UNRBA Monitoring Plan

For Submission to the North Carolina Department of Environment and Natural Resources, Division of Water Resources

E213006400

Cardno
Shaping the Future

Document Information

Prepared for	Upper Neuse River Basin Association
Project Manager	Lauren Elmore
Date	May 23, 2014

Prepared for:

Upper Neuse River Basin Association
P.O. Box 270, Butner, NC 27509

Prepared by:

Cardno ENTRIX
5400 Glenwood Ave, Suite G03, Raleigh, NC, 27612

Table of Contents

Appendices

Tables

Figures

1 Upper Neuse River Basin Association Monitoring Plan

This monitoring plan was developed jointly by Cardno ENTRIX and the Upper Neuse River Basin Association (UNRBA). Significant input on the monitoring plan was provided by the Path Forward Committee, individual UNRBA members, the UNRBA Executive Director, and technical advisors. Multiple meetings were held with the Path Forward Committee to discuss and revise the monitoring plan. The monitoring plan is also based on a compilation of supporting work conducted by Cardno ENTRIX under contract with the UNRBA over the last two years. The technical memoranda (TM) that document this work include:

Task 1 TM: Framework for a Re-examination of Stage II of the Falls Nutrient Strategy. 2013.

Task 2 TM: Review Existing Data and Reports for Falls Lake and the Watershed. 2012.

Task 3 TM: Estimation of Nutrient Loading to Falls Lake. 2013.

Task 4 TM: Review of Existing Models and Recommendations for Future Studies. 2013.

2014 TM: Description of the Water Quality Model Framework under the Re-examination Provision of the Falls Lake Rules.

2014 TM: Evaluation of the Sensitivity of the Falls Lake Nutrient Response Model

2014 TM: Comparison of Flow Estimation Methods.

2014 TM: Water Quality Estimation and Monitoring Optimization.

In 2010 the Environmental Management Commission (EMC) passed the Falls Lake Nutrient Management Strategy, requiring two stages of nutrient reductions (N.C. Rules Review Commission 2010). The Rules establish a Nutrient Management Strategy for Falls of the Neuse Reservoir aimed at attaining

> "…the classified uses of Falls of the Neuse Reservoir set out in 15A NCAC 02B .0211 from current impaired conditions related to excess nutrient inputs; protect its classified uses as set out in 15A NCAC 02B .0216, including use as a source of water supply for drinking water; and maintain and enhance protections currently implemented by local governments in existing water supply watersheds encompassed by the watershed of Falls of the Neuse Reservoir." (15NCAC 02B .0275)

Stage I of the Nutrient Management Strategy requires "intermediate or currently achievable controls throughout the Falls watershed with the objective of reducing nitrogen and phosphorus loading, and attaining nutrient-related water quality standards in the Lower Falls Reservoir as soon as possible but no later than January 15, 2021, while also improving water quality in the Upper Falls Reservoir…." (15NCAC 02B .0275 (4) (a)). Based on modeling and evaluation by the NC Division of Water Quality (NCDWR), Stage I requires a 20 percent and 40 percent reduction in loading of total nitrogen and total phosphorus, respectively, for point sources and agriculture. For existing development, the rules require that loading be reduced to the baseline year (2006) levels established by NCDWR. Stage I requires local jurisdictions to establish requirements to control nutrient inputs from new development.

Stage II requires that all areas of Falls Lake achieve the nutrient-related water quality standard of 40 µg/l of chlorophyll *a*. Based on NCDWR modeling and evaluation, the additional loading reductions required to achieve this goal are 40 percent and 77 percent for total nitrogen and total phosphorus, respectively, relative to the baseline year. NCDWQ reservoir monitoring data will be used to assess compliance with the goals of the Strategy and determine if additional load reductions to a particular lake segment are needed. As stated in the Rules:

> "Stage II requires implementation of additional controls in the Upper Falls Watershed beginning no later than January 15, 2021 to achieve nutrient-related water quality standards throughout Falls Reservoir by 2041 to the maximum extent technically and economically feasible…." (15NCAC 02B .0275 (4) (b))

Section 5 (f) of the Falls Lake Nutrient Management Strategy recognized the uncertainty associated with the water quality modeling and the Stage II requirements and allows a re-examination of the rules after additional data collection:

> 5(f) Recognizing the uncertainty associated with model-based load reduction targets, to ensure that allowable loads to Falls Reservoir remain appropriate as implementation proceeds, a person may at any time during implementation of the Falls nutrient strategy develop and submit for Commission approval supplemental nutrient response modeling of Falls Reservoir based on additional data collected after a period of implementation. The Commission may consider revisions to the requirements of Stage II based on the results of such modeling as follows:
>
> > (i) A person shall obtain Division review and approval of any monitoring study plan and description of the modeling framework to be used prior to commencement of such a study. The study plan and modeling framework shall meet any Division requirements for data quality and model support or design in place at that time. Within 180 days of receipt, the division shall either approve the plan and modeling framework or notify the person seeking to perform the supplemental modeling of changes to the plan and modeling framework required by the Division;
> >
> > (ii) Supplemental modeling shall include a minimum of three years of lake water quality data unless the person performing the modeling can provide information to the Division demonstrating that a shorter time span is sufficient;
> >
> > (iii) The Commission may accept modeling products and results that estimate a range of combinations of nitrogen and phosphorus percentage load reductions needed to meet the goal of the Falls nutrient strategy, along with associated allowable loads to Falls Reservoir, from the watersheds of Ellerbe Creek, Eno River, Little River, Flat River, and Knap of Reeds Creek and that otherwise comply with the requirements of this Item. Such modeling may incorporate the results of studies that provide new data on various nutrient sources such as atmospheric deposition, internal loading, and loading from tributaries other than those identified in this Sub-item. The Division shall assure that the supplemental modeling is conducted in accordance with the quality assurance requirements of the Division;
> >
> > (iv) The Commission shall review Stage II requirements if a party submits supplemental modeling data, products and results acceptable to the Commission for this purpose. Where supplemental modeling is accepted by the Commission, and results indicate allowable loads of nitrogen and phosphorus to Falls Reservoir from the watersheds of Ellerbe Creek, Eno River, Little River, Flat River, and Knap of Reeds Creek that are substantially different than those identified in Item (3), then the Commission may initiate rulemaking to establish those allowable loads as the revised objective of Stage II relative to their associated baseline values.

As established in Section 5 (f) of the Falls Lake Nutrient Management Strategy this UNRBA monitoring plan is being submitted to the Division of Water Resources for their review and approval so that the UNRBA can proceed with their monitoring program. The UNRBA would like to begin their monitoring program at the beginning of July 2014.

This document presents the Upper Neuse River Basin Association's proposed routine monitoring program along with special studies needed to support the UNRBA's three main goals for the monitoring program. This proposed monitoring program assumes that the existing USGS flow gages within the Falls Lake watershed will continue to be supported throughout the four to five year monitoring program. If support is discontinued for any station(s) in the future, the UNRBA may need to provide funds from its monitoring budget to continue to support flow monitoring (See Figure 1).

The Path Forward Committee of the UNRBA prioritized three monitoring program objectives:

1. Lake response modeling,
2. Support of regulatory options, and
3. Source allocation and estimation of jurisdictional loading.

Objectives 1 and 3 involve routine monitoring at sites on tributaries and in the lake and all three objectives will be supported by targeted special studies aimed at elucidating model parameters, nutrient transformations and nutrient source allocation, and linking water quality to designated uses. This document describes the routine monitoring plan for lake response modeling and at jurisdictional boundaries agreed upon by Cardno ENTRIX and the UNRBA in Section 1.1. It also identifies special studies to be conducted in support of lake response modeling, identifying source allocation, and facilitating future regulatory options. Not all special studies identified by UNRBA are financially feasible; this document lists only those studies prioritized by the UNRBA with the goal of being completed over the four to five year monitoring program.

A summary of the proposed monitoring plan is presented in Table 1. This table describes the recommended monitoring components for Years 1 through 4 with an optional fifth year to provide data if abnormal hydrologic conditions are encountered in previous years. As data are collected and analyzed each year, monitoring plans for subsequent years may be refined. The data collected each year will be reviewed and the overall monitoring program re-evaluated to confirm whether adjustments are needed in the frequency and location of data collection or the collection of particular water quality parameters. For example, specific water quality parameters such as chlorophyll *a* collected at the lake loading stations may not be needed for all monitoring years. Any revisions to the monitoring plan will be submitted to the DWR for review and approval prior to the beginning of the next monitoring year.

Tributary sampling locations are shown in Figure 1 and are listed in Tables 2 (Lake Loading sites) and 5 (Jurisdictional Boundary sites) along with the recommended monitoring frequencies, coordinates, and drainage areas of the sampling locations.

Figure 2 identifies the locations in the lake where water quality is monitored by the North Carolina Division of Water Resources (DWR), North Carolina State University's Center for Applied Aquatic Ecology (CAAE), the City of Raleigh, and the City of Durham. Much of the CAAE work is funded by the City of Raleigh.

Detailed information regarding the individual monitoring program components are provided in the following sections. Routine monitoring is described in Section 1.1 and recommended special studies are presented in Section 1.2. The details of each special study can be found in Appendix A.

Table 1 Recommended UNRBA Monitoring Program

Monitoring Program Component	Year 1	Year 2	Year 3	Year 4	Year 5 (optional)
Lake Loading at 18 stations	**Twice a month** Ellerbe, Eno, Little, Flat, and Knap of Reeds; **Monthly** all other locations.	**Twice a month** Ellerbe, Eno, Little, Flat, and Knap of Reeds; **Monthly** Little Lick, Lick, Ledge, New Light, and Upper Barton; **Quarterly** all other locations.			
20 jurisdictional boundary stations	**Monthly** monitoring at all locations				
Special Studies	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5 (optional)**
Storm event sampling	x	x	x	x	x
Benthic flux and in-lake processes		x	(alternate year)		
Stream-bank erosion		x			
Quarterly diurnal water quality studies	x	x	x	x	x
Fish monitoring at seven stations	x	x	x	x	x
Drinking water quality and lake monitoring	x	x	x	x	x
Recreational data		x	x	x	x

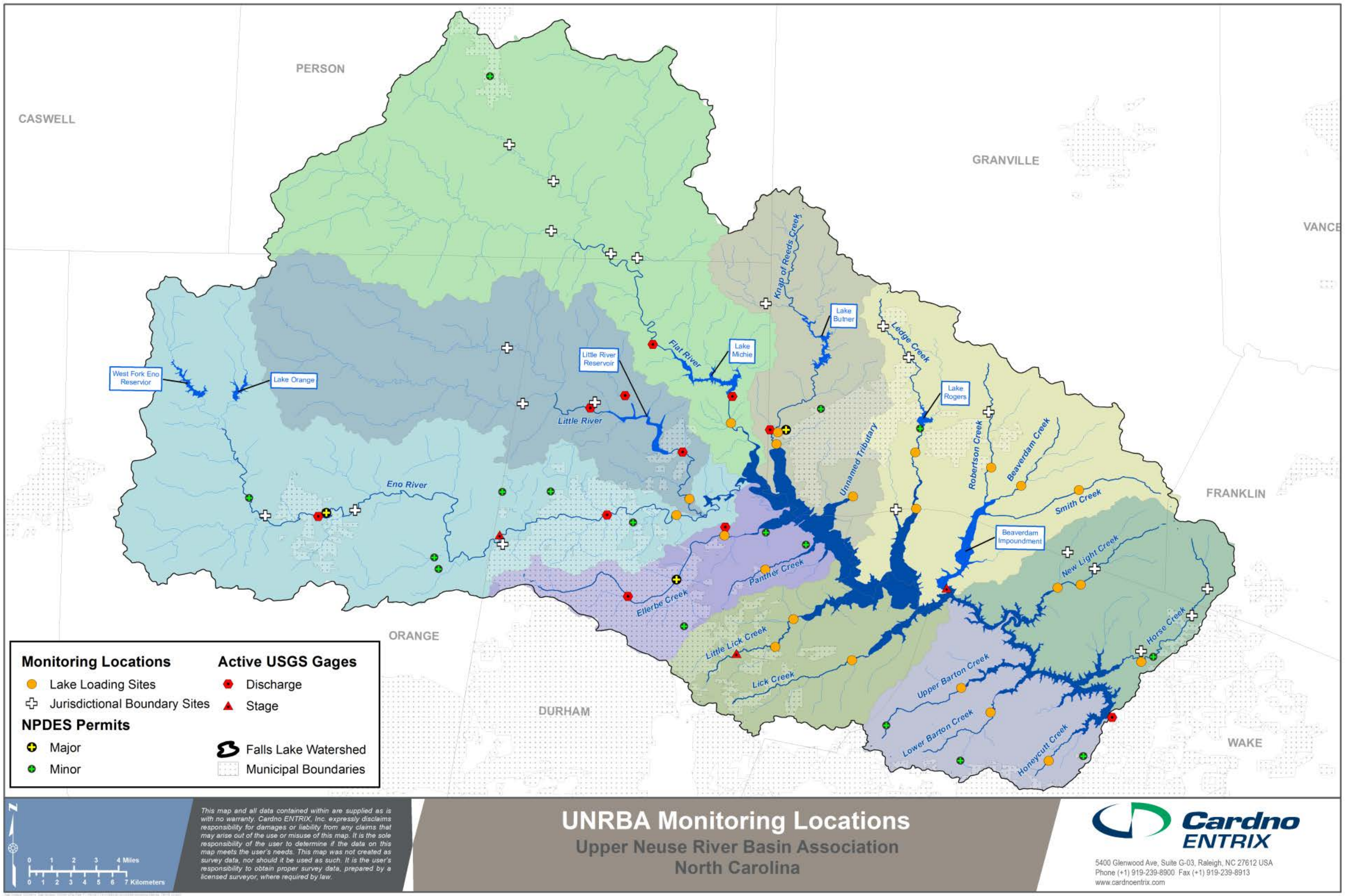

Figure 1 **UNRBA Lake Loading and Jurisdictional Boundary Monitoring locations and existing USGS gages.** Tributaries with 2 Lake Loading Sites displayed will only be monitored at one of the locations shown; the final monitoring site determination will be made based on site visits.

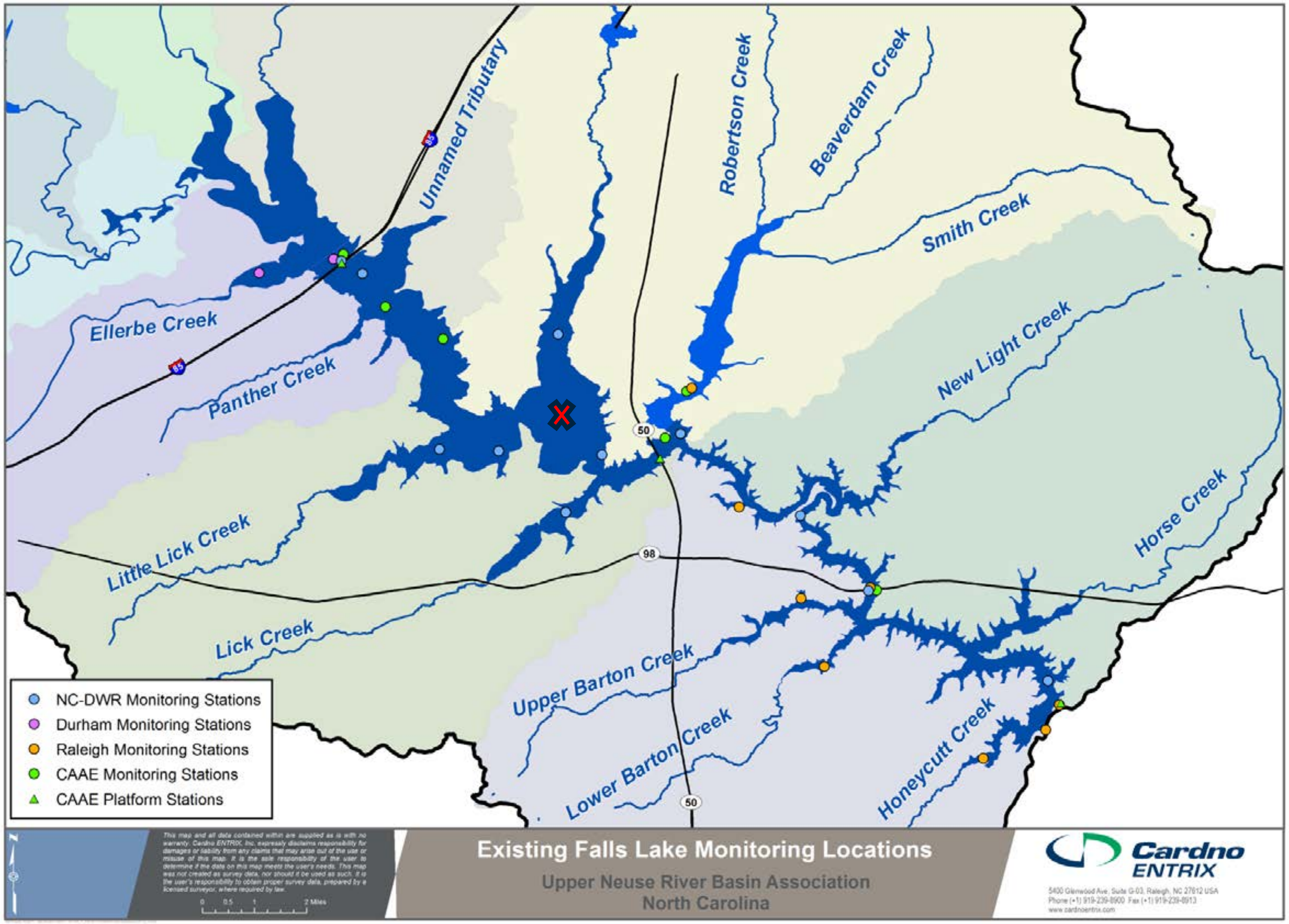

Figure 2 **Falls Lake DWR, CAAE, City of Raleigh, and City of Durham Monitoring Locations. Red X indicates new station UNRBA is requesting that DWR add to their monthly monitoring of Falls Lake.**

1.1 Routine Monitoring

The objectives of the UNRBA monitoring program will be supported by routine monitoring of key water quality parameters (e.g. nutrients, sediment, carbon, and chlorophyll *a*, depending upon location) at designated locations for characterization of loading to the lake, in-lake concentrations, and concentrations at jurisdictional boundaries.

1.1.1 Lake Loading Sites

As described previously by Cardno ENTRIX (2012), the majority of the watershed monitoring data has been collected in the areas that drain to the upper lake. To characterize tributary inputs to support lake modeling, measurements or estimates of flow and water quality are needed at the mouths of each of the tributaries. The current EFDC model setup includes 17 tributary input points. Monitoring data will be collected at 18 tributary input points (the Little River and Eno River will be sampled separately rather than collecting data downstream of their confluence) to facilitate multiple uses of the data including watershed modeling, BMP prioritization, etc.

The tributary sampling will capture various hydrologic regimes. Monitoring at all lake loading sites includes the following parameters: chlorophyll *a*, NH3, NO2/NO3, TKN, Ortho-P, TP, total suspended solids (TSS), total organic carbon (TOC), dissolved organic carbon (DOC), 5-day carbonaceous biochemical demand (CBOD5), specific UV absorbance (SUVA), and field parameters.

The UNRBA monitoring plan balances precision in ability to estimate daily loads with monitoring costs. Sampling will occur twice a month at the five upper lake tributaries which contribute roughly 70-80 percent of the nutrient loading to Falls Lake; it is important to have greater confidence in nutrient load estimates in these areas. The remaining 13 tributaries will be monitored monthly for the first year. Following this sampling frequency for the four years will allow the models presented in the Water Quality Estimation and Optimization Technical Memorandum (Cardno ENTRIX 2014c) to estimate daily concentrations of TN and TP with 90 percent confidence that the relative errors on the estimates are 11 and 18 percent, for TN and TP respectively. If historical data from the 5 largest tributaries (collected by DWR, the United States Geological Survey, and UNRBA member organizations) were included in model development, these relative errors would decrease to approximately 8 and 13 percent, for TN and TP respectively. As stated in the Water Quality Estimation and Optimization Technical Memorandum (Cardno ENTRIX 2014c), these relative errors are for comparison purposes only, as alternative models may ultimately be selected for use in estimating daily loads from tributaries.

In years 2 through 4, some tributary loading stations may be reduced to quarterly sampling with only very slight increases in the associated relative error of load estimates (within a percent or two) if monitoring data from the first year validate the statistical models. However, it is also possible that UNRBA may want to increase sampling frequency at some stations after reviewing initial monitoring data. Such alterations in monitoring frequency will be considered annually by the UNRBA. The current monitoring plan assumes 8 lake loading stations (which together make up less than 10% of the Falls Lake drainage area) could be reduced to quarterly sampling in years 2 through 4.

Table 2 identifies the lake loading stations which will be monitored and sampling frequencies for year 1. Specific tributary sampling locations are identified by nearest road crossing and coordinates. Drainage areas are also provided. These locations are also shown on Figure 1.

Table 2 **Lake Loading Monitoring Locations and Sampling Frequency for the First Monitoring Year.** A total of 18 locations will be selected. Four tributaries have two sites listed (Knap of Reeds, Little Lick, Ledge, and New Light). Only one of each pair of listed sites will be monitored. The final site determination will be made based upon field visits.

	Waterbody	Road Crossing	Latitude	Longitude	Drainage Area (mi^2)	Recommended Frequency
LL01a	Knap of Reeds Creek	at SGWASA WWTP	36.128000	-78.798530	41.9	Twice per month
LL01b	Knap of Reeds Creek	access off of Brickhouse Road	36.118226	-78.798476	44.7	Twice per month
LL02	Flat River	at Old Oxford Highway	36.131900	-78.827981	169	Twice per month
LL03	Little River	at Old Oxford Road	36.081667	-78.854722	104	Twice per month
LL04	Eno River	at Old Oxford Highway	36.072642	-78.862700	149	Twice per month
LL05	Ellerbe Creek	at Glenn Road	36.059583	-78.832200	21.9	Twice per month
LL06	Panther Creek	at end of Cooksbury Drive	36.036971	-78.806446	3.24	Monthly
LL07a	Little Lick Creek	at Patterson Road	36.004633	-78.787502	13.8	Monthly
LL07b	Little Lick Creek	at Stallings Road	35.986681	-78.799173	10.1	Monthly
LL08	Lick Creek	at Southview Rd south of Hwy 98	35.977936	-78.749565	10.8	Monthly
LL09	Unnamed Tributary	at Northside Road	36.084307	-78.748911	3.43	Monthly
LL10a	Ledge Creek	at Old Weaver Trail	36.076554	-78.707685	24.1	Monthly
LL10b	Ledge Creek	at Highway 15	36.113126	-78.708498	20.3	Monthly
LL11	Robertson Creek	at Brassfield Road	36.102984	-78.659167	12.0	Monthly
LL12	Beaverdam Creek	at Horseshoe Road	36.091260	-78.639854	12.7	Monthly
LL13	Smith Creek	at Lawrence Road	36.088429	-78.602448	6.30	Monthly
LL14a	New Light Creek	at Woodlief Road	36.024974	-78.616262	17.1	Monthly
LL14b	New Light Creek	at Mangum Dairy Road	36.027012	-78.601325	12.3	Monthly
LL15	Horse Creek	at Thompson Mill Road	35.979137	-78.561741	11.9	Monthly
LL16	Upper Barton Creek	at Mt Vernon Church Road	35.959915	-78.678645	8.26	Monthly
LL17	Lower Barton Creek	at State Road 1834 (Norwood Road)	35.943928	-78.659621	10.4	Monthly
LL18	Honeycutt Creek	at Honeycutt Road	35.912558	-78.622060	2.76	Monthly

Parameters recommended for routine monitoring are based on input requirements of the EFDC model along with input from UNRBA member organizations (Table 3). In addition to the standard field parameters and lab analyses for nutrients, TSS, TOC, and chlorophyll *a*, a few additional parameters have been identified for collection and are described below.

Table 3 Water Quality Indicators to be Measured at Lake Loading Sites

Field Measurements	Laboratory Analyses
Water temperature Air temperature Specific conductance Dissolved Oxygen pH	Total Kjeldahl nitrogen Nitrate + nitrite Ammonia Total phosphorus Orthophosphate Total organic carbon Dissolved organic carbon Chlorophyll *a* Total suspended solids Color (or Tannins and Lignin based on Lab input) UV absorbance (at 254nm) Carbonaceous biochemical oxygen demand (CBOD5)

DOC is a state variable used in the EFDC model along with particulate organic carbon (POC). The POC data will be split into labile and refractory fractions. Monitoring TOC and DOC will allow POC to be calculated by difference. Five-day carbonaceous biochemical oxygen demand (CBOD5) will be used to estimate the partitioning of labile and refractory forms of carbon (Hendrickson et al 2002). This partitioning of carbon will be used in combination with empirical relationships between C:N and C:P ratios as a function of carbon lability in order to further estimate the lability of nutrients (Hendrickson et al 2002).

Color and UV absorbance, which is used with DOC to obtain specific UV absorbance (SUVA), will be used for multiple purposes. Color and SUVA are indicators of the concentration of humic substances in water (Cuthbert and del Giorgio 1992, Weishaar et al. 2003) and can be used to estimate how labile or refractory the carbon pool is (how easily can bacteria break it down?) as well as to identify how much of the carbon pool comes from terrestrial sources versus instream primary production. This can be an important distinction because control of these two sources is achieved by different methods. Color can be used secondarily to inform the coefficient of background light extinction used in the lake response model. This coefficient affects the availability of light for primary production in the lake. Depending upon the variability of color by tributary or by season, this could be an important factor to consider for calibration of the lake model. Measurement of color and SUVA do not require complicated or time intensive lab work and should be relatively inexpensive. This assumption will be verified with laboratories conducting the analyses.

All data will be evaluated after each year of collection to verify that the data are meeting the stated objectives. As part of the annual program review, the temporal and spatial resolution of sample collection will be evaluated and changes suggested where appropriate.

1.1.2 **Falls Lake Monitoring**

Monitoring of Falls Lake provides data for calibration and validation of a revised EFDC model (e.g. concentrations of chlorophyll *a*, nutrients, and carbon) as well as data for informing model parameters (e.g. light extinction coefficient). Ongoing monitoring by DWR, CAAE, and local governments provides data for these efforts (Table 4).

Additional Falls Lake monitoring by the Division of Water Resources (DWR) is requested as part of this monitoring program. A specific proposal that requests that DWR conduct additional lake monitoring will be submitted separately to DWR in conjunction with this monitoring plan. In summary the UNRBA is requesting that DWR add the following water quality analyses to their monthly data collection: total suspended solids (TSS), color, 5-day carbonaceous biochemical oxygen demand (CBOD5), dissolved organic carbon (DOC), and specific UV absorbance (SUVA). The collection of these parameters will help with model calibration. The combination of color, CBOD5, DOC and SUVA will help the UNRBA determine whether carbon sources are primarily derived from inside or outside of the lake. They will also be used to calculate the particulate organic carbon (POC) concentration needed for the model and to estimate what portions of the total are labile and refractory. These data would support future calibration of a revised model, and evaluation of impacts to water quality. The model can be run at the expected ranges of these values to see how the revised model chlorophyll *a* predictions respond to changes in these values. These are not parameters routinely monitored by DWR, but the availability of this data would enhance the re-examination effort and address potential important water supply implications of nutrient levels. If DWR cannot analyze these parameters, their inclusion as a special study of the monitoring program will be considered by the UNRBA and Path Forward Committee. The UNRBA will also request that DWR add one new lake water quality station in the center of the lake downstream of the mouth of Ledge Creek (coordinates are approximately 36.025,-78.716). The location of this proposed new station is shown as a red X on Figure 2. The addition of this station to the DWR's Falls lake monitoring program would provide data for the model in an area of the lake which is considered underrepresented by current monitoring. If the DWR cannot add this station, its inclusion as a special study in one or more subsequent years will be considered by the Path Forward Committee. Based on DWR's response to the additional proposed Falls Lake monitoring plan it may be necessary to modify this monitoring plan. At previous meetings with DWR, there was general indication that, if possible, the Division would be willing to provide some additional monitoring coverage to enhance the UNRBA's program.

The Center for Applied Aquatic Ecology (CAAE) monitors DO, temperature, pH, and specific conductivity every three hours at multiple depths at three platforms located at I-85, Creedmoor Road, and at Raleigh's intake. Additional parameters are monitored monthly and up to bi-weekly during the summer at these stations. The CAAE data will be used to inform model calibration and can be paired with diurnal water quality sampling as a recommended special study (Appendix A). This study will provide the UNRBA with data needed to support development of site specific water quality criteria or a sub-classification use attainability analysis, and correlates chlorophyll *a* concentrations with conditions that influence aquatic health. The study will also provide additional calibration data for the EFDC model.

Table 4 Current Lake Sampling by DWR, Cities of Durham and Raleigh, and CAAE. Frequencies are provided in parentheses: M-monthly, W-weekly. Data from municipalities and CAAE are derived from data supplied to Cardno ENTRIX in 2012 and will be verified.

Samples	DWR	City of Durham	City of Raleigh	CAAE
TOC	Photic Zone Composite (M)	Surface and/or Photic Zone Composite[1] (W)	Surface (M)	Monthly with seasonal increase in frequency at the three platforms (I-85, Hwy 50, and Raleigh Intake), variable frequency elsewhere[2]
Chlorophyll *a*	Photic Zone Composite (M)	Surface and/or Photic Zone Composite[1] (W)	Surface (M)	**Hwy 85, Hwy 50, and Raleigh Intake** 1-2 meters, 2x/month **Variable sampling frequency at other locations**
TN	Photic Zone Composite (M)	Surface and/or Photic Zone Composite[1] (W)	Surface (M)	Monthly with seasonal increase in frequency at the three platforms (I-85, Hwy 50, and Raleigh Intake), variable frequency elsewhere[2]
TKN	Photic Zone Composite (M)	Surface and/or Photic Zone Composite[1] (W)	Surface (M)	Monthly with seasonal increase in frequency at the three platforms (I-85, Hwy 50, and Raleigh Intake), variable frequency elsewhere[2]
NO2 + NO3	Photic Zone Composite (M)	Surface and/or Photic Zone Composite[1] (W)	Surface (M)	Monthly with seasonal increase in frequency at the three platforms (I-85, Hwy 50, and Raleigh Intake), variable frequency elsewhere[2]
NH3	Photic Zone Composite (M)	Surface and/or Photic Zone Composite[1] (W)	-	Variable
TP	Photic Zone Composite (M)	Surface and/or Photic Zone Composite[1] (W)	Surface (M)	Monthly with seasonal increase in frequency at the three platforms (I-85, Hwy 50, and Raleigh Intake), variable frequency elsewhere[2]
Orthophosphorus	-	Surface and/or Photic Zone Composite[1] (W)	-	-
Turbidity	Photic Zone Composite (M)	-	Surface (M)	-

Samples	DWR	City of Durham	City of Raleigh	CAAE
TSS	-	-	-	Monthly with seasonal increase in frequency at the three platforms (I-85, Hwy 50, and Raleigh Intake), variable frequency elsewhere[2]
pH	Depth Stratified (M)	Surface (W)	Surface (M)	Platforms[3]
Conductivity	Depth Stratified (M)	Surface (W)	Surface (M)	Platforms[3]
Dissolved oxygen	Depth Stratified (M)	Surface (W)	Surface (M)	Platforms[3]
Temperature	Depth Stratified (M)	Surface (W)	Surface (M)	Platforms[3]

[1] Durham has two stations: one has data only for surface samples, the other has data for surface and photic zone composite samples.

[2] Data are available for a number of CAAE sites which are either no longer sampled, are sampled only in summer months or have variable sampling frequency for these parameters.

[3] These data are collected from *in situ* monitoring platforms at multiple depths every three hours.

1.1.3 **Jurisdictional Boundary Sites**

Establishment of water quality monitoring stations at jurisdictional boundaries and key loading points such as the outlets of major tributaries within a jurisdiction can be used to 1) provide data to support the jurisdictional reporting requirements of the Falls Lake Nutrient Management Strategy, 2) prioritize BMP implementation in areas with the highest nutrient loading, 3) calibrate watershed models and, potentially, 4) assess changes in loading over time.

Twenty unique stations have been selected to characterize water quality at jurisdictional boundaries within the Falls Lake watershed (excluding those covered under the lake loading stations) based on input from the UNRBA Path Forward Committee (Figure 1, Table 5). These 20 stations will be monitored every month for the first year. Cost savings may be realized in subsequent years if sampling frequency can be reduced to every-other month or quarterly at some stations. However, since many of these are new stations, and there is no historic data to supplement the database and reduce the uncertainty associated with the statistical models presented in the Water Quality Estimation and Optimization Technical Memorandum (WQTM, Cardno ENTRIX 2014c) and per Path Forward Committee recommendations, we assume that the monthly sampling frequency will continue in each year. Monitoring frequency will be revisited with the UNRBA on at least an annual basis.

The water quality measurements at jurisdictional boundary locations will initially include the following parameters: ammonia (NH3), nitrate plus nitrite (NO2/NO3), total Kjeldahl nitrogen (TKN), total phosphorus (TP), total suspended solids (TSS), total organic carbon (TOC), and field parameters (temperature, dissolved oxygen, pH, and conductivity). These parameters are listed in Table 6.

Table 5 Jurisdictional Boundary Monitoring Locations. All stations will be sampled monthly.

	Waterbody	Road Crossing	Boundary	Latitude	Longitude	Drainage Area (mi^2)	Monitoring Frequency
JB01	Eno River	at Dimmocks Mill Road	upstream of Hillsborough	36.070127	-79.129530	60.5	Monthly
JB02	Eno River	at Hwy 70 and Riverside Drive	downstream of Hillsborough	36.075417	-79.071636	73.2	Monthly
JB03	Eno River	at Cole Mill Road	downstream of Orange County	36.059290	-78.978042	121	Monthly
JB04	North Fork Little River	at New Sharon Church Road	between Orange and Durham Counties	36.180164	-78.975432	21.9	Monthly
JB05	South Fork Little River	at Guess Road (Hwy 157)	between Orange and Durham Counties	36.145465	-78.962187	37.4	Monthly
JB06	Little River	at Johnson Mill Road	upstream of City of Durham	36.141643	-78.919265	78.3	Monthly
JB07	North Flat River	at Highway 57	downstream of Roxboro	36.310638	-78.969420	15.8	Monthly
JB08	North Flat River	at Helena-Moriah Road	Person Co. before confluence with South Flat	36.288983	-78.942891	32.8	Monthly
JB09	South Flat River	at Highway 57	Person Co. before confluence with North Flat River	36.256842	-78.944337	54.4	Monthly
JB10	Flat River	at Moores Mill Road	downstream of Person county	36.241864	-78.905769	102	Monthly
JB11	Deep Creek	at Smith Road	downstream of Person County	36.240278	-78.888885	32.1	Monthly
JB12	Camp Creek	at Camp Butner	between Durham and Granville Counties	36.209510	-78.805304	4.99	Monthly
JB13	Little Ledge Creek	at Old Weaver Trail	downstream of Granville	36.075904	-78.720953	3.74	Monthly
JB14	Ledge Creek	at Old Route 75	downstream of Stem	36.194856	-78.729220	1.79	Monthly
JB15	Ledge Creek	at W Lyon Station Road	upstream of Butner	36.176079	-78.714097	3.49	Monthly
JB16	Robertson Creek	at Sam Moss Hayes Road	upstream of Creedmoor	36.139193	-78.660785	4.43	Monthly
JB17	Buckhorn Creek	at Buckhorn Lane	between Granville and Wake Counties	36.048080	-78.609717	1.21	Monthly
JB18	New Light Creek	at Bold Run Hill Road	between Granville and Wake Counties	36.037485	-78.592078	9.90	Monthly
JB19	Horse Creek	at Holden Road	between Franklin and Wake Counties	36.024301	-78.518988	4.78	Monthly
JB20	Horse Creek	at Purnell Road	upstream of Wake Forest	36.007058	-78.529087	7.11	Monthly

Table 6 Water Quality Parameters to be Measured at Jurisdictional Boundary Sampling Locations

Field Measurements	Laboratory Analyses
Water temperature Air temperature Specific conductance Dissolved oxygen pH	Total Kjeldahl nitrogen Nitrate + nitrite Ammonia Total phosphorus Total organic carbon Total suspended solids

1.2 Special Studies Component of the Monitoring Program

In addition to routine monitoring as described in Section 1.1 of this Monitoring Plan, several short-term studies will provide critical data needed to support each of the UNRBA's monitoring objectives. Over the past several years, UNRBA members and Cardno ENTRIX have identified many special studies that would inform the program's monitoring objectives; however, the total cost of these studies exceeds the UNRBA budget. This section presents the special studies which have been ranked highly jointly by Cardno ENTRIX and the UNRBA Path Forward Committee and are selected for inclusion in the 4-5 year monitoring program.

Recommended special studies along with their timing are presented in Table 7 and are grouped according to the three UNRBA monitoring objectives: lake response modeling, jurisdictional loading and source allocation, and support for regulatory options. Not all recommended special studies occur every year, and several studies will only occur in one or two years. The Study ID number corresponds to further discussion of the study in Appendix A and follows the format SS.XX.#, where SS stands for "Special Study", XX refers to the monitoring objective the special study meets. The monitoring objectives are "LR" for "Lake Response Modeling", "SA" for "Source Allocation", or "RO" for "Regulatory Options". The final number distinguishes among special studies within a given category.

Table 7 Special Studies and Data Use, Importance, and Timing of Study Implementation

Study ID	Special Study Description	How information will be used by UNRBA and why it is important to the UNRBA	Estimated Duration
Lake Response Modeling (Loading Estimation)			
SS.LR.1	Storm event sampling and comparison of loading methods	Determine which method (various LOADEST options or WQ statistical model) most accurately calculates nutrient loads to Falls Lake. The TN and TP load estimate doubles depending on the method used as shown in the Model Sensitivity TM. Estimating lake loads based on the most accurate method will result in substantially more accurate model predictions and increased confidence in resulting Stage II targets.	1-2 storms per year, each at one site. Sites will vary for each storm.
SS.LR.2	Obtain additional internal loading from lake sediments, as well as other model parameters such as algal respiration, reaeration rates, and algal growth rates	Improve accuracy and calibration of EFDC model. If EPA cannot collect this data, the data collected by DWR will be used to revise model setup, applying the higher nutrient flux measurements in upper lake areas. Although DWR collected data at two sites and obtained different flux rates at each, the current model uses a single value for the entire lake.	UNRBA will seek DWR cooperation to petition EPA to conduct these surveys for Falls Lake.
Source Allocation: Determining Loading from Different Watershed Sources			
SS.SA.1	Tracking BMP Implementation, Inspections and Repairs	The following information should be collected: description of each BMP, geographic position, parcel square footage, square footage by land use draining to the BMP, and BMP inspections and maintenance performed. The Nutrient Scientific Advisory Board (NSAB) is currently establishing guidance regarding data collection efforts for BMPs that will be needed to calculate credits. To continue receiving nutrient loading credits from BMPs, local governments should inspect and repair BMPs on an annual basis.	This information should be tracked annually by member jurisdictions.
SS.SA.2	Measure cross sections and sediment concentrations at five locations previously monitored by USGS; estimate sediment and nutrient loading associated with stream bank erosion	Determine how much of the nutrient loading to the lake could be associated with stream bank erosion; may be used to support development of nutrient reduction credits assigned to stream restoration activities. Provides members the ability to prioritize implementation practices and reduce compliance costs.	Conduct in year 2. UNRBA will discuss with USGS to determine if they are interested in revisiting these studies.

Study ID	Special Study Description	How information will be used by UNRBA and why it is important to the UNRBA	Estimated Duration
Support of Regulatory Options - Linkage of Water Quality with Designated Uses			
SS.RO.1	Water quality studies at three Center for Applied Aquatic Ecology (CAAE) diurnal stations (I-85, Highway 50, and Raleigh Intake) during high-chlorophyll periods.	Supports regulatory options and structural equation/ Bayesian modeling, and EFDC model calibration. Provides data needed to support development of site specific water quality criteria or a sub-classification use attainability analysis. Correlates chlorophyll *a*, nutrient, DO and pH concentrations with conditions that influence aquatic health.	Years 1, 2, 3, 4
SS.RO.2	Fish monitoring by WRC at DWR Lake monitoring stations (or at the three CAAE locations)	Support regulatory options and structural equation/ Bayesian modeling. Correlates fish population, size and length with water quality conditions in the three main segments of the lake.	Years 1, 2, 3, 4
SS.RO.3	Coordinate with the City of Raleigh to conduct paired water quality sampling (nutrients, chlorophyll *a*, TOC, DOC, SUVA, and color) at intake to correlate with finished water quality testing performed by Underwriters Laboratories (UL) (taste and odor and DBPs)	Support regulatory options and structural equation/Bayesian modeling. Provides data to identify how water quality at the intake is linked with disinfection byproduct formation and taste and odor issues in the finished water.	Years 1, 2, 3, 4
SS.RO.4	Recreational surveys and count models that link visitation with water quality parameters	Support regulatory options and structural equation/Bayesian modeling. Correlates lake water quality with recreational uses. These data are needed for development of a site specific criterion or a sub-classification use attainability analysis.	Years 2, 3, 4, and 5 if needed

2 List of References

Cardno ENTRIX. 2012. Task 2: Review Existing Data and Reports for Falls Lake and the Watershed. Support of Long Term Planning and Regulatory Nutrient Activities in the Falls Lake Watershed. Prepared for the Upper Neuse River Basin Association.

Cardno ENTRIX. 2013a. Task 1: Framework for a Re-examination of Stage II of the Falls Nutrient Strategy. Support of Long Term Planning and Regulatory Nutrient Activities in the Falls Lake Watershed. Prepared for the Upper Neuse River Basin Association.

Cardno ENTRIX. 2013b. Task 3: Estimation of Nutrient Loading to Falls Lake. Support of Long Term Planning and Regulatory Nutrient Activities in the Falls Lake Watershed. Prepared for the Upper Neuse River Basin Association.

Cardno ENTRIX. 2013c. Task 4: Review of Existing Models and Recommendations for Future Studies. Support of Long Term Planning and Regulatory Nutrient Activities in the Falls Lake Watershed. Prepared for the Upper Neuse River Basin Association.

Cardno ENTRIX. 2014. Description of the Water Quality Model Framework under the Re-examination Provision of the Falls Lake Rules. Prepared for the Upper Neuse River Basin Association.

Cardno ENTRIX. 2014a. Evaluation of the Sensitivity of the Falls Lake Nutrient Response Model. Prepared for the Upper Neuse River Basin Association.

Cardno ENTRIX. 2014b. Comparison of Flow Estimation Methods. Prepared for the Upper Neuse River Basin Association.

Cardno ENTRIX. 2014c. Water Quality Estimation and Optimization Technical Memorandum. Prepared for the Upper Neuse River Basin Association.

Cuthbert, I. D., and P. del Giorgio. 1992. Toward a standard method of measuring color in freshwater. Limnology and Oceanography 37:1319–1326.

Hendrickson, J., N. Trahan, E. Stecker, and Y. Ouyang. 2002. TMDL and PLRG Modeling of the Lower St. Johns River Technical Report Series Volume 1: Calculation of the External Load. St. Johns River Water Management District, Palatka, FL.

N.C. Rules Review Commission. 2010. Falls Nutrient Strategy Rules Approved by the RRC on December 16, 2010. Effective Date - January 15, 2011.

North Carolina State University, Biological and Agricultural Engineering Department and North Carolina Department of Environment and Natural Resources. 2011. Jordan/Falls Lake Stormwater Nutrient Load Accounting Tool. Version 1.1. November 2011. http://portal.ncdenr.org/web/wq/ps/nps/fallslake

Triangle J Council of Governments (TJCOG). 2012. Upper Neuse Water Quality Monitoring Plan. September 2012. http://www.tjcog.org/upper-neuse-water-quality-monitoring.aspx

Weishaar, J. L., G. R. Aiken, B. A. Bergamaschi, M. S. Fram, R. Fujii, and K. Mopper. 2003. Evaluation of specific ultraviolet absorbance as an indicator of the chemical composition and reactivity of dissolved organic carbon. Environmental Science & Technology 37:4702–8.

DRAFT UNRBA Monitoring Plan

APPENDIX A

DESCRIPTION OF SPECIAL STUDIES

Appendix A

A.1 Studies to Support Revised Lake Response Modeling

The existing Falls Lake EFDC lake response model was developed based on lake and watershed data collected from 2005 to 2007. In addition to the routine monitoring described in the main text of this document to better characterize tributary loading of nutrients, carbon, and chlorophyll *a*, several potential special studies have been identified which could reduce the reliance on assumptions for model development and influence the model response.

The following special studies related to Lake Response Modeling are deemed high priority and may be conducted within the currently projected UNRBA monitoring budget. Future changes to the budget or monitoring priorities established by the UNRBA may influence whether these special studies can be completed.

SS.LR.1: Storm Event Sampling

In a recent TM describing the sensitivity of the EFDC lake response model, Cardno ENTRIX demonstrates several methods for estimating nutrient loads to the lake based on flow and water quality data. The loads resulting from each method were highly variable and a determination of which method was most accurate could not be made based on the data available. Conducting storm event sampling where flow and water quality samples are collected frequently over the course of a storm would provide the data needed to determine which of the methods were most accurate in determining loading to the lake. The following water quality parameters should be included: turbidity, NH3, NO2/NO3, TKN, Ortho-P, total P, TSS, TOC, field parameters, and sediment partitioning. Sampling frequency may vary based on the intensity and duration of the storm. It is recommended that these studies be initially conducted where an existing 15-minute USGS flow gage is present. One to two sites will sampled, each for a single storm event, in each year of the monitoring program.

SS.LR.2: Internal Lake Loading and Lake Processes

The assessment of nutrient loading to the lake should account for internal loading due to releases from lake sediment. Benthic flux rates should be measured for ammonia, nitrate plus nitrite, phosphate, and sediment oxygen demand (SOD). There are a small number of existing measurements of benthic flux in Falls Lake that were conducted in support of the EFDC lake response modeling, and these results suggest that different rates may apply to different locations within the lake. However, the existing Falls Lake EFDC model assumed a single rate for each parameter across the lake which was adjusted as a calibration factor. In addition, the existing measurements were conducted in the spring when hypoxic conditions at the sediment-water interface were likely not present. Low dissolved oxygen conditions stimulate the release of phosphorus from lake sediments, so the existing monitoring may not have characterized the actual variability in this nutrient loading source.

A better understanding of the spatial variability in these lake processes would improve model calibration and provide the data needed to simulate these processes spatially rather than assuming that one set of factors applies in all areas of the lake. Future model updates could account for the observed spatial variation at additional stations, and sampling events would provide greater characterization of the spatial and temporal variability across the lake as whole. Additional monitoring for benthic flux should include both temporal (seasonal) and spatial variation.

Benthic nutrient flux and sediment oxygen demand may be measured *in situ* using sealed chambers or in a laboratory using extracted sediment cores and either deionized water or lake water. In each method, samples are extracted from the water above the sediments and changes in nutrient concentration are used to calculate flux (mass per time). Measurements are typically taken in triplicate at each site. Site locations should be selected to assess longitudinal changes in nutrient flux from the upstream end of the lake to the dam.

The existing EFDC lake response model also uses literature values and model calibration to approximate nutrient transformations, algal growth and settling, background light extinction, organic hydrolysis, nitrification, sedimentation, etc. Given the long residence time of the lake, these parameters have implications for how nutrients are cycled and converted within the lake model. Because the sediment oxygen demand studies require the presence of dissolved oxygen at the sediment-water interface to measure rates of change in this parameter, these benthic studies will not be conducted under anoxic conditions when phosphorus flux is typically greatest.

The UNRBA will petition US-EPA Region 4 to conduct these studies. If EPA does not conduct these studies, then the model may be modified to use the higher flux rates obtained by DWR at I-85 to represent conditions in the lake upstream of Creedmoor Road. The lower flux rates will be used to represent conditions in the lake downstream of Creedmoor Road. Alternatively, the two spatial measurements could be used to define a linear change in benthic flux rates defined for several modeling segments. Both approaches could be tested during preliminary model revisions and the sensitivity of the model to these parameters could be assessed.

A.2 Source Allocation and Estimation of Jurisdictional Loading and Nutrient Transport within the Falls Lake Watershed

In order to achieve compliance with chlorophyll *a* water quality standards throughout the Lake, the State has determined that nutrient loading to the lake from the upper five tributaries should be reduced by 40 percent for nitrogen and 77 percent for phosphorus. The Falls Lake Nutrient Management Strategy rules identify the parties (municipalities, counties, agriculture, and state and federal entities) responsible for implementing the nutrient reductions, which are to be achieved by requiring stormwater controls and implementation of best management practices (BMPs) for new and existing development, point source discharges, and agricultural non-point sources. Due to the requirements specified in the Falls Lake Nutrient Management Strategy (.0275 5(b)(i)), nutrient loading to Falls Lake Reservoir must be evaluated and reported to the EMC every five years, beginning in 2016.

Current evaluations of the watershed model indicate that there is a high degree of uncertainty associated with the watershed loads predicted by the Falls Lake watershed loading (WARMF) model. Issues and uncertainties associated with the model have been described by Cardno ENTRIX (2013b).

Targeted monitoring within the watershed will reduce uncertainties associated with specific loading sources and jurisdictional allocations. This monitoring can be supplemented by the statistical models developed by Cardno ENTRIX in the Water Quality Estimation and Optimization TM (Cardno ENTRIX April 2014). The following studies would provide data that can be used to refine the watershed loading estimates to Falls Lake, validate and refine the statistical models, and increase the accuracy of jurisdictional load allocation. Future changes to the budget or monitoring priorities established by the UNRBA may influence whether these special studies can be completed as described.

SS.SA.1: Tracking BMP implementation, inspections, and repairs

Local governments in the Falls Lake watershed are required to track BMP implementation and estimate resulting nutrient load reductions. Local governments should begin collecting data to support this requirement and provide the data needed for credit accounting tools such as the Jordan/Falls Lake Stormwater Nutrient Loading Accounting Tool (NCSU-BAE and NCDENR 2011). The following information should be collected: description of each BMP, geographic position, parcel square footage, square footage by land use draining to the BMP, and BMP inspections and maintenance performed. The Nutrient Scientific Advisory Board (NSAB) is currently establishing guidance regarding data collection efforts for BMPs that will be needed to calculate credits. To continue receiving nutrient loading credits from BMPs, local governments should inspect and repair BMPs on an annual basis. Cardno ENTRIX suggests that each UNRBA member document these efforts in an electronic database or spreadsheet. These efforts will be covered by individual local governments. The local governments should treat this as a high priority effort.

SS.SA.2: Streambank erosion and nutrient loading

Little is known regarding the contribution of streambank erosion to nutrient loading in the Falls Lake watershed. Monitoring to measure the relative importance of this source is recommended. There are several locations in the watershed where USGS obtained stream channel cross section measurements. Revisiting these sites and measuring the cross sections will provide an estimate of the mass of sediment lost. Collecting stream bank and stream bed sediment data for analysis of nutrient and carbon content will provide a corresponding estimate of loading for these parameters. Another option (more resource intensive) is to develop Bank-Stability and Toe-Erosion Models (BSTEM) that rely on additional field data and the use of bank erosion modeling to estimate sediment loading under baseline and management scenarios. Given the other priorities associated with this monitoring program, Cardno ENTRIX recommends the simpler option that relies on cross section and sediment nutrient concentration data. This is a high priority study because its results will provide the UNRBA with information needed to prioritize BMPs on upland areas versus stream bank restoration projects.

A.3 Support of Regulatory Options and Linkage of Water Quality to Designated Uses

Falls Lake is listed as impaired for chlorophyll *a* based on the water quality criteria of 40 µg/L. The framework for re-examining the Falls Lake Nutrient Management Strategy relies on a linkage between water quality and designated uses: wildlife enhancement and aquatic life, recreation, drinking water supply, and flood storage. To date, little data has been collected in Falls Lake to support this linkage, and even DWR staff have stated that "based on what DWR staff has read in files from the 1970s, Water Resources Research Institute (WRRI) did not have a specific designated use that they were trying to protect by utilizing the 40 µg/L chlorophyll *a* criteria" (August 29, 2005 Falls of the Neuse and High Rock Lakes Combined Technical Advisory Committee meeting). Several studies are needed to provide a better linkage between water quality and designated uses, particularly with respect to the chlorophyll *a* standard.

The following special studies related to supporting regulatory options are deemed high priority and may be conducted within the currently projected UNRBA monitoring budget. Future changes to the budget or monitoring priorities established by the UNRBA may influence whether these special studies can be completed as described.

SS.RO.1: Falls Lake diurnal pH and DO monitoring with water quality sampling

The purpose of this study is to obtain additional data throughout the water column to link the aquatic life use support category with concentrations of chlorophyll *a*, nutrients, and related fluctuations in dissolved oxygen (DO) and pH. An over-abundance of algae may cause diurnal variations in DO concentrations and pH levels as the processes of photosynthesis and respiration occur. Die-off and decay of algae also result in the consumption of DO.

North Carolina State University's Center for Applied Aquatic Ecology (CAAE) collects field data at three hour increments at three locations in Falls Lake with at least monthly water quality sampling. Diurnal sampling of DO, pH, and temperature at these three CAAE platform locations (at multiple depths) in the lake will provide an indication of whether aquatic organisms are likely experiencing stress due to elevated levels of algae in the water column. To supplement the CAAE field data collection, water quality samples should be collected during 2-3 high algal growth periods and one lower algal growth period to link chlorophyll *a* and nutrient concentrations with fluctuations in DO and pH and document conditions which can impact support of the aquatic life use. Data will be collected once per day for a 4-day period as a photic zone composite and at three discrete depths. Sampling depths should be co-located at the depths monitored by the automated platform and be approximately one meter from the surface, one meter from the bottom (or at the deepest CAAE platform sampling depth), and near the middle of the water column. Monitoring will include the following parameters: chlorophyll *a*, NH3, NO2/NO3, TKN, Ortho-P, total P, TSS, color, SUVA, TOC, and DOC. Algal unit density (units/ml) and biovolume (mm^3/m^3) will also be obtained for the following three groups of algae: diatoms, green algae, and cyanobacteria.

The data from this study can be used to demonstrate support of the aquatic life use and for development of an alternative chlorophyll *a* criterion for sections of Falls Lake. This data will also be used to help calibrate the EFDC model and provide insight on day to day variability in nutrient and chlorophyll *a* concentrations. If day-to-day variability is found to be high, the time interval between water quality samples may be decreased for subsequent monitoring events. This is a high priority study.

SS.RO.2: Fish monitoring with water quality sampling

The NC Wildlife Resources Commission (WRC) conducts fish monitoring in Falls Lake once per year for either largemouth bass or black crappie. The majority of the fish monitoring occurs in the Lower Lake downstream of Highway 50 (94 percent of current surveys focus on the Lower Lake). Fish monitoring in the Upper Lake would provide information on the biological health in this part of the system. This effort would involve coordinating with the WRC so that the fish sampling occurs within a few days of the monthly lake sampling conducted by DWR. This will provide an indication of how water quality affects fish utilization of the lake. Coordination with the WRC will be required to develop this sampling plan. This is a high priority study.

SS.RO.3: Drinking Water Supply and Water Quality Monitoring

The City of Raleigh currently collects data on taste and odor, disinfection by-products, and other parameters associated with the quality of the raw water supply at several places below Highway 50 (Figure 2). Cardno ENTRIX recommends water quality sampling of raw water for additional parameters including nutrients, chlorophyll *a,* TOC, DOC, SUVA, and color to link water quality at the intake with quality measures for finished water.

SS.RO.4: Recreational Data and Water Quality Sampling

Weekly recreational count data are available from the State Park System for the period 2000 to 2011. Starting in 2012, daily data are available. User perception surveys conducted to supplement the State Park System counts will be implemented online to assess how water quality conditions (clarity, aesthetics, odor, etc.) impact the quality of the recreational experience and dictate choices regarding where and when people choose to recreate. These online surveys will provide a linkage between water quality and attainment of the recreational designated uses for the reservoir. Surveys should target a mix of recreational uses including fishing, swimming, and boating to determine if water quality affects these uses in different ways.

The following recreational survey and count model development is recommended:

- Year 2: analyze count data from State Parks and develop count model to assess trends with weather, lake water quality, etc. Present results as a power point presentation to the UNRBA and develop a user-perception survey if needed (this will depend on the trends and strengths of the count model)
- Year 3: implement the user perception survey via internet to 1000 participants during the summer months. Update the count model and draft a report that summarizes the count model and the results of the user perception survey. Determine if additional surveys are needed in Year 4.
- Year 4 as needed: implement the user perception survey via internet to 1000 participants during the summer months. Update the count model and update the report that summarizes the count model and the results of the user perception survey. Determine if additional surveys are needed in Year 5.
- Year 5 if needed: implement the user perception survey via internet to 1000 participants during the summer months. Update the count model and report that summarizes the count model and the results of the user perception survey.

Table A-1. Summary of Special Studies.

Study ID	Priority	Study	Year 1	Year 2	Year 3	Year 4	Year 5 (Optional)
SS.LR.1	High	Storm event sampling	2 events	1 event	2 events	2 events	2 events
SS.LR.2	High	Internal lake loading and in-lake processes. Petition EPA to conduct these studies.	Work with DWR to petition EPA to conduct studies	Schedule studies	Schedule studies – Alternate Year		
SS.SA.1	High	Tracking BMP Implementation, Inspections, and Repairs	x	x	x	x	x
SS.SA.2	High	Measure cross sections and sediment nutrient concentrations at five previously monitored locations; estimate sediment and nutrient loading associated with stream bank erosion		x			
SS.RO.1	High	Quarterly water quality studies at three CAAE diurnal stations	x	x	x	x	x
SS.RO.2	High	Fish monitoring at seven stations	x	x	x	x	x
SS.RO.3	High	Drinking water quality and lake water quality monitoring	x	x	x	x	x
SS.RO.4	High	Recreational data		x	x	x	x