on these revisions.

Consistent with established legislation, the UNRBA recommends that the NC DEQ-DWR and EMC move forward promptly with the revisions to the Falls Lake Rules taking into consideration these

consensus principles. The UNRBA does not recommend delaying rule revisions while these objectives continue to be developed and evaluated. Readoption of the Falls Lake Rules remains the first priority so ongoing implementation efforts in the watershed can proceed.

Urban Development, State and Federal Lands, and Institutional Lands

The UNRBA recommends an investment-based approach to continue improvements on existing lands. In addition to the eligible activities listed in the IAIA Program Document, stakeholders have identified the following additional activities for inclusion or consideration in the revised nutrient management strategy. **It is noted that the specifics of how to accomplish these actions will need to be considered, evaluated, vetted, and accepted before they are incorporated into the rules or operating procedures. Different communities will have different needs and constraints and may elect to implement the concepts that best support their situation. The opportunities for retrofits will also vary by jurisdiction.** It is anticipated the list of eligible projects and activities would be expanded in a similar manner allowed under the IAIA.

- Expand education activities to address SCM maintenance
  - Focus on Homeowner Association (HOA) Boards and other SCM owners
- Coordinate to fund retrofits for existing and re-development
  - Provide incentives to owners to encourage participation
  - Pay for retrofits and take over inspection and maintenance, but practice ownership would not change (e.g., Hillsborough dry ponds)
  - Evaluate use of development bonds for SCMs as a funding source for maintenance and repairs; local government would not count funds expended from the bond as part of their investment, but staff resources to identify and research bonds and their applicability would count as in-kind investment
- Improve existing stormwater infrastructure on publicly owned lands and privately owned lands under a voluntary agreement
- Improve HOA management and maintenance
  - Inspection and maintenance
  - Outflow management to ensure proper discharge (e.g., cleaning trash debris racks, preventing/repairing erosion downstream of outfalls).

Additional projects and activities will be added to this list as the revised nutrient management strategy is developed.

Opportunities for Partnering on Agricultural Lands

In the Falls Lake watershed, the acreage of land in agricultural production (crops and pasture) has declined by approximately 45 percent since 2006. Most of the operations in the watershed are relatively small and have already implemented best management practices and reduced fertilizer application rates. Many of the streams in the watershed are buffered. The revised strategy should consider the footprint of this land use and its potential for nutrient input to Falls Lake.

In 2006, land identified as agricultural was approximately 89,000 acres. For the study period (2014 to 2018), agricultural land in the watershed was approximately 50,000 acres. The estimated percent contribution of total nitrogen from this land use is 18 percent and total phosphorus is 10 percent. Nonetheless, when incremental improvement is the goal, any reduction of nutrient input is helpful.

The UNRBA recognizes the importance of supporting agriculture in this watershed to maintain its rural nature and support the local food economy. As the revised strategy is being developed, farm-supporting organizations like the NC Farm Bureau and NCDA&CS have helped the UNRBA interface with farmers and make sure we present our common interests in productive ways. The following concerns have been raised during these discussions which should be considered in the transition to rule making to ensure that the interests of all parties are protected and to provide long-term stability for planning and implementation. For some of these concerns, potential solutions were offered (shown in italics). All of these concerns will require additional discussion as rulemaking commences:

- Potential risks to farmers who have received funding from non-agricultural organizations if the structure of the Rules or the accounting methods change in the future; the farmers would have lost reduction credits to other sectors. *Regulatory certainty will need to be addressed with input from DWR; as stated in this document, agriculture would continue to track nutrient loss reductions regardless of the source of funding.*
- Different funding structures or fluctuating levels of funding could affect allocations to the local Soil and Water Conservation Districts. *Funding the Agriculture Cost Share Program with consistent levels of funding is one way to address these allocation issues.*
- Local government funds used for investment credit should be in addition to current levels (2023), so the programs are expanded. *The recommendations in this document have been modified to include a year on which increases will be based.*
- There is a risk that the legislature may reduce funding for the Agriculture Cost Share Program since more funds would be provided by local governments.
- Fluctuating contribution levels from year to year could lead to instabilities in program administration. *Representatives suggest that a recurring minimum contribution level and/or multi-year planning periods with stated commitments (e.g., 5 years like the IAIA) would be helpful for planning and staffing purposes.*
- Farmers want to continue to receive best management practice and technical assistance from existing, trusted organizations like local Soil and Water Conservation Districts. *Funding the Agriculture Cost Share Program with consistent levels of funding would continue existing procedures for funding practices and for technical assistance.*
- Depending on the level of funding increase, additional administrative work may overwhelm staff at NCDA&CS. *Allocating some percent of contributions to support staff would help this issue.*
- Farmers are concerned that their stormwater fees will continue to increase to fund this program. One farmer indicated he pays as much as $1,000 per year in stormwater fees. *By including funding of the Agriculture Cost Share Program as an eligible investment by local governments, farmers are more likely to receive direct benefits under this framework. Alternatively, the fees may increase under the revised nutrient management strategy but would fund projects like stormwater control measures on developed areas, sewer improvement projects, or land conservation.*
- Farmers are used to the existing rule structure that has been in place since 2011 and wary of change that may impact operations and regulatory burdens. Future changes in staff at regulatory agencies or changes in membership of the Watershed Organization could risk stability of the partnership. *Additional outreach is needed to build trust. Formal agreements are needed to protect all stakeholders. Inclusion of representatives of agriculture in the Watershed Organization and its bylaws and committees would solidify partnerships.*

It is always necessary in coordinating with agriculture and in working on all projects to respect the landowner's decision on participation. Since streambank erosion is a significant factor in phosphorus loading and streams normally intersect multiple landowners, farm agencies can help

facilitate coordination with farmers and large landowners on stream projects crossing multiple properties. As the following section of this document deals with forest lands in the watershed, farming-interest representatives pointed out that farmers often own large areas of forest land. Coordination with farmers on potential forest-related projects or initiatives could also be a favorable aspect of agricultural participation in a Watershed Organization.

During the Scenario Screening process, representatives of agriculture met several times with the local agricultural councils to determine if potential additional activities in the watershed could be implemented to further reduce nutrient losses from agriculture. These discussions indicated that in this watershed, additional actions would not significantly decrease nutrient losses.

While large-scale changes may not be feasible, there remain opportunities for local governments and other Tier 1 Watershed Organization members to continue to partner with agriculture. An eligible activity for a local government to meet their investment requirement under the revised nutrient management strategy could include contributing additional funds above and beyond existing investment commitments (for example 2023 levels) to support the following:

- Soil and Water Conservation District activities including soil conservation, water conservation, streambank restoration, and stormwater control measures
- Agricultural best management practices, projects, equipment, and materials
- Local technical assistance, grants, and tracking support
- Voluntary Agricultural Districts (allows for Enhanced Voluntary Agricultural Districts to protect farms from development for 10 years)
- Conservation Reserve Enhancement Program
- Farmland Preservation Program

The most efficient means to provide this funding to agriculture is to utilize existing organizations and programs. For example, the Agriculture Cost Share Program is currently administered by NCDA&CS who coordinates and allocates funding to the local soil and water conservation districts. Utilizing this existing structure minimizes change in current administration of these programs and would rely on their existing decision-making frameworks.

The representatives of agriculture also indicated that they would prefer to maintain their own tracking and reporting systems for production acreages, nutrients applied, cost-share funding, projects implemented, and nutrient loss reductions. The agricultural community has invested a tremendous amount of time and resources into the Nitrogen Loss Estimation Worksheet (NLEW) which was developed by researchers at NC State University Extension. The UNRBA supports the agricultural community conducting its own tracking and reporting, which would be supplemental information to the investment-based compliance metrics under the revised nutrient management strategy. When projects have a method for quantifying nutrient reductions, agriculture would track these projects and reductions in their reporting. Representatives of agriculture indicate they may want to separately track joint projects (with funding support from others) and agriculture-only projects.

The UNRBA is not recommending nutrient reduction or investment regulatory requirements be placed on the agricultural sector, either collectively or individually. The UNRBA proposal is to work cooperatively with agriculture to identify where investment from local governments and other Tier 1 Watershed Organization members could support projects, technical assistance programs, and reporting. This approach would allow the Tier 1 members to work toward their own investment requirements while supporting agriculture in the watershed and allowing agriculture to maintain its autonomy.

The representatives from agriculture that participate in UNRBA meetings and workgroups have noted that an expanded outreach effort is needed as the revised strategy is developed. These representatives (Farm Bureau and NCDA&CS/DSWC) have begun these discussions to gage farmer interest in these concepts and offered to continue these discussions as rule making progresses. The UNRBA would provide support to these discussions as requested and directed by the agricultural representatives.

Forest Lands

Forest lands comprise approximately sixty percent of the Falls Lake watershed. Forests are an important part of a healthy ecosystem as they store, cycle, and release nutrients. Atmospheric deposition in dry and wet forms provides continual inputs of nitrogen, phosphorus, and carbon to all land and water surfaces including forested areas. Natural breakdown of forest debris contributes nutrients to the system. Many stakeholders have expressed the importance of preserving and protecting forested areas in the Falls Lake watershed.

Sediment, nutrient, and carbon loading rates from forests are heavily influenced by hydrologic conditions. Antecedent conditions are important to consider as a dry forest will hold more rainfall than a saturated forest. Destructive storms that disturb the root zone of trees can result in much higher loads of nitrate for an extended period of time (Yeakley et al. 2003, Schaefer et al. 2000, Hogan et al. 2020).

Researchers in Norway are evaluating change to atmospheric deposition of nitrate and sulfate on changes to the biogeochemical processes in forested areas (Deininger et al. 2020). Their findings indicate that "declining sulfur deposition, through reducing the ionic strength in soil water, increases the solubility and mobility of organic soil compounds and may result in increased leaching of organically bound N [nitrogen] to freshwaters." Similar observations of decreased inorganic nitrogen loads coupled with increased organic nitrogen loads were noted in DWR's 20-yr status report for the Neuse and Tar-Pamlico Estuaries (DWR 2023, draft).

Based on the work of the Scenario Screening Group, there are projects and activities that can be implemented to reduce nutrient inputs and exports from forests. The UNRBA recommends that these activities be considered as eligible under the revised nutrient management strategy. Again, the UNRBA does not recommend that these would be regulatory requirements, but rather opportunities for local governments and other Tier 1 Watershed Organization members to invest in activities that would improve water quality and quantity. The first three bullets are currently included in the IAIA Program; the remaining bullets represent an expansion of the Program:

- Forest preservation
- Stream, wetland, and buffer restoration/enhancement
- Floodplain expansion
- Enhancement of Forestry Best Management Practices: stream crossings, haul roads, temporary skid trails, etc.
- Consideration of water usage by tree species in forestry management
- Nitrate capture/denitrification following large, destructive storms through temporary active treatment or passive treatment to enhance denitrification in an improved hyporheic zone
- Controlled burns, harvesting, forest management, vegetation management (native/non-native)
- Phytoremediation (using plants to clean up contaminated environments)

While there are contiguous areas of forests in the watershed, these typically are fractured in terms of ownership. Projects and activities that affect multiple owners will complicate implementation. The Watershed Organization would need to foster relationships with the associations listed and other

groups, including agricultural organizations (since a lot of forest land is on land that includes farming activity.)

As the UNRBA continues to develop the revised nutrient management strategy, stakeholder engagement will be expanded to include the NC Forest Service, NC Forestry Association, and other forest management organizations. Representatives of agriculture have existing working relationships with these associations and have offered to support this outreach. One suggestion has been to fund the NC Forest Service Forest Development Program that provides financial support to replant trees after harvesting or when agricultural production has ceased. As with the Agriculture Cost Share Program, this approach would fund existing organizations who have established administrative procedures, decision-making, and fund-allocation processes.

Streambank Erosion

Stream bank erosion is a significant contributor to the sediment and total phosphorus loads delivered to Falls Lake. Streams may become unstable following channelization, changes to land use, increased impervious surfaces, and changing hydrology. Stream restoration and/or infiltration of stormwater can be implemented to regain stability.

Based on the UNRBA WARMF watershed model, approximately 15 percent of the total phosphorus load to Falls Lake comes from streambank erosion. At the scale of the Falls Lake watershed, the model does not account for previously implemented stream restoration projects or site-scale conditions. While there is uncertainty with the stream bank loading estimates, their relative magnitude compared to other sources indicates opportunities for pollutant reductions (Figure 8).

The UNRBA is not proposing any specific regulatory requirements or projects associated with stream bank erosion, but rather allowing the local governments and other Tier 1 members to fund these projects as an eligible activity. The proposed activities associated with streambank erosion are currently allowed by the IAIA Program:

- Stream, wetland, buffer restoration/enhancement
- Floodplain expansion

Streambank erosion represents a truly “distributed” nutrient source in the watershed. The basin has many miles of streams and rivers. Streams and rivers cross multiple property and jurisdictional boundaries which will complicate implementation of this practice. Many organizations and researchers have studied stream bank erosion in the Falls Lake watershed including City of Durham, USGS, and researchers at NC State University. As a result of the UNRBA modeling study, the NC Collaboratory has recently funded a study to identify hot spots of streambank erosion and potential restoration activities that reduce potential of erosive flows that contribute to streambank erosion. The City of Raleigh is also working with USGS on a streambank erosion study.

Atmospheric Deposition and Climate Resilience

Atmospheric deposition of nitrogen, phosphorus, and carbon affects all land uses and waterbodies, including Falls Lake. While this deposition is a natural process needed to cycle nutrients through the environment, human sources of air emission impact atmospheric concentrations of pollutants, and remote air pollution sources move into the watershed based on weather and prevailing winds. This source may provide an opportunity for reducing the amount of nutrients deposited to the system each year.

According to DWR’s 2021 Status Report for Falls Lake, atmospheric deposition of nitrogen has declined by approximately 20 percent since the baseline period. Improvements to air quality

globally, regionally, and locally have contributed to this reduction. Estimates of reduction since baseline vary annually because the amount of rainfall influences the amount of wet deposition.

Changing weather patterns are important to consider as well. Large storms not only result in greater rates of deposition as direct inputs, but they also erode soil, disturb root systems, and increase runoff volumes and shallow ground water inputs to streams. Drought conditions at critical times can concentrate nutrients near the land surface and when rainfall occurs, wash larger loads of nutrients into waters when algal activity can be stimulated. Warmer temperatures for longer periods can cause biological, chemical, and ecological changes. Together, these factors can result in greater nutrient loading, increased algal growth and species shifts, and impact to downstream waterbodies. Therefore, the revised rules should promote projects and activities that are resilient, effective, and sustainable to provide long-term protection of the lake and the watershed.

The UNRBA recommends that the revised nutrient management strategy employ a systems-based approach that will require looking beyond the actions of individual landowners and facility operators. Tier 1 members could fund the following projects and activities to support this holistic effort. The first three bullets are currently included in the IAIA Program; the remaining bullets represent an expansion of the Program:

- Green infrastructure/infiltration devices
- Floodplain restoration and reconnection
- Projects and activities that focus on flooding that have an associated water quality benefit
- Farmer and forest landowner voluntary conservation work which can significantly contribute to climate solutions and offer many other ancillary benefits including soil health, water quality, and pollinator and wildlife habitat within the watershed.
- Climate sustainability and resiliency projects for water/wastewater/stormwater infrastructure (e.g., elevating key operational equipment like pumps at wastewater treatment plants to mitigate the risk of failure due to flooding)
- Tree planting adjacent to busy streets and highways, e.g., the Center for Watershed Protection Forest- Friendly Codes and Ordinance Worksheet and the Wake County Land Cover Analysis and Tree Canopy Assessment that provides tree-planting priorities by municipality
- Air pollution reduction technologies for point source and vehicle emissions
- Public transportation and green energy sources
- Flood preparedness communications (e.g., operations at watershed impoundments)

Distributed Wastewater Sources

In terms of the total nutrient load delivered to Falls Lake, distributed wastewater sources contribute a minor fraction of the load. Distributed wastewater sources include septic systems, discharging sand filter systems, and sanitary sewage releases. However, the smaller tributaries and headwaters may benefit from projects and activities that reduce nutrient loading. From a public health perspective, these projects and activities can be very beneficial.

The UNRBA does not recommend regulatory requirements in the revised rules for private landowners; however, local Health Departments may require private owner action due to violations of local and state health law and rule. The UNRBA recommends that Tier 1 members work toward their investment requirements by continuing to provide funding and technical assistance to support improvements. The activities listed below are currently included in the IAIA Program and should continue to be eligible under the revised rules:

- Address sanitary sewer overflows (SSO) and sewer exfiltration

- Continue to implement measures that reduce volumes reaching the stream
- Continue to identify and repair potential issues
- Develop grant programs for addressing failing sewer lateral lines

- Address failing on-site wastewater treatment systems (OWWS) and failing discharging sand filters (DSF)
  - Continue to conduct state-mandated operation and maintenance (O&M) inspections to proactively reduce failure rates, investigate and repair malfunctioning systems, prioritize inspections in older neighborhoods, and provide grant programs to subsidize homeowner costs for new systems/repairs
  - Continue to allow credits for connecting onsite systems to sewer systems
  - Consider that expanding sewer may reduce the number of onsite systems but will increase development intensity and impervious surfaces
  - Address regulatory issues with State-issued new permits for DSF
  - Consider financial assistance for system repair or connection to regional wastewater systems to address failing systems.

Point Sources (Major and Minor)

As noted in the "Key Findings from the Monitoring and Modeling Studies," major and minor WWTPs contribute approximately six to ten percent of the total nitrogen load and three to six percent of the total phosphorus load delivered to Falls Lake. One reason these relative contributions are comparatively small is that the three largest dischargers have reduced their collective total nitrogen and total phosphorus loads by 57 percent and 73 percent, respectively, from the 2006 baseline (DWR 2021). Further reductions to nutrients discharged from the major facilities would be extremely expensive and energy intensive. Some of the minor facilities have also achieved significant reductions from the baseline period.

These relative contributions are based on actual discharges from each facility. None of the three major facilities are currently discharging at flows as high as their permit limits. The revised nutrient management strategy will need to address the potential for future facility expansions.

Based on the cost of additional facility upgrades relative to the percent contribution of delivered nutrient loads from WWTPs, the UNRBA is not recommending additional regulatory requirements for the WWTPs in the watershed beyond what has already been achieved. Major and minor wastewater treatment plant owners should continue to optimize treatment performance using currently installed technologies. Review of plant performance should be included as a provision of the 25-year review. Plant and collection system owners should continue to track emerging technologies that may become technically and financially feasible in the future for further improvements to plant operations including biosolids handling. Work should continue to identify and eliminate exfiltration from sewer lines and sanitary sewer overflows.

The revised rules should incorporate requirements for new wastewater treatment facility requests or expansion requests including provisions for technology upgrades, joint-compliance permits (e.g., the Lower Neuse Compliance Association's permit), nutrient offsets, and/or nutrient credit trading using practices on managed lands.

Additionally, the UNRBA recommends that Tier 1 members have the opportunity to fund upgrades and improvements to reduce nutrient discharges from minor WWTPs serving low-income households

in the basin. Technical support to improve operations would also be eligible to meet the investment requirements described by the proposed strategy. The minor facilities are a very small percentage of the load to Falls Lake (one percent or less), but improvements at these facilities would contribute to incremental progress in the watershed.

New Development

The UNRBA proposes that the new development rules would mostly continue as currently prescribed in the Falls Lake Nutrient Management Strategy. Proposals to make slight modifications to these rules have been discussed at UNRBA meetings. One example is possibly waiving the requirement for a stormwater assessment by a professional engineer when family property is parceled and inherited by heirs. Another example is to evaluate the nutrient-related allowances and post-development nitrogen and phosphorus exports that are inherent to the currently-accepted exclusive use of low impact development (LID) criteria, as specified in the 2009 North Carolina Low Impact Development Guidebook to ensure that development meets both the hydrologic goals of LID and the water quality improvement goals for Falls Lake.

Additional activities that would support implementation of the new development rules and address concerns with land disturbance are proposed as eligible activities under the revised nutrient management strategy:

- Include joint consultation among watershed organization members to assess and document consistent application of new development requirements,
- Consider changes to Unified Development Ordinances to allow flexibility in implementing beneficial practices and activities.
- Incentivize green infrastructure, disconnected impervious services, soil improvement, low maintenance lawns, etc.
- Revisit soil improvement practice with NC Division of Energy, Mineral, and Land Resources (DEMLR). This practice is currently creditable only for existing development but is most beneficial for new development.
- Adopt policies allowing stormwater treatment within street rights of way or other easements.
- Encourage, partner, and incentivize larger, regional SCMs that treat upstream existing development and the new development for which new SCMs are being permitted.
- Improve information transfer from developers to HOA Boards.
- Build from current jurisdictional approaches including current inspection programs, enforcement programs, etc.
- Coordinate workshops among members to share information about existing programs and best practices.

Transfer Responsibility of SCMs to Local Governments (Not Recommended)

One suggestion proposed that stormwater systems be transferred into true utilities where existing and new SCMs would be placed under the jurisdiction of the local government. This migration would transfer the systems to the local governments so HOAs and private owners would not be tasked with maintaining them. Several issues were identified as reasons this approach would not be feasible or successful. These notes are included in this document as the UNRBA anticipates this suggestion will be posed again in the future.

- There are thousands of existing SCMs with new ones added regularly.
- Local stormwater programs are already underfunded and understaffed; the workload associated with managing and maintaining thousands of SCMs would be overwhelming.

- Fee increases to provide resources for this action would be large in most jurisdictions and very large in some. Increasing taxes and fees is already challenging, and approved rates are often less than originally proposed. Increased funding through additional taxes and fees could not be expected to provide the staffing levels needed. This approach also transfers the cost of maintenance to all rate payers, including low-income households.

The jurisdictions operating the local government stormwater programs (inspections, education, maintenance, and enforcement), indicate the current approach is the most efficient way to handle SCMs operation and maintenance. For these reasons, the UNRBA does not recommend transferring stormwater systems into utilities operated by the local governments.

Program Administration

Preliminary discussions by the UNRBA members and its advisors are leaning toward establishment of a watershed organization (to be named later). This "Watershed Organization" would include the local governments and utilities that currently comprise the UNRBA as well as other potential partners as described above. Formation of a Watershed Organization would occur as outlined in State law (NCGS 143-214.14). To allow for administration of the Program(s) managed by this organization, it would likely need to register with the State of NC and adopt Bylaws to establish the governance of the Watershed Organization and administer the revised nutrient management strategy. The State of NC would need to delegate authority to the Watershed Organization to implement the revised strategy. Establishing a Watershed Organization to coordinate compliance provides a clear line of communication with the membership and the regulatory agency.

The Collaboratory is funding a study to examine the legislative requirements and operational constraints that may apply to the Watershed Organization. As the rules revision process proceeds, the UNRBA will be working with the Collaboratory, Mr. McLawhorn, the UNRBA legal group, and UNRBA's legal advisor to ensure that State and Federal statutory and regulatory requirements are met.

The Bylaws of the Watershed Organization will need to address the following elements:

- Organizational structure including committees
- Voting and decision making
- Annual administrative dues
- Adding members to the program
- Member resignation and termination - members that resign or are terminated will need to make arrangements with DWR to demonstrate compliance under an alternate framework; it will be the responsibility of the member leaving the program to contact DWR and to determine the actions they need to take to meet these requirements
- Revisions to minimum annual investment amounts
- Joint-funding of special projects)
- Definition of Tier 1 and Tier 2 members; flexibility to add additional member tiers as the program evolves

Participation in the Program will need to be confirmed by the Bylaws of the Watershed Organization, adoption of the program document for the revised strategy, and submission of a resolution of commitment by the members of the Watershed Organization.

Proposed Structure of the Watershed Organization

The preliminary concepts for the new Watershed Organization are to establish two membership tiers. Tier 1 would include local governments, state and federal agencies, and utilities that would have specific requirements under the revised nutrient management strategy. These requirements would likely be investment-based (cash and in-kind) as under the current IAIA Program. Internal and external stakeholders, including staff from DWR and environmental advocacy groups, indicate they would like to see this approach continued under the revised strategy. Tier 1 members would be responsible for funding projects and activities as well as administration of the program. Administrative costs could include meeting coordination and development of meeting materials, compiling annual reports from members, generating a summary report for submittal to DWR, providing technical advisory support, and answering questions about the program from members of the Watershed Organization, regulatory agencies, elected officials, and the public.

Tier 2 members would not have specific requirements under the revised strategy. Their participation would be strictly voluntary. Tier 2 members would be potential partners in the implementation of practices and actions that improve water quality and quantity across the watershed. Tier 1 members would coordinate with and support Tier 2 members to identify and, if appropriate, implement projects across a wide range of land uses and nutrient sources. Funds from Tier 1 members may also be used by Tier 2 members to support reporting and tracking efforts as well as technical assistance programs. Tier 2 members would receive the benefits of investments from Tier 1 members but maintain their own tracking and reporting.

Tier 1 and Tier 2 members would maintain control of actions affecting their lands and interests and provide oversight by leading committees within the Watershed Organization that are focused on their area of responsibility. For example, a committee established to identify opportunities for supporting agriculture in the watershed would be led by representatives from agriculture. The same approach would apply to NC DOT.

As with the IAIA, it is not anticipated that the new Watershed Organization will receive or manage funds from members investing in their own projects, or on projects undertaken by agreement with other participants or other organizations. The current IAIA provides for the funding of "special" projects coordinated through the UNRBA, and the Bylaws for the Watershed Organization should address this potential. As envisioned currently, participating members would develop the necessary agreements and track and report individual and joint contributions. Participants would directly provide the investment funding or support to successfully complete projects and maintain appropriate project files for future reference. Project plans and specific information related to design, installation, operation, and maintenance would not have to be submitted to DEQ but should be kept on file by the participants in accordance with their file retention practices.

Investments

Investments in eligible projects and activities may be "cash" or in-kind (e.g., self-funded projects, donation of technical-service hours, or use of equipment). Individual members will provide annual reports to DEQ that identify each project and the investment amount (for multi-year activities/projects, the participating member will show a total investment and note the projected investment for the coming years). On the basis of these reports, the Watershed Organization will provide a summary report to DWR and to the membership on total participation and total investment.

As envisioned currently, each participant may allocate resources using one or more of four funding options. Participants can use a combination of project funding approaches and can change which funding options they utilize from year to year. Investment credits generated from multi-partner

projects shall be credited to the partners based on individual participant contribution levels including accounting for long-term operation and maintenance costs. The project agreement may provide other allocations for investment credits. The four funding options are listed below:

- Self-funded – An individual participant may use funds for eligible projects and activities within and managed by their own organization.
- Interlocal agreement – Individual participants may enter into interlocal agreements in which eligible projects and activities are jointly funded by two or more jurisdictions.
- Funding existing local organizations - Individual participants may contribute funds towards eligible projects or activities to other local organizations including local Soil and Water Conservation Districts, County Health Departments, School Districts, watershed improvement associations, land conservation groups, and Tier 2 members that do not have investment requirements that may implement projects to improve water quality. The receiving local organization is responsible for prioritizing and selecting from the list of eligible projects and activities under their established procedures for setting priority. Use of funds by other local organizations is limited to projects and activities associated with water quality and watershed improvement benefits. A separate agreement/contract may be required to specify use of funds by other local organizations. Local government funding of agriculture-related projects is discussed in the section called "Opportunities for Partnering on Agricultural Lands."
- Development of a special project– individual participants may contribute to a special project as would be described in the bylaws. These projects would involve the Watershed Organization to manage the project and coordinate the project development steps. Project management subcontractors may be necessary if projects are complex or large. Joint funding would have to cover project management costs, either as managed by the Watershed Organization or by a contractor. The Watershed Organization would likely recommend that the two or more members participating in a proposed special project consider the alternative of a joint project through an interlocal or other type of acceptable agreement. Special projects must fall under the approved list of project types provided in the latest version of the program document.

If a local government receives grant funding for an eligible project, only the investment from the local government(s) used to contribute a match to the project may be counted toward their annual investment commitment under the program (i.e., the grant award may not be counted). It is the responsibility of the participant(s) to ensure that the requirements of the grant are met.

Minimum annual investment commitments for the Tier 1 members will be negotiated during the rules review process and specified in the program document for the revised strategy. Tier 1 members will be responsible for their assigned annual commitment, and if financial resources are made in excess of the annual commitment, the excess may be credited against the member's future years commitment. Each member will have the option to withdraw from the program in accordance with the bylaws of the Watershed Organization as long as an alternate compliance framework is agreed upon by DWR prior to withdrawal. Alternate compliance frameworks may be specified in the revised rules but are not included in this document.

Duration

The revised nutrient management strategy for Falls Lake will be a long-term plan to improve water quality and quantity. Based on stakeholder input, the UNRBA proposes a 25-year program with interim evaluations of success and potential areas of improvement as part of an adaptive management program. The UNRBA recommends that the rules not include the specifics of the program because it will be extremely difficult to use adaptive management provisions. An approved program document referenced by the rules with specific renewal periods (e.g., five years) would be a

more reasonable and adaptative approach. This approach is similar to the IAIA where the Stage I Existing Development Rules reference the IAIA Program Document as the joint-compliance approach.

The initiation date of the revised nutrient management strategy will be determined by the readoption of the Falls Lake Rules which must be achieved in accordance with Session Law 2018-5. This session law specifies that the EMC must begin rule re-adoption no later than December 31, 2024. It is anticipated by DWR that readoption of the rules will occur no later than 2027. The current IAIA program has an initial 5-year investment commitment. The program began on July 1, 2021, and is scheduled to end on June 30, 2026. Depending on the status of rule readoption, the IAIA program may need to be renewed to continue compliance with the Stage I Existing Development Rule. Implementation of the revised strategy will need to take into consideration the status of the IAIA.

Previous and ongoing nutrient reduction activities and projects, including those implemented prior to and under the IAIA will be credited as actions, investments, and/or reductions in the revised strategy. The UNRBA and its members are committed to making sure that projects and activities implemented prior to readoption of the rules are included in the framework for compliance with the readopted Falls Lake Nutrient Management Strategy.

Reporting

Annual reports would be submitted by each Tier 1 member to DWR. These annual reports will list all eligible projects and activities implemented under the program and include an assessment of compliance with respect to minimum investment requirements. Copies of annual reports will be provided to the Watershed Organization for tracking and summary purposes. The Watershed Organization will provide a summary report each year to DWR that summarizes the total investments and commitments for the previous fiscal year. Annual reports from Tier 1 members would be submitted to DWR (with copy to the Watershed Organization) by September 30th following the end of each fiscal year. A summary report based on the individual reports would be generated for consideration by the Watershed Organization at their following meeting in November with submittal to DWR by November 30th.

Regardless of the type of funding arrangement used to demonstrate participation under the revised strategy, each Tier 1 member will need to report, in accordance with the program document, the following types of information depending on the funding option utilized (i.e., as information is available). A template for reporting has been developed to support the IAIA Program and can be modified to support this expanded program:

- Funding option and partners
- Primary organization responsible for management and distribution of funds
- Types and locations of projects and activities planned and linkage to addressing water quality in the watershed and the Lake
- Status of projects and activities (e.g., permitting, construction, completion status)
- Funds allocated (cash and in-kind)
- Estimated nitrogen and phosphorus reductions associated with projects and activities if quantifiable, or other tracking metric, based on the information available for the action/project, for activities without State-approved nutrient credits (e.g., acres conserved, linear feet of pipe repaired). Nutrient credits determined and based on approved crediting methods effective at the time the project is planned, designed, and developed that may be needed for any future credit accounting requirements will not be decreased at a later time based on revisions to credit accounting methods or assumptions. **Note that for projects related to agriculture, Tier 1**

members may include their investments in their tracking reports, but the estimated nutrient reductions associated with the projects will be maintained in the agricultural reporting system.

- Anticipated timeline for completion

As noted previously, the primary reporting and compliance assessment metric will be based on investments. Actions and projects with State-approved nutrient reduction credits would continue to be tracked and reported in annual reports for informational purposes. Representatives of agriculture would continue to maintain their tracking methods and reporting for agricultural production and nutrient losses.

In addition to the annual reports, interim reports (e.g., every five years) will be developed summarizing the previous period of implementation. Interim evaluations and reporting can address concerns and assist with tracking trends and accomplishments during the 25-year assessment period. Challenges that arose during the preceding five years will be noted and revisions to the program suggested as needed. DWR's assessment of water quality and nutrient loading to Falls Lake in their five-year status reports will be summarized as well. Water quality conditions in other impoundments in the watershed will also be summarized. Additionally, these interim reports will be used to identify and track questions and issues that need to be considered in the full reassessment. These interim reports would be submitted by the Watershed Organization based on information and discussions with members and partners including DWR. Interim assessments provide an opportunity to revise the program to address challenges, concerns, and new technologies. Changes and modifications to the program may be considered by the Watershed Organization and DWR. As with the IAIA, the five-year report will also be used to reaffirm commitments of participating jurisdictions and support their capital improvement project planning. Members who choose not to participate in the program for the following years would negotiate a compliance framework with DWR. Alternative compliance frameworks may be developed during the rules review process and included in the revised rules.

The UNRBA recommends the revised strategy include a long-term reassessment of the program (e.g., 25 years) to evaluate performance, identify necessary program changes, and consider evolving technologies and climatological conditions. It is anticipated that the Watershed Organization would coordinate this review process and include a technical assessment of water quality conditions to help guide the readoption of the program with appropriate revisions as part of the reevaluation. The technical assessment would review monitoring data collected by DWR and other organizations and may recommend collection of additional monitoring data. The technical assessment may also require modeling support to assess proposed changes to the program. DWR and the Watershed Organization will work cooperatively to provide the data needed to support the evaluation. To prepare for this assessment, the Watershed Organization could hire a contractor to develop a monitoring plan and other supporting guidelines for the collection and analysis of data, including modeling as needed. DWR would work in conjunction with the Watershed Organization to develop this assessment process and would provide support in the collection of additional data. This adaptive management provision provides a reasonable period of time to assess the program and to determine if changes are needed for the future. Planning for this report and supporting studies should begin no later than 20 years after the start of the program.

Compliance Determination

The revised nutrient management strategy will likely be submitted to the NC EMC as a joint compliance framework for the continued improvement to water quality and quantity in the Falls Lake watershed. Compliance will likely be determined based on the Tier 1 members meeting and reporting on their annual investment levels as specified in an approved program document. This approach is consistent with EPA's Integrated Planning for Municipal Stormwater and Wastewater

which “allows a municipality to balance Clean Water Act requirements in a manner that addresses the most pressing public health and environmental protection issues first.” To better align with the requirements of the Integrated Planning Program, NPDES permit holders may need to reference this approach in their permit.

The revised program will likely be a joint compliance effort, but compliance under this program will be assessed individually for each Tier 1 member. An approved program document will be developed with this understanding and with the following basic provisions for demonstrating compliance:

- Each Tier 1 member must document and track investments and eligibility of funded actions or projects and submit annual reports to DWR (with copies provided to the Watershed Organization).
- A member’s adherence to the provisions of the program represents compliance with the readopted Falls Lake Rules.

If a Tier 1 member resigns or is terminated under the provisions of the Bylaws, the following is a list of guidelines related to the impacts and actions that the departing member must address or that will impact the member in departing:

- Reentry to the program can only be considered under the membership provisions of the Bylaws
- It is the responsibility of the departing member to contact DWR and to determine the actions it must take and the schedule it must follow to comply with the readopted rules
- The member must address specific program commitments made when joining the Watershed Organization as described in the Bylaws including agreements with other members on joint projects

The group as a whole is not out of compliance if a member drops out.

Financial resource commitments of the departing member for any joint projects not yet completed would be controlled by the agreement in place between the joint project members that developed the joint project.

The total investment level will change in the fiscal year following the departure or addition of a member by the amount of the commitment assigned to the member, but the remaining members investment commitments will not be revised.

Projects can be implemented anywhere in the watershed through this program. Additionally, the provisions of 15A NCAC 02B .0703 Nutrient Offset Credit Trading do not apply to existing land uses and therefore do not apply to the revised program.

Demonstration of compliance can be accomplished with a brief description of relevant programs or activities being implemented (e.g., heightened permitting or land use requirements, education programs, recurring program expenditures) by the applicable jurisdictions and are considered eligible practices under the program. This information will be provided by the participant in their individual annual report provided to DWR.

Participants should ensure that all local, state, and federal requirements under their jurisdictional control are met. These include but are not limited to water supply watershed protection, buffer rules, MS4 permits, and sediment and erosion control requirements. In determining whether to be the host jurisdiction (where the project would be located) for an SCM project, the host jurisdiction should be alert to the requirements of other permit programs and determine, in consultation with the Division of Energy, Mineral, and Land Resources, if the SCM will become a part of the MS4 inventory of local government owned facilities.

Proposed Legislative Changes

The NC Collaboratory is funding a study to evaluate potential changes to the Falls Lake Rules that would allow for a more collaborative, system-based approach to nutrient management in the watershed. The UNRBA is working with the lead author of this study, Dan McLawhorn, to better understand existing legal constraints on its proposals and where legislative changes may be required. A link to the presentation on this topic at the 2023 Falls Lake Nutrient Management Study Symposium hosted by the NC Collaboratory is available here. The UNRBA will begin developing recommendations for potential rule changes after its December 2023 submittals and will coordinate this effort with DWR. Rules will be amended to be consistent with the General Statutes and Session Laws which apply to the program.

Status of the UNRBA Recommendations

This Concepts and Principles Document was developed based on input from the PFC and the Board of Directors as well as input from external stakeholders, including staff from DWR and representatives from agriculture, DOT, and NGOs. These discussions identified several program components to guide development of the revised Falls Lake Rules. Many of the program components identified are designed to promote flexible implementation of the rules.

Feedback provided to date supports the inclusion of significant flexibility in the revised strategy. Much of the existing land use or non-point source components of the revised rules need to be built on the submission of joint compliance plans for approval. This flexibility needs to provide for the opportunity to revise programmatic components of the efforts under the existing land use provisions of the strategy. Because the proposal is looking at a 25-year implementation period with planning for data analysis and potential additional data collection and modeling beginning by year 20, it is clear that the rules will not be open for change for a long period of time. Operational activity and the need for adjusting program components will likely arise before the formal assessment of the strategy. If the program is prescribed in the rules, revisions will be extremely difficult to manage. An approved program document referenced by the rules would be much more reasonable and adaptative.

This Concepts and Principles has been distilled into an updated set of Consensus Principles (called Consensus Principles II) for consideration by the governing bodies of the UNRBA members (e.g., county commissioners, town councils, city councils, utility boards). Once the individual governing bodies have signed the Consensus Principles II and endorsed the UNRBA recommendations for the revised nutrient management strategy, the UNRBA will submit these documents to the EMC and DWR by December 2023.

As the rules readoption process unfolds, discussions among UNRBA members and other external stakeholders will continue. Additional recommendations and responses to stakeholder feedback will be considered during this process.

To provide your input on this document, please email
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